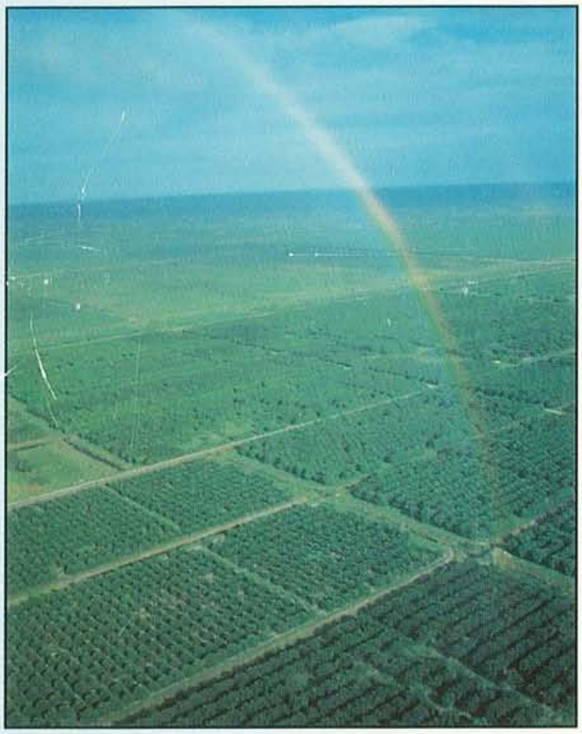

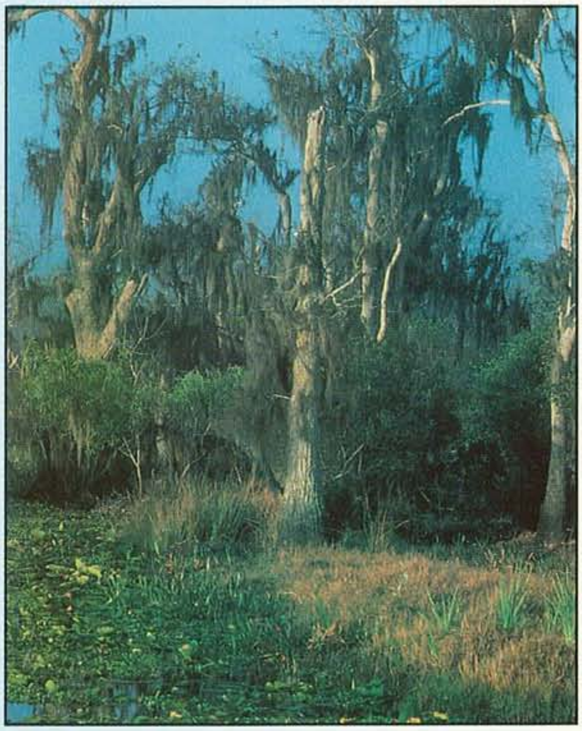

Lower West Coast WATER SUPPLY PLAN

BACKGROUND DOCUMENT

Volume II

Prepared by the Planning Department Staff

SOUTH FLORIDA
WATER MANAGEMENT DISTRICT

WEST PALM BEACH, FL

February 1994

LOWER WEST COAST

WATER SUPPLY PLAN

Volume II:
Background Document

by

Planning Department Staff

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South Florida Water Management District
Upper District Planning Division
West Palm Beach, Florida

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I. INTRODUCTION

PURPOSE AND SCOPE

The South Florida Water Management District (SFWMD or District) has undertaken development of long-term, comprehensive regional and county-level water supply plans to provide better management of South Florida's water resources. The Lower West Coast (LWC) Planning Area is one of four regional planning areas, as indicated on Figure I-1. These regions are defined by hydrologic divides and represent areas displaying similarities in development patterns, degree of urbanization, and water management issues and concerns.

The LWC Water Supply Plan is comprised of three documents: the LWC Water Supply Plan Planning Document (Volume I), the LWC Water Supply Plan Background Document (Volume II), and the LWC Water Supply Plan Appendices (Volume III).

This purpose of this LWC Water Supply Plan Background Document (LWC Background Document) is to provide a common set of data, assumptions, and potential water supply options for use by the District, the LWC Advisory Committee, other agencies, counties, municipalities, utilities, and other interested parties in development of the LWC Planning Document. The planning document, which is based on input from the background document, describes the results of the ground water modeling process, and makes recommendations that address problem areas where resource protection criteria were unmet. The planning document provides the framework within which the District may implement the LWC Water Supply Plan through regulation/permitting, planning, research, and land acquisition.

Local governments and utilities may use the planning document, background document and appendices, which comprise the LWC Water Supply Plan, to modify and update their local comprehensive plans, ordinances, and individual or regional utility plans.

BACKGROUND DOCUMENT DESCRIPTION

This Background Document is organized into six chapters: Chapters I through III provide an overview of the planning area, including its water resources, treatment facilities, and environmental features. Chapter IV documents the SFWMD's projections of water demands for urban and agricultural uses through the year 2010. In Chapter V, water conservation measures that reduce water demands, and supply alternatives that increase water supply are introduced, some of which are simulated with the ground water models used in the Planning Document. Chapter VI is an analysis of the alternatives to meet future demands that minimize the acreage where resource protection criteria were unmet. The "References Cited" section provides a list of literature cited in the three volumes of the LWC Water Supply Plan.

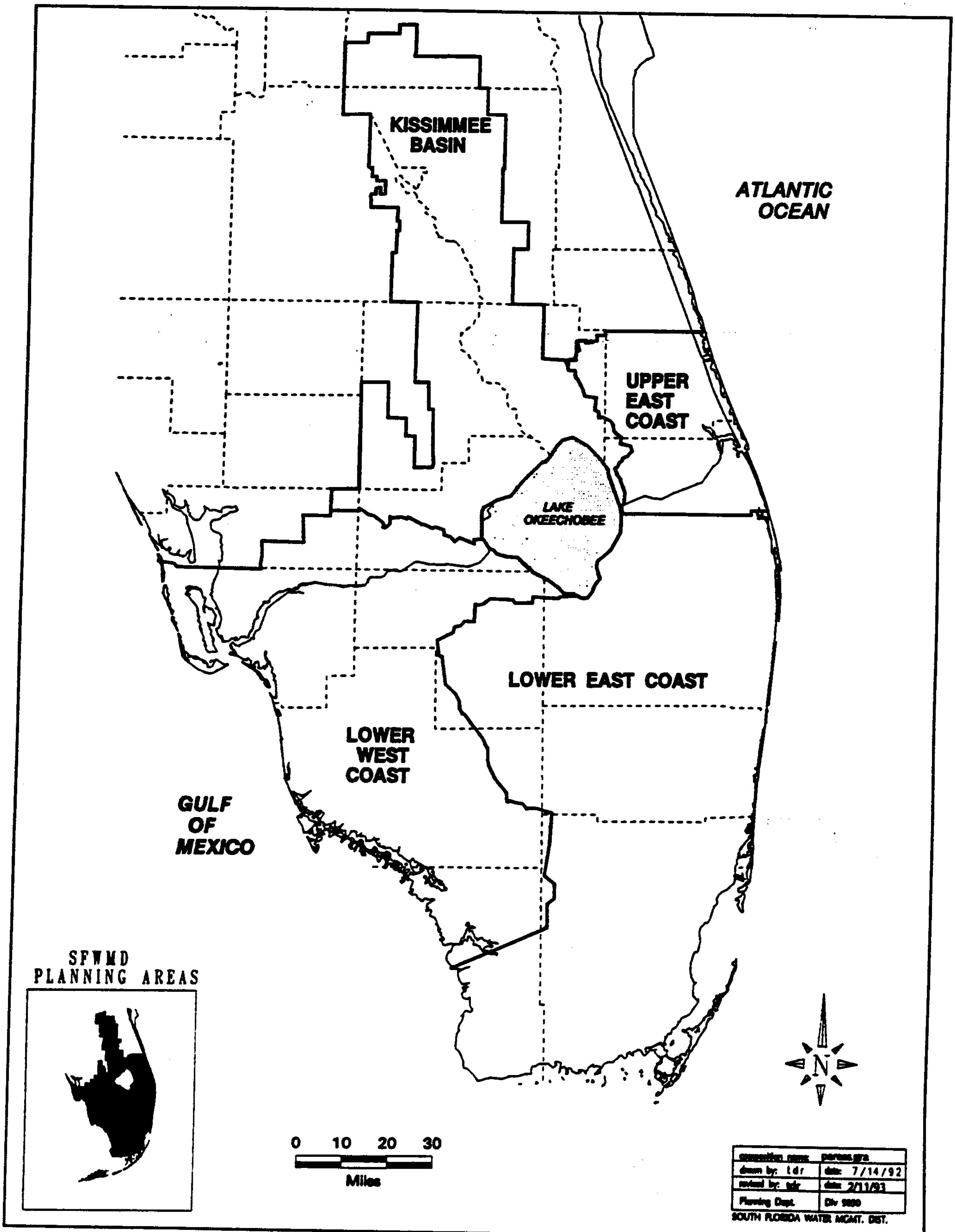

FIGURE I-1. Four Regional Planning Areas.

BASIS OF WATER SUPPLY PLANNING

Legal Authority and Requirements

The District is charged by the Florida Legislature with managing water use in South Florida. One important task in this charge is planning for future water demand in specific geographic regions within the District. In partial fulfillment of this requirement, the District has prepared a water supply plan for the LWC Planning Area. The following discussion describes the legal basis for the District's water supply planning program. Excerpts of specific Florida statutes and administrative codes cited in this section are provided in Appendix A.

Water supply planning activities were first required of the state's water management districts following adoption of the Florida Water Resources Act of 1972 (Chapter 373, Florida Statutes). The authors of *A Model Water Code* (Maloney *et al.*, 1972), upon which much of Chapter 373 is based, theorized that proper water resource allocation could best be accomplished within a statewide, coordinated planning framework. The "State Water Use Plan" (Section 373.036, Florida Statutes) and the "State Water Policy" (Chapter 17-40, Florida Administrative Code) are the primary planning documents to achieve proper water resource allocation.

Chapter 373, F.S. requires the Florida Department of Environmental Protection (FDEP) to prepare a State Water Use Plan. The State Water Use Plan defines objectives and operating policies which implement selected goals and policies of the State Comprehensive Plan (Ch. 187, F.S.). Chapter 187 provides guidance for all state agencies as they develop their "agency functional plans," and to the water management districts, as they develop their water management plans. More specific guidelines for these plans are provided in the State Water Policy (Ch. 17-40, F.A.C.).

Water management districts, pursuant to Part V of the State Water Policy, are required to prepare water management plans. These plans must be consistent with the State Water Policy and the Florida Water Resources Act of 1972. The water management plans are to include an assessment of water needs and supply sources and identification of critical water supply problem areas within the next 20 years. Each district must complete a water management plan by November 1, 1994, which at a minimum, must be updated every five years.

Water Supply Planning Initiative

The District is undertaking efforts to develop a water management plan, ensure prudent management of South Florida's water resources, and fulfill the planning and implementation directives of the Florida Water Resources Act of 1972. The District's initiative incorporates five components, each of which are described below:

- Develop water supply policy guidelines.
- Develop regional water supply plans and, where appropriate, more localized water supply plans for one or more counties.
- Prepare water supply elements for Surface Water Improvement and Management (SWIM) plans.
- Update the District's Basis of Review (BOR) for Consumptive Use Permitting.
- Address other water supply related programs (i.e, Water Supply Needs and Sources, and Critical Water Supply Problem Area Rule).

Develop water supply policy guidelines. The District's Water Supply Policy Document was accepted by the Governing Board in December 1991. This direction-setting document is the SFWMD's interpretive summary of the many water supply policy directives and statements that are found in the state statutes and administrative rules. A summary of the District's goals and policies, as derived from state law, are summarized on page I-5 of this document.

Develop regional water supply plans and, where appropriate, more localized water supply plans for one or more counties. Water supply plans are based upon data that is related to the specific needs, sources and environmental features of distinct planning areas, including individual county plans where appropriate. The District's schedule calls for four regional plans, including plans for the Lower East Coast, the Lower West Coast, the Upper East Coast and the Kissimmee Basin. These four regional plans will cover the entire SFWMD. The LWC Water Supply Plan is an important regional component of the water management plan. Please refer to the References Cited section (under SFWMD) for a listing of the available water supply plans.

Prepare water supply elements for Surface Water Improvement and Management (SWIM) plans. The integration of water supply planning and SWIM planning is a critical link between efforts to balance the environmental water quantity and quality requirements with the maximum reasonable-beneficial use of the resource. Because water supply elements are key components of SWIM plans, the water supply planning process takes into consideration the water quantity, environmental, and other related goals of SWIM plans. This will allow the water supply plans for specific regions to be incorporated into SWIM plans with minimal conflict.

Three SWIM plans have begun implementation: the Biscayne Bay SWIM Plan, the Indian River Lagoon SWIM Plan, and the Lake Okeechobee SWIM Plan. Both the Biscayne Bay SWIM Plan and the Indian River Lagoon SWIM Plan were adopted in 1988 and revised in 1989. Updates to these plans are underway, and both plans are expected to be completed in early 1994. The Lake Okeechobee SWIM Plan was enacted in 1989 and updated in January 1993. The 1993 update added new elements to address water supply, flood protection and environmental aspects of Lake Okeechobee management.

Update the District's Basis of Review (BOR) for Consumptive Use Permitting. The term *Basis of Review* refers to the District's "Management of Water Use Permitting Information Manual Volume III" (1993). The BOR is the District's formal criteria document governing the issuance of water use permits, and is part of the District's regulatory program. As the result of the development of the Water Supply Policy Document and new regulatory criteria generated from the water supply plans, the District's Basis of Review for consumptive use permits will be amended and serve as an important tool to implement the water supply planning initiative.

Other Water Supply Related Programs. The District has other water supply related programs that lend themselves to development and implementation of the Water Management Plan. The "Water Supply Needs and Sources" document, completed in 1992, provides a preliminary identification of the District's projected demands and supply potential for specific regions over the next 20 years. The demand and supply projection periods have been established from 1990 to 2010 in the

Water Supply Needs and Sources document and the water supply plans to facilitate the process of completing the District Water Management Plan.

In addition, the Critical Water Supply Problem Area Rule (Chapter 40E-23, F.A.C.), as required by Chapter 17-40, F.A.C., was adopted in October 1991. This rule identifies areas that presently have, or are expected to have, critical water supply problems during the next 20 years. A reasonable amount of reuse of reclaimed water from domestic wastewater treatment facilities is required within these areas. A majority of the LWC Planning Area is designated as a Critical Water Supply Problem Area, except for Charlotte County and a portion of Glades County. The State Water Policy requires these designations to be updated within one year of completion of the District Water Management Plan and its future updates.

District Goals, Directives and Policies

The District's Water Supply Policy Document provides an interpretative summary of state statutes and rules governing the uses of surface and ground waters in Florida. Selected excerpts from state water law can be found in Appendix A of the LWC Water Supply Plan. The District's overall water resources goal, as presented in the State Comprehensive Plan (Chapter 187, F.S.) is:

> "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 and ground water quality. Florida shall improve and restore the quality of waters not presently meeting water quality standards."

This goal will be achieved by balancing six principal water supply directives embodied in Florida law, and implementing them through the related water use policies established by state law, administrative rule, and the District's Governing Board. The six directives are presented in Figure I-2.

WATER USE DIRECTIVES

1. Prevent wasteful, uneconomical, impractical, or unreasonable uses of the water resources.
2. Promote economic development of the water resources consistent with other directives and uses.
3. Protect and enhance environmental resources while providing appropriate levels of service for drainage, flood control, water storage, and water supply.
4. Maximize levels of service for legal users, consistent with other directives.
5. Preserve and enhance the quality of the state's ground and surface waters.
6. Develop and maintain resource monitoring networks and applied research programs (such as forecasting models) required to predict the quantity and quality of water available for reasonable-beneficial uses.

FIGURE I-2. Six Water Use Directives Derived from State Law.
Source: SFWMD Water Supply Policy Document, 1991.

The state's policies strongly endorse conservation of available supplies, diversification of potential supply sources, protection and enhancement of water quality, and protection of environmental, fish and wildlife resources. At the same time, the state and the District are sensitive to the requirements of the region's population, and the need to provide clean water for drinking, other domestic uses, and agriculture.

PUBLIC AND AGENCY PARTICIPATION

Public and agency involvement was critical in the preparation of the LWC Water Supply Plan. The steps listed below were taken by the District to ensure adequate public input.

LWC Water Supply Plan Advisory Committee

One important aspect of the water supply planning process for the LWC Planning Area was the formation of a broad-based advisory committee consisting of representatives from interested and affected parties in the study area. Committee participants include representatives from utilities, agribusiness, government, environmental interest groups and others. The responsibility of this committee is to review and comment on this background document, and to advise and participate in development of the LWC Water Supply Plan. The advisory committee provided an effective forum for all interested parties to participate in plan development. Committee meetings were open to any interested members of the public that wish to attend. Dates and locations of the advisory committee meetings were provided in various mailings, such as meeting announcements, periodic newsletters, and notices published in the Florida Administrative Weekly. A list of Advisory Committee members is provided in Appendix J.

LWC Newsletter

In addition to the LWC Advisory Committee, the District published the LWC Water Supply Newsletter, which was directed towards informing affected and interested parties of the status and progress of the LWC Water Supply Plan. The newsletter includes summaries of advisory committee meetings, opportunities for input and participation, and other associated information. Four newsletters were mailed throughout 1991 and 1992 to approximately 150 individuals and groups including elected officials, civic groups, utilities, environmental groups, agribusiness and other individuals.

Data Confirmation

The technical information incorporated into this background document is the basis for discussions of water demand and availability in the LWC Planning Area; it is also the key data for computer evaluation (i.e., predictive modeling and analysis of water management alternatives) of the water resources. Therefore, it is important that this information is accurate so that areas where projected demands may exceed resource protection criteria are identified and the most appropriate solutions are presented.

The District initiated data collection and preliminary planning efforts for the LWC Water Supply Plan in 1991. As part of this effort, many entities, such as local governments, state and federal agencies, environmental groups, agricultural interests, and utilities within the LWC Planning Area, were contacted to gather initial input and information, and informal meetings were held with several of these groups. Examples of agencies contacted early in the process are:

- Collier County Utilities Department
- Collier County Growth Planning Department
- Big Cypress Basin Board
- Collier County Environmental Services Division
- Florida Game and Fresh Water Fish Commission (Punta Gorda Office)
- Southwest Florida Regional Planning Council
- Lee County Division of Water Resources
- Lee County Department of Growth Management
- Lee County Department of Community Development
- Lee County Division of Environmental Sciences
- Lee County Regional Water Supply Authority
- Hendry County Planning Department
- Hendry County Agriculture Extension Office
- Gulf Citrus Growers Association

Utility Information

It is important that the LWC Water Supply Plan is consistent with existing water supply utilities. To accurately reflect historic, current and projected water supply practices by the utilities in the LWC Planning Area, the District initiated an exhaustive survey of all regional public and private water and wastewater utilities in the study area. The utilities were sent a questionnaire addressing existing and future customers, service areas, treatment technologies, average daily flows, treatment plant locations, number of wells, interconnects with other utilities, and planned expansions for their respective utilities. Follow-up telephone calls were made to those utilities who did not respond, or whose response was incomplete.

This information was tabulated in a computerized spreadsheet and checked against other District sources, such as permits and comprehensive planning documents, for accuracy. Where inaccuracies were found, additional follow-up contacts were made. To assist utilities in planning their future wellfields, information on wellfield protection ordinances was collected and is provided in Appendix H.

Population and Urban Demand Projections

Population projections were taken from local government comprehensive plans so that the LWC Water Supply Plan is consistent with, and supports, local and state growth management policies. The population projections were broken down by utility service area and further adjusted to account for self supply. The District's population and per capita water demand calculations were mailed to local governments and utilities for their review. Their comments and concurrence on the population and demand projections was requested.

PLANNING AREA DESCRIPTION

Plan Boundaries

The LWC Planning Area is one of four regional planning areas for which the District is preparing regional water supply plans, as indicated in the introduction. The planning areas are defined by the drainage divides of major surface water systems in South Florida. The major water bodies considered in establishing these boundaries include the Kissimmee River, Lake Okeechobee, the Everglades and the Big Cypress Swamp. The series of canals, levees, pump stations, and storage areas that comprise the Central and South Florida Flood Control (C&SF) Project were also considered when the boundaries were established because these structures have altered the hydrology of the natural water bodies (see Surface Water Resources discussion in Chapter II).

The LWC Planning Area includes all of Lee County, most of Collier and Hendry counties, and a portion of Charlotte, Glades, Dade, and Monroe counties (Figure I-3). Only Lee County is entirely within the planning area; the remaining counties are shared with other regional planning areas. The portions of these counties within the LWC Planning Area are referred to as the Collier County Area, Hendry County Area, Charlotte County Area, Glades County Area, Dade County Area, and Monroe County Area. The boundaries of the LWC Planning Area generally reflect the drainage patterns of the Caloosahatchee River basin and the Big Cypress Swamp. The northern boundary corresponds to the drainage divide of the Caloosahatchee River, which is also the SFWMD/SWFWMD jurisdictional boundary in Charlotte County, while the eastern boundary delineates the divide between the Big Cypress Swamp and Everglades system. The area east of this divide is in the Lower East Coast Planning Area.

The modeling analysis of water supply alternatives for this plan focused upon Lee County and those portions of Collier and Hendry counties within the LWC Planning Area because most of the current and projected demand occurs in these areas. However, agricultural demand estimates were developed for the Charlotte County and Glades County portions of the planning area. There are no agricultural or urban demands for the Dade and Monroe county areas because these areas entirely consist of portions of Everglades National Park and the Big Cypress National Preserve. The portion of Dade County within the LWC Planning Area is too small to effectively be represented in the LWC Water Supply Plan.

Related Planning Areas

The District has established four water supply planning areas for the (1) Upper East Coast, (2) Lower East Coast, (3) Lower West Coast, and the (4) Kissimmee River Basin regions. Lake Okeechobee is considered part of each of the planning areas, which are connected to the lake through a surface water system. The Kissimmee River is the predominant inflow to the lake, while the remaining three planning areas receive outflows from the lake. The major outflows are to: (a) the Caloosahatchee River to the Lower West Coast, (b) St. Lucie Canal to the Upper East Coast, and (c) the West Palm Beach, Hillsborough, North New River, and Miami canals to the Lower East Coast. The Caloosahatchee River (C-43) and the St. Lucie Canal (C-44) are used primarily for water releases from the lake when lake levels exceed water stages of the U.S. Army Corps of Engineer's regulation schedule.

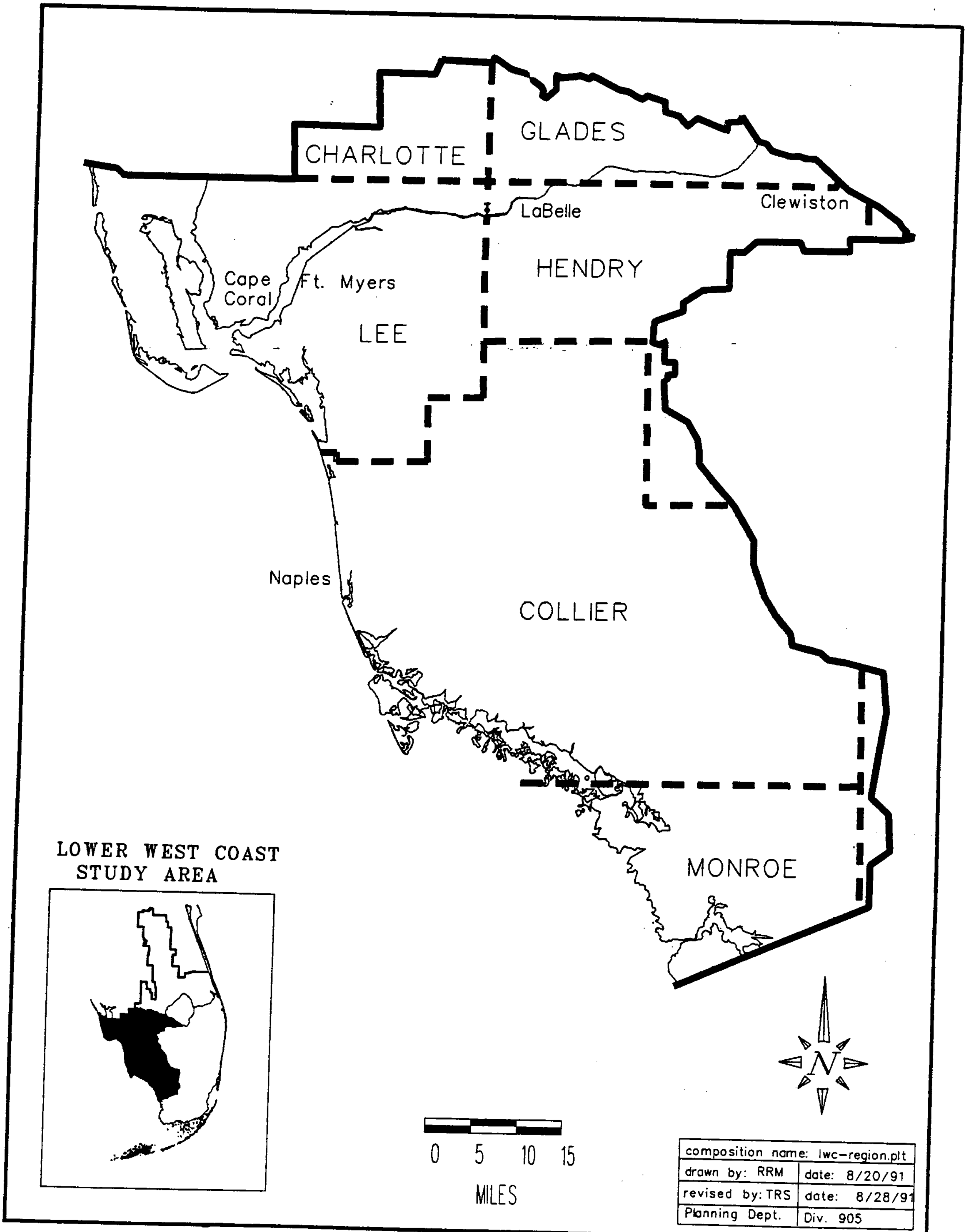

FIGURE I-3. Lower West Coast Planning Area.

In addition to regulatory discharges for flood protection, these canals receive water deliveries from the lake to maintain water levels for navigation, salinity control, and water supply. In the Caloosahatchee River, these water deliveries provide salinity control for potable water supply intakes located at the freshwater terminus of the river (C-43).

The LWC Planning Area is partially dependent on the lake for supplemental water supply and aquifer recharge. The Lake Okeechobee SWIM planning process will evaluate changes to the lake regulation schedule that are proposed to reduce excess flows from regulatory releases, while maintaining navigational requirements. The process will also consider potential impacts to the Caloosahatchee Estuary that may result from changes in lake levels. The Lake Okeechobee SWIM Plan analysis does not take into consideration the effects of lake levels on water supply to the Caloosahatchee basin.

The Lower East Coast Regional Water Supply Plan is examining the effects of future water supply demands on lake levels, storage, and impacts to the Caloosahatchee Estuary. The results of the Lake Okeechobee SWIM Plan and Lower East Coast Regional Water Supply Plan analyses will be considered in terms of effects on water supply from the Caloosahatchee River in the next update of the Lower West Coast Water Supply Plan.

Land Use

Table I-1 shows the percentage of land uses in each of the regions within the LWC Planning Area. The LWC Planning Area is predominantly agricultural, especially in the Charlotte, Glades, and Hendry county areas. The Monroe County Area is almost entirely covered with wetlands, while Lee County contains the most urban land use. Land use maps for each of the counties are provided in Appendix B.

The system of drainage networks that make Southwest Florida fit for human habitiation and agriculture have resulted in profound changes to the landscape. Very little of the original Everglades remains on the northeastern margin of the LWC Planning Area since its rich peat soils were drained for agricultural development. In other developed areas, such as Golden Gate Estates North in Collier County, urban growth has occurred on otherwise uninhabitable land. Golden Gates Estates South, however, is shown as wetlands on the land use map (Figure B-2) because it remains undeveloped and is planned for restoration under the Conservation and Recreation Lands (CARL) program.

TABLE I-1. Percent Land Use by Region.

Land Use	Charlotte Co. Area	Collier Co. Area	Glades Co. Area	Hendry Co. Area	Lee Co.	Monroe Co. Area
Agriculture	46%	12%	52%	61%	17%	0%
Urban	1	9	2	4	38	0
Wetlands	31	68	8	26	24	87
Forest	19	9	19	6	16	1
Rangeland	2	1	16	1	1	0
Barren	1	0	1	0	1	0
Water	0	1	1	0	2	12
Total Area (mi^2)	208	1,908	316	607	1,027	472

Source: SFWMD, 1986-1988 data.

Physical Features

Geography and Climate

The LWC Planning Area covers approximately 4,300 square miles. Average monthly temperatures in Southwest Florida range from 64.3 degrees in January to 82.6 degrees in August (SWFRPC, 1990). Annual average rainfall in the LWC Planning Area ranges from 51.77 inches in Hendry County to 54.50 inches in Collier County. Nearly two-thirds of annual rainfall occurs during the May to October wet season. Rainfall is further discussed in Appendix C.

Physiography

South Florida is characterized by low topographic relief and a high water table. With this type of flat terrain, a few vertical feet may have a profound effect on surface water drainage, vegetation, and settlement patterns. The dominant surface water feature of South Florida is the Kissimmee-Okeechobee-Everglades (KOE) drainage system, which is critical to the ecology of South Florida. The Kissimmee River, which is currently undergoing restoration, once meandered through a marsh floodplain into Lake Okeechobee. The natural outflow of the lake in the past was through the Everglades to the south. This sheetflow to the "River of Grass" has been replaced with a series of water control structures which regulate the stage and flow of the KOE drainage system.

A large part of the LWC Planning Area lies within the boundary of the Big Cypress physiographic province. This region, which is flat and has large areas with solution-riddled limestone at the surface, drains to the coastal marshes and mangrove swamps of the Ten Thousand Islands. The only major waterway in the LWC Planning Area other than the Caloosahatchee River is the system of canals in western Collier County which are monitored, controlled, and managed by Big Cypress Basin (a sub-unit of the SFWMD). The physiography of South Florida is discussed in further detail in "Environments of South Florida: Present and Past II" (Gleason, 1984).

Population

The estimate of total population of the LWC Planning Area for 1990 was 512,985. The total population is projected to increase 90 percent to 975,595 in 2010. Most of the population is settled in Lee and Collier counties. More detailed population figures and their associated demands are discussed in Chapter IV. The data sources and methodologies that were used to develop population estimates and projections are provided in Appendix G.

EVALUATION OF WATER SUPPLY ALTERNATIVES

Ground water declines are expected to increase in the future, due to the projected increases in ground water withdrawals. A variety of adverse impacts may be associated with long-term declines in ground water levels. Adverse impacts were addressed by determining thresholds that define excessive water level declines (resource protected criteria), and comparing simulated ground water levels against resource protection criteria to identify potential future problem areas. Once these areas were identified, alternative model scenarios were developed to address these problem areas. These scenarios included reserving sources of water in competing use situations, increasing agricultural irrigation efficiency, increasing use of reclaimed water, and modifying control structures to increase the level of surface water. The evaluation of these scenarios, as well as other mechanisms (i.e., land acquisition) the District may use to minimize future water supply problems are discussed in Chapter VI.

II. WATER RESOURCES AND SYSTEM OVERVIEW

PRECIPITATION AND EVAPORATION

The average annual precipitation in the LWC Planning Area is approximately 53 inches. Nearly two-thirds of the rainfall occurs during the six-month wet season from May through October. Much of this rainfall is returned to the atmosphere by plant transpiration or evaporation from soils and water surfaces. Hydrologic and meteorologic methods are available to measure and/or estimate the combined rate at which water is returned to the atmosphere by transpiration and evaporation. The combined processes are known as evapotranspiration (ET). ET, like rainfall, is generally expressed in inches per year. Approximately 45 inches of water per year is returned to the atmosphere by evapotranspiration in South Florida. The excess of average precipitation over average ET is equal to the combined amounts of average surface water runoff and average ground water recharge. A detailed description of rainfall in the LWC Planning Area is provided in Appendix C.

SURFACE WATER RESOURCES

Lakes, Rivers, and Canals

Surface water bodies in the LWC Planning Area include lakes, rivers, and canals which provide storage and conveyance of surface water. Lake Trafford and Lake Hicpochee are the two largest lakes within the planning area, but neither lake is considered a good source of water supply. Plate 1, in the back of this document, shows the lakes, rivers and canals of the 10 drainage basins (see below) in the LWC Planning Area.

The Caloosahatchee River is the most important source of surface water in the region and extends across seven of the ten drainage basins in the planning area. The river is supplied by inflows from Lake Okeechobee and runoff from within its own basin. The freshwater portion of the river (C-43) extends eastward from the Franklin Lock and Dam (S-79) towards Lake Okeechobee and the cities of La Belle and Moore Haven. West of S-79, the river mixes freely with estuarine water as it empties into the Gulf of Mexico.

The remaining rivers and canals in the LWC Planning Area drain either into the Caloosahatchee River or the Gulf of Mexico. The majority of canals were constructed as surface water drainage systems rather than for water supply purposes. The C-43 Canal is the only major canal used for water supply and it is maintained by releases from Lake Okeechobee.

Drainage Basins

The planning area is divided into 10 major drainage basins according to their respective hydrologic characteristics (Plate 1). These basins are the (1) North Coastal Basin, (2) Tidal Caloosahatchee Basin, (3) Telegraph Swamp Basin, (4) West Caloosahatchee Basin, (5) East Caloosahatchee Basin, (6) C-21 Basin, (7) S-236 Basin, (8) Estero Bay Basin, (9) West Collier Basin, and (10) East Collier Basin. The West Collier and East Collier basins have extensive wetland systems, which are described in Chapter III of this document.

This section focuses on the major lakes, rivers, and canals of the drainage basins as they relate to water supply. Some of these basins have surface water bodies with regional water supply potential. Those surface water bodies are addressed in the Regional Recommendations section of the LWC Planning Document and include the Big Cypress Basin canal system and the Caloosahatchee River. The planning document recommends that the District identify opportunities to cooperatively evaluate the feasibility of using the Caloosahatchee River as a seasonal source of supply; and implementation of long-term modifications of the Big Cypress Basin canal system in Collier County. Other regional recommendations in the planning document include assisting Lee County in adopting the Lee County Surface Water Management Plan, which recommends increasing water supply within the county's basins; and working with public water suppliers and local governments in identifying additional sites for ASR projects.

North Coastal Basin

The North Coastal Basin is in southeastern Charlotte County and northwestern Lee County. There are numerous creeks within this basin. The basin drains via overland flow from the C.M. Webb Wildlife Management Area in Charlotte County into the Gator Slough watershed within northwestern Lee County. Most of this basin drains through the Gator Slough Canal into Cape Coral's canal system. This basin could provide a source of water supply for direct use or recharge (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 in this basin. These creeks are tidally influenced and are not suitable as a major source of surface water withdrawal. The Lee County Interim 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. The report suggests that Trout Creek and the channelized portion 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; placing a weir in the creek would enhance its water supply potential. In the Lehigh Acres area, the weirs in Able Canal (the channelized portion of the Orange River) provide recharge to the area. If it were feasible to connect the weir system, a water treatment facility injection retrieval system could be developed. The LWC Planning Document recommends looking into opportunities to cooperatively evaluate the feasibility of using the Caloosahatchee River as a seasonal source of supply.

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 watershed (approximately 92 square miles) with sheetflow discharge, there is a potential for this basin to be a good recharge area (Johnson Engineering *et al.*, 1990).

West and East Caloosahatchee, C-21, and S-236 Basins

The West and East Caloosahatchee, C-21, and S-236 basins extend along the freshwater portion of the Caloosahatchee River (C-43 Canal), from S-79 (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. In 1990, 24.4 percent (or 9.56 MGD) of the total public water supply for Lee County came from the Caloosahatchee River.

Although the C-43 is already allocated, it may be able to yield additional amounts of water during the wet season for 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 untreated surface water ASR from a water quality and permitting standpoint. The LWC Planning Document recommends that the District work with public water suppliers and local government in identifying additional sites for ASR projects, and with the FDEP to address 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 agricultural projects within the basins and public water supply for the City of Fort Myers and part of Lee County. A primary purpose for the canal is to provide relief 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 (S-77, S-78 and S-79) which 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 (S-77) to Franklin Lock (S-79). Water levels upstream of S-78 are maintained at approximately 11 feet national geodetic vertical datum (NGVD), and 3 feet NGVD downstream. The S-79 structure also serves as a saltwater barrier. 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 public water supply facilities (SFWMD, 1987).

Estero Bay Basin

In the Estero Bay Basin in southern Lee County, there is a two-fold water management problem. Overdrainage is a problem in areas that lack control structures that could increase water levels in the canal system. Conversely, lack of conveyance in other areas result in flooding. The basin includes Hendry Creek, Mullock Creek, Ten Mile Canal, Kehl Canal, Estero River, and the Imperial River. These waterways, with the exception of Ten Mile Canal and Kehl Canal, are all tidally influenced to some degree.

Several waterwork projects have been completed, or are underway, to increase water levels in the western part of the basin and to protect the water resources against saltwater intrusion. Hendry Creek has a saltwater barrier, while in Ten Mile Canal, weirs have been raised to increase the water levels within Six Mile Cypress Slough. Johnson Engineering (1990) concluded that the Estero Bay Basin does not have a major source of surface water available for water supply. However, because the basin has good recharge areas, saltwater barriers (weirs), could be used to increase water levels within the basin for recharge. An additional measure to help maintain water levels during the dry season could be the application of ASR technology. The Lee County Regional Water Supply Authority is planning a treated-water ASR pilot project at the Lee County Corkscrew Water Treatment Plant, which is expected to be completed in late 1996.

The Estero River east of U.S. 41 has slow conveyance and is considered a good recharge area, as is the Imperial River east of I-75. The Kehl Canal is connected to this river and drains the water levels within this basin in the dry season. The District and Lee County cost-shared the construction of the weir on the Kehl Canal. This weir serves as a saltwater barrier and increases water levels in the canal during the dry season.

In the eastern part of the basin, where flooding is a chronic problem, Lee County is planning conveyance structures to help alleviate flooding. However, further study is recommended to provide alternatives to address flooding and future development within the eastern basin.

West Collier Basin

The West Collier Basin extends from State Road 29 westward to the Gulf of Mexico and northward to the Lee County border, and includes part of Glades County. The basin does not have a major source of surface water for year-round water supply. Lake Trafford, in the northern section of the basin, has a drainage area of approximately 30 square miles. The lake is relatively small (2.3 square miles) and is not considered an important source of water storage for the region. The Gordon and Cocohatchee rivers are the two major rivers in this basin. Both of these rivers are tidally influenced and connect to the extensive canal system within this basin. This canal system, operated and managed by the Big Cypress Basin Board, serves primarily as a drainage network. Control elevations in these canals are being revised by the Big Cypress Basin Board in accordance with their five-year plan to raise the water levels and prevent overdrainage of the basin. Since the primary source of water for this system is rainfall, the canals have little or no flow during the dry season. In addition, three salinity control structures are planned for the Cocohatchee Canal system to help preserve water resources (one structure is being contracted to be built, one has been permitted, and one is still in the design stage).

Two projects using aquifer storage and recovery (ASR) technology are scheduled for Collier County. One project, managed by the Collier County Utilities Division, has been constructed, but the evaluation is still ongoing. The project is near the intersection of U.S. 41 and S.R. 951 and will be used to provide potable water. The second ASR project, is in the planning stage and involves a cooperative effort between the Big Cypress Basin Board and the Collier County Utilities Division. The ASR system will inject canal water from the I-75 canal and the Golden Gate main canal during the rainy season, and recover the water during the dry season. The recovered water will be used for irrigation purposes on large residential developments in the Livingston Road area of Collier County.

The West Collier Basin has extensive wetland systems. These systems include the Corkscrew Regional Ecosystem Watershed (CREW), Fakahatchee Strand State Preserve, and the Collier-Seminole State Park (Figure III-1). An assessment of the CREW area was completed in September 1993. The assessment indicated that wellfield development and/or aquifer augmentation could affect the wetlands within the CREW boundaries. The assessment recommends detailed three-dimensional analyses prior to any proposed wellfield development.

East Collier Basin

The East Collier Basin extends from State Road 29 eastward to the LWC Planning Area boundary, and northward approximately three miles into southern Hendry County. The Big Cypress National Preserve forms most of this basin (Figure III-1). There are no major rivers or major sources of surface water for year-round water supply use in this basin.

Drainage Districts

Chapter 298, Florida Statutes governs local drainage districts. These 298 districts (Figure II-1) are empowered to develop and implement a plan for draining and reclaiming the lands within 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 may also enter into contracts, adopt rules, collect fees, and hold, control, acquire or condemn land and easements for the purpose of construction and maintenance.

The SFWMD's past practice has been to issue consumptive use permits to the 298 districts for surface water use, while not requiring individual permits for users within these districts. Some 298 districts, however, may not have received a consumptive use permit; in these cases individual permits would be issued. The individual 298 district must still meet all conditions for issuance of a permit. The permit should indicate how water will be allocated, and should list the type and quantity of water use for each user.

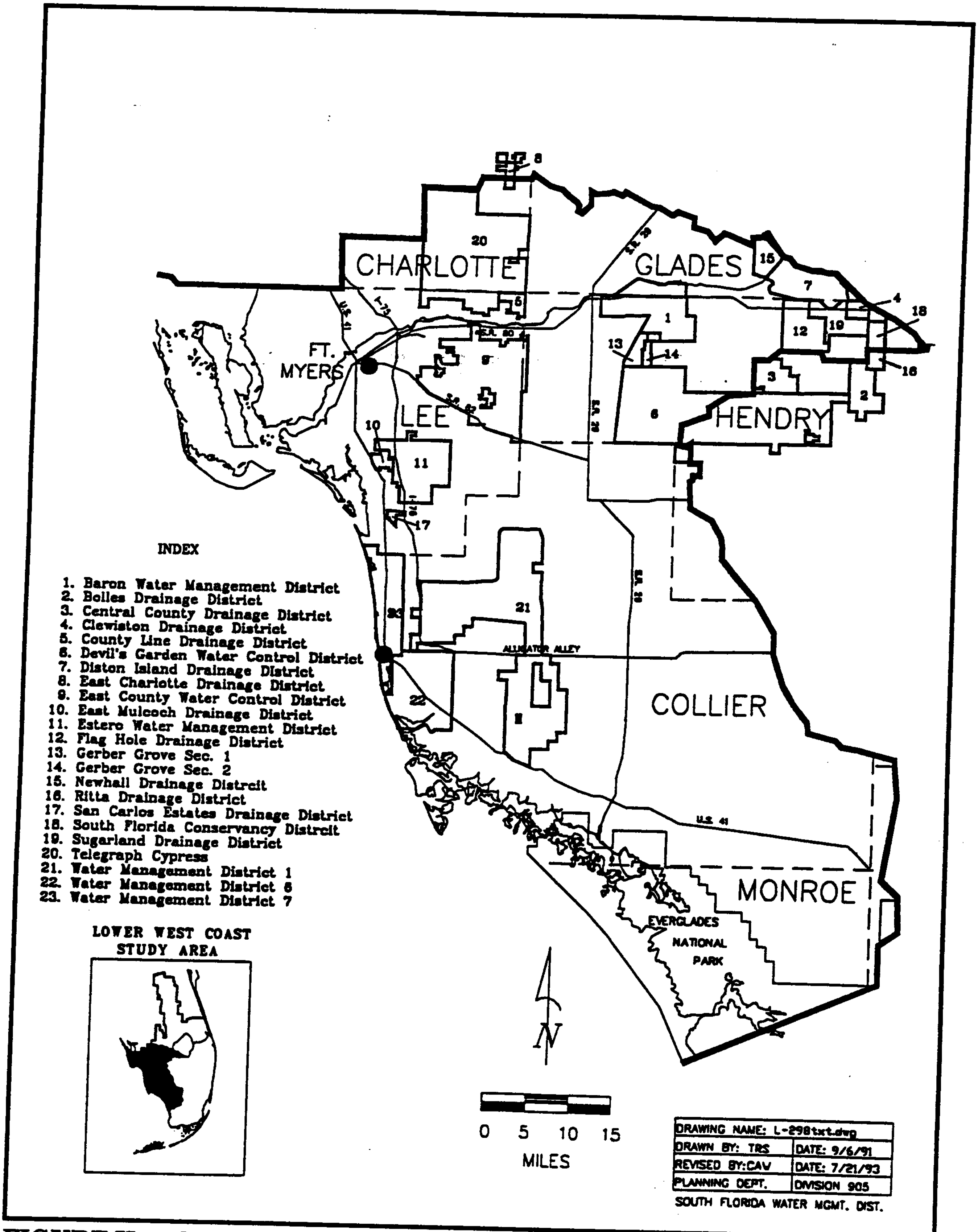

FIGURE II-1. Chapter 298 Districts.

GROUND WATER RESOURCES

Hydrogeologic formations are defined by their ability to store and transmit water. Those capable of yielding significant quantities of water are termed aquifers. Those which do not yield significant quantities of water, and impede or restrict ground water movement to or from an aquifer are called aquitards. When an aquitard overlies or underlies an aquifer it is labeled a confining zone.

The hydrogeology of South Florida is diverse. It includes aquifers which are confined (in which ground water is under greater than atmospheric pressure and isolated from vertical recharge), semi-confined (having some vertical recharge), and unconfined (ground water is at atmospheric pressure and water levels correspond to the water table). Within an individual aquifer, hydraulic properties and water quality may vary both vertically and horizontally. Because of this diversity, ground water supply potential varies greatly from one place to another. It is the purpose of this section to identify the aquifers in the region, and describe their current usage and water producing capability.

Three major aquifer systems have been recognized within the LWC Planning Area: the Floridan Aquifer System (FAS), Intermediate Aquifer System (IAS), and Surficial Aquifer System (SAS). These aquifer systems are summarized for the three counties modeled for this plan (Collier, Hendry and Lee) in tables II-1 through II-3. The ground water flow models used to evaluate hydrogeologic systems and identify problem areas are discussed in the planning document. A more detailed table (D-1) showing the temporal and physical relationships between these different aquifer systems, along with corresponding figures (D-1 to D-4), is located in Appendix D. Maps showing the elevation and thickness of each of the hydrogeologic units (figures D-5 to D-15) are also provided in the appendix. In addition, information on ambient groundwater quality, contamination sites, and saltwater intrusion is provided in Appendix H.

Although portions of Charlotte, Glades, and Monroe counties are within the planning area, they are not included in the ground water analysis. The Charlotte County Area has no significant urban water demands, and the agricultural water demand accounts for less than two percent of the total demand in the planning area. There are two major wetlands systems in the Charlotte County Area, one of them preserved for environmental protection, and the other proposed for public acquisition. In the Glades County Area, most of the land use is agricultural, with agricultural water demand accounting for over eight percent of the total demand in the planning area. Presently, there is not enough data on the hydrogeology of Glades County to develop a ground water model for the LWC Water Supply Plan, but a ground water reconnaissance study is underway and is anticipated for completion in 1996. There are no urban or agricultural demands in the Monroe County Area, as it is wholly protected as part of the Everglades National Park.

Floridan Aquifer System

The FAS, which underlies all of Florida and portions of southern Georgia and Alabama, contains several distinct producing zones which are described by Wedderburn *et al.*, 1982. Although it is the principal source of water in Central Florida, the FAS yields only nonpotable water throughout most of the LWC 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.

TABLE II-1. Ground Water Systems in Collier County.

Hydrogeologic System	Hydrogeologic Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Water Table Aquifer	20-100	Most productive aquifers in the county. Yield high quality water, except for isolated areas with high iron content. Potential for saltwater intrusion in coastal areas.
	Lower Tamiami Aquifer	40-180	
Intermediate Aquifer System	Sandstone Aquifer	0-110	Yields large amounts of water in the northern portion of the county, but is absent south of Alligator Alley. Suitable for mostly agricultural uses.
	Mid-Hawthorn Aquifer	60-120	Aquifer is low yielding and produces poor quality water. Suitable only for micro irrigation uses.
Floridan Aquifer System	Lower Hawthorn/ Suwanee Aquifer	Insufficient Data	Capable of high yields, but require desalination treatment. Some zones may be suitable for use in aquifer storage and recovery.

TABLE II-2. Ground Water Systems in Hendry County.

Hydrogeologic System	Hydrogeologic Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Water Table Aquifer	3-99	Extensive throughout Hendry County. Productivity varies widely. Heavily used in isolated areas where other aquifers do not exist, or are low yielding.
	Lower Tamiami Aquifer	0-135	Most productive aquifer in Hendry County. Heavily used in the southeast county area. Thin or nonexistent in the northern and western portions of the county.
Intermediate Aquifer System	Sandstone Aquifer	0-120	Occurs in western Hendry County. Heavily used in areas where the lower Tamiami is thin or nonexistent. Moderately productive; water nonpotable in many areas.
	Mid-Hawthorn Aquifer	No Data	Limited occurrence in Hendry County. Very low productivity; water quality not suitable for most irrigation uses.
Floridan Aquifer System	Lower Hawthorn/ Suwanee Aquifer	No Data	Little is known about the Floridan in Hendry County. It is believed to be capable of producing large volumes of water through flowing wells. Water is not suitable for irrigation.

TABLE II-3. Ground Water Systems in Lee County.

Hydrogeologic System	Hydrogeologic Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Water Table Aquifer	20-80	Yields moderate amounts of high quality water, but already heavily allocated. Susceptible to saltwater intrusion near the coast
	Lower Tamiami Aquifer	0-140	Absent from northern Lee County. Where present, yields moderate-to-large amounts of high quality water. Susceptible to saltwater intrusion near the coast.
Intermediate Aquifer System	Sandstone Aquifer	0-110	Yields large quantities of good quality water in south central Lee County, but is absent in the north and east.
	Mid-Hawthorn Aquifer	40-120	Yields small quantities of good quality water in Cape Coral and north of C-43. Elsewhere suitable only for micro irrigation uses.
Floridan Aquifer System	Lower Hawthorn/ Suwanee Aquifer	Insufficient Data	Capable of high yields, but requires desalination treatment. Some zones may be suitable for use in aquifer storage and recovery.

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, the lower Hawthorn and Suwannee aquifers have not been extensively developed for water supply in the planning area. Currently, only four utilities, the City of Cape Coral, Greater Pine Island, Marco Island Utilities, and Sanibel Island Water Association, obtain water from the lower Hawthorn or Suwannee aquifers. Elsewhere, the aquifers supply only a few agricultural irrigation wells. Improvements in desalination treatment technology will make development of these aquifers increasingly feasible; continuing development in the LWC Planning Area, moreover, will make it necessary. Portions of the producing zones may also have potential for use in ASR projects.

In the deeper producing zones of the FAS, there are areas of extremely high transmissivity, known as "boulder zones." Although they are not used as supply sources within the planning area due to the high salinity and mineral content, these formations may serve other purposes. In some areas the boulder zones have been used as disposal areas for treated wastewater effluent or residual brines from the desalination process.

Intermediate Aquifer System

The IAS consists of five zones of alternating confining and producing units which are further described in other District Publications (Wedderburn *et al.*, 1982; Smith and Adams, 1988; and Knapp *et al.*, 1984. The producing zones which comprise the IAS include the mid-Hawthorn and Sandstone aquifers.

Although present throughout the LWC 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 a 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 formerly provided water for the City of Cape Coral and the Greater Pine Island water utility. However, its limited water-producing characteristics made it an unreliable source. Both utilities have been forced to develop other sources, using the mid-Hawthorn wells for backup supply only. Today, the greatest use of the mid-Hawthorn is for domestic irrigation in Cape Coral and the area southwest of Fort Myers. It is also used for domestic self supply in those areas of Cape Coral not served by city water and for small water utilities north of the Caloosahatchee River. Elsewhere the aquifer is used only occasionally for agricultural irrigation.

The Sandstone aquifer, like the mid-Hawthorn, has variable thickness. It averages over 100 feet near Immokalee and portions of central Lee County, but pinches out to the south around Alligator Alley, to the northwest in part of Cape Coral, and to the east in the middle of Hendry County.

The productivity of the Sandstone aquifer is highly variable. It provides all of the water withdrawn by the Lehigh Acres public water supply wellfield and a portion of that withdrawn by the Lee County Corkscrew and Florida Cities Green Meadows wellfields. In western Hendry County, where the lower Tamiami aquifer is absent, it is an important source of water for agricultural irrigation, but is not capable of supporting large-scale agricultural operations in most areas. Only marginally acceptable for potable uses in Hendry and Collier counties, water from the Sandstone aquifer is suitable for irrigation purposes throughout its extent, with the exception of the La Belle area, where it has been contaminated by flowing Floridan wells.

Surficial Aquifer System

The SAS may be divided into two aquifers, the water table and lower Tamiami, which are separated by leaky confining beds over much of the area. The thickness of the SAS ranges from more than 200 feet in central and southern Collier to four feet southwest of La Belle in Hendry County. The SAS is further described by Bower *et al.*, 1990, Smith and Adams, 1988; and Knapp *et al.*, 1986.

The water table aquifer includes all sediments from land surface to the top of the Tamiami confining beds. Within Lee County, four major public water suppliers, all located in areas where the confining beds are absent, pump water from the water table aquifer. These are Lee County Utilities (Corkscrew wellfield), Gulf Utilities, Florida Cities (Green Meadows wellfield), and the City of Fort Myers. The aquifer also furnishes irrigation water for many uses, including truck crops, nurseries, and landscape irrigation. In Hendry County, the water table aquifer is generally used only where no suitable alternative is available, though it may yield copious quantities of water in isolated areas. It produces good quality water, except in areas with high concentrations of chlorides and dissolved solids near La Belle and parts of the coast, and isolated areas with high iron concentrations.

The lower Tamiami is the most prolific aquifer in Hendry and Collier counties. The lower Tamiami aquifer supplies water to Bonita Springs, City of Naples, Immokalee, and North Naples, as well as many domestic self suppliers and landscape and agricultural irrigation wells. Because of the large demands on the aquifer, it has been endangered by saltwater intrusion on the coast, and is frequently included in water shortage declarations.

CONSUMPTIVE USE PERMITTING

All water uses within the District require authorization from the District via a permit except water used in a single family dwelling or duplex, and provided that the water is obtained from one well for each single family dwelling or duplex, and is used either for domestic purposes or outdoor uses. Water used for fire fighting and the use of reclaimed water is also exempt from permitting. A water use permit will be granted as long as the applicant provides justification that the proposed water use is consistent with the public interest, is a reasonable-beneficial use of water, and one that will not interfere with any existing legal use of water.

The District issues permits for water withdrawals via the Consumptive Use Permitting (CUP) Program. The "Management of Water Use Permitting Information Manual Volume III" (1993), commonly referred to as the Water Use Basis of Review or BOR, is the document that identifies the procedures and information used by District staff in permit application review. The District issues water use permits in two forms, individual water use permits and general water use permits. An individual water use permit is issued for projects whose average day water use exceeds 100,000 gallons per day (GPD) while general permits are issued when the use does not exceed 100,000 GPD, except in areas designated as reduced threshold areas (RTAs). The duration of a general permit is 20 years, while an individual permit is based on the applicant's demonstrated ability to meet demand. This generally does not exceed ten years for public water supply and industrial uses, and three years for dewatering; duration for irrigation permits, except golf, is normally established by basin expiration dates. Golf uses are not to exceed the lesser of the basin expiration date or three years. In Lee County, water use permits are not to exceed five years.

As a result of existing and potential water supply problems, four types of specially designated areas have been established by the District, as described below. Three of these designations (reduced threshold areas, areas of special concern, and critical water supply problem areas) occur within the LWC Planning Area, as shown in Figure II-2. The fourth designation, restricted allocation areas, is provided in the text for the reader's information.

Reduced Threshold Areas

The volume of usage which distinguishes a general permit from an individual permit is referred to as the permit threshold. In resource depleted areas where there has been an established history of substandard water quality, saline water movement into ground water and surface water bodies or the lack of water availability to meet projected needs of a region, the District has reduced this threshold to 10,000 GPD average daily use. These areas are referred to as reduced threshold areas (RTAs) and include: Lee County, Coastal Collier County, Southwestern Glades County, and Northwestern Hendry County.

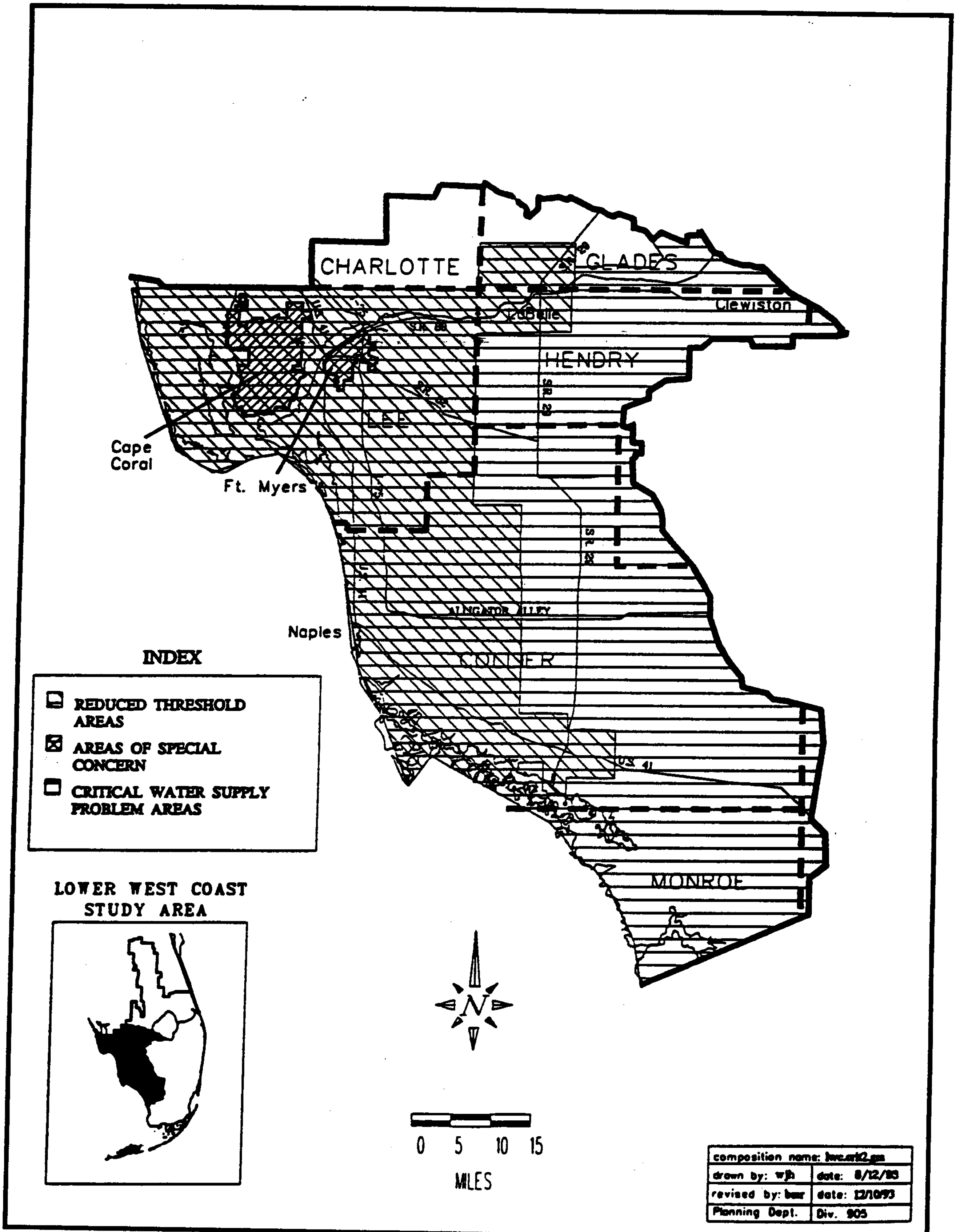

FIGURE II-2. Specially Designated Areas within the LWC Planning Area.

Areas of Special Concern

An area is of special concern because either there are limitations on water availability or there are other potentially adverse impacts associated with a proposed withdrawal. These areas are determined by the District on a case-by-case basis. The designated areas of special concern in the LWC Planning Area are the potable water service areas for the cities of Fort Myers and Cape Coral.

Critical Water Supply Problem Areas

Critical water supply problem areas are those areas that have experienced or are anticipated to have water supply problems within the next 20 years. Most of the LWC Planning Area is designated as a Critical Water Supply Problem Area. District rules specify that these areas must make use of a reclaimed water source unless the applicant demonstrates that its use is either not economically, environmentally or technologically feasible.

Restricted Allocation Areas

Restricted Allocation Areas (RAAs) are areas designated within the District for which allocation restrictions are applied with regard to the use of specific sources of water. The water resources in these areas are managed in response to specific sources of water for which there is a lack of water availability to meet the needs of the region from that specific source of water. There are no RAAs within the LWC Planning Area; however, this designation exists in the other three planning areas.

WATER TREATMENT

Potable Water Facilities

Potable water in the LWC Planning Area is supplied by three main sources: (1) regional municipal or privately owned water treatment facilities, (2) smaller developer/homeowner association or utility owned water treatment facilities, and (3) self-supplied individual wells that serve individual residences. Many of the smaller facilities are constructed as interim facilities until regional potable water becomes available. At that time, the smaller water treatment facility is abandoned upon connection to the regional water system.

There are 29 regional water treatment facilities in 21 service areas within the LWC Planning Area. These facilities, which serve about 80 percent of the planning area population, have capacities of 0.50 MGD or greater. The utility service areas are shown in Figure II-3. Most of these facilities use raw water from ground water, rather than surface water, sources. Twenty-six of the facilities use ground water, while five use surface water for all or a portion of their raw water sources. Due to regulatory constraints, as well as the quantity and quality of available surface waters, most of the utilities are considering ground water sources to meet future demands. The locations of the wellfields for these facilities are shown in Figure II-4. Detailed maps showing the location of each treatment facility and associated wellfield(s) are provided in Appendix E. Other detailed information provided in the appendix includes the source aquifer and pump capacity for each of the wells; existing, proposed, and future sources of raw water; and water treatment methods for each facility. Water demand estimates for all potable water treatment facilities, including those with capacities less than 0.50 MGD are discussed in Appendix G.

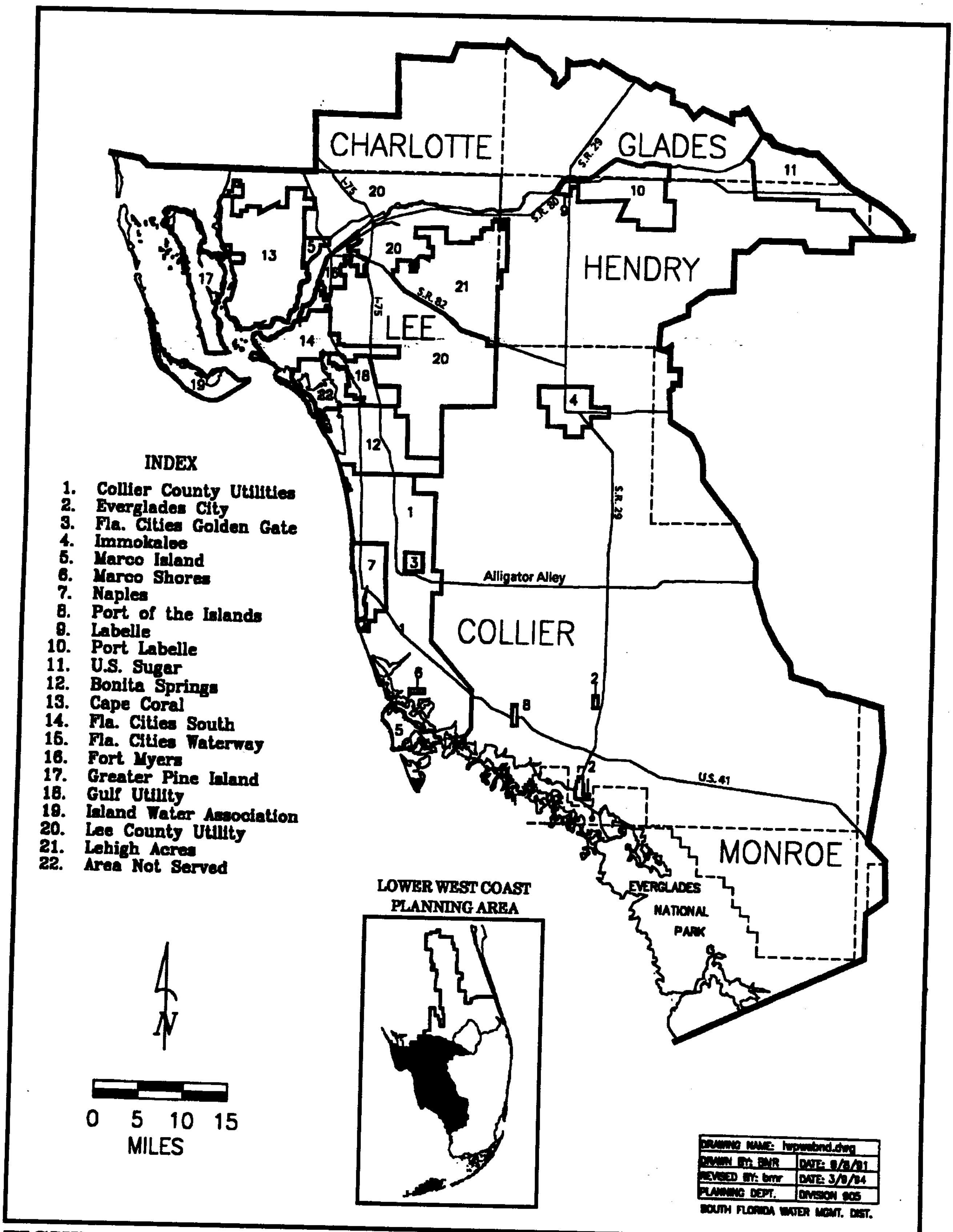

FIGURE II-3. Regional Water Utility Service Areas.

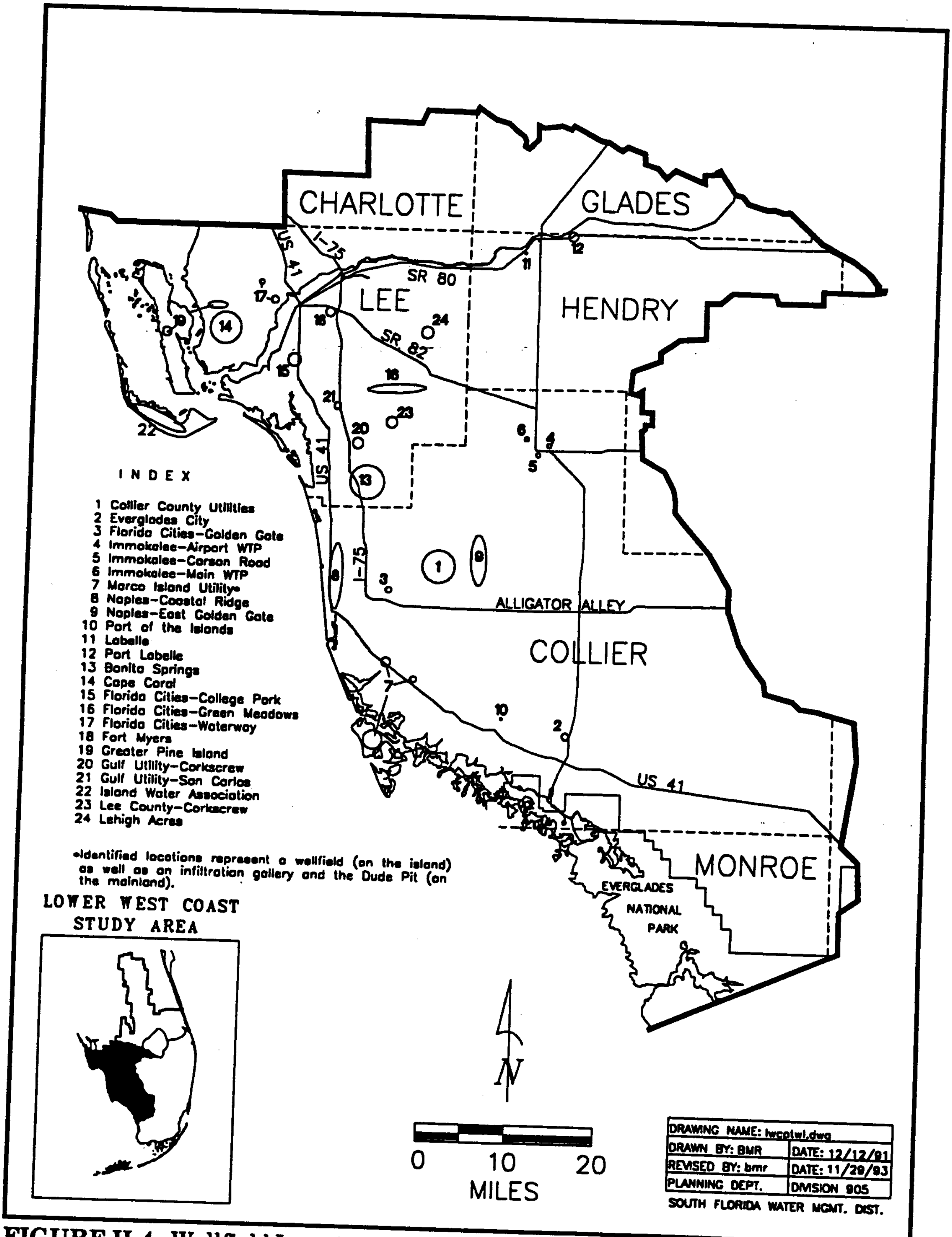

FIGURE II-4. Wellfield Locations of Potable Water Treatment Facilities.

The existing treatment technologies employed by the facilities are lime softening, reverse osmosis, and electrodialysis. Of the 29 facilities, 21 (72 percent) use lime softening exclusively, five (17 percent) use membrane technology and/or electrodialysis, and three (10 percent) uses a combination of reverse osmosis and lime softening. Generally, lime softening is used in all areas, except on barrier islands and areas where saltwater intrusion has occurred. More stringent future drinking water standards (see Chapter V), combined with deteriorating water quality and decreasing freshwater supplies, necessitates that greater emphasis be placed on nonconventional methods of treatment (e.g., membrane technologies) and alternative raw water sources (e.g., brackish/saline water).

All public water systems in the LWC Planning Area are regulated by the Florida Department of Environmental Protection (FDEP), with the following exceptions: (1) those water systems that have less than 15 service connections, or (2) facilities which regularly serve less than 25 individuals daily at least 60 days out of the year, or (3) facilities which serve at least 25 individuals daily less than 60 days out of the year, or (4) facilities located in Lee County, where the FDEP has delegated the responsibility of all public water systems to the Lee County Health Department. All other similar systems in the remaining counties are regulated by the local health departments (Chapter 17-550, F.A.C.).

Wastewater Treatment Facilities

Wastewater treatment in the LWC Planning Area is provided by regional municipal or privately owned wastewater treatment facilities, smaller developer/homeowner associations or utility owned wastewater treatment facilities, and septic tanks. There are approximately 350 wastewater treatment facilities permitted by the FDER with approved capacities between 0.0035 and 12 MGD in the planning area. Of these, 21 facilities have a capacity of 0.50 MGD or greater. This discussion focuses on these 21 facilities because they have sufficient flows that could have a positive impact on the water resource through reuse. The smaller facilities (<0.50 MGD) tend to be constructed as interim facilities until regional wastewater treatment becomes available, at which time the smaller wastewater treatment facility is abandoned upon connection to the regional wastewater system. The utility service areas for the regional systems are shown in Figure II-5. In 1990, these regional facilities treated 41.76 MGD of wastewater.

All the regional facilities use the activated sludge treatment process. The methods of reclaimed water/effluent disposal include surface water discharge, reuse, and deep well injection. Seven facilities use surface water discharge to the Caloosahatchee River, sixteen utilize reuse, and one uses deep well injection. For three of these facilities, the surface water discharge and deep well injection serve as a backup disposal method to their reuse system. Figure II-6 shows the 1990 utilization of each of these disposal methods. Uses of reclaimed water include irrigation of golf courses, residential lawns, and other green spaces; irrigation of hay fields; and ground water recharge by percolation ponds.

Specific information on each of these 21 regional facilities, as well as 2 future facilities, can be found in Appendix E. The information includes existing facility descriptions, as well as the proposed and future plans of the utilities.

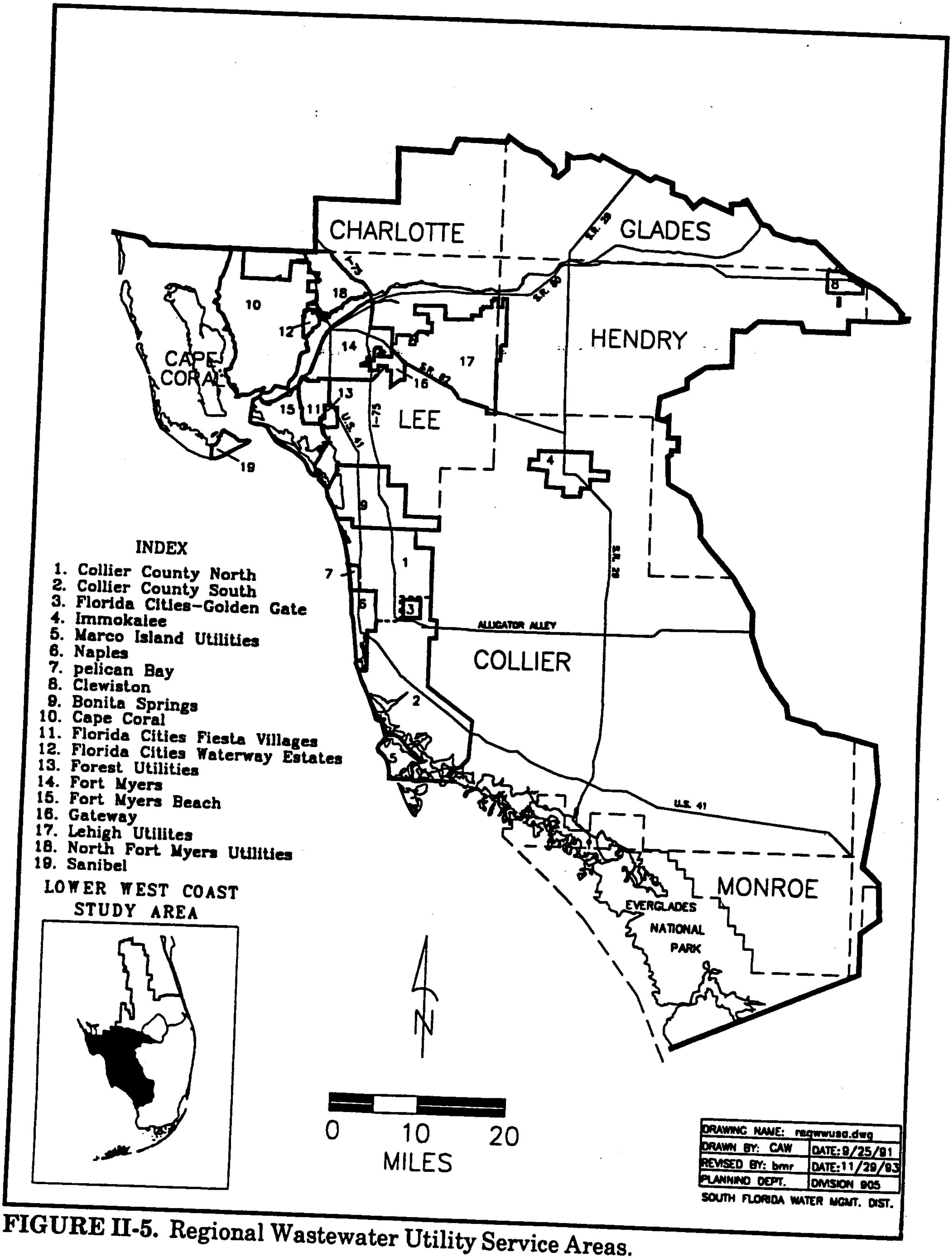

FIGURE II-5. Regional Wastewater Utility Service Areas.

Wastewater treatment in the LWC Planning Area is regulated by the FDEP for all facilities, with the following exceptions: (1) those with a design capacity of 2,000 GPD or less which serve the complete wastewater and disposal needs of a single establishment, or (2) septic tank drainfield systems and other on-site sewage systems with subsurface disposal and a design capacity of 5,000 GPD (3,000 GPD for restaurants) or less, which serve the complete wastewater disposal needs of a single establishment. All other systems are regulated by the local health department for each county (Chapter 17-600, F.A.C.).

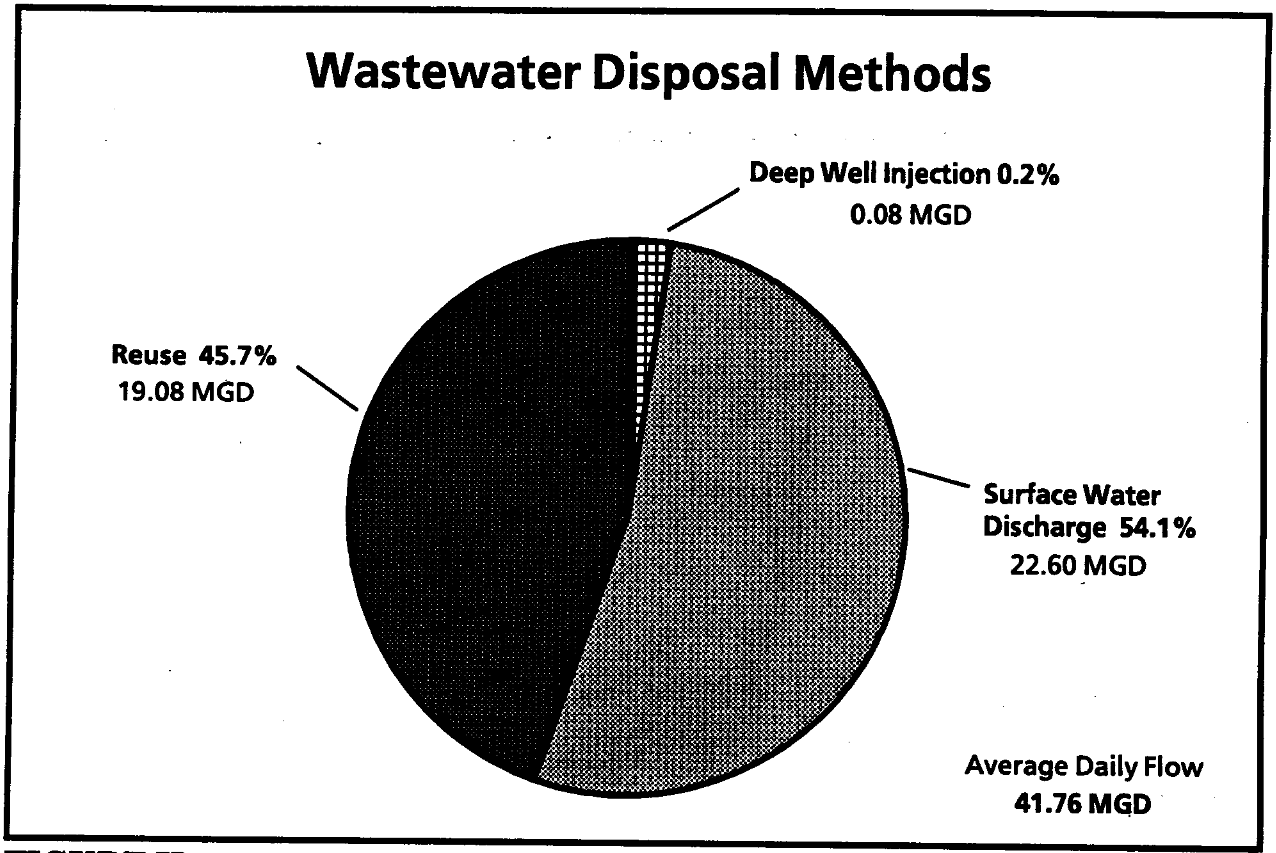

FIGURE II-6. LWC Planning Area Wastewater Disposal Methods for 1990.

III. ENVIRONMENTAL RESOURCES AND NEEDS

The LWC Planning Area contains a wide variety of natural resources, ranging from its coastal barrier islands, mangrove forests, bays, beaches and estuaries to its inland mosaic of forested, shrub/scrub and herbaceous wetlands and uplands. Many of these areas are public and private preserves, aquatic preserves, and lands proposed for public acquisition (Figure III-1). In this chapter, inland resources and coastal resources are addressed separately, even though they are an ecological continuum. The inland resources include lakes, rivers, canals, freshwater wetlands and uplands. The coastal resources include estuaries, tidal wetlands, beaches, sand dunes and barrier islands.

This chapter also addresses the "Outstanding Natural Systems" (ONS) within the LWC Planning Area. Through the water supply planning process, an ONS map was created "to identify the natural systems that should receive a higher level of review to protect them from deleterious impacts resulting from permitted water use, in order to maintain the ecological function of the region." The ONS map (Plate 2) delineates large areas that are relatively pristine natural systems and areas with valuable habitat that have been modified by human activities. Two categories of ONS lands are identified on the map: ONSe and ONSm. The ONSe lands are areas that have been purchased for environmental preservation/ conservation purposes. The ONSm lands are natural systems that are currently used for multiple purposes (i.e., agriculture, residential, water supply, surface water management etc.).

INLAND RESOURCES

Inland Southwest Florida has numerous freshwater swamps, sloughs, and marshes. A number of these systems are relatively pristine wetland areas and are recognized as having national and regional importance (e.g., Big Cypress National Preserve, Corkscrew Swamp Sanctuary, and Fakahatchee Strand). These wetland areas serve as important habitat for a wide variety of wildlife and have numerous hydrological functions.

Before development of the region, inland areas were comprised of vast expanses of cypress and hardwood swamps, freshwater marshes, sloughs, and flatwoods. Scattered among these systems were oak/cabbage palm and tropical hammocks, coastal strand and xeric scrub habitats. A large portion of the area contained seasonally flooded wetlands which sheetflowed fresh water from the northeast to the southwest.

Wetlands

Wetlands, in general terms, are lands transitional between uplands and aquatic systems, and are defined by plants, soils, and hydrology. A more technical definition, as defined by the U.S. Army Corps of Engineers (1988), identifies wetlands as "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." The major types of freshwater wetland systems within the LWC Planning Area are forested, scrub/shrub, and herbaceous wetlands.

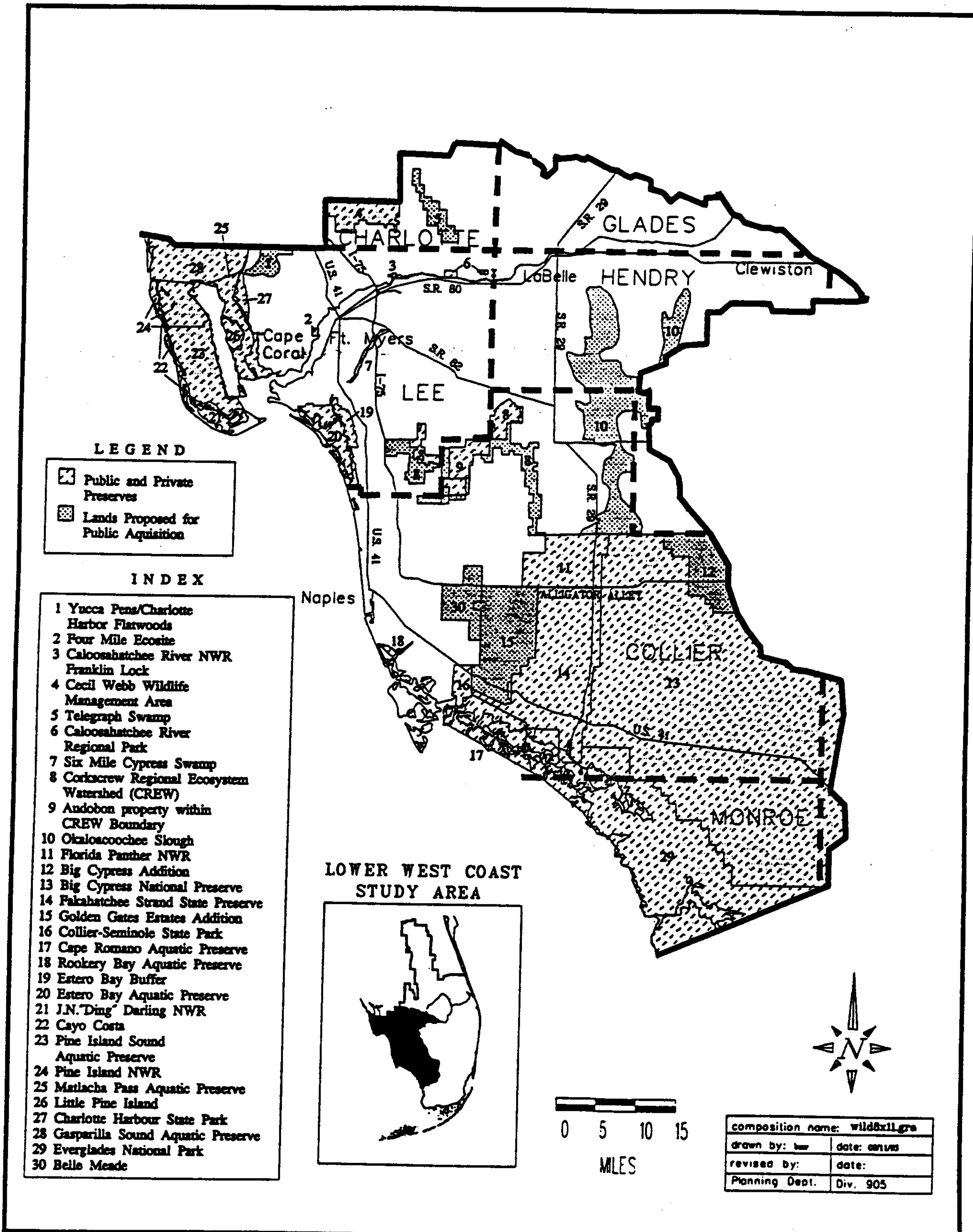

FIGURE III-1. Public and Private Preserves, Aquatic Preserves, and Lands Proposed for Public Acquisition.

Distribution of Wetlands in the LWC Planning Area

Wetland systems in the LWC Planning Area were classified and delineated by the National Wetlands Inventory (NWI), a branch of the U.S. Fish and Wildlife Service. The NWI is a nationwide wetland mapping system which was completed for the state of Florida in 1984. This wetland inventory was used as a base against which changes in wetland distribution were detected in the planning area. The NWI data was updated by the District using 1990 and 1991 satellite images and aerial photographs. This update was not a detailed re-evaluation of the LWC Planning Area wetlands, but a generalized overview of the changes that have occurred in the region since the original NWI maps were created. Plate 3 shows the updated wetland systems map of the LWC Planning Area. The major wetland systems are described below for the counties within the planning area. These wetlands can be found in Figure III-1.

Charlotte County. In eastern Charlotte County, a portion of Cecil Webb Wildlife Management Area and Telegraph Cypress Swamp cover nearly 10,000 acres. Both systems are diverse with a mixture of low pine flatwoods, cypress strands and marshes.

Collier County. In Collier County, major wetland areas include the Okaloacoochee Slough, Fakahatchee Strand, the Big Cypress National Preserve, and the Corkscrew Regional Ecosystem Watershed (CREW lands).

Okaloacoochee Slough is one of the two most important surface water flowways in Collier County, with Lake Trafford-CREW being the other (Gore, 1988). This slough system is composed largely of herbaceous plants with trees and shrubs scattered along its fringes and central portions. It provides habitat for a wide array of wildlife such as the endangered Florida panther.

Fakahatchee Strand is the southwest branch of the Okaloacoochee Slough. The strand contains a diversity of plant communities such as, mixed hardwood swamps, cypress forest, prairies, hammocks, pine forest, and pond apple sloughs. There are at least 30 species of plants and animals in the strand that are considered endangered, threatened, or rare by the State of Florida (U.S. Fish and Wildlife Service, 1984).

Big Cypress National Preserve encompasses a vast area (570,000 acres) within Collier County. Habitats within the preserve are primarily cypress forest, pine flatwoods and marshes. There are in excess of 100 species of plants and 20 species of animals in the preserve listed by the state as endangered or threatened.

CREW is a large project covering 50,000 acres in Lee and Collier County and consists of Corkscrew Sanctuary, Corkscrew Swamp, Camp Keais Strand, Flint Pen Strand, and Bird Rookery Swamp. CREW lands are dominated by cypress forest, low pine flatwoods, hardwood hammocks, marshes, mixed swamps and ponds. This system provides valuable habitat which supports at least 65 species of plants and 12 species of animals listed by the state as endangered or threatened.

Glades County. The major wetland in western Glades County is Fisheating Creek. Fisheating Creek is an extensive riverine swamp system that forms a watershed covering hundreds of square miles. Although Fisheating Creek is located in the Kissimmee Basin Planning Area, it delineates the northern boundary of the LWC Planning Area. Fisheating Creek is the only free flowing tributary to Lake Okeechobee. The creek attenuates discharges from heavy storm events and improves water quality before the storm water enters the lake. The creek also serves as a feeding area for wading birds such as the endangered wood stork, white ibis, and great egrets, when stages in the marshes surrounding Lake Okeechobee are too high.

Hendry County. The Big Cypress Swamp occupies a large section of southern Hendry County, including part of the Big Cypress Seminole Indian Reservation. The area is characterized by cypress forests, small pine hammocks, and marshes. The headwaters of the Okaloacoochee Slough are in northern Hendry County. The slough extends southward to Collier County, where it eventually branches to the Fakahatchee Strand.

Lee County. Major wetland areas in Lee County include the Six Mile Cypress Slough and Flint Pen Strand, which is within CREW. Six Mile Cypress Slough encompasses 2,000 acres in Lee County and is dominated by cypress, interspersed with numerous ponds. The native plant communities which fringe the slough are pine flatwoods, hardwoods, and wet prairies. Heavy infestation of melaleuca has occurred in the southern one-third of the slough.

Monroe County. The Monroe County Area lies entirely within Everglades National Park. The Everglades ecosystem supports a diverse array of tropical and subtropical plants and animals, some of which are found no where else in the world. Major plant communities include sawgrass, wet prairies, tree islands, willow heads, cypress forests, upland forests, and mangroves. At this time 18 endangered species are known to be within the park. The Everglades SWIM Plan (SFWMD, 1992) contains further information.

Functions and Values of Wetlands

Wetlands provide a wide variety of functions and values that can be grouped into three general categories: (1) biological, (2) hydrological, and (3) socioeconomic. The biological and hydrological categories are concerned with the natural "functions" attributed to wetlands, whereas the socioeconomic category is concerned with those "values" that are considered important for monetary, cultural, educational, or aesthetic purposes. All the natural functions associated with wetlands may not be apparent in every wetland. However, the importance of a wetland is not automatically diminished if all functions are not fully expressed.

Biological. Wetlands provide a number of important biological functions to the regional ecosystem, including:

- Habitat for fish and wildlife, including rare, threatened and endangered species
- Habitat utilized by adjacent semiaquatic and terrestrial species
- Areas for aquatic primary and secondary production that are a critical component of the regional food web

Wetland habitats provide a variety of usages for wildlife. Some organisms depend totally on wetlands for their entire existence, while other semiaquatic and terrestrial species use wetlands sporadically. Their dependence on wetlands may be for over-wintering, residence, 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.

Hydrological. Wetlands provide a number of important hydrological functions to the regional water management system, including:

- Flood storage and conveyance
- Water quality enhancement through filtration and nutrient cycling
- Recharge and discharge areas for ground water
- Maintenance of an estuarine water balance
- Erosion control
- Evaporative surfaces for rainfall development

As stated previously, hydrology is the dominant factor which determines the species composition and wetland type that can develop within a given area. Wetlands hydrologically function as a receiving and storage area for surface water runoff. This is important in controlling flooding, erosion, and sedimentation on the regional scale. As surface water enters a wetland, water is stored until its overflow capacity is reached and water is slowly released downstream. Wetland systems, such as the floodplain of rivers, creeks and sloughs, convey water through the landscape to downstream locations. As water flows are attenuated, sediment is deposited and nutrients are assimilated, improving water quality. Some wetlands may function as recharge areas, while others function primarily as ground water discharge areas. Freshwater wetlands are an integral component of the estuarine systems in the LWC Planning Area, providing base flows of fresh water to maintain the proper salinity balance.

Socioeconomic. Socioeconomic values refer to man's monetary benefits associated with preserving the natural water resource functions of wetlands, as well as cultural and aesthetic aspects. As human values, perceptions and knowledge of wetlands change, so do perceived values placed upon wetlands.

Wetlands are a rich source of information and education. They can provide a better understanding of our cultural heritage. For instance, the remains of prehistoric Indian middens have contributed to our understanding of local Indian cultures and specifically the importance of wetlands in their everyday living. Wetlands provide social and economic benefits such as:

- Commercial and sport fisheries production
- Agricultural and aquacultural production
- Recreation
- Education and research
- Aesthetic and open space
- Cultural aspects

Uplands

Upland communities in the LWC Planning Area, as identified by the SFWMD, are shown in Plate 4. Some of the upland habitats found within the planning area are flatwoods, tropical hammocks and xeric scrub communities, with flatwoods being the dominant upland habitat. Flatwood communities are divided into two types: dry and hydric. Dry flatwood communities are characterized by an open canopy of slash pine with an understory of saw palmetto. Hydric flatwood communities are vegetatively similar to dry flatwoods. However, dry flatwoods are located in a slightly higher elevation in the landscape and are rarely inundated.

Distribution of Uplands in the LWC Planning Area

Large areas of flatwoods are found throughout Hendry and Lee counties, as well as portions of Charlotte, Glades and Collier counties. Upland flatwoods are the native habitats most affected by the expansion of citrus into Southwest Florida. Flatwoods 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. Pine flatwoods have greater richness of vertebrate species than either sand pine scrub or dry grass prairies (Myers and Ewel, 1990).

Tropical hammocks are scattered throughout the LWC Planning Area. This diverse woody upland plant community occurs on elevated areas, often on Indian shell mounds along the coast, or on marl or limestone outcroppings inland. Tropical hammocks are not widespread in occurrence, and as a result of conversion to other land uses, tropical hammocks are among the most endangered ecological communities in South Florida.

Xeric, sand pine scrub communities most commonly occur along sand ridges and ancient dunes. The southernmost of these communities was once found on Marco Island in Collier County, but has since been lost to development. Sand pine scrub is most often associated with relict sand dunes formed when sea level was higher than it is today. These well-drained sandy soils are important areas of aquifer recharge for coastal communities. The sand pine scrub is the most endangered ecological community present within the LWC Planning Area. It is rapidly being eliminated by conversion to other land uses.

Functions and Values of Uplands

Upland plant communities (e.g., flatwoods, sand pine scrub) 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 reduces erosion, and absorbs nutrients and other pollutants that might be generated during a storm event.

With a few exceptions, the functions and values attributed to wetlands also apply to upland systems. As stated earlier, the upland/wetland systems are ecological continuums, existing and adapting to geomorphic variation. The classification of natural systems is artificial and tends to convey a message that they survive independently of each other. In reality, wetland and upland systems are interdependent on each other. To preserve the structure and functions of wetlands, the linkage between uplands and wetlands must be maintained (Mazzotti *et al.*, 1992).

WATER NEEDS OF THE INLAND ENVIRONMENT

Both the needs and functions of natural systems must be considered as part of the overall water supply planning process. Regional water supply plans are developed to first ensure that the water supply demands of the environment are met and that enough fresh water is available for urban, industrial and agricultural uses. Wetland and upland communities play an integral role in maintaining regional water supplies by allowing for natural recharge of the aquifers.

Wetland Water Supply Needs

The needs of wetland systems are dependent upon a number of factors including hydrology, fire, geology and soils, climate, and ecological succession (see "Factors Affecting Wetland Water Needs" in Appendix F). Hydrology is the dominant influence regulating wetland community structure and function. Actions that modify or alter wetland hydrology also significantly affect the species composition and ecology of wetland ecosystems. Lowered ground water tables in areas surrounding wetland communities have been shown to decrease surface water depths and shorten the hydroperiod (length of time that standing water inundates a wetland). The most obvious impact of reducing water levels is a decrease in the size of the wetland. This is especially true of shallow, low gradient wetlands, which may be entirely eliminated. Decreased wetland size reduces the available wildlife habitat and the area of vegetation capable of nutrient assimilation. It also reduces the water surface area and corresponding evapotranspiration rates, which can have an influence on the rain cycle and regional climatic conditions. Lowered water levels and reduced hydroperiod also (a) induce a shift in community structure towards species more characteristic of drier conditions, (b) reduce rates of primary and secondary aquatic production, (c) increase the frequency and/or intensity of fire, (d) cause the subsidence of organic soils, and (e) allows for exotic plant invasion. Maintaining appropriate wetland hydrology (water levels and hydroperiod) probably is the single most critical factor in maintaining a healthy wetland ecosystem (Duever, 1988; Mitsch and Gosselink, 1986; Erwin, 1991).

Studies of Southwest Florida wetland communities indicate that species composition and community type are largely determined by water depth and hydroperiod (Carter *et al.*, 1973; Duever, 1984; Duever *et al.*, 1986). Some wetlands types contain water depths of three feet or more and are inundated year-round, while other community types are characterized by saturated soils or water depths of less than a few inches that inundate the land for relatively short periods of time during the wet season. Wetland plant species adapted to deep water and long periods of inundation are generally not well adapted to shallow water or a shortened hydroperiod. Complete drainage of a wetland severely alters wetland community organization and species composition. Partial drainage of wetlands can be caused by ground water withdrawals in adjacent upland areas. These withdrawals effectively lower underlying water tables and "drain" wetlands (Rochow, 1989). Drainage facilities such as canals and retention reservoirs constructed near wetlands have a history of draining and reducing hydroperiods of South Florida wetlands (Erwin, 1991). A major concern of reduced water depths and hydroperiod within wetlands is the invasion of exotic plants such as melaleuca and Brazilian pepper.

Rainfall, along with associated ground water or surface water inflows, is the primary source of water for the majority of wetlands in the LWC Planning Area. Rainfall in South Florida is highly variable. Although the region has a distinct wet and dry season, the timing and amount of rainfall which falls upon a particular wetland varies widely from year to year. As a result, wetland hydroperiod also varies annually. Hydroperiod information collected from a wetland during a series of wet years may vary considerably from data collected during a dry year. This wide variation in annual rainfall makes it difficult to determine what the appropriate water level or hydroperiod should be for a specific wetland ecosystem. Determining appropriate water level or hydroperiod conditions for a wetland often requires a data collection effort that spans a sufficient period of record. Hofstetter and Sonenshein (1990) suggest alterations that shorten hydroperiods may be detectable within 8 to 10 years.

Several attempts have been made by researchers to define annual inflows and water budgets for some of the larger wetland ecosystems present within the LWC Planning Area such as the Big Cypress Swamp (Klein *et al.*, 1970; Freiberger, 1972; Carter *et al.*, 1973; Duever *et al.*, 1979, 1986), Corkscrew Swamp (Duever *et al.*, 1974, 1975, 1976, 1978), Fakahatchee Strand (Burns, 1984), and Six Mile Cypress (Johnson Engineering *et al.*, 1990). However, no data currently exists which quantifies the environmental water demands for the region.

Current computer modeling programs focus primarily on describing the volume of water available within the various aquifers underlying wetland communities. Although numerous wetland models are available (Mitsch *et al.*, 1988), few regional models exist which have the resolution and sophistication to quantitatively estimate the amount of surface water present or available within the LWC Planning Area wetlands. Although several models could be used to estimate water levels or hydroperiods which should be maintained to protect these systems, their accuracy is questionable. In addition, relatively little long-term hydrological data exists to run these models. In short, no data or model with a high resolution of accuracy currently exists which can describe the volume of water necessary to maintain the LWC Planning Area wetlands in their present condition.

Upland Water Supply Needs

The water supply needs of upland plant communities are not well known. It is assumed that the upper six to ten feet of the surficial aquifer is utilized by forest and herbaceous plant vegetation. Flatwoods are the dominant upland habitat within the LWC Planning Area. These plant associations are characterized by low, flat topography and poorly drained, acidic, sandy soils. In the past this ecosystem was characterized by open pine woodlands and supported frequent fires (Myers and Ewel, 1990). Three factors (fire frequency, soil moisture, and hydrology) play important roles in maintaining plant community structure and function and are also considered important as determinants of the direction of plant community succession. Fire is the factor which most strongly influences the structure and composition of upland plant communities.

Fire, under natural conditions, maintains flatwoods as a stable and essentially nonsucessional plant association. However, when the natural frequency of fire is altered by drainage improvements and construction of roads and other fire barriers flatwoods can succeed to several other plant community types. The nature of this succession depends on soil characteristics, hydrology, available seed sources or other local conditions (Myers and Ewel, 1990).

The hydrology of upland plant communities varies with elevation and topography. Seasonal variations as well as local withdrawals from ground water play an important role in determining the type of upland vegetation that will develop.

Wildlife Water Supply Needs

In South Florida, the dominant physical factors which influence the species composition, distribution and abundance of wildlife are the annual pattern of rainfall, water level fluctuations, and fire, as well as occasional hurricanes, frosts and freezes. Biological factors such as predation, competition and feeding habits also play important roles in configuring wildlife communities.

Alterations in water depth and/or hydroperiod that result in changes to vegetative composition and diversity may lead to the degradation of fish and wildlife habitat. One of the causes of melaleuca infestation is a decrease in water table levels which, when a seed source is present, can result in monotypic stands of tightly packed trees that have the potential to cause a localized decrease in biodiversity.

Wetland vegetative productivity usually exceeds that of other habitat types. Reduction in size of a wetland reduces food production at the bottom of the food chain. Alterations of the seasonal wet and dry pattern can also cause impacts. "The life cycle of many species are tied to this cycle. Wood storks, for example, are unable to successfully fledge their young without the dry season concentration of food. Anything that interferes with the cycle, too much water in the dry season or not enough in the wet season, tends to reduce fish and wildlife populations" (University of Florida, Center for Government Responsibility, 1982).

Flooding of wetlands during the summer months initiates the production of aquatic plants such as attached algae (periphyton) and macrophyte communities. These plants are consumed by small fish and invertebrates. Maximum numbers of fish and invertebrates occur near the end of the wet season. As marsh water levels decline during the dry season, these organisms are concentrated into smaller and smaller pools of water where they become easy prey for wading birds and other species of wildlife. Fish and invertebrates are the major dietary components of South Florida wading and water bird populations. Wading bird nesting success is highly dependent upon the natural seasonal fluctuations in hydroperiod of these marsh systems and the concentration of food resources. Kahl (1964) and SFWMD (1992) link the nesting success of wood storks and white ibis to the hydrologic status of regional wetland systems.

COASTAL RESOURCES

Southwest Florida has some of the most pristine and productive coastal waters within the state. Five of these areas are contained in aquatic preserves, including Matlacha Pass, Pine Island Sound, Charlotte Harbor, Estero Bay, and Rookery Bay. Tourism, the major industry in Southwest Florida, is closely linked to its unique coastal resources. The coastal resources include areas such as estuarine systems, barrier islands and beaches.

Estuarine Systems

Coastal areas are dominated by large estuarine systems where the waters of the Gulf of Mexico mix with the freshwater inflows from numerous river systems, sloughs and overland sheetflow. These estuarine areas are characterized by shallow bays, extensive seagrass beds, and sand flats. Extensive mangrove forests dominate undeveloped areas of the shoreline. Two large open water estuarine systems, Charlotte Harbor and the Caloosahatchee River estuary, dominate the northwest portion of the planning area. Other associated habitats are high salt marshes and riparian fringing marshes. More than 40 percent of Florida's rare, endangered or threatened species are found in Southwest Florida estuaries. One of the most renowned is the West Indian manatee, which depends on a healthy seagrass community as its major food source. The bald southern eagle also relies to a large extent on the estuary as its feeding grounds.

Coastal areas subject to tidal inundation support extensive mangrove forests and salt marsh areas. Coastal mangroves protect against erosion from storms and high tides, and assimilate nutrients from flowing water to produce organic matter (leaves), which forms the base of the estuarine food chain. Mangroves and salt marsh communities serve as important nursery and feeding grounds for many economically important species of finfish and shell fish, 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 southwest Collier County and southern Lee County. The Ten Thousand Island region, which dominates the southern portion of Collier County, is the largest intact mangrove forest in the world.

Barrier Islands

Barrier islands form a chain from northern Lee County to southern Collier County. Barrier islands also protect the mainland from major storm events, act as a buffer for sensitive estuarine areas, and provide habitat for shorebirds and wildlife. These low lying, narrow strips of sand play an important role in the region's tourism economy by attracting visitors to the beaches.

WATER NEEDS OF THE COASTAL ENVIRONMENT

Maintenance of appropriate base flows of fresh water to rivers and downstream estuaries should be an essential component of the Lower West Coast water supply planning process. Estuaries receive inflows of fresh water from rivers, upstream wetlands, and ground water discharges. Riverine input varies in volume, with largest flows occurring during the wet season and lowest flows occurring at the end of the dry season. Estuarine salinity varies in relationship to the amount of fresh water discharged into the system, with the saltwater/freshwater interface moving down the estuary during high flow conditions, and moving up the estuary during low flow conditions.

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

Estuaries are important as nursery grounds for many commercially important fish species. Many freshwater wetland systems in the planning area provide base flows to extensive estuarine systems in Lee, Collier, and Monroe counties. Wetlands as far inland as the Okaloacoochee Slough in Hendry County contribute to the base flows entering some of these estuarine systems. Maintenance of these base flows is crucial to propagation of many fish species that are the basis of extensive commercial and recreational fishing industries.

The estuarine environment is sensitive to freshwater releases, and disruption of the volume, distribution, circulation, temporal patterns of freshwater discharges could place severe stress on the entire ecosystem. "Such salinity patterns affect productivity, population distribution, community composition, predator-prey interactions, and food web structure in the inshore marine habitat. In many ways, salinity is a master ecological variable that controls important aspects of community structure and food web organization in coastal systems" (Myers and Ewel, 1990). Other aspects of water quality, such as turbidity, dissolved oxygen content, nutrient loads, and toxins, also affect functions of these areas (USFWS, 1990; USDA, 1989; Myers and Ewel, 1990).

OUTSTANDING NATURAL SYSTEMS

The Outstanding Natural Systems (ONS) concept and map (Plate 2) were developed at the direction of the Lower West Coast Water Supply Plan Advisory Committee. The map was prepared to identify large natural systems which should be preserved to ensure the ecological integrity of the region. The Advisory Committee selected a subcommittee to prepare the map, which was composed of representatives from public utilities, environmental groups, the agricultural community, Big Cypress Basin, the SFWMD, Florida Game and Fresh Water Fish Commission, U.S. Geological Survey, and county governments.

The ONS areas identified were predominately wetlands, due to their sensitivity to hydrologic changes. Uplands were included where they formed a mosaic with wetlands and/or provided corridor links between wetlands. In a few instances, uplands were included because they were known to support endangered species. The inclusion of lands on the map does not automatically preclude further development of these areas, nor does the exclusion of any natural areas from the map lessen their existing level of protection.

The map identifies two categories of ONS lands: ONSe and ONSm. The ONSe lands are areas that have been purchased for environmental preservation/ conservation purposes. The ONSm lands are natural systems that are used for multiple purposes (i.e., agriculture, residential, water supply, surface water management, etc.).

The process and specific criteria used to prepare the ONS map, as well as implementation strategies for the map, are further discussed in Chapter I of the LWC Planning Document.

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IV. DEMAND ESTIMATES AND PROJECTIONS

The water demands of urban and agricultural users are the topic of this chapter. Chapter III, Environmental Resources and Needs, addresses environmental needs for water.

OVERVIEW OF DEMAND ESTIMATES AND PROJECTIONS

This chapter presents the estimates and projections for the water demands of the Lower West Coast (LWC) Planning Area. For 1990, the South Florida Water Management District (SFWMD) estimated that total water demand for the LWC Planning Area was 307,061 million gallons for the year (MGY). Figure IV-1 shows the relative water demand by each category of use. As used in this document, *public water supply* refers to all potable water supplied by regional water treatment facilities to all types of customers, not just residential. The other four categories of water use identified in this document are self-supplied. *Commercial and industrial* refers to water that is self-supplied by commercial and industrial operations using over 100,000 gallons per day. *Recreation self supplied* includes landscape and recreational use demand and golf course irrigation demand. The golf course category includes only those operations which obtain water from their own irrigation wells. The landscape grouping includes water used for parks, cemeteries and other irrigation applications greater than 100,000 gallons a day. *Residential self-supplied* is used to designate only those households whose primary source of water are private wells. *Agriculture* includes water used to irrigate all crops, and for cattle watering.

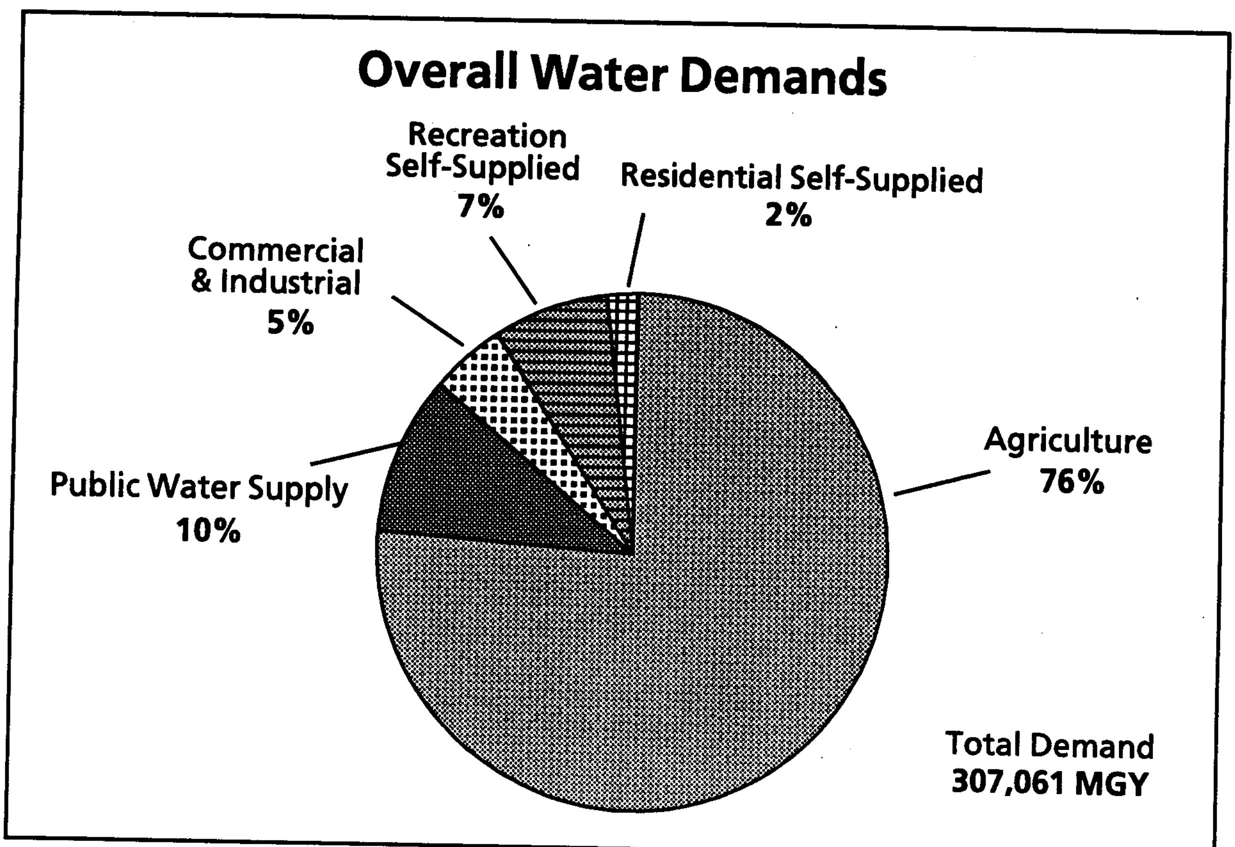

FIGURE IV-1. Overall Water Demands for 1990 in the LWC Planning Area.

Table IV-1 identifies the water demand estimates for 1990, by category, as well as the projected demands for 2010. Figure IV-2 illustrates the relative growth in demand projected for each category from 1990 to 2010. During the 20-year period, overall water demand is projected to increase by 54 percent to 471,507 MGY. Public water supply has the largest projected increase of 97 percent. However, agricultural water demand is projected to remain the single largest category of use.

TABLE IV-1. Overall Water Demands for 1990 and 2010 in the LWC Planning Area (MGY).

Category	Estimated Demands 1990	Projected Demands 2010	% Change 1990-2010
Agriculture	234,636	334,644	43%
Public Water Supply	30,328	59,856	97%
Residential	5,026	7,465	49%
Commercial & Industrial	14,447	27,660	91%
Recreation	22,624	41,882	85%
TOTAL	307,061	471,507	54%

In 1990, agriculture accounted for 76 percent of the total demand. Agricultural demands are projected to increase by 43 percent by 2010, accounting for 71 percent of the total demand.

Charlotte, Glades (with the exception of one golf course), and Monroe counties were not included in the tables showing demands for urban water uses. Although portions of these counties are in the planning area, their demand for urban uses is small.

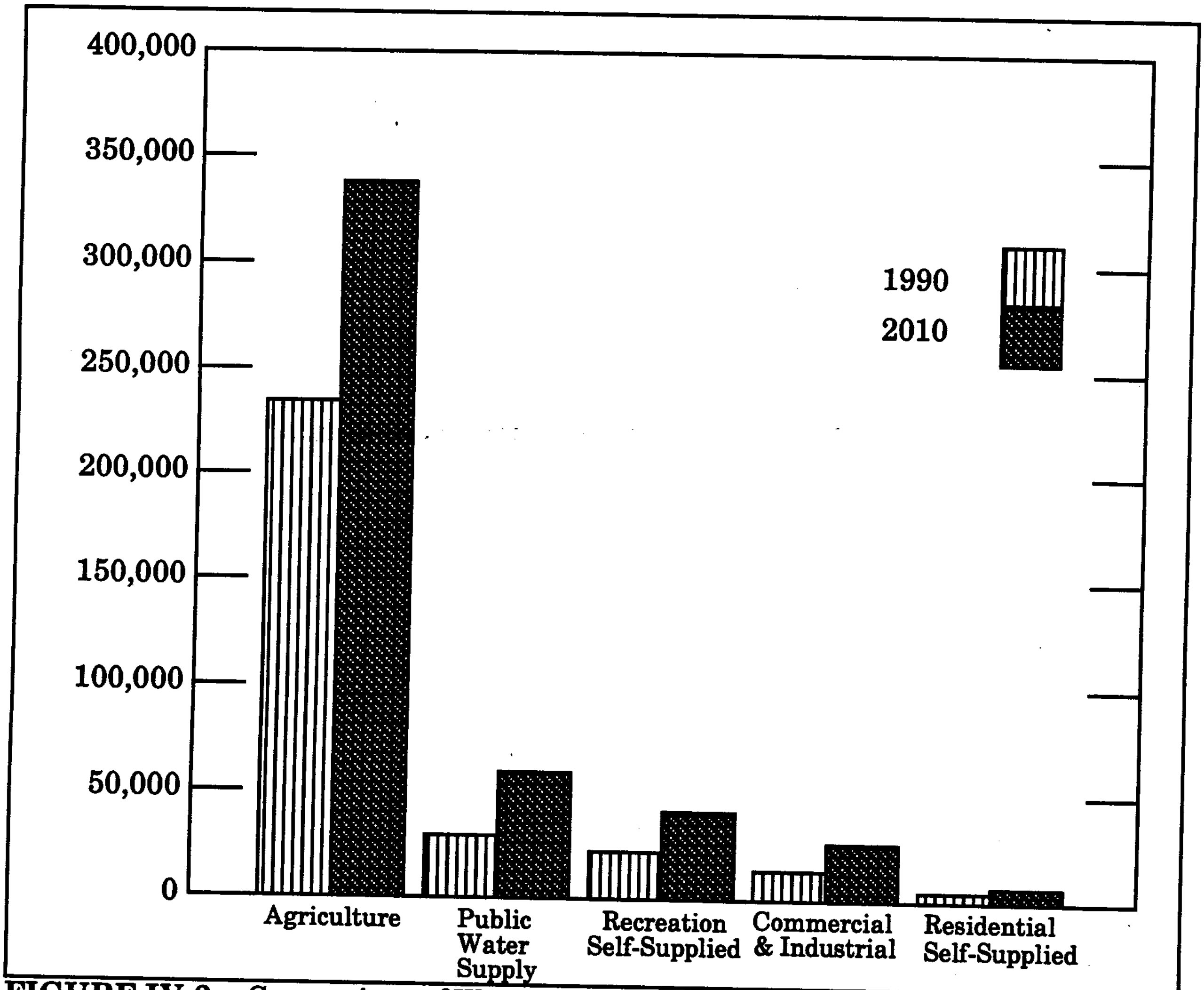

FIGURE IV-2. Comparison of Water Demands (MGY) for 1990 and 2010 in the LWC Planning Area.

URBAN DEMAND

Summary of Urban Demand

The five categories of urban water demand analyzed for this report include: (1) public water supply provided by utilities; (2) domestic self supply; (3) commercial and industrial self supply; (4) landscape and recreation; and (5) golf course. Urban water demand in 1990 is estimated to be approximately 73 billion gallons per year. Public water supply provided by utilities represents the largest component (41%) of urban water demand in 1990, followed by commercial and industrial self supply (20%), golf course irrigation (17%), landscape and recreation (14%), and domestic self supply (8%). Urban water demand is estimated to increase by a factor of approximately 1.9 to 137 billion gallons per year in 2010. The proportions of the urban demand components in the year 2010 are anticipated to be similar to the proportions in 1990.

Public Water Supply and Domestic Self-Supplied

Public water supply and residential self-supplied demand projections were developed for the modeled areas of the LWC Planning Area for the period through 2010. Table IV-2 shows total demands for Collier, Hendry and Lee counties. More detail on specific utility service area populations and water demands are found in Appendix G. An overview of the methodology used to develop these values is also provided in the appendix.

TABLE IV-2. Public Water Supply and Residential Self-Supplied Estimates and Projections for the LWC Planning Area (MGD).

County	1990		2010	
	Utility Supplied	Residential Self Supplied	Utility Supplied	Residential Self Supplied
Collier County Area	36.7	4.6	71.3	8.4
Hendry County Area	3.9	1.7	6.2	2.7
Lee County	42.5	7.7	86.5	9.8
TOTAL	83.1	14.0	164.0	20.9

The total population of the LWC Planning Area for 1990 was 512,985. The total population is projected to increase by 90 percent to 975,595 in 2010. The estimated water demand for urban users was 97 million gallons per day (MGD) in 1990. Water demand is projected to increase 91 percent from 1990 to 2010 to a total water demand of 185 MGD.

Commercial and Industrial Self-Supplied

Included in the demand projections for this section are self-supplied commercial and industrial users. PWS supplied commercial and industrial demands are included with other PWS demands. The projection methodology and data sources are provided in Appendix G. Commercial and industrial demand projections for the LWC Planning Area are presented in Table IV-3. Hendry County's only significant industrial demands are supplied by a public utility.

TABLE IV-3. Commercial and Industrial Self-Supplied Demand in the LWC Planning Area (MGD).

County	1985	1990	1995	2000	2005	2010
Collier County Area	7.1	8.3	10.2	12.1	14.0	16.0
Lee County	18.7	31.3	38.8	46.2	53.0	59.8
TOTAL	25.8	39.6	49.0	58.4	67.0	75.8

Recreation Self Supplied

Landscape and Recreational Use

Included in the demand projections for this section are individual permits for landscaping and recreation, excluding those for golf courses. The projection methodology and data sources are provided in Appendix G. Landscape and recreational self-supplied demand projections for the LWC Planning Area are presented in Table IV-4. Hendry County does not have any significant landscape and recreational self-supplied demand.

TABLE IV-4. Landscape and Recreational Self-Supplied Demand in the LWC Planning Area (MGD).

County	1985	1990	1995	2000	2005	2010
Collier County Area	2.8	4.0	4.9	5.9	6.8	7.8
Lee County	12.7	23.5	29.1	34.7	39.8	44.9
TOTAL	15.5	27.5	34.0	40.6	46.6	52.7

Note: Demand under average rainfall conditions.

Golf Course Irrigation Demand

Golf course irrigation requirement estimates (Table IV-5) were made by time horizon and month. Projection methodology and data sources are provided in Appendix G.

TABLE IV-5. Irrigation Requirements for the Primary Irrigated Golf Course Acreage Projection in the LWC Planning Area (MGD).

County	1985	1990	1995	2000	2005	2010
Collier County Area	13.8	16.5	20.5	24.2	28.6	32.7
Lee County	12.7	17.2	19.2	22.3	25.4	28.6
Hendry County Area	0.8	0.8	0.8	0.8	0.8	0.8
Glades County Area	0.1	0.1	0.1	0.1	0.1	0.1
TOTAL	27.4	34.6	40.6	47.6	54.9	62.2

Note: Demand under average rainfall conditions.

AGRICULTURAL WATER DEMAND

Summary of Agricultural Demand

The nine categories of agricultural water demand analyzed for this report include: (1) citrus; (2) citrus nursery; (3) sugarcane; (4) tropical fruit; (5) vegetables; (6) field crops; (7) sod; (8) ornamental nursery; and (9) cattle watering. Agricultural water demand in 1990 is estimated to be approximately 235 billion gallons per year. Approximately 92 percent of the 1990 agricultural water demand is for citrus (40%), sugarcane (35%), and vegetables (18%). Sod and ornamental nurseries each use approximately three percent of the total 1990 agricultural water demand. Field crops use represents approximately one percent of the 1990 agricultural water demand. The combined water demand for tropical fruit, cattle watering, and citrus nurseries is approximately one percent of the total 1990 agricultural water demand.

Agricultural water demand is forecast to increase by a factor of approximately 1.4 to 335 billion gallons per year in the year 2010. Approximately 94 percent of the agricultural water demand in the year 2010 is anticipated to be for citrus (50%), sugarcane (31%), and vegetables (13%). Sod and ornamental nurseries are each projected to represent approximately two percent of the total 2010 agricultural water demand. The projected water demands for citrus nursery, tropical fruit, field crops, and cattle watering are less than one percent each in the year 2010.

The LWC Planning Area continues to experience growth in irrigated agricultural acreage. The irrigated crops in this region are citrus, sugarcane, tropical fruit, vegetables, field crops, sod, and ornamental nursery. These crops are spreading onto land which was formerly pasture. Pasture is seldom irrigated in the LWC Planning Area, and when irrigation takes place, it is invariably in a period of extreme drought, and is done to prevent the grass from dying. There are, however, some requirements for cattle watering associated with the total pasture acreage. Descriptions of the agricultural acreage in each county, projection methodology, and the calculation of irrigation requirements, including data sources, are detailed in Appendix G.

Agricultural irrigation requirements are seasonal, especially for crops such as vegetables which are grown only at specific times of the year. This seasonality is misleadingly smoothed if the annual demands are averaged and presented as million gallons per day. Therefore, agricultural requirements are presented by month for each crop in each county, and the summations for the LWC Planning Area are presented as million gallons per year.

Table IV-6 shows the annual average agricultural irrigation demand by crop. Figure IV-3 presents a graphical comparison of agricultural demand by crop type for 1990 and 2010. During the 20-year period, agricultural water demand is projected to increase by 43 percent to 334,644 MGY. For a complete description of agricultural water demand by crop in individual counties, see Appendix G.

The actual and projected irrigation demands presented in this chapter are based on historical crop acreage data. These data were available on a county level, which for ground water modeling purposes, lack the resolution to identify problem areas. Therefore permit data, which show the locations of permitted withdrawals, were used in the modeling process because these data have the level of resolution required by the ground water models. This is further discussed in Chapter VI in the Demand Assumptions section.

Citrus

The LWC Planning Area has the fastest growing citrus acreage of any area in Florida. While acreage has grown continuously since 1966 (the first year for which data is available), the most significant increases have occurred since 1986, and are associated with the interregional movement of citrus acreage from Central to Southwest Florida following several severe freezes in the mid-1980s.

Citrus water demand is projected to remain the single largest category of use. In 1990, citrus accounted for 40 percent of the total agricultural demand. Citrus

TABLE IV-6. Water Demands by Crop in the LWC Planning Area (MGY).

Category	Estimated Demands 1990	Projected Demands 2010	% Change 1990-2010
Citrus	93,871	167,692	79%
Citrus Nursery	176	283	61%
Sugarcane	81,567	105,377	29%
Tropical Fruit	1,765	2,410	37%
Vegetables	41,096	42,322	3%
Field Crops	2,256	2,256	0%
Sod	7,209	7,209	0%
Ornamental Nursery	6,142	6,579	7%
Cattle Watering	554	516	-7%
TOTAL	234,636	334,644	43%

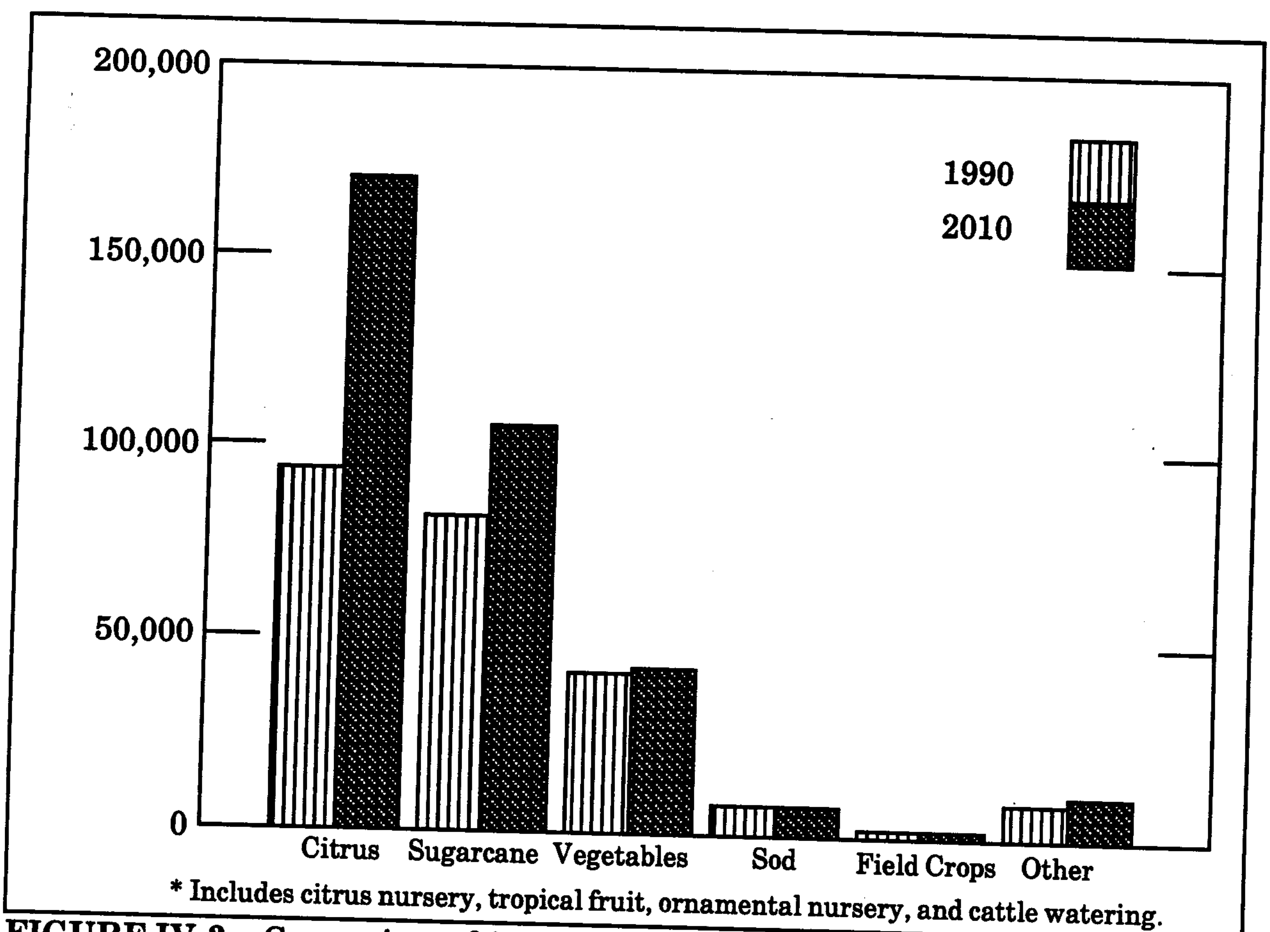

FIGURE IV-3. Comparison of Agricultural Demands for 1990 and 2010 in the LWC Planning Area (MGY).

demands are projected to increase by 79 percent by 2010, accounting for 50 percent of the total agricultural demand.

Citrus acreage is projected to grow from 94,770 acres in 1990 to 186,255 acres in 2010. This growth in acreage represents an increase in average irrigation requirements from 93,871 MGY in 1990 to 167,692 MGY in 2010.

Citrus Nursery

Hendry is the only county in the LWC Planning Area with a significant citrus nursery acreage, and this is forecast to increase from 134 acres in 1990 to 344 acres in 2010. The associated increase in average irrigation requirements is from 176 MGY in 1990 to 283 MGY in 2010.

Sugarcane

Sugarcane is produced in Hendry and Glades counties. In 1990 there were 54,141 acres of sugarcane in the portion of these counties in the LWC Planning Area, and this is forecast to increase to 83,919 acres by the year 2010. Because of the production practices used for sugarcane (ratoon and fallow), there is roughly an additional 20 percent of land used for sugarcane production which is idle in any given year. The projected increase in sugarcane acreage represents a rise in average irrigation requirements from 81,567 MGY in 1990 to 105,377 MGY in 2010.

Tropical Fruit

Lee is the only county in the LWC Planning Area with significant tropical fruit acreage (other than citrus), and this is forecast to increase from 1,680 acres in 1990 to 2,680 acres in 2010. The associated increase in average irrigation requirements is from 1,765 MGY in 1990 to 2,410 MGY in 2010.

Vegetables

Vegetable crops grown in the LWC Planning Area include cucumbers, peppers, tomatoes, potatoes, watermelons, squash, eggplant, latin vegetables, sweet corn, snap beans, and cabbage. Different types of vegetables are often grown interchangeably, and in 1990, there were 49,276 acres of land used for vegetable production. This is projected to increase to 50,261 acres by 2010, and represents an increase in the average irrigation requirements from 41,096 MGY in 1990 to 42,322 MGY in 2010.

Field Crops

Field crop production in the LWC Planning Area is limited to the Charlotte County Area. This acreage varies from year to year based on the demand for seed corn, which in turn is primarily dependent on production in other parts of the country. This variation in production is more of a fluctuation than a real trend.

An agricultural commodity summary (1991) was developed for Charlotte County by the local Soil Conservation Service office at the request of the District. The summary reported 2,123 acres of seed corn production (1,423 acres in the spring and 700 acres in the fall) and 1,000 acres of soybeans (all in the spring). While fluctuations are anticipated, the magnitude of these acreages are typical. These combined acreages have irrigation requirements of 2,256 MGY.

Sod

In 1990 there were a total of 4,268 acres of irrigated sod production in the LWC Planning Area. There is additional sod harvested from pasture land, but this is rarely irrigated. Sod production is projected to remain fairly constant through 2010, with associated average irrigation requirements of 7,209 MGY.

Ornamental Nursery

In 1990 there were 3,420 acres of ornamental nursery in the LWC Planning Area, and this is projected to increase to 5,060 acres by the year 2010. This represents an increase in average irrigation requirements from 6,579 MGY in 1990 to 6,994 MGY in 2010. The increase in irrigation demands is moderated by the District's higher irrigation efficiency permitting standards.

Cattle Watering

Although pasture is seldom irrigated in the LWC Planning Area, there is a demand for cattle watering and barn washing associated with cattle production (which is in turn associated with pasture acreage). This was assessed at 554 MGY in 1990, and is projected to decline slightly to 516 MGY in 2010. This decline is associated with the displacement of pastureland with irrigated agricultural crops (especially citrus).

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V. WATER CONSERVATION MEASURES AND SUPPLY ALTERNATIVES

WATER CONSERVATION MEASURES

Water conservation, also called demand management, refers to water use practices and technologies which provide the services desired by the users while using less water. The water conservation measures discussed in this section achieve long-term permanent reductions in water use. This separates them from the short-term water conservation measures and cutbacks that are required of users during water shortage situations or when short-term problems with the capacity of supply systems occur. Because of their short-term emergency nature, water shortage reductions rely almost exclusively on behavioral changes by the users (e.g., skipping or rescheduling lawn watering and taking shorter showers). Water conservation, on the other hand, generally requires changes in water use systems and technology, and little behavioral change.

The water use reductions resulting from conservation provided a basis for adjusting historical rates and patterns of water use in the modeling of the LWC Planning Document. The 2010 modeling scenarios included the water conservation measures that have been incorporated in the District's water use permit rules. The cost effectiveness of these measures are discussed in Appendix I.

Mandatory Water Conservation Measures

In District water use permitting rule amendments adopted in October 1992, specific water conservation requirements were imposed on potable water utilities (and associated local governments), on commercial/industrial users, on landscape and golf course users, and on agricultural users. All of these requirements apply to users required to obtain individual water use permits. Water use (consumptive use) permitting is further discussed in Chapter II.

Water Utilities

A conservation plan incorporating the mandatory measures is required of water utilities as a condition of permit issuance or renewal. The required conservation measures are: (a) adoption of an irrigation hours ordinance, (b) adoption of a Xeriscape landscape ordinance, (c) adoption of an ultra-low volume fixtures ordinance, (d) adoption of a water conservation-based rate structure, (e) implementation of a leak detection and repair program, (f) adoption of a rain sensor device ordinance, (g) implementation of a water conservation public education program, and (h) an analysis of reclaimed water feasibility.

Adoption of an Irrigation Hours Ordinance. The irrigation ordinance is defined as a permanent ordinance restricting urban landscape irrigation to the hours of 4:00 P.M. to 10:00 A.M. The restricted hours do not apply to hand watering with a self-cancelling nozzle, low volume irrigation systems, irrigation systems whose sole source is treated wastewater or seawater, or to operations for the purpose of system repair or maintenance.

This option will affect irrigators who do not already water between the hours of 4:00 P.M. and 10:00 A.M. It is assumed that most urban landscape irrigation already takes place during acceptable hours.

Irrigation during daytime hours is generally less efficient. The sunlight and increased winds during the restricted daytime hours cause some of the water to evaporate before hitting the ground or to blow onto impervious surfaces such as sidewalks, roads and driveways. The wind also causes the water that reaches the plants to be more unevenly applied. For there to be reductions in water withdrawn for irrigation application, users who switch from daylight hours will need to learn that the time and frequency of irrigations can be somewhat reduced and take the appropriate actions. Public education programs can contribute to the irrigation hours ordinance by informing irrigators how they can reduce applications while still meeting the water requirements of their plants. Even if applications are not reduced, more water will reach the plants and soil when the prescribed hours are followed. When the amount of water in the soil is increased, the soil profile will saturate more quickly when rains occur, and provide recharge to the Surficial Aquifer System.

To date, an irrigation ordinance has been adopted by Lee County and the cities of Fort Myers and Sanibel.

Adoption of a Xeriscape Landscape Ordinance. Xeriscape is defined by the Florida Legislature to mean "a landscaping method that maximizes the conservation of water by the use of site-appropriate plants and an efficient watering system" (Section 373.185 F.S.). The principles of Xeriscape include planning and design, soil analysis, efficient irrigation, practical turf areas, appropriate plant selection, and mulching. The legislation requires that the water management districts establish incentive programs and provide minimum criteria for qualifying Xeriscape codes. These codes prohibit the use of invasive exotic plant species, set maximum percentages of turf and impervious surfaces, include standards for the preservation of existing native vegetation, and require a rain sensor for automatic sprinkler systems. District rules, as mandated by the legislature, require that all local governments consider a Xeriscape ordinance and that the ordinance be adopted if the local government finds that Xeriscape would be of significant benefit as a water conservation measure relative to the cost of implementation.

Because of the autonomy of the cities in the LWC Planning Area regarding landscaping regulations, individual landscape codes will have to be considered and adopted by each city, and by each county for the unincorporated areas, in order for this option to be fully implemented. To date, Cape Coral, La Belle, Sanibel and Lee County have adopted complete Xeriscape ordinances.

The Xeriscape landscape ordinance will affect new construction and landscapes undergoing renovation which require a building permit. Although the ordinance will not directly affect the majority of existing landscapes, there will be some indirect impact because of the plant materials, designs and irrigation scheduling aids used for new landscapes.

Adoption of an Ultra-Low Volume Fixture Ordinance. This option requires adoption of ultra-low volume (ULV) indoor plumbing fixtures into building codes. These standards, as contained in the District's water use permit regulations, specify that the fixtures perform as follows when the water pressure is 80 pounds per square inch (psi): toilets, a maximum of 1.6 gal/flush; shower heads, a maximum of 2.5 gal/min. flow; and faucets, a maximum of 2.0 gal/min. flow.

Building requirements apply to all new construction and major renovations. They do not require early replacement of existing fixtures. Having such an ordinance improves the stocking of the ULV devices and may also increase their use as replacements in cases in which the ordinance is not applicable. The adoption of such an ordinance by appropriate local governments is a required element of utility water conservation programs.

ULV fixtures save water by using less water to provide the services desired. Available data indicate that the performance of the systems is such that the savings per unit (per flush or per minute) will not be offset by having the users increase the number of units (number of double flushes or length of shower). Thus these permanent ongoing water savings can be obtained without any behavioral changes by the users.

Until recently, the ~~current standard~~ and practice for plumbing devices throughout South Florida was that of the low volume devices (3.5 gal/flush, 3.0 gal/min shower heads, and 2.5 gal/min faucets). These are the standards that would be in effect without the ordinance. However, over the past several years, the technology of the ULV devices has become more widely accepted. Manufacturers have also increased their capacity for the production of these devices so that they can serve large markets. Because of movement to these more conserving devices throughout the country and their inherent cost effectiveness, they are capturing a large portion of the new and replacement plumbing device market irrespective of whether an ordinance is enacted. To date, an ultra-low volume fixture ordinance has been adopted by the cities of Fort Myers, Cape Coral, Sanibel and Lee County.

Adoption of a Conservation Rate Structure. A conservation rate structure is a charging system used by utilities that includes increasing block rates, seasonal rates, quantity-based surcharges, and/or time of day pricing as means of reducing demands while providing for cost recovery. This measure is a mandatory element of the conservation plans required of all utilities. Water conservation rates are generally either (a) increasing block rates, where the marginal cost of water to the user increases in two or more steps as water use increases, or (b) seasonal pricing, where water consumed in the season of peak demand, such as from October through May, is charged a higher rate than water consumed in the off-peak season. Maddaus (1987) also lists uniform commodity rates as a conservation rate structure.

This option provides a financial incentive for users to reduce demands. Those users faced with higher rates will often achieve water conservation by implementing a number of the conservation measures discussed in this chapter. The most frequently used conservation rate structure used by utilities is increasing block rates. This rate structure generally is expected to have the largest impact on heavy irrigation users. However, the effectiveness of a block rate structure is negated when users switch to another source of water in response to increased rates.

An additional concern with regard to adoption of conservation rate structures is the impact of such structures on the ability of utilities to recover costs. In general, the demand for water has been found to be inelastic. Thus, as rates are raised to promote conservation, water use declines less than proportionally, and the total revenues to the utility increase in the short term. If conservation rates are implemented in conjunction with one or more other conservation measures, the effect of the combination of measures on utility revenues and costs cannot be determined without looking at the specific conservation program.

Approximately 50 percent (10) of the regional utilities in the LWC Planning Area have adopted a water conservation rate structure.

Adoption of a Utility Leak Detection and Repair Program. The utility leak detection and repair program affects the utility production and distribution system up to the customers' meters. It includes water auditing procedures for utilities to accurately determine unaccounted-for water, leak detection efforts to identify leak locations, and repair efforts to minimize leaks. A less than 10 percent unaccounted-for loss in the distribution system is the target maximum level for public water supply utilities. The requirement that utilities implement a leak detection program if they have unaccounted-for losses greater than 10 percent has been incorporated in District rules.

A recent phone survey (August 1993) indicates that several utilities have ongoing leak detection programs. As might be expected, most of those which have ongoing programs are the larger utilities. This does not mean that smaller utilities do not undertake periodic leak detection and repair programs, or that most utilities do not have acceptable levels of performance with regard to unaccounted-for losses. A major difficulty in assessing the potential savings from leak detection and repair program is that, until a thorough water audit is completed, the proportion of unaccounted-for water due to leaks is not known with the requisite degree of accuracy. Data submitted to the District by the utilities indicate that many utilities are already maintaining losses close to or below the targeted 10 percent leakage loss ratio. Therefore, the potential for water savings appears to be concentrated in a few utilities which have unaccounted-for losses above 10 percent.

Adoption of a Rain Sensor Device Ordinance. Any person installing an automatic sprinkler system is required to install a rain sensor devise or an automatic switch which will overide the irrigation cycle of the sprinkler system when adequate rainfall has occurred. Rainfall sensors are also required in the Xeriscape ordinance.

Implementation of a Water Conservation Public Education Program. Public information, as a water conservation measure, involves a series of reinforcing actions to inform citizens of opportunities to reduce water use, give reasons why they should choose to practice water conservation, and publicize the conservation options being promoted by the District, local governments and utilities. Virtually all users can be affected by public information efforts, although they are typically targeted at the uses with the broadest participation, including domestic indoor and outdoor landscaping uses.

Like the restructuring of rates, public information provides incentives which encourage users to take specific actions to reduce water use. Public information efforts can also change users' behavior and encourage them to purchase water-conserving devices and systems.

The District has developed extensive conservation information for water shortage management, public education, and school programs. Public information programs conducted by the District in the LWC Planning Area have focused on Xeriscape and water shortage conservation. Approximately 75 percent (15) of the regional utilities in the LWC Planning Area have some form of a public information program.

Analysis of Reclaimed Water Feasibility. For potable public water supply utilities who control a wastewater treatment plant, an analysis of the economic, environmental, and technical feasibility of making reclaimed water available is required. Wastewater reuse is discussed in the "Water Supply Alternatives" section of this chapter.

Commercial/Industrial Users

District regulations require that all individual commercial/industrial permit applicants submit a conservation plan. This plan must include:

a. An audit of water use,
b. Implementation of cost-effective conservation measures,
c. An employee water conservation awareness program,
d. Procedures and time frames for implementation, and
e. The feasibility of using reclaimed water.

Landscape and Golf Course Users

Landscape and golf course permittees are required to use Xeriscape landscaping principles for new projects and modifications when they find this to be of significant benefit as a conservation measure relative to its cost. They are also required to install rain sensor devices or switches, to abide by the prohibition of irrigation between the hours of 10:00 A.M. and 4:00 P.M., and analyze the feasibility of using reclaimed water. There are, however, six specific exceptions to the irrigation hours limitations in the rule which provide for protection of the landscape during stress period and help assure the proper maintenance of irrigation systems.

Agricultural Users

Citrus and container nursery permittees are required to use micro irrigation systems or other system of equivalent efficiency for new installations of irrigation systems or upon modification to existing irrigation systems. Because citrus and nurseries are among the crops expected to increase in acreage in the LWC Planning Area, this requirement will limit their future water allocations and use. The permittees are also required to analyze the feasibility of using reclaimed water.

Supplementary Water Conservation Measures

Residential and Commercial Users

Indoor Audit and Retrofit. Indoor audits provide information and services directly to households and other water users to achieve efficiency in the use of interior water-using appliances. This option generally includes inspections to locate leaks and determine if plumbing devices are operating properly, repair of minor problems, and information on conservation measures and devices. In some cases, a retrofit program will include installation of water-conserving shower heads and toilet dams.

Residential retrofit measures encourage the installation of ULV plumbing fixtures or modifications which improve the performance of existing fixtures. One possible incentive is a partial financial subsidy to increase the installation of ULV water fixtures. Another incentive, recently undertaken in Tampa, is the delivery of retrofit kits to homes. The targeting and participation in efforts such as this will generally affect only a portion of the population. Utilities and local governments can devise programs which carefully target the most cost-effective applications of these measures.

Residential retrofit programs are designed to provide essentially the same service from toilets, showerheads, and faucets as existing conventional devices but at lower water use levels. In retrofit programs, a decision needs to be made as to whether to target residences with only high water consuming fixtures (generally those built pre-1980) or to include residences with low water use fixtures (post-1980) for retrofit with ULV water use fixtures.

Another characteristic which will increase the savings and the cost effectiveness of retrofit of the earlier dwelling units (homes) is that many of these units have fewer bathrooms and fixtures per unit and per person. The larger the number of people using a retrofit device, the more cost effective and water saving the retrofit. An appropriate strategy would be to target homes with large numbers of persons per fixture for complete retrofit, and other homes for retrofit of only the most heavily used fixtures. This suggests that a particularly suitable target for retrofit programs are public restrooms and other facilities which have high use rates.

Landscape Audit and Retrofit. Landscape audits are measures that improve the efficiency of irrigation systems, and include services to determine if the irrigation system is operating properly. This may include adjustments to irrigation timers (to assure that a water-conserving schedule is being followed), head replacement (to assure that the system is providing adequate coverage and not wasting water by irrigating impervious surfaces), recalibration of the irrigation system, and installation of rainfall sensing/irrigation controlling devices.

Landscape retrofit measures provide information and incentives for users to implement physical changes to their landscapes and irrigation systems. Devices suitable for landscape retrofit include those that prevent unnecessary irrigation by detecting recent rainfall or sensing soil moisture. Rainfall detecting equipment is considerably less costly, more completely tested, reliable, and available for widespread use than soil moisture sensing equipment. It is mandated in Florida Law that all new irrigation systems have rainfall sensing devices. Although soil moisture sensing equipment is much more costly and requires more frequent maintenance, it has greater potential for reducing irrigation. Soil moisture sensing equipment will meet the needs of some large users, particularly if the landscape design and conditions are such that only one sensor is necessary and the landscape is professionally maintained. Other retrofit options include converting drought-susceptible plants to drought-tolerant plant materials, rezoning irrigation systems, mulching, and installing landscape.

Audits are generally implemented by utilities and other water management agencies, and are usually aimed at indoor water use. However, because of the large outdoor component of water use in South Florida, irrigation audits can be effective. This is particularly important due to the peaking of outdoor demand during periods of low rainfall and maximum stress on water resources. Participation in landscape audits is voluntary. Audits usually focus on single family homes, although in many situations commercial and multifamily landscapes should be included.

Water Utilities

Utility Filter Backwash Recycling. This option requires water utilities using filter systems that are cleaned by backwashing (cleaning the filter by reversing the flow of water) to allow the backwash water to settle and then be retreated. Without the backwash recycling, the water is usually disposed of into a pit from which the water seeps back into the ground.

Utility Pressure Control. Water-conserving utility pressure control measures help to reduce water usage while providing acceptable water pressures to all customers. The pressure levels should keep water-using devices working properly and provide for public health and fire safety needs. Installing pressure reduction valves, as well as interconnecting and looping utility mains, are some of the means used to equalize and, therefore, reduce overall operating pressure. Unlike the pressure reduction efforts during water shortages, which call for reductions in pressures to levels necessary to meet minimums for fire flow, these changes target reductions at locations where pressures are high within the system.

Control of pressures can save water in a number of ways. High pressures exacerbate losses of water through leaks, and increase use when the amount of water used is based on time rather than the volume of water discharged. Irrigation systems on timers are the major uses wherein the use is for set periods of time. High pressures cause increases in water application and can cause atomization of the spray, which reduces irrigation efficiency. Low pressures, however, reduce the areas covered by poorly designed sprinkler systems, and this results in stress to the uncovered areas. This may encourage users to increase irrigation time in an attempt to improve the results of the irrigation efforts.

By installing pressure reduction valves, and looping and interconnecting transmission mains, utilities are able to balance pressures throughout their systems. Assuring that multistory buildings have appropriate booster pump capacity will also alleviate the need to maintain high pressures in utility lines which service these few customers.

Wastewater Utility Infiltration Detection and Repair. Wastewater utility infiltration detection and repair includes estimation and detection efforts to quantify and locate the infiltration of ground- or surface-water into wastewater collection systems, and repair efforts to reduce the infiltration.

The problem of infiltration is important in the LWC Planning Area because some of the wastewater lines in coastal areas are located below the water table for much of the year. Reducing the infiltration of fresh ground water prevents waste by allowing the ground water to be used for other purposes. Reducing the infiltration of saline water, also, prevents waste by helping the wastewater to be more acceptable for reuse. When utilities reduce infiltration, they can often delay or avoid making additions to plant and disposal capacities.

Agricultural Users

Irrigation Audit and Improved Scheduling. The District, as well as other state and federal agencies, has actively encouraged growers to adopt irrigation management practices which conserve water. For instance, agricultural irrigation audits are carried out by the District-funded Mobile Irrigation Laboratory which operates in the LWC Planning Area. Agriculture is a major water user in the area and elsewhere in the District. Changing on-farm irrigation scheduling and water management practices will play an increasingly important role in agricultural water conservation.

Irrigation management practices and technology interact, so that for example, a change in the type of irrigation system will generally require a change in irrigation scheduling to achieve the goal of water conservation while maintaining crop yield and economic return. An additional factor in agricultural water conservation is the energy savings possible through water conservation.

The irrigation audit, improved scheduling options, and the adoption of micro irrigation systems are designed to improve the "efficiency" of irrigation water use. There are a variety of different definitions of irrigation efficiency. A report prepared by the Institute of Food and Agricultural Sciences (IFAS) at the University of Florida (Smajstrla *et al.*, 1991), identifies the following concepts of efficiency: reservoir storage efficiency, water conveyance efficiency, irrigation application efficiency, and overall irrigation efficiency, which is the product of the other three types of efficiency. In addition, this report identifies effective irrigation efficiency, which adjusts overall irrigation efficiency for water which is reused or which is restored to the original water source with no reduction in water quality.

Micro Irrigation Systems. Micro irrigation systems achieve water savings by directly applying a high percentage of water to the root zone of the crop in controlled amounts, so losses through deep percolation, drainage, etc. are reduced. In addition, application of water to areas not underlain by the root zone is limited. Installation of micro irrigation systems, or systems of equivalent efficiency, are required for new citrus and container nursery crops. Additional water savings can be achieved by promoting the installation of water-conserving irrigation systems on crops where it is not required (such as vegetables), and retrofitting irrigation systems for existing citrus and nursery crops.

Different irrigation systems achieve different levels of efficiency in delivering water to meet the water requirements of crops. The major factors affecting the efficiency of an irrigation system are system design and management. In addition to differences between individual irrigation systems, irrigation efficiency varies with "the stage of crop development, time of year, climatic conditions, and other factors" (Smajstrla *et al.*, 1991).

The percentages of crops irrigated by micro irrigation systems (drip and trickle) during 1990 is shown in Table V-1 for the portions of counties within the LWC Planning Area. There are no irrigated crops in the Monroe County Area, as it is wholly protected as part of the Everglades National Park. None of the irrigated nurseries and none of the irrigated vegetable acreage in the LWC Planning Area were identified as having micro irrigation systems.

TABLE V-1. Percentage of Crop Acreages Irrigated with Micro Irrigation Systems in 1990.

County Area	Citrus	Tropical Fruit
Lee County Area	50%	10%
Collier County Area	72%	100%
Hendry County Area	60%	0%
Charlotte County Area	100%	NA
Glades County Area	77%	NA

WATER SUPPLY ALTERNATIVES

Supply augmentation is a method of increasing available water supply, and generally includes ways to optimize wellfield locations, modify otherwise unusable water, store excess water and recover it for later use, and transport or import water. Unlike water conservation measures, which include practices that reduce both indoor and outdoor water use, water supply alternatives do not address demand reduction. Instead, as explained below, water supply alternatives identify ways to expand and diversify the supply of water available to consumers in the LWC Planning Area.

Wellfield Expansion

Expansion of an existing public water supply wellfield is usually selected by a utility when additional raw water is required. The costs related to wellfield expansion for the major aquifer systems in the LWC Planning Area are provided in Table V-2.

TABLE V-2. Estimated Well Costs for Aquifer Systems in LWC Planning Area.

Aquifer System	Drilling Cost (per well)	Equipment Cost (per well)	Engineering Cost (per well)	O&M Cost (per 1000 gal)	Energy Cost (per 1000 gal)
Surficial	$36,000	$49,000	$13,000	$.003	$.02
Intermediate (1)	35,000	49,000	13,000	.003	.024
Intermediate (2)	50,000	49,000	12,000	.003	.028
Floridan (3)	92,000	52,000	14,000	.003	.032

Notes: Intermediate (1) Northern Lee and Hendry counties; Intermediate (2) Collier and southern Lee counties; and Floridan (3) Lee county.
Source: PBS&J Water Supply Cost Estimates, 1991.

Ground water wells are limited in the amount of water they can yield by the rate of water movement in the aquifers, the rate of recharge, the storage capacity of the aquifer, environmental impacts, and proximity to sources of contamination by saltwater intrusion or poor quality ground water. These factors together determine the number, size, and distribution of wells that can be developed at a specific site. Long-range planning by the water suppliers to identify future wellfield sites, and to protect those future sites from contamination by controlling land use activities within the influence of the wellfield, is important in ensuring satisfactory future water supply.

Utility Interconnections

Interconnection of treated and/or raw water distribution systems between two or more utilities can provide a measure of backup water service in the event of disruption of a water source or treatment facility. Additionally, when considering future potable water needs, bulk purchase of treated water from neighboring utilities should be evaluated in lieu of expanding an existing source or treatment plant. A detailed study of distribution systems proposed for interconnection should address system pressures, physical layout of the supply mains, impacts on fire flows and compatibility of the treated waters.

Wastewater Reuse

Encouragement and promotion of wastewater reuse and water conservation are formal state objectives. The State Water Policy requires the FDEP and water management districts to advocate and direct the reuse of reclaimed water as an integral part of water management programs, rules, and plans. Several regulations also require an evaluation of reuse versus other disposal methods prior to issuance of Department permits.

Reuse is the deliberate application of reclaimed water for a beneficial purpose, in compliance with the Florida Department of Environmental Protection (FDEP) and water management district rules. Reclaimed water is wastewater that has received at least secondary treatment and is reused after flowing out of a wastewater treatment plant (Chapter 17-610, F.A.C.). Potential uses of reclaimed water include landscape and agricultural irrigation, ground water recharge, industrial uses, environmental enhancement and fire protection. Additional discussion of reuse, including reclaimed water regulations and more detailed information on potential uses, is provided in Appendix I.

Reuse Costs

The costs associated with implementation of a reuse program varies depending on the size of the reclamation facility, the facility equipment needed, the extent of the reclaimed water distribution system, and the regulatory requirements. The major construction components of a water reclamation facility and reclaimed water distribution system are:

- Filtration system with associated chemical feed facilities
- Disinfection system
- Continuous reclaimed water monitoring equipment for disinfectant residual and turbidity
- System mandated storage
- Reclaimed water pumping facility
- Reclaimed water distribution system

In addition to the varying equipment costs with size, the reclaimed water distribution system cost is also dependent on the area type (e.g., rural, suburban, and urban), and possible right-of-way acquisition. Operation and maintenance (O&M) costs must also be considered in the implementation of a reuse system.

Existing Treatment Facilities

Currently, there are 21 wastewater treatment facilities that have a FDER rated capacity of 0.50 MGD or greater in the LWC Planning Area. These facilities treated 42.76 MGD of wastewater in 1990. Of this, 16 facilities utilized reuse for disposal which accounted for 19.08 MGD. In addition to reuse, 0.08 MGD was disposed of by deep well injection and 22.60 MGD was disposed of by surface water discharge (see Figure II-5). This water that was disposed of by deep well injection or discharge to surface water could be made available with the addition of regulatory mandated equipment including filtration and the associated chemical feed system, disinfection facilities and reclaimed water monitoring equipment. The volume of wastewater is projected to increase to over 146 MGD by 2010. This summarized wastewater facility information, including the FDEP's antidegradation policy, is provided in detail in Appendix E.

Surface Water Storage

Surface water storage could be utilized by pumping surface water runoff and ground water seepage into regional storage systems during periods of excessive rainfall to provide additional water supply and flood protection. The capture of surface water runoff and ground water seepage in canals of the primary water management system, and storage of these waters in existing or new surface water reservoirs or impoundments, provides an opportunity to increase the supply of fresh water during subsequent dry periods. The primary problems associated with surface water storage are the expense of building and operating large capacity pumping facilities, the cost of land acquisition, appropriate treatment costs, the potential environmental impacts of discharging large volumes of polluted stormwater runoff, the availability of suitable storage locations, and the high evaporation rates of surface water bodies.

Aquifer Storage and Recovery (ASR)

Aquifer storage and recovery (ASR) is defined as the underground "storage" of injected water in an acceptable aquifer during times when water is available, and the subsequent "recovery" of this water when it is needed. Simply stated, the aquifer acts as an underground reservoir for the injected water, reducing the water loss to evaporation. Sources of injection water could include treated and untreated ground- and surface-water, and reclaimed water.

In the last few years, water utilities have been forced to face the realities of limited water resources, increasing demands, and more stringent water quality restrictions. Because of these limitations, ASR technology is receiving growing attention. The regulatory criteria for ASR permitting is discussed in Appendix I.

ASR Costs

Estimated project costs for ASR consisting of a 900-foot, 16-inch well, with two monitoring wells using treated water in Florida are shown in Table V-3. 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. Using the assumptions that the capital costs are amortized at 8 percent over 20 years, that the water recovery efficiency is 75 percent, and that the total water recovered in any year is 100 times the daily recovery capacity, the costs in Table V-3 translate into costs of $.23 to $.27 per thousand gallons. However, utilities implementing ASR systems may incur additional costs for surface facilities, such as piping, storage, and rechlorination. Other available data indicate that "typical unit costs for water utility ASR systems now in operation tend to range from $200,000 to $600,000 per mgd of recovery capacity" (CH2M Hill, 1993). At the same annual recovery rate used above (100 times the daily recovery capacity), the costs per thousand gallons recovered would be $.30 to $.70 per thousand gallons. These systems have well capacities in the range from .3 to 3 mgd and store treated water. Savings in treatment system costs are likely to be substantial when the ASR system offsets the need for capacity to meet peaks in demands.

TABLE V-3. Aquifer Storage and Recovery System Costs.

	Well Drilling Cost	Equipment Cost	Engineering Cost*	O&M Cost (per 1000 gal)	Energy Cost (per 1000 gal)
Treated Water at System Pressure	$200,000	$30,000	$360,000	$.004	$.06
Treated Water Requiring Pumping	$200,000	$100,000	$400,000	$.006	$.06

* Engineering costs include the permitting process, hydrogeologic investigation, monitoring during well construction, and design.

Source: PBS&J,Water Supply Cost Estimates, 1991.

Existing ASR Facilities

There are a number of ASR facilities in operation throughout the United States in New Jersey, Nevada, California, and Florida. ASR development studies are currently underway in Washington, Utah, Arizona, Georgia, South Carolina, Texas, and Virginia. Of these operational facilities, five are in Florida: Manatee County (1983), Peace River (1984), Cocoa (1987), Port Malabar (1989), and Boynton Beach (1993). These facilities all use treated water and are further discussed in Appendix I.

Evaluating a Potential ASR Project

In evaluating a potential aquifer storage and recovery program, eight major factors should be considered:

- Quantity and availability of injected water
- The quality of the injected water
- The amount of underground storage available in the aquifer, and at what depth
- The ability of the aquifer to accept and store the injected water and how readily can the water be recovered
- Impact of the injected water quality on the receiving aquifer
- Effect of the native water and the geologic formation on the stored water
- The reaction of the aquifer to chemical, physical and/or biological processes that may be introduced
- The amount of stored water that will be recoverable and its quality

Each potential ASR site must be assessed on its own merit from an economic as well as a technical point of view due to the large number of variables involved.

Advantages and Disadvantages

The following are potential advantages and disadvantages of ASR:

Advantages

- Small-scale land acquisition required, compared to surface water storage
- No loss of water to evaporation, as compared to surface water storage, where evaporation losses can be significant
- Ability to locate an ASR facility at the point of need
- Use of recovered water during the dry season does not adversely affect the surficial aquifer, water conservation, or wetlands
- Improved reliability of the utility system in the event of an emergency or drought

Disadvantages

- The quantity of water recovered may be less than the amount injected due to the degradation of the stored water over time
- Increased well maintenance may be needed - formation of deposits, which result from mixing of chemically dissimilar waters, is accelerated
- Initial start up cost for an ASR well is expensive compared to a surficial well - an ASR well requires greater depth and has more stringent well construction design criteria

Floridan Aquifer System (FAS)

The FAS yields only nonpotable water throughout most of the planning area. The quality of water in the FAS deteriorates, increasing in hardness and salinity to the south. 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 in the LWC Planning Area where chloride concentrations are not prohibitively high. Because of its depth and poor quality, few wells have penetrated the FAS in this area. Hydrogeologic data about the system are sparse. However, the system is areally persistent and normally displays hydrogeologic characteristics favorable to ASR development.

The cost of tapping the FAS in a given location would depend on a number of variables, including well construction, operation and maintenance, and water treatment. Cost estimates for drilling wells in the major aquifer systems of the LWC Planning Area are discussed in the "Wellfield Expansion" section. Treatment costs of desalination technologies (e.g., reverse osmosis and electrodialysis reversal) are discussed in the "Water Treatment Technologies" section.

Water quality varies throughout the upper portion of the FAS. Generally speaking, the two parameters of greatest concern for use by reverse osmosis and other water treatment technologies are total dissolved solids (TDS) and chloride. Common values for TDS in the upper portion of the FAS are 1,900 mg/L to 8,500 mg/L, chloride range from 1,000 mg/L to 2,000 mg/L. These values vary with depth and production zone.

Presently, the District has contracted for a detailed literature review and mapping of the upper portion of the FAS and its potential treatability by reverse osmosis. Recommendations for a range or amount of water available from the upper portion of the FAS cannot be made at this time due to lack of information. The U.S. Geological Survey information indicates that the major constraint on future development of the upper portion of the FAS is degradation of water quality rather than limited quantity. Upconing of deep saline water in some areas is important to consider in planning additional development in the upper portion of the FAS.

Seawater

Seawater averages about 3.5 percent dissolved salts, most of which is sodium chloride, with lesser amounts of magnesium and calcium. Seawater treatment systems are used successfully worldwide in areas with very limited freshwater supplies. In these areas, reverse osmosis and distillation are two treatment methods which have been used for conversion of seawater to fresh water. While seawater is plentiful and obtainable along the Gulf Coast, costs associated with the construction and operation of seawater reverse osmosis and distillation systems are very high. As with all surface waters, the ocean is also vulnerable to discharges or spills of pollutants which could impact a water treatment system.

Water Treatment Technologies

Lime Softening

Lime softening is used at 25 of the 29 water treatment facilities in the LWC Planning Area. Lime softening treatment systems are designed primarily to soften hard water, reduce color and to provide the necessary treatment and disinfection to ensure the protection of public health.

Lime Softening Process. Lime softening refers to the addition of lime to raw water to reduce water hardness. When lime is added to raw water, a chemical reaction occurs that reduces water hardness by precipitating calcium carbonate and magnesium hydroxide. Disinfectant may be added at several places in the treatment process, but adequate disinfectant residual and contact time must be provided prior to distribution to the consumer. The lime softening process is effective at reducing hardness, but is relatively ineffective at controlling contaminants such as chloride, nitrate, trihalomethane (THM) precursors and others (Hamann *et al.*, 1990).

Community public water supplies are required to provide adequate disinfection of the finished/treated water and to provide a disinfectant residual in the water distribution system. The use of free chlorine as a disinfectant often results in the formation of levels of trihalomethanes (THMs) that exceed the maximum contaminant level (MCL) of 0.10 mg/L. THMs are formed when free chlorine combines with naturally occurring humic materials in the raw water source.

Lime softening is ineffective in removing the chloride ion and only fairly effective at reducing total dissolved solids (TDS). Chloride levels of raw water sources expected to serve lime softening facilities should be below the chloride maximum contaminant level of 250 mg/L to avoid possible exceedences of the standard in the treated water. The current finished water TDS MCL is 500 mg/L. Concentrations above 500 mg/L in the treated water are acceptable so long as no other MCLs are exceeded.

Nitrate is not effectively removed by the lime softening process. Lime softening facilities with raw water sources with nitrate concentrations exceeding the MCL of 10 mg/L will probably require additional treatment to meet the standard.

Proposed Safe Drinking Water Act regulations for THMs and disinfection byproducts (DBPs) will require that many existing lime softening facilities modify their treatment processes to comply with the standards for these groups of compounds. Add-on treatment technologies that are effective at removing these compounds or preventing their formation include ozone disinfection, granular activated carbon (GAC), and air stripping.

Lime Softening Treatment Costs. Capital construction costs for lime treatment facilities tend to be similar to those of other treatment processes (Table V-4). Lime softening's cost advantages are in operating and maintenance expenses, where costs are typically 20 percent less than for comparable membrane technologies (see Table V-8). However, an increase in total hardness of the raw water source will require increased amounts of lime to maintain the same water quality. In addition, any free carbon dioxide present in the raw water must first be satisfied by the lime before any significant softening can occur, which will impact the costs associated with this treatment process.

TABLE V-4. Lime Softening Treatment Costs.

Facility Size (MGD)	Capital Cost ($ per gal/day capacity)	Engineering Cost ($ per gal/day capacity)	Land Require-ments (Acres)	O&M Cost ($ per 1000 gal)	Energy Cost ($ per 1000 gal)
3	$1.30	$.20	1.5	$.48	$.018
5	1.25	.19	2.5	.45	.018
10	1.22	.18	4.0	.40	.017
15	1.00	.15	6.0	.33	.016
20	.90	.13	8.0	.30	.016

Source: PBS&J, Water Supply Cost Estimates, 1991.

Reverse Osmosis

Reverse Osmosis (RO) technology has been used in Florida for a number of years. About 100 membrane treatment systems are operational in the state with a combined capacity of about 50 MGD. Major Florida public water supply RO facilities include Cape Coral, Venice, Sanibel, Englewood and Jupiter.

Reverse Osmosis Process. RO is a pressure-driven process that relies on forcing water molecules (feed water) through a semipermeable membrane to produce fresh water (product water). Dissolved salts and other molecules unable to pass through the membrane remain behind (concentrate or reject water). RO is capable of treating feed waters of up to 45,000 mg/L total dissolved solids (TDS) which approximates seawater. Most RO applications involve brackish water feed waters ranging from about 1,000 to 10,000 mg/L TDS. Transmembrane operating pressures vary considerably depending on TDS concentration (Table V-5). In addition to treating a wide range of salinities, RO is effective at rejecting naturally occurring and synthetic organic compounds, metals and microbiological contaminants. The molecular weight cutoff (MWC) determines the level of rejection of a membrane.

TABLE V-5. Reverse Osmosis Operating Pressure Ranges.

System	Transmembrane pressure operating range (psi)	Salinity TDS range (mg/L)	Recovery Rates (%)
Seawater	800-1500	10,000-50,000	15-55
Standard pressure	400-650	3,500-10,000	50-85
Low pressure	200-300	500-3500	50-85
Nanofiltration	45-150	Up to 500	75-90

Source: AWWA, Water Quality and Treatment, 1990.

Advantages of RO membrane treatment systems include their ability to reject organic compounds associated with formation of THMs and other disinfection by-products (DBPs), small space requirements, modular type construction and easy expansion. Disadvantages of RO systems include high capital cost, requirements for pretreatment and post-treatment systems, high corrosivity of the product water, and disposal of the reject.

Disposal of RO reject is regulated by the FDEP. Various disposal options include surface water, deep well injection, land application and reuse. Whether a disposal alternative is permittable depends on the characteristics of the facility and disposal site (letter dated December 12, 1990 from B.D. DeGrove, Point Source Evaluation Section, FDER, Tallahassee, FL).

Reverse Osmosis Costs. RO treatment and associated concentrate disposal costs for a typical South Florida system, (2,000 mg/L TDS, 400 PSI) are provided in tables V-6 and V-7. Variables unique to RO capital costs include system operating pressures and concentrate disposal, while variables unique to RO operations and maintenance costs include electrical power, chemical costs, membrane cleaning and replacement, and concentrate disposal.

TABLE V-6. Reverse Osmosis Treatment Costs.

Facility Size (MGD)	Capital Cost ($ per gal/day capacity)	Engineering Cost ($ per gal/day capacity)	Land Require-ments (Acres)	O&M Cost ($ per 1000 gal)	Energy Cost ($ per 1000 gal)
3	$1.40	$.21	.4	$.46	$.23
5	1.27	.19	.4	.43	.23
19	1.17	.18	.5	.41	.23
15	1.14	.17	.63	.40	.23
20	1.16	.16	.78	.30	.23

Source: PBS&J, Water Supply Cost Estimates, 1991.

TABLE V-7. Concentrate Disposal Costs.

Deep Well Disposal Facility (MGD)	Capital Cost ($ per gal/day capacity)	Engineering Cost ($ per gal/day capacity)	Land Requirements (Acres)	O&M Cost ($ per 1000 gal)
3	$.58	$.087	.5	$.032
5	.44	.066	.5	.024
10	.40	.060	1.0	.022
15	.37	.056	2.0	.02
20	.30	.045	3.0	.16

Source: PBS&J, Water Supply Cost Estimates, 1991.

Methods of determining capital and O&M costs vary from utility to utility, and as a result, cost comparisons of treatment processes can be difficult (Dykes and Conlin, 1989). Site-specific costs can vary significantly as a result of source water quality, reject disposal requirements, land costs, use of existing water treatment plant infrastructure, etc. Detailed cost analyses are necessary when considering construction of RO water treatment facilities. As a general rule, however, RO costs are 10 percent to 50 percent higher than conventional water treatment technologies.

Membrane Softening

Membrane softening or nanofiltration (NF) is an emerging technology that is currently in use in Florida. Membrane softening differs from standard RO systems in that the membrane has a higher MWC, lower operating pressures and feed water requirements of 500 mg/L or less of TDS. One significant advantage of membrane softening technology is its effectiveness at removing organics that function as THM and other DBP precursors. Given the direction of increasing federal and state regulation of drinking water quality, membrane softening seems to be a viable treatment option towards meeting future standards. A number of membrane softening facilities have been installed in Florida.

The costs associated with membrane softening are similar to those of reverse osmosis with operations and maintenance expenses tending to be lower because of higher energy rates and lower relative energy costs. Membrane softening treatment costs are presented in Table V-8.

TABLE V-8. Membrane Softening Treatment Costs.

Facility Size (MGD)	Capital Cost ($ per gal/day capacity)	Engineering Cost ($ per gal/day capacity)	Land Requirements (Acres)	O&M Cost ($ per 1000 gal)	Energy Cost ($ per 1000 gal)
3	$1.33	$.20	.4	$.44	$.159
5	1.21	.18	.4	.42	.159
10	1.12	.17	.5	.40	.159
15	1.10	.17	.63	.38	.159
20	1.06	.16	.78	.37	.159

Source: PBS&J, Water Supply Cost Estimates, 1991.

Electrodialysis and Electrodialysis Reversal

Electrodialysis (ED) is an electrochemical process that involves the movement of ions through anion- and cation- selective membranes from a less concentrated solution to a more concentrated solution by the application of direct electrical current. Electrodialysis reversal (EDR) is a similar process but provides for the reversing of the electrical current which causes a reversing in the direction of ion movement. ED and EDR are useful in desalting brackish water with TDS feedwater concentrations of up to 10,000 mg/L. ED/EDR, however, is generally not considered to be an efficient and cost-effective organic removal process and therefore is usually not considered for THM precursor removal applications (AWWA, 1988). Available cost data for ED/EDR is limited, but for the same area appear to be 5 to 10 percent higher than RO treatment (Boyle Engineering, 1989).

Distillation

The distillation treatment process is based on evaporation. Saltwater is boiled and the dissolved salts, which are non-volatile, remain behind. The water vapor is cooled and condenses into fresh water. Two distinct treatment processes are in use: multistage flash (MSF) distillation and multiple effect distillation (MED). Capital construction costs and operation and maintenance expenses are three to five times as expensive as more conventional processes such as brackish water RO systems and/or EDR (Buros, 1989).

VI. ANALYSIS OF WATER SUPPLY ALTERNATIVES

Ground water is the most significant source of the water supply for urban and agricultural demands in the LWC Planning Area, and it is anticipated that it will continue to be the most significant source of water for these needs in the foreseeable future. Both the continuously increasing demand for ground water as well as historical flood control and drainage practices have caused local and regional declines in ground water levels. Ground water declines are expected to increase in the future, due to the projected increases in ground water demands. A variety of adverse impacts may be associated with long-term declines in ground water levels. These adverse impacts can be separated into three generalized categories: (1) environmental resource impacts, (2) ground water resource impacts, and (3) geotechnical impacts.

Environmental resource ~~impacts are generally caused~~ by decreases in the amount and duration of water occurring at, or immediately below, the land surface. An example of this is a decrease in the seasonal inundation for a particular wetland system that leads to a change of species composition or distribution. Ground water resource impacts are those which result in a decrease in the quantity or quality of water available from an aquifer or aquifer system. Examples include seawater intrusion, movement of saline water into a freshwater zone, aquifer compaction, and decreased well yields. The geotechnical category includes impacts which may not harm the quantity or quality of water available from an aquifer, but are, nevertheless, significantly adverse. Examples of geotechnical impacts include regional land subsidence and local sinkhole formation. Physical changes to wells such as collapsed casing and/or screens, encrustation and/or air blockage of screens could also be placed in this category.

A five-step process was used to define criteria which when exceeded may result in adverse impacts as described above when applying these criteria to existing and future demand scenarios:

1. Identify potentially significant adverse impacts. The potential adverse impacts caused by ground water level drawdowns were identified. Adverse impacts which could be significant were identified for further analysis.

2. Determine levels of significance. This is an evaluation of those declines in water levels that may cause significantly adverse impacts. This step essentially requires the determination of thresholds at which the adverse impacts from water level declines are considered significant. This can be difficult. Often the relationship between water level declines and the resulting impacts may not truly be a threshold phenomenon. In other cases the threshold may not be known, or the frequency and duration of a drawdown may be more important than the amount of drawdown. Published research and the experience of various experts are used to assess significance, but determining a threshold of significance ultimately requires judgment.

3. Develop resource protection criteria. These criteria are essentially minimum ground water levels that were developed both for ongoing planning purposes and for future regulatory authority. Resource protection criteria for this plan were developed with consideration to all four of the principal elements of the SFWMD's mission, and are used in this plan in three ways: (1) to define excessive water-level decline in the context of this plan, (2) to identify where excessive declines might occur in the future using ground water flow models,

and (3) to assist in evaluating the effectiveness of alternative modeling scenarios in avoiding or mitigating the adverse impacts of excessive water-level declines.

4. Simulate water levels. Ground water flow models were used to predict water levels in the aquifers based on simulated conditions of rainfall and water demands in the year 2010.

5. Locate areas not meeting resource protection criteria. The simulated ground water levels produced by ground water flow models are compared to the resource protection levels to identify potential future problem areas. This step was accomplished utilizing a variety of tools including geographic information system software.

Based on the results of this five-step process, alternative modeling scenarios were developed and modeled to decrease the extent of areas which did not meet resource protection criteria. These scenarios included: (1) changes to projected water demands, (2) changes to new water sources, (3) changes to District operations, and (4) various combinations of these scenarios. The results of the alternative modeling scenarios were used to develop specific recommendations intended to minimize future adverse impacts. These recommendations are found in Chapters III and IV of the Planning Document.

RESOURCE PROTECTION CRITERIA

Three resource protection criteria were developed for analysis using ground water flow models. These criteria are standards to measure the level of protection of both wetlands and the ground water resources a number of adverse impacts caused by the pumping of ground water. The criteria include specific definitions of the severity, duration, and frequency of excessive declines in ground water levels.

Wetland Protection Criterion

The potential for impacts to natural systems as a result of ground- and surface-water withdrawals to meet future demands is of concern. Withdrawals can alter the natural hydrology by lowering ground- and surface-water levels and reducing hydroperiods. Hydrology is the single most important factor in determining the type of vegetation that occurs across the landscape. Fire frequency and soil type are additional important factors that are often closely related to hydrology. Man-induced alterations in hydrology can affect species composition and distribution as well as the functions and values of natural systems.

Current District rules are narrative in nature and do not clearly define what impacts are considered unacceptable to natural systems with regard to altering their hydrologic conditions. This narrative rule has been translated to a guideline that withdrawals must not lower the water table by more than one foot under a wetland after 90 days of maximum pumpage with no recharge. Development of better criteria in terms of severity/duration/frequency is needed to reflect the District's current understanding of natural system needs. This will be accomplished through a team approach using the departments of Research, Planning, and Regulation. The Research Department is working to define the requirements of natural systems. The Planning Department will bring forward the concepts and results of research through the planning process, to the public for review and input. The Regulation Department will then initiate rulemaking changes and implement the new rules on a day-to-day basis.

The specific wetland protection criteria identified the potential of impacts to wetland systems from future ground water withdrawals. The analysis used simulations of man-induced drawdowns of the water table aquifer for the year 2010. These simulations were generated by ground water flow models and were stated in terms of severity, duration and frequency of drawdowns. The projected water table aquifer drawdowns was then evaluated with respect to regional wetlands systems in the LWC Planning Area.

This analysis included an evaluation of current regulatory guidelines for drawdown under wetlands as well as evaluation of alternative guidelines. Variations on the future water use and withdrawal scenario were also incorporated into the analysis. Recommendations for specific wetland protection drawdown criteria were formulated and presented. The recommended criteria is based on the need to prevent significant harm to natural systems while providing adequate water to meet future demands.

Seawater Intrusion Criterion

This criterion applies to selected locations along the Gulf Coast in Lee and Collier counties based on evidence of historical seawater intrusion or upon geologic evidence of susceptibility to seawater intrusion at these locations. Minimum allowable ground water levels in the Intermediate and Surficial aquifer systems were chosen for these locations to prevent seawater intrusion except during more extreme drought events. The seawater intrusion criterion is generally defined as follows: Ground water levels should not decline below the criterion level for any period of time during any drought event that occurs more frequently than once every ten years.

General Aquifer Protection Criterion

The general aquifer protection criterion applies to all locations in the LWC Planning Area, and is based on the recognition that certain declines in ground water levels are potentially associated with a number of significant adverse impacts including reduced well yields, aquifer compaction, land subsidence, sinkhole formation, and brine migration. To prevent such impacts, minimum allowable ground water levels (criterion levels) are set at an elevation above the top of the aquifer. The distance from the top of the aquifer to the general aquifer protection criterion level is approximately the uncertainty associated with knowing where the top of the aquifer actually is. For example, if the top of the aquifer is estimated to be at an elevation of 50 feet below sea level with an uncertainty of 10 feet (i.e., -50 feet plus or minus 10 feet), then the criterion levels would be set at an elevation of 40 feet below sea level. The general aquifer protection criterion is defined as follows: Ground water levels should not decline below the criterion level for any period of time during any drought event that occurs more frequently than once every ten years.

MODELING ANALYSIS OF RESOURCE PROTECTION CRITERIA

Ground Water Modeling Approach

Ground water flow models were used in this plan to help evaluate excessive ground water declines during long-term average hydrologic conditions (steady-state conditions) and during short-term dry periods (transient conditions) when water demand is high and the supply, ultimately derived from precipitation, is low. The ground water simulation periods for short-term dry periods ranged from 12 to 24 months in duration. The dry periods were extracted from historical rainfall records for Collier, Hendry and Lee counties in tables C-2 through C-4 (Appendix C). These simulation periods were chosen because most droughts in South Florida are of two years duration or less. The models simulated ground water levels in response to current and future demands from the aquifers.

Three separate site-specific ground water models were developed by the SFWMD using generic computer code prepared by the U.S. Geological Survey (McDonald and Harbaugh, 1988) as well as site-specific information representing hydrologic conditions. The geographic areas represented by the models are shown in Figure VI-1. The models, although complex in many respects, are simplified representations of the real hydrologic systems and processes, and they incorporate certain assumptions concerning the physical characteristics and processes occurring in the real hydrologic systems. The hydrologic processes simulated by the ground water models included: (1) horizontal and vertical ground water flow in response to differences in water levels; (2) ground water recharge from precipitation; (3) flow to and from major rivers and ground water; (4) drainage from ground water to major canals and drains; (5) evapotranspiration; (6) return flow (deep percolation) of applied agricultural irrigation water; (7) ground water pumping for public water supply; and (8) ground water pumping for agriculture and other irrigated demands. The details of how these processes are simulated by the models can be found in other District publications (Bower *et al.*, 1990; Smith, 1990; Bennett, 1992).

Major aquifers occurring in the LWC Planning Area are represented as individual layers in the ground water models. Within each layer there is a grid of squares, or cells, each having an area of one square mile. Solutions to the various ground water flow model scenarios utilized for this plan yielded water levels that are representative of the entire volume of each cell.

The approach to modeling ground water conditions in the year 2010 involved the identification of a hypothetical set of conditions representing future water demands. This hypothetical set of conditions is collectively referred to as the base case for the purposes of this report. The hypothetical conditions, or assumptions, of the base case represent a view of the future if no additional water supply or water conservation measures are implemented beyond those which are currently mandated.

Demand Assumptions

The water supply for urban and agricultural demands are represented as withdrawals from specific layers of the ground water models. These demands have been summarized previously in Chapter IV of this volume. The categories of urban and agricultural water demand are combined somewhat differently for use in the model simulations than was presented in Chapter IV. In general, there are two categories of water demands used by the flow models: (1) seasonal water demands that vary by calendar month but which do not vary as a function of specified monthly

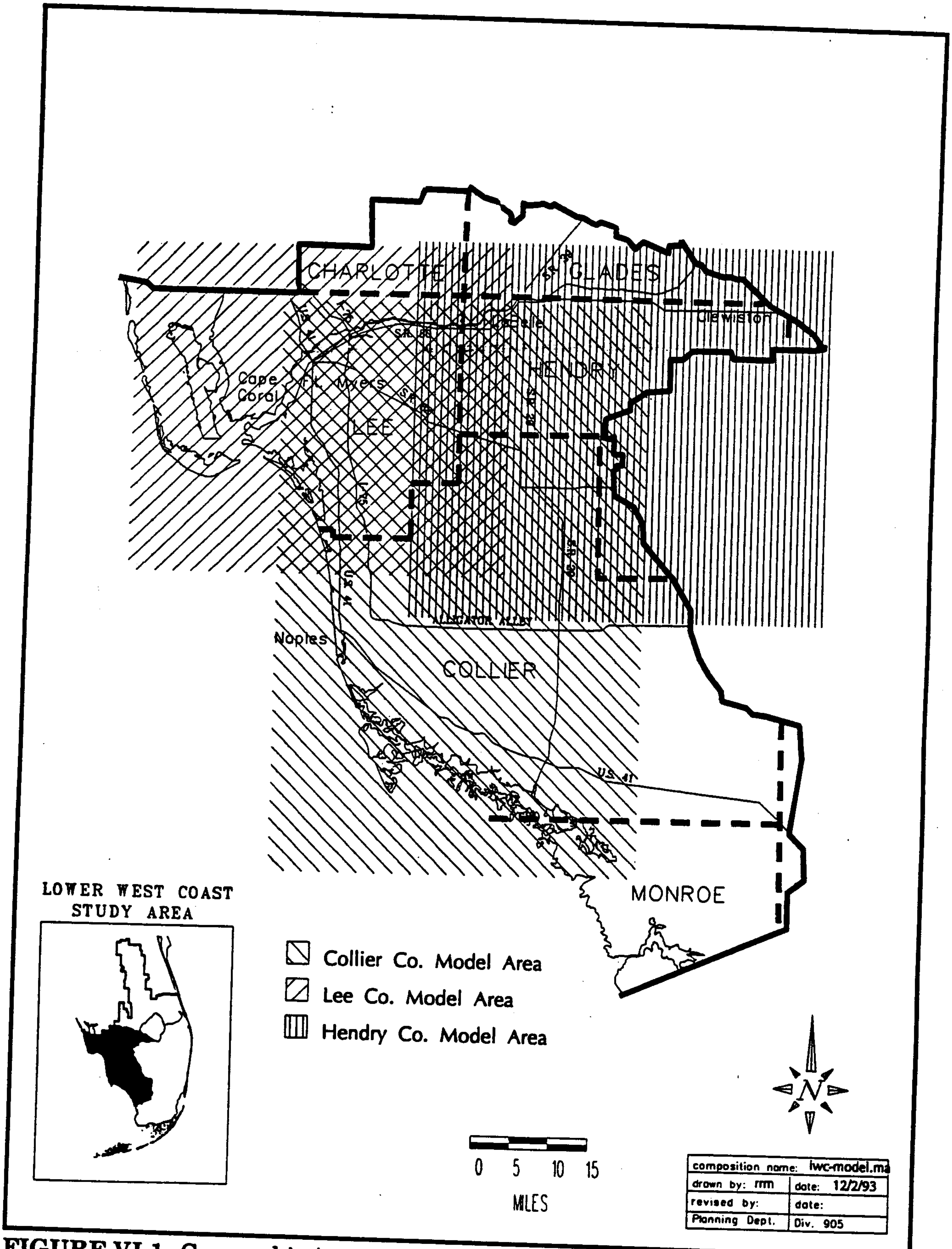

FIGURE VI-1. Geographic Areas Represented by Ground Water Models.

rainfall amounts, and (2) water demands that are explicitly dependent upon precipitation and that vary as a function of the specified monthly rainfall amounts. The first category generally includes public water supply provided both by utilities and individuals (domestic self supply). The second category includes all of the agricultural water demands as well as landscape and golf course irrigation.

Public Water Supply

The simulation of ground water pumping for public water supply was based on population estimates and per capita water consumption compiled from various information sources. Ground water pumping for public water supply was adjusted for seasonal variation in demand based on average values for calendar-month time periods. The per capita demands for water provided by utilities were adjusted downward for the year 2010 to reflect a number of mandatory and voluntary conservation measures, as described in Chapter V, that will be in place by 2010.

Agricultural Water Demands

The simulation of ground water pumping for agricultural water supply was based on crop acreage, crop type, and specified monthly rainfall amounts. The actual and projected irrigation demands presented in Chapter IV are based on historical crop acreage data, as discussed in Appendix G. These data were available on a county level, which lack the resolution to identify problem areas in the ground water model grids. Therefore permit data, which show the locations of permitted withdrawals, were used in the modeling process because these data have the level of resolution required by the ground water models. The permitted demand level for 1990 was used to represent the 1990 irrigation demands. To represent the 2010 demands, the projected demand data for 2010 were developed using the methodology described in Appendix G.

The 1990 permitted demand is considerably higher than the actual 1990 demand level presented in Chapter IV because considerably more agricultural acreage was permitted in 1990 than was actually planted. Actual crop acreages are usually less than the permitted acreage due to the lags between permitting and planting. The 2010 projected land use represents anticipated actual land use rather than forecast permitted land use.

Alternative Modeling Scenarios

A systematic, analytic process was followed in developing final recommendations for the Lower West Coast Water Supply Plan. The first step of this process involved applying the demand assumptions and resource protection criteria described above using the ground water models to arrive at 1990 and 2010 base case model results. The base case results were used as the constant, or measuring standard, when analyzing regional alternative modeling scenarios. The base case runs assumed no changes to the current methods of supplying water to the lower west coast; they simply portrayed what might occur if 1990 and 2010 water demand were applied against the resource protection criteria and all other conditions remained constant. Measurable results were counted in terms of wetland impacts, saltwater intrusion and aquifer protection criteria being exceeded.

Next, a series of regional alternative modeling scenarios were developed and analyzed using the ground water models. The results of the alternative model scenarios were compared to the base case model results using the following measures:

(1) The total area of wetlands (in acres) in which wetland criteria were not met.

(2) The number of coastal model cells in which seawater intrusion criteria were not met and the number of months during a simulation when these model cells did not meet the criteria.

(3) The number of model cells in which seawater intrusion criteria were not met and the number of months during a simulation when these model cells did not meet the criteria.

The following model scenarios were simulated for this plan:

Scenario 1 - Remove public water supply demands from the shallow aquifers. Two variations on this model scenario were simulated for both Collier and Lee counties. Public water supply demand is a relatively small component of the total demand in Hendry County, so scenario 1 was not simulated for Hendry County. All public water supply withdrawals were removed from the shallow aquifers in scenario 1a. This scenario eliminated any problems in not meeting the resource protection criteria due to public water supply withdrawals. In scenario 1b, the increase in public water supply withdrawals between the 1990 permitted demand level and 2010 projected demand level was removed from the shallow aquifers. Scenario 1b isolates the effect of the increased public water supply demand with respect to meeting the resource protection criteria. Although both modeling scenarios 1a and 1b remove the public water supply demand from the shallow aquifers, neither scenario specifies nor simulates an alternative source for these demands. The most probable alternative source for these demands is the Floridan aquifer system; however, simulation of flow in the Floridan cannot be done with the existing models.

Scenario 2 - Reduce agricultural water use by increased irrigation efficiency. Three variations of this modeling scenario were simulated. In scenario 2a, the irrigation efficiency for small vegetable crops was increased to 75 percent for all users currently below that efficiency level. In scenario 2b, the irrigation efficiency for citrus was increased to 85 percent for all users currently below that level. Scenario 2c was a combination of scenarios 2a and 2b. All three model scenarios were simulated by reducing irrigation withdrawals for small vegetable and/or citrus crops in the model runs.

Scenario 3 - Increase use of reclaimed water. The total amount of reclaimed water available for irrigation was assumed to be the average of the three minimum flow months for each regional wastewater treatment plant in the LWC Planning Area for 2010. Wastewater flows exceeding the simulated irrigation requirements and flows for which an application area could not be defined were assigned to the treatment plant's alternative disposal source and/or to demands not incorporated in the model. This scenario was simulated by reducing well withdrawals and replacing them with reclaimed water.

Scenario 4 - Implement proposed long-term modifications of the Big Cypress Basin canal system. Modifications to this canal system included elimination of canals in the South Golden Gate Estates area and addition of control structures on the Miller and Faka Union canals directly north of Alligator Alley. Control elevations for the new structures were set at one foot below land surface to maintain higher water levels north of I-75. This scenario is specific to Collier County and was simulated with the Collier County model by adjusting the simulated canal levels accordingly. The proposed modifications to the Big Cypress canal system include facilities for backpumping water to the north Golden Gate Estates area and other routing of surface water through the canals; however, these modifications cannot be fully represented in the ground water model. A watershed management plan will be developed by the Big Cypress Basin Board within the next year. This watershed management plan should be able to provide more detailed evaluations of the benefits of the proposed modifications.

Scenario 5 - Combination of Scenarios 1 and 3. This scenario has two variations. Scenario 5a combines scenario 1a, in which all water supply withdrawals were removed from the shallow aquifers, with scenario 3, in which irrigation withdrawals were partially replaced by reclaimed water. Scenario 5b combines scenario 1b, in which the increase in public water supply withdrawals between 1990 and 2010 were removed from the shallow aquifers, with scenario 3.

Scenario 6 - Evaluate combination of Scenarios 1, 2c, and 3. Modeling scenario 6 had two variations: (1) scenario 6a, which combined modeling scenario 1a (remove all public water supply from the shallow aquifers), modeling scenario 2c (improving the irrigation efficiency of both small vegetables and citrus), and modeling scenario 3 (increase use of reclaimed water); and (2) scenario 6b, which combined modeling scenario 1b (remove **future** public water supplies from the shallow aquifers), modeling scenario 2c, and modeling scenario 3. Modeling scenarios 1a, 1b, and 3 involved urban water supplies and reclaimed water, neither of which are very large in Hendry County. Scenarios 1a, 1b, and 3 were not simulated for Hendry County. Similarly, modeling scenarios 6a and 6b were not modeled for Hendry County.

The results of the scenario analyses described above are presented in Chapter II of the Planning Document.

WATER SUPPLY ALTERNATIVES

Changes to Demand

Following is a brief description of several ways to change the demand for water. These changes were first put in the modeling efforts to estimate future impacts. If impacts of these actions were deemed appropriate, implementation would occur. Essentially, the methods described below modify the reasonable-beneficial requirement of Section 373.223, F.S. Chapter V of this document provides a more detailed discussion of the following alternatives and issues related to each.

Alterations to Supplemental Crop Requirements for Irrigation Use Class

It is possible for the District's rules to alter, by use class and/or crop type, the drought frequency upon which water is allocated. This translates to an alteration of protection from drought events, thus changing the certainty of permitted water rights. The more infrequent a drought event which is used to calculate an allocation occurs, the higher the quantity of water allocated. The allocation of water in this manner, then has the corollary effect of "locking-up" water from others' use, thereby reducing the supply (at the time of allocation) and restricting the water available for allocation to subsequent users. The allocation of supply to specified use classes/crop types will be accompanied by descriptions of geographic area, supply source impacted, linkage to water shortage triggers and, when implemented after rulemaking, permit duration.

Irrigation Demand Management

As with urban water demand, the District has implemented a series of irrigation demand management, or water conservation, techniques. These have been implemented primarily through the permitting process. However, in some instances it may be appropriate for this plan to recommend additional irrigation demand management techniques in areas where resource protection criteria are projected to be violated. By doing so, users would become more efficient, thereby, maximizing the amount of water available for irrigation.

Urban Demand Management

The District, in cooperation with local governments, has been successful in establishing and implementing a series of urban demand management, or water conservation, techniques. These have been implemented through a combination of permitting activities, local government ordinances, and public information. However, in some instances it may be appropriate for this plan to recommend additional urban demand management techniques in areas where resource protection criteria are projected to be violated. By doing so, users would become more efficient, thereby, maximizing the amount of water available for future development.

Source Changes

In some instances, it may be appropriate for the plan to recommend that a user, or group of users, pursue withdrawals from a different aquifer than one they are presently using. In the LWC Planning Area this usually means using the Floridan Aquifer System (FAS) as a new source. Chapter V explains several issues related to using the FAS, including water quality. The following paragraphs explain which use classes may likely be required to use the FAS and any criteria that must be considered when using the FAS.

Required Users. Several factors must be considered when evaluating which users should be required to pursue using the FAS. These factors include the location of FAS producing zones, the concentration or dispersal of users, and the efficiency of distribution. When these factors are evaluated it becomes clear that the most appropriate group of users to consider using the FAS is the urban group. Urban users, including utilities, are generally concentrated near the coast and can take advantage of a relatively compact distribution system.

Development Criteria for Alternative Aquifers. When developing criteria for requiring the use of alternative aquifers the following matters will be considered:

1. Minimum aquifer heads,
2. Aquifer degradation criteria,
3. Discharge of brine,
4. The use of pumps, and
5. Mitigation issues related to existing users.

New Source and Treatment Development

The plan recommends mandatory use of new sources. Treatment technologies necessary to use new sources are also discussed. Chapter V of this Background Document presents a thorough review of new sources and technologies including cost estimates for the new technologies. Following is a listing of the sources and technologies described in more detail in Chapter V:

a. Aquifer Storage and Recovery (ASR),
b. Wastewater Reuse,
c. Surface Water Storage, and
d. Alternative Technologies such as Reverse Osmosis (RO), Membrane Softening, Electrodialysis and Electrodialysis Reversal, Distillation, and Small Systems.

Source Reservation

In some areas, competition for limited resources creates a need to match the sources of water with specific water use categories. This is in keeping with the state's direction to use the lowest quality of water for the intended use, to maximize reasonable-beneficial use of water and to allocate under competitive situations to the user most in the public interest.

In defining which water use type best promotes the public interest, which are in part defined by the goals and objectives of the LWC Water Supply Plan, portions of water supply sources (surface and ground water) may be "zoned" to assign priority for a specific water use category when two or more categories of users are competing for the same water source. These zones can be based on those uses which are most reasonable-beneficial and most in the public interest in light of other uses. Zones may be based on the characteristics of the use itself as well as local government planning decisions. Supply source reservation will provide to water users advance notice of the District's definition of public interest in a competing use situation. Finally, when all rights to the specific remaining source are equal, consideration of the relative economic return of the proposed use will be the deciding factor.

Location of Public Water Supply Withdrawals. Portions of the Surficial Aquifer System underlying the urban coastal area could be zoned to assign priority for public water supply. Under this concept, other use types (industrial, commercial, agricultural) could be encouraged to consider other sources of water (surface water, reuse, Floridan, etc.).

Location of Agricultural Water Withdrawals. In situations where applicants are competing for water rights, portions of the surface water system or areas of the shallow aquifer could be designated to give agricultural uses a priority based on the industry's lack of water supply options in some geographic areas. Such a decision would have to be based on public interest tests, economic factors, and other considerations.

The assignment of priority might not preclude successful applications for water rights by other user categories, but could result in more stringent permit conditions, including: reduced drought protection; more stringent water shortage requirements; and shorter duration permits.

Location of Other Urban Withdrawals. In situations where applicants are competing for water rights, portions of the available water supply could be designated to give preference to other urban categories to reduce competition with public water supplies and to match sources with lower water quality with users which can tolerate the reduced quality. For example, in areas with brackish or saline water, or areas where saltwater intrusion is a concern, an area might be zoned for uses which are salt tolerant or which are able to remove salt.

Elimination of Unpermitted Domestic Irrigation in Critical Areas. The District does not require permits for domestic wells. In some areas, the aggregate effect of all these wells may impact a local water utility and may constitute a competitive use. Therefore under certain circumstances, the District could require the permitting of domestic wells, especially when competing against uses deemed more reasonable and beneficial, such as public water supply.

Mitigation Banking

Legislation passed in 1993 required the water management districts and FDEP to adopt mitigation banking rules for wetland impacts under Part IV of Chapter 373 F.S. by January 1994. These rules have been adopted and are currently in effect. Mitigation banks will provide an alternative to traditional on-site mitigation.

In the past, the SFWMD has permitted mitigation only for impacts associated with "dredge and fill" or storm water management projects. The Lower West Coast Water Supply Plan recommends that the District develop specific rules and criteria to allow mitigation for impacts associated with consumptive use withdrawals. Support for this concept is found in the legal interpretation of the term "reasonable-beneficial use" under the water use permitting criteria. When applying the reasonable-beneficial use test, several factors are balanced. These factors include the potential for environmental impacts, the ability to mitigate for such impacts and the social or public interest values of allowing impacts in order to take advantage of a water source. The prevention of harm "to water resources of the area" as required by Section 373.219 F.S., can be achieved by providing mitigation benefiting the ecological community of the area as a whole, even when localized harm occurs.

For example, there may be benefits to the public interest in using the last remaining economically viable source of water in an area for public water supply. These benefits may outweigh harm to a small, isolated, and degraded wetland, when the harm can be mitigated through enhancement of a nearby regional wetland. Without the use of mitigation in this type of a situation, an essential source of water would be locked away from development in order to prevent harm to a marginal wetland, when mitigation could be utilized to offset the harm and benefit the water resources as a whole.

The mitigation banking concept is intended to provide long-term sustainability of mitigation efforts and to preserve the functional values of large wetland/upland systems. This need to focus on the long-term sustainability of large natural systems is consistent with the ONS concept that is described in Chapter III. The ONS map delineates the large, relatively intact natural systems within the LWC Planning Area. It can be used to identify potential mitigation banking areas.

Figure VI-2 identifies several areas within or adjacent to the ONS boundaries that have been impacted by human activities and have potential to provide mitigation through restoration and/or enhancement of the natural systems. Table

VI-1 contains a breakdown of the land cover types occurring within these areas. Potential mitigation opportunities for these sites include: removal and control of exotic species; filling of ditches and placement of structures within canals to restore hydroperiods; prescribed burning; and reclamation of agricultural areas to native wetland and/or upland communities. On-site inspections and detailed analyses are needed to determine the specific type of mitigation that may be appropriate for each of these sites.

There are also extensive areas within the ONS boundaries that have not been impacted by human activities. In these areas, there is potential to provide mitigation through acquisition and preservation of the existing natural systems. Most of the areas designated as ONSm have potential to provide mitigation through acquisition and preservation. This type of mitigation should be closely coordinated with the District's Save Our Rivers Program.

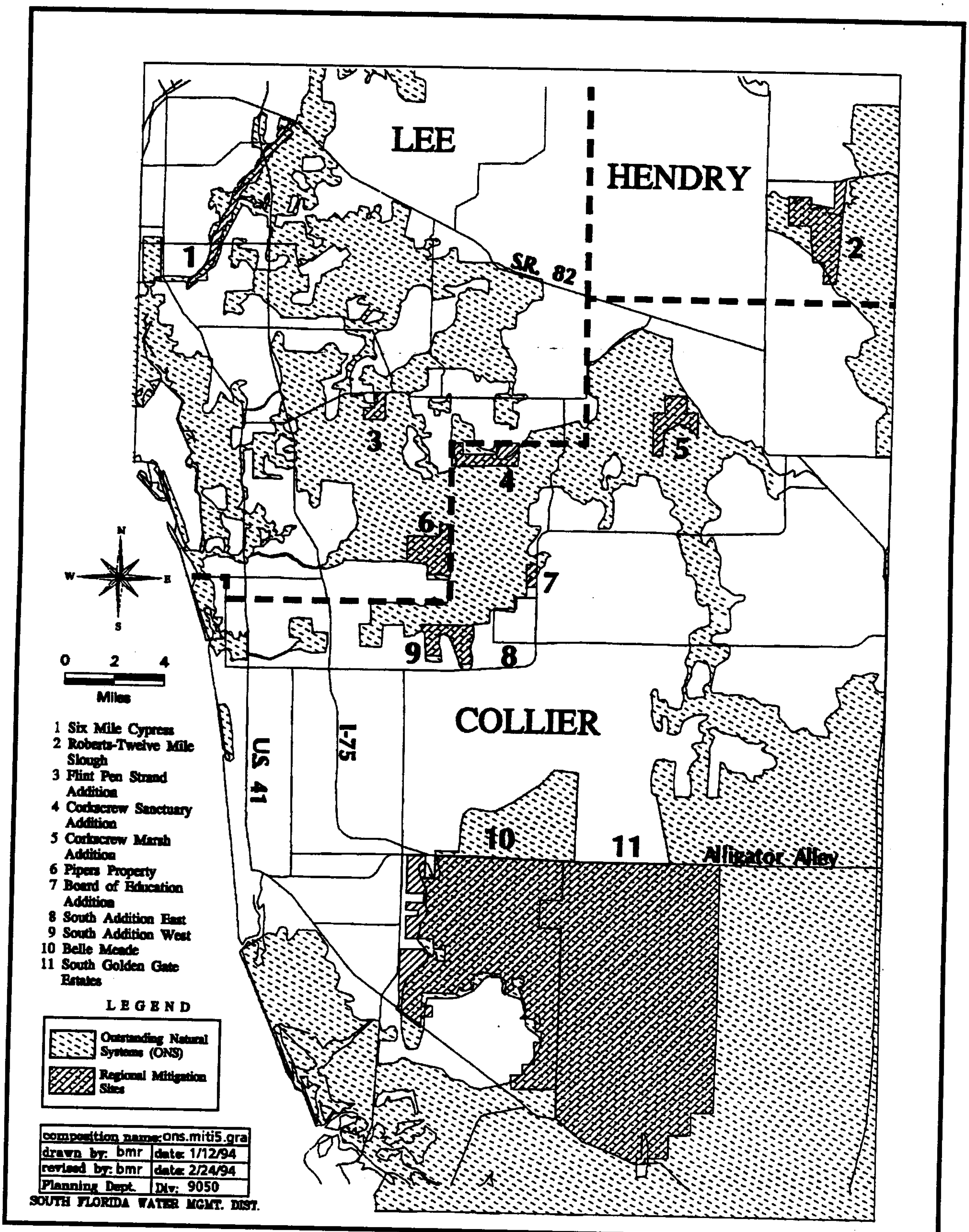

FIGURE VI-2. Outstanding Natural Systems with Regional Mitigation Sites.

TABLE VI-I. Mitigation Banking Sites in the LWC Planning Area.

SITE/COMMUNITY TYPE	ACREAGE
1 Six Mile Cypress	
Forested Swamp, Cypress dominated	1,558
Forested Swamp, non-cypress dominated	230
Scrub/Shrub Swamp	1
Freshwater marsh	13
Upland	197
TOTAL	1,999
2 Robert's Twelve Mile Slough	
Forested Swamp, Cypress dominated	4
Forested Swamp, non-cypress dominated	7
Scrub/Shrub Swamp	20
Freshwater marsh	1,993
Upland	1,609
TOTAL	3,633
3 Flint Pen Strand Addition	
Forested Swamp, Cypress dominated	86
Forested Swamp, non-cypress dominated	16
Scrub/Shrub swamp	0
Freshwater marsh	6
Upland	431
TOTAL	539
4 Corkscrew Sanctuary Addition	
Forested Swamp, Cypress dominated	404
Forested Swamp, non-cypress dominated	188
Scrub/Shrub Swamp	57
Freshwater marsh	22
Upland	759
TOTAL	1,430
5 Corkscrew Marsh Addition	
Forested swamp, Cypress dominated	110
Forested Swamp, non-cypress dominated	124
Scrub/Shrub swamp	211
Freshwater marsh	343
Upland	851
TOTAL	1,639

TABLE VI-I. Mitigation Banking Sites (Continued).

SITE/COMMUNITY TYPE	ACREAGE
6 Pipers Property	
Forested Swamp, Cypress dominated	1,648
Forested Swamp, non-cypress dominated	302
Scrub/Shrub Swamp	13
Freshwater marsh	31
Upland	35
TOTAL	2,029
7 Board of Education Addition	
Forested Swamp, ~~Cypress dominated~~	145
Forested Swamp, non-cypress dominated	19
Scrub/Shrub Swamp	2
Freshwater marsh	56
Upland	86
TOTAL	308
8 South Addition East	
Forested Swamp, Cypress dominated	710
Forested Swamp, non-cypress dominated	161
Scrub/Shrub Swamp	155
Freshwater marsh	79
Upland	1,027
TOTAL	2,132
9 South Addition West	
Forested Swamp, Cypress dominated	570
Forested Swamp, non-cypress dominated	691
Scrub/Shrub Swamp	23
Freshwater marsh	38
Upland	366
TOTAL	1,688
10 Belle Meade	
Forested Swamp, Cypress dominated	15,919
Forested Swamp, non-cypress dominated	5,705
Scrub/Shrub Swamp	1,996
Freshwater marsh	690
Upland	4,515
TOTAL	28,825
11 South Golden Gate Estate	
Forested Swamp, Cypress dominated	21,306
Forested Swamp, non-cypress dominated	18,828
Scrub/Shrub Swamp	5,628
Freshwater marsh	7,343
Upland	3,303
TOTAL	56,408

Other District Implementation Alternatives

The District has a variety of methods of implementing the LWC Water Supply Plan beyond those described above. Many of the alternatives described earlier are regulatory in nature. However, the District influences water supply in other ways than regulation of the supply. Examples of other District functions that can be evaluated when addressing water supply issues follow.

Operations and Maintenance

Alternatives will be considered which alter the levels and timing of water in the District managed canals. Water levels in the shallow aquifers can be influenced by the management of the District's canals. Existing structures can be raised and releases can be timed to meet water supply objectives for specific geographic areas.

Research

The District can perform research on issues related to water supply problems in the LWC Planning Area. An example of this is the wetland impact research initiative. The District has initiated a research effort to evaluate the potential impacts to natural systems by adjacent water withdrawals. This effort will be managed by the Department of Research in cooperation with the Planning Department. The ONS map described in Chapter III will be utilized to focus the research program. The ONS areas will be compared with simulations of water table aquifer drawdowns for the year 2010. Areas that have the most potential for impacts will be identified and used to target the research effort.

Land Acquisition

The District has an active land acquisition program. The program is designed to address the mission of the District which includes water supply. The SFWMD uses federal and state agency monies, combined with monies from its own sources, to purchase lands throughout the 16 county boundary, including the LWC Planning Area. This is an alternative that will be considered by the LWC Water Supply Plan.

Review of Local Comprehensive Plans

The SFWMD has been charged with providing comments on local government comprehensive plans when they are first prepared and when they are amended. Land use, environmental, and utility issues can be addressed through this process to further the objectives of the LWC Water Supply Plan.

Cooperative Actions

Alternative solutions to water supply problems in the LWC Planning Area will be considered that involve agencies and groups other than the District. In fact, it will be imperative that others participate in the solution of the problems. Below is a brief description of some of the actions that agencies and groups other than the District could implement.

Management Agreements

In areas where competing uses will exceed the identified source, management agreements which address issues such as well locations, withdrawal amounts and timing, and environmental impacts may be the appropriate means for users to better manage the resource and increase the certainty of their supply.

Regional Water Supply Authorities (RWSAs) and Interconnects

The Lee County RWSA is the only RWSA in the LWC Planning Area. The RWSA has been charged with providing a long-term and reliable source of water for the urban utilities in Lee County. The RWSA is investigating numerous alternatives, including utility interconnects, which will be considered for use in the LWC Water Supply Plan.

Reuse Systems

Reuse systems have been used successfully in the LWC Planning Area, particularly Cape Coral. These systems have proven useful in freeing up water that would otherwise be lost from the water supply inventory. Problem areas identified in the LWC Planning Area may be targeted for new or expanded reuse systems to prolong water supply sources.

On-Site Storage

On-site storage of water to meet water supply objectives is an alternative that can be considered in specific cases in the LWC Planning Area. It is unlikely that on-site storage can address regional water supply issues; however, it can be used to offset local water supply and environmental issues and will therefore be considered in this plan.

Water Shortage Assumptions of Risk

The District's water shortage triggers will set levels at which point users can expect water use cutbacks to be implemented by use class. Some users may choose to accept a higher incidence of mandatory cutbacks by continuing to use water at a given location which routinely triggers declaration of water shortage restrictions. The District will accept such users' tolerance of a less certain supply, but only within a defined return frequency. For example, a public water supply may attempt to develop a coastal wellfield to such a point that water shortage triggers for Phase III restrictions will be activated every other year. The District would strive to prevent frequent water shortages caused by such withdrawals. However, a less frequent and severe incidence of water shortage triggering would be tolerable.

Wellfield Development and Relocation/Protection

If the resource protection criteria and water shortage triggers indicate to a particular user that present or future intended well locations may be precarious due to significant potential to cause resource impacts, such user should consider well relocation and development in less jeopardized locations.

Water Shortage Planning

During drought conditions, when the drought frequency events assumed in the modeling assumptions are exceeded, restrictions on water usage will be phased in to restrict demands on the natural system. The determining factors, called water shortage indicators, for initiation of water shortages include: (1) trigger levels in aquifers, (2) the presence of salinity in monitoring wells/ground water gradients identifying saltwater intrusion, and (3) reduced ground water levels in selected environmental areas or public water supply production areas. Once a water shortage is declared, the District's Water Shortage Plan will be implemented and will curtail water usage by use class within the specific water shortage declaration areas.

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GLOSSARY

Acre-foot. Volume of a domain (generally water) with a base area of one acre and a height of one foot; 43,560 cubic feet; 1,233.5 cubic meters; 325,872 gallons.

Aquifer. A geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield useful quantities of ground water to wells, springs or surface water.

Aquifer Storage and Recovery (ASR). The injection of fresh water into an 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 series of geologic formations which consist of two or more aquifers divided by lower permeability units.

AWWA. American Water Works Association.

Backpumping. The practice of pumping water that is leaving an area back into a surface water reservoir.

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; a division of the University of Florida.

Best Management Practices (BMPs). Agricultural management activities designed to achieve an important goal, such as reducing pollutants in farm runoff, or optimizing water use.

BOD. Biochemical Oxygen Demand.

Basis of Review (BOR). The District's "Management of Water Use Permitting Information Manual Volume III," the formal criteria document governing the issuance of water use permits.

Brackish. Water with a chloride level greater than 250 mg/L and less than 19,000 mg/L.

CARL. Conservation and Recreation Lands.

CFR. Code of Federal Regulations.

COD. Chemical Oxygen Demand.

Cone of Influence. The area around a producing well which will be affected by its operation.

Consumptive Use. Any use of water which reduces the supply from which it is withdrawn or diverted.

Control Structures. Man-made structures designed to regulate the level and/or flow of water in a canal (e.g., weirs, dams).

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.

CREW. Corkscrew Regional Ecosystem Watershed.

Critical Water Supply Problem Areas. Areas that have experienced, or are anticipated to experience water supply problems in the next 20 years.

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.

Desalinization. A process which treats saline water to remove chlorides and dissolved solids.

Dewatering. The use of wells or other such equipment to temporarily lower a water level as may be necessary during construction activities.

Drawdown. When a well is pumped, water is removed from the aquifer surrounding the well, and the water table or piezometric surface is lowered. The drawdown at a given point is the distance the water level is dropped.

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.

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.

FAS. Floridan Aquifer System.

FASS. Florida Agricultural and Statistics Service; a division of the Florida Dept. of Agriculture and Consumer Services.

FDACS. Florida Dept. of Agriculture and Consumer Services.

FDER. Florida Dept. of Environmental Regulation.

FDEP. Florida Dept. of Environmental Protection. New agency (7/1/93) created by the consolidation of the FDER and FDNR.

FDNR. Florida Dept. of Natural Resources.

Flatwoods (Pine). Natural communities that occur on level land and are characterized by an open pine canopy with an understory of shrubs and herbaceous plants. Depending upon soil drainage characteristics and position in the landscape, flatwoods can exhibit xeric to wet conditions.

GPD. Gallons Per Day.

GPM. Gallons Per Minute.

Ground Water. All water found beneath the surface of the earth in the voids, fractures, and pores or other openings of soil and rock material.

Hydroperiod. The period of time (duration) that water is available, above or below the substrate, to influence the development of plant and/or animal communities.

IFAS. The Institute of Food and Agricultural Sciences; the agricultural branch of the University of Florida, including research, education, and extension.

Infiltration. The movement of water through the soil surface into the soil under the forces of gravity and capillarity.

Inorganic. Pertaining to, or composed of chemical compounds other than plant or animal origin.

Irrigation. The application of water to crops by artificial means. Purposes for irrigating may include, but are not limited to, supplying evapotranspiration needs, leaching of salts, and environmental control.

Irrigation Audit. A procedure in which an irrigation system's application rate and uniformity are measured.

Irrigation Efficiency. The ratio of the volume of water delivered to the target use to the volume of water withdrawn from a source.

Irrigation Uniformity. A measure of the spatial variability of applied or infiltrated water over the field.

Kissimmee Basin (KB) Planning Area. The study area which extends from Orlando to Lake Okeechobee and which includes portions of Orange, Osceola, Polk, Highlands, Glades, and Okeechobee counties.

Lake Okeechobee. This lake measures 730 square miles and is the second largest freshwater lake wholly within the United States.

Levee. An embankment to prevent flooding, or a continuous dike or ridge for confining areas of land for irrigation by surface flooding.

Lower East Coast (LEC) Planning Area. The study area which includes a portion of Lake Okeechobee, portions of Collier, Monroe and Hendry counties, and all of Dade, Broward, and Palm Beach counties.

Lower West Coast (LWC) Planning Area. The study area which includes all of Lee County, most of Collier and Hendry counties, and a portion of Charlotte, Glades, and Monroe counties.

Lower West Coast Advisory Committee. A broad-based advisory committee consisting of representatives from interested and affected parties in the LWC Planning Area, including representatives from utilities, agribusiness, government, and environmental interest groups.

MCL. Maximum Contaminant Level.

MG. Million Gallons.

MGD. Million Gallons per Day.

mg/L. Milligrams per Liter.

MGY. Million Gallons per Year.

Micro irrigation. The application of water directly to, or very near to the soil surface in drops, small streams, or sprays (i.e., drip irrigation).

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; reference sea level from which elevations are measured.

Nuclide. A species of atom characterized by the number of protons, number of neutrons, and energy content in the nucleus, or alternatively by the atomic numbers, mass numbers, and atomic mass.

National Wetland Inventory (NWI). A branch of the U.S. Fish and Wildlife Service that is responsible for defining, classifying and inventorying the wetlands of the United States and its territories.

Outstanding Natural Systems (ONS). Natural systems identified by the ONS Subcommittee, which should receive a higher level of review to protect them from deleterious impacts resulting from permitted water use, in order to maintain the ecological function of the region

ONSe. ONS lands that have been purchased for environmental preservation/ conservation purposes.

ONSm. ONS lands that are used for multiple purposes (i.e., agriculture, residential, water supply, surface water management, etc.)

ONS Subcommittee. A subcommittee of the Lower West Coast Advisory Committee formed to prepare a map of the outstanding natural systems in the LWC Planning Area.

Organics. Being composed of, or containing matter of, plant and animal origin.

Permeability. The ability of porous media to transmit fluid.

Potable Water. Water that is suitable for drinking, cooking, and other domestic purposes. The maximum chloride concentration is 250 mg/L.

Potable Water. Water that is suitable for drinking, cooking, and other domestic purposes. The maximum chloride concentration is 250 mg/L.

Process Water. Water used for nonpotable industrial usage, e.g., mixing cement.

Projection Period. The period over which projections are made, e.g., the 20 year period from 1990 to 2010.

PWS. Public water supply; potable water for public use.

Pyrophyte. A woody plant with unusual resistance to fire because of an exceptionally thick bark.

Pyrophytic. Relating to, or made up of pyrophytes.

Radionuclides. Unstable forms of chemical elements that produce radioactivity.

Reclaimed Water. Water that has received at least secondary treatment and is reused after flowing out of a wastewater treatment facility.

Reservoir. A man-made or natural lake where water is stored.

Reuse. The deliberate application of reclaimed water, in compliance with Dept. of Environmental Protection and District rules, for a beneficial purpose.

Reverse Osmosis (RO). The process of pressurizing a saline solution to force it through a semi-permeable membrane and separate water from solutes.

Rock Pits. Open pits created when shell rock or limestone is excavated

Retrofitting. The replacement of existing water fixtures, appliances and devices with more efficient fixtures, appliances and devices for the purpose of water conservation.

SAS. Surficial Aquifer System.

Saline Water. Water with a chloride concentration greater than 250 mg/L. The term saline water includes brackish water and seawater.

Saline Water Interface. The hypothetical surface of chloride concentration between fresh water and seawater where the chloride concentration is 250 mg/L at each point on the surface.

Saline Water Intrusion. This occurs when dense saline water moves laterally inland from the seacoast, or moves upward, to replace fresher water in an aquifer (upconing).

SCS. The Soil Conservation Service; a federal agency which provides technical assistance for soil and water conservation, natural resource surveys, and community resource protection management.

Seawater. Ocean water which has a chloride concentration equal to or greater than 19,000 mg/L; seawater is also characterized by a total dissolved solids concentration of 35,000 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 vertical flow that can store ground water and also transmit it slowly from one aquifer to another. The rate of vertical flow is dependent on the head differential between the semi-confining beds and those above and below them.

Stage. The elevation of water surface in a water body with respect to a specified datum.

Superfund Sites. Hazardous waste or contaminated sites that pose substantial threat to human health and the environment; these sites are put on the National Priority List (NPL) by the USEPA for remediation measures by responsible parties or government.

SWFRPC. Southwest Florida Regional Planning Council.

Storm Water. Rainfall that does not percolate into the ground or evaporate.

Subsidence. Lowering of the soil level caused by the shrinkage of organic layers. This shrinkage is due to desiccation, consolidation and biological oxidation.

Surface water. Water upon the surface of the earth, whether contained in bounds created naturally or artificially or diffused.

SWIM Plan. Surface Water Improvement and Management Plan, prepared according to Chapter 373, Florida Statutes.

TAZ. Traffic Analysis Zone; a geographic area used in transportation planning.

Transmissivity. The rate at which water is 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 the aquifer's production potential.

Turbidity. The measure of suspended material in a liquid (generally water).

Uplands. Areas that do not qualify as wetlands because the hydrologic regime is not sufficiently wet to cause the development of vegetation, soils and/or hydrologic characteristics associated with wetlands.

Upper East Coast (UEC) Planning Area. The study area which includes most of Martin and St. Lucie counties, and a small portion of eastern Okeechobee County.

USCOE. United States Army Corps of Engineers.

USFWS. United States Fish and Wildlife Service.

USGS. United States Geological Survey.

USEPA. United States Environmental Protection Agency.

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 Conservation Areas (WCAs). That part of the original Everglades ecosystem that is now diked and hydrologically controlled by man for flood control and water supply purposes. These are located in the western portions of Dade, Broward, and Palm Beach counties, and preserve a total of 1,337 square miles, or about 50 percent of the original Everglades.

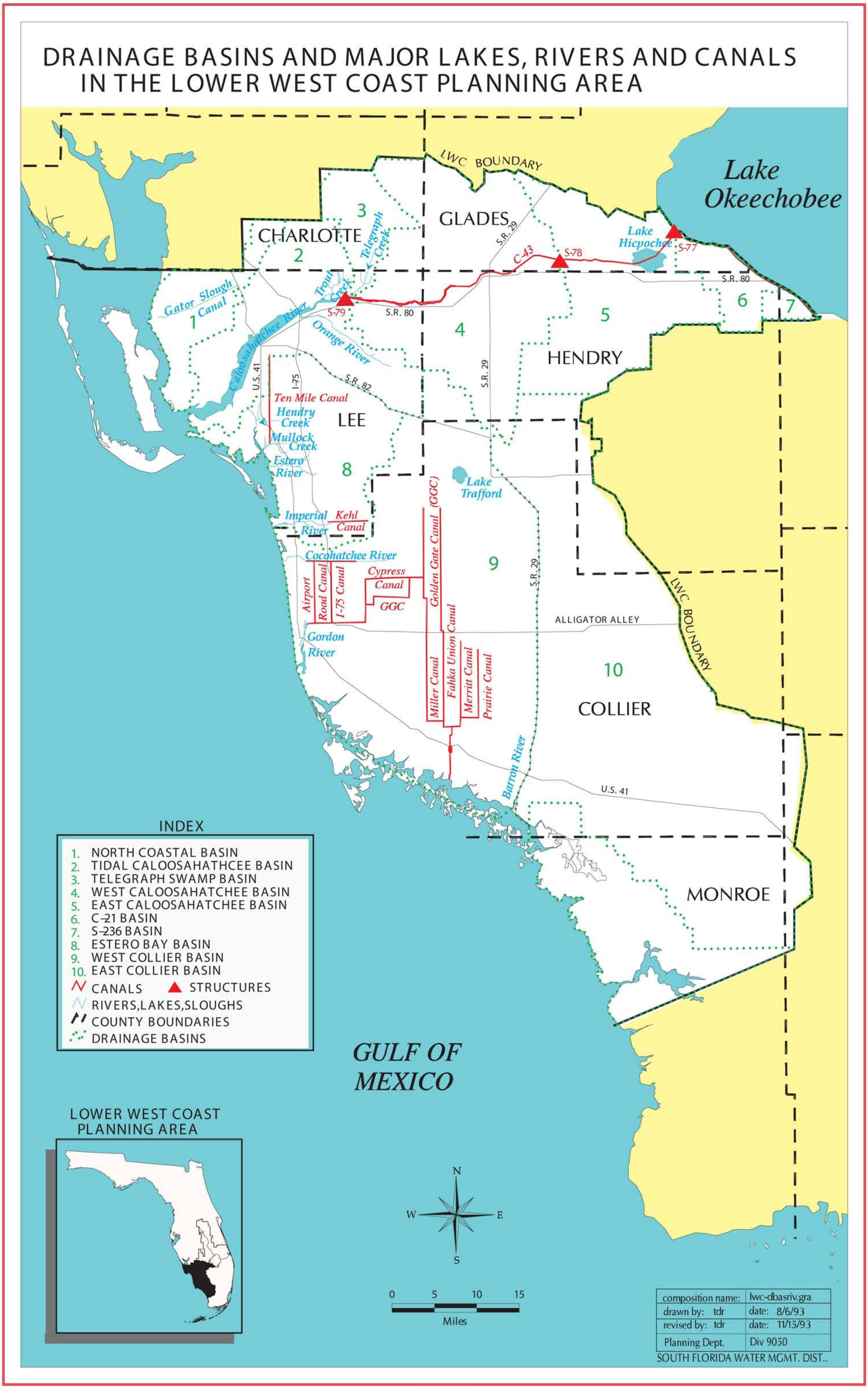
Watershed. The land area which contributes to the flow of water into a receiving body of water.

Water Supply Plans. Regional water resource and demand analyses generated by the District to provide a detailed evaluation of available water supply and projected demands through the year 2010.

Wetlands. Areas that are inundated or saturated by surface or ground water with a frequency sufficient to support, and under normal circumstances do or would support, a prevalence of vegetative or aquatic life that requires saturated or seasonably saturated soil conditions for growth and reproduction.

Xeric. A plant, community of plants or ecosystem requiring only a small amount of moisture.

Xeriscape. The use of landscaping techniques to conserve water and reduce maintenance. Techniques include the use of drought tolerant plants, landscape layout, irrigation system design, and irrigation system management.


DRAINAGE BASINS AND MAJOR LAKES, RIVERS AND CANALS IN THE LOWER WEST COAST PLANNING AREA
LWC BOUNDARY
Lake Okeechobee
CHARLOTTE
GLADES
HENDRY
LEE
COLLIER
MONROE
Lake Hicpochee
Lake Trafford
C-43
S-79
S-78
S-77
S.R. 29
S.R. 80
S.R. 82
U.S. 41
I-75
ALLIGATOR ALLEY
Gator Slough Canal
Caloosahatchee River
Trout Creek
Telegraph Creek
Orange River
Ten Mile Canal
Hendry Creek
Mullock Creek
Estero River
Imperial River
Kehl Canal
Cocohatchee River
Airport Road Canal
I-75 Canal
Cypress Canal
GGC
Golden Gate Canal (GGC)
Gordon River
Miller Canal
Fahka Union Canal
Merritt Canal
Prairie Canal
Barron River
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1. NORTH COASTAL BASIN
2. TIDAL CALOOSAHATHCEE BASIN
3. TELEGRAPH SWAMP BASIN
4. WEST CALOOSAHATCHEE BASIN
5. EAST CALOOSAHATCHEE BASIN
6. C-21 BASIN
7. S-236 BASIN
8. ESTERO BAY BASIN
9. WEST COLLIER BASIN
10. EAST COLLIER BASIN
CANALS
STRUCTURES
RIVERS,LAKES,SLOUGHS
COUNTY BOUNDARIES
DRAINAGE BASINS
GULF OF MEXICO
LOWER WEST COAST PLANNING AREA
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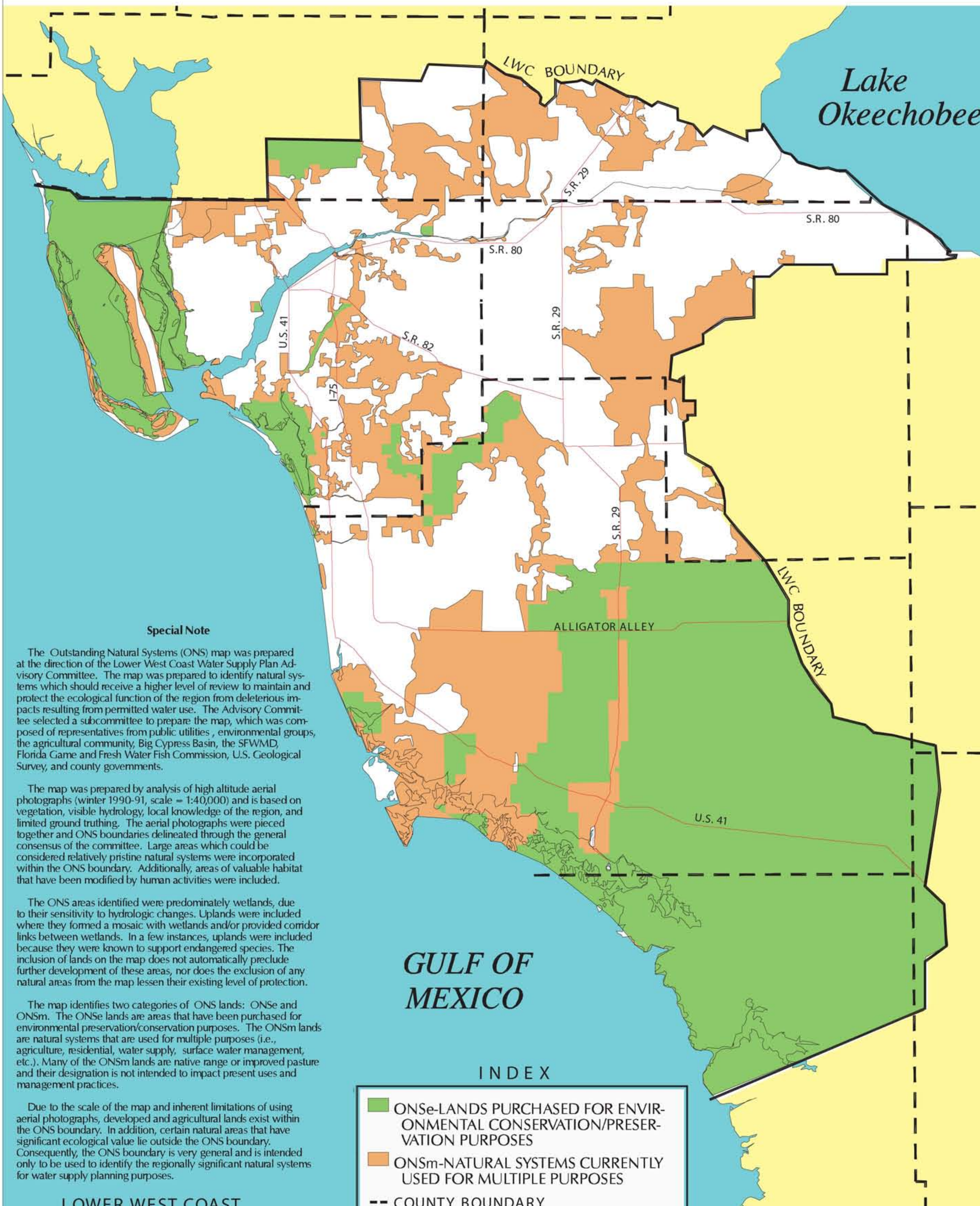
PLATE 1

OUTSTANDING NATURAL SYSTEMS IN THE LOWER WEST COAST PLANNING AREA



Special Note

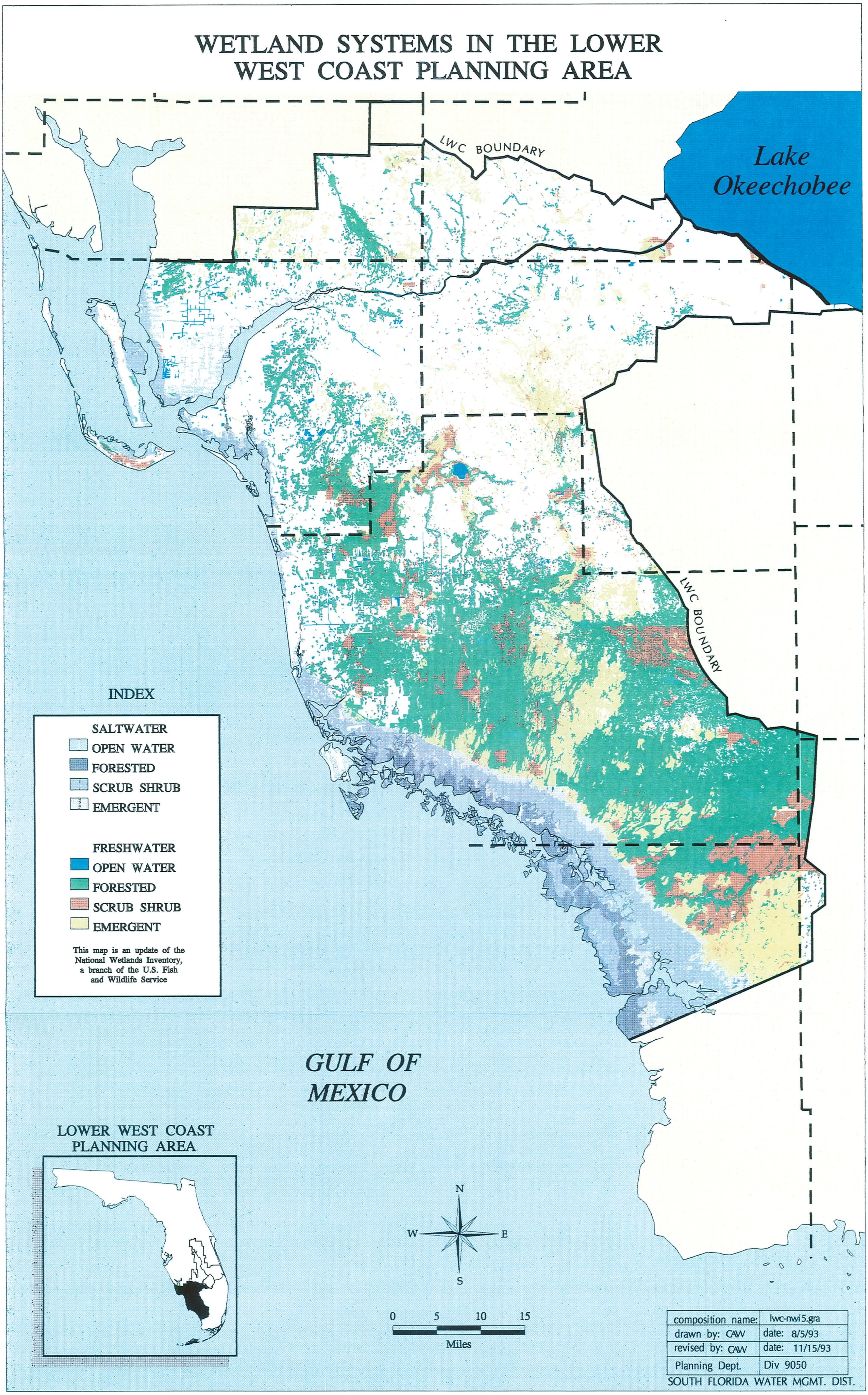
The Outstanding Natural Systems (ONS) map was prepared at the direction of the Lower West Coast Water Supply Plan Advisory Committee. The map was prepared to identify natural systems which should receive a higher level of review to maintain and protect the ecological function of the region from deleterious impacts resulting from permitted water use. The Advisory Committee selected a subcommittee to prepare the map, which was composed of representatives from public utilities , environmental groups, the agricultural community, Big Cypress Basin, the SFWMD, Florida Game and Fresh Water Fish Commission, U.S. Geological Survey, and county governments.

The map was prepared by analysis of high altitude aerial photographs (winter 1990-91, scale = 1:40,000) and is based on vegetation, visible hydrology, local knowledge of the region, and limited ground truthing. The aerial photographs were pieced together and ONS boundaries delineated through the general consensus of the committee. Large areas which could be considered relatively pristine natural systems were incorporated within the ONS boundary. Additionally, areas of valuable habitat that have been modified by human activities were included.

The ONS areas identified were predominately wetlands, due to their sensitivity to hydrologic changes. Uplands were included where they formed a mosaic with wetlands and/or provided corridor links between wetlands. In a few instances, uplands were included because they were known to support endangered species. The inclusion of lands on the map does not automatically preclude further development of these areas, nor does the exclusion of any natural areas from the map lessen their existing level of protection.

The map identifies two categories of ONS lands: ONSe and ONSm. The ONSe lands are areas that have been purchased for environmental preservation/conservation purposes. The ONSm lands are natural systems that are used for multiple purposes (i.e., agriculture, residential, water supply, surface water management, etc.). Many of the ONSm lands are native range or improved pasture and their designation is not intended to impact present uses and management practices.

Due to the scale of the map and inherent limitations of using aerial photographs, developed and agricultural lands exist within the ONS boundary. In addition, certain natural areas that have significant ecological value lie outside the ONS boundary. Consequently, the ONS boundary is very general and is intended only to be used to identify the regionally significant natural systems for water supply planning purposes.


WETLAND SYSTEMS IN THE LOWER
WEST COAST PLANNING AREA
LWC BOUNDARY
Lake
Okeechobee
LWC BOUNDARY
INDEX
SALTWATER
OPEN WATER
FORESTED
SCRUB SHRUB
EMERGENT
FRESHWATER
OPEN WATER
FORESTED
SCRUB SHRUB
EMERGENT
This map is an update of the National Wetlands Inventory, a branch of the U.S. Fish and Wildlife Service
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revised by: CAW date: 11/15/93
Planning Dept. Div 9050
SOUTH FLORIDA WATER MGMT. DIST.

PLATE 3

UPLAND SYSTEMS IN THE LOWER WEST COAST PLANNING AREA