Acknowledgments

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Executive Summary

The purpose of this report is to document the data, methods and assumptions used by staff of the South Florida Water Management District (SFWMD) to develop minimum flow and level (MFL) technical criteria for Lake Istokpoga. The Florida Water Resources Act requires that water management districts develop a priority list and schedule for the establishment of MFLs for surface waters and aquifers within their jurisdiction (Section 373.042 (1), F.S. (Florida Statutes) (see **Appendix A**). This list is included in the *District Water Management Plan* for the SFWMD (SFWMD 2003a). The 2004 update to this list identified the need to develop MFL criteria for Lake Istokpoga by 2005.

At 27,692 acres, Lake Istokpoga is the fifth-largest lake in Florida. The lake is generally shallow, averaging only 4 to 6 feet in depth. The major tributaries into Lake Istokpoga are Arbuckle Creek from the north and Josephine Creek from the northwest. Water is discharged from the lake through two primary outlets: the Istokpoga Canal, which flows eastward to the Kissimmee River, and the S-68 Structure, which releases water through a series of canals southeastward to both Lake Okeechobee and the Kissimmee River. A reduction of high lake levels has provided the catalyst for development around the lakeshore, including agriculture (citrus and caladium farms), pasture land, and residential and commercial establishments. Many lakeside areas that once flooded seasonally or infrequently are now drained. The lake is treasured by local residents for its recreational and scenic qualities. It is also an important regional resource that is being studied as part of the Kissimmee River Restoration Project and the Comprehensive Everglades Restoration Project (CERP).

The Lake Istokpoga watershed is located in Highlands and Polk counties, and the lake is currently managed to prevent flooding of surrounding lands and to maintain water levels sufficient to provide recreational access, maintain fish and wildlife habitats and serve as a source of water supply for agricultural areas to the south in Glades County. Prior to development, most of the area around Lake Istokpoga was characterized by nearly level, poorly drained flatwoods, and the land south of Lake Istokpoga once contained an extensive marsh and swamp. Today, drainage ditches and water supply canals cut across historic flowways, accelerating runoff into the lake and diverting water from parts of the watershed, lake and surrounding lands toward the Kissimmee River and Lake Okeechobee. Water is withdrawn from canals and groundwater wells to support large citrus groves situated on the Lake Wales Ridge, cattle farms on the Indian Prairie and commercial farming of ornamental landscape plants and truck crops on former wetlands located south of Lake Istokpoga. These water supply, structural and land use changes were considered during MFL criteria development.

Section 373.042 (1), F.S., (**Appendix A**) defines the *minimum level* as follows:

> the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area

For purposes of establishing minimum levels, SFWMD Rule 40E-8.021 (**Appendix A**) defines *significant harm* as follows:

> the temporary loss of water resource functions that result from a change in surface or groundwater hydrology, that takes more than two years to recover, but which is considered less severe than serious harm

Water resource functions protected under Chapter 373, the Florida Water Resources Act, are broad and include flood control, water quality protection, water supply and storage, fish and wildlife protection, navigation and recreation. Water management districts may also consider any changes and/or structural alterations that have occurred within the watershed and may develop a recovery and prevention strategy for water bodies that do not, or are not expected to, meet the proposed criteria during the planning horizon.

Establishing minimum flows and levels alone will not be sufficient to maintain a sustainable resource over the broad range of water conditions occurring within the managed system. Setting a minimum flow is viewed as a starting point to define water needs for sustainability. The necessary hydrologic regime for restoration of defined priority water bodies also includes the use of water reservations and other water resource protection tools. Achieving the required water levels throughout these systems is an overall, long-term restoration goal. MFLs are intended as part of a comprehensive water resources management approach geared toward ensuring the sustainability of the water resources. The proposed MFL criteria are not a "stand-alone" resource protection tool but should be considered in conjunction with all other resource protection responsibilities granted to the water management districts by law. These include consumptive use permitting, water shortage management and water reservations.

For Lake Istokpoga, water level stabilization has caused a wide range of impacts to the resource by greatly altering historic patterns of drying and flooding that once occurred every few years. Natural patterns of water level fluctuations are critical for organisms that have growth and reproduction cycles associated with specific hydrologic conditions. Setting a minimum level is viewed as a starting point to define water needs for protection against *significant harm*. The present report documents a great variety of water resource issues associated with Lake Istokpoga, while technical criteria development focuses specifically on the establishment of minimum levels.

Pursuant to the requirements contained within Chapter 373 of the Florida Water Resources Act, water resource functions are identified and their technical relationships to water flow and level are described on the basis of the best available information, including the following: results of a literature review; analysis and synthesis of present and historical water level data for the lake; and data, results and conclusions from previous and ongoing investigations.

Proposed minimum water level criteria for Lake Istokpoga are linked to the concept of protecting valued ecologic components from *significant harm*. A *significant-harm* condition for Lake Istokpoga is based primarily on the concept of any negative impact to the lake's biological resources that lasts more than two years. The specific valued ecosystem components that have been identified are fishery resources and the remaining wetland communities that fringe the lake shore (submerged and emergent aquatic vegetation, marshes and swamps). After examining available technical information, related field studies and the monitoring data collected before and after the 2001 drawdown for environmental enhancement, the SFWMD staff proposes the following MFL criteria for Lake Istokpoga:

> A MFL violation occurs within Lake Istokpoga when surface water levels fall below 36.5 feet NGVD for 20 or more weeks within one calendar year, more often than once every four years.

The MFL criteria are intended to address low water levels that occur from regional drought conditions and/or from withdrawals of water from the lake or adjacent aquifers. Currently the lake receives an adequate supply of fresh water, and water levels are controlled by a fixed regulation schedule. Since the implementation in 1988 of a more comprehensive management program for lake levels, water levels have remained above 37.0 feet NGVD (National Geodetic Vertical Datum: a sea level standard measure based upon vertical datum from 1929), except during a managed drawdown as part of an environmental enhancement project. It is unlikely that a violation of the MFL criteria will occur under the current operational schedule except during controlled drawdown and enhancement projects. Establishment of MFL criteria for Lake Istokpoga may be useful as a guide for managing the frequency and magnitude of such planned drawdown events. But it is recognized that under certain circumstances, it may be necessary to conduct a controlled drawdown of lake levels of a duration or return frequency that may exceed those outlined in the proposed criteria.

An adaptive management strategy for Lake Istokpoga recognizes that the proposed MFL criteria are based on best available information, with the understanding that more information is needed in order to refine assumptions used in criteria development. Ongoing and proposed research and monitoring efforts in the Lake Istokpoga watershed will continue to provide more information that will improve our understanding of Lake Istokpoga's resources. This information will provide SFWMD staff with an opportunity to reevaluate the proposed criteria and to refine the MFL criteria in accordance with the development and implementation of the Kissimmee Basin Water Supply Plan.

The MFL criteria developed in the present document should be used as the basis for SFWMD rule development and for the issuance of consumptive use permits, both individually and cumulatively, within the Kissimmee Basin Planning Area. It is recommended that the current research and monitoring efforts by the SFWMD and the Florida Fish and Wildlife Conservation Commission, both individually and jointly, should continue, since these efforts will provide useful data for refinement of the MFL criteria and of other lake management criteria. The monitoring programs associated with drawdown and ecologic enhancement projects should consider an enhanced focus on wetland monitoring consistent with the needs of gauging *significant harm* to these resources.

Table of Contents

Document Structure

The following is a guide to the structure of the present document in its entirety. The purpose of this report is to document the data, methods and assumptions used by staff of the South Florida Water Management District (SFWMD) to develop minimum flow and level (MFL) technical criteria for Lake Istokpoga

- **Chapter 1** serves as an introduction to the document.
- **Chapter 2** describes the geographic setting, the resources at risk and major issues concerning the use and conservation of resources within Lake Istokpoga.
- **Chapter 3** describes resource functions, considerations and exclusions for Lake Istokpoga.
- **Chapter 4** documents the methods used to establish *significant harm* criteria for the different areas, resources and functions.
- **Chapter 5** presents results of analyses used to define *harm* standards for Lake Istokpoga and a summary of specific relevant factors considered.
- **Chapter 6** provides the specific hydrologic criteria developed to indicate the point at which *significant harm* occurs and includes a discussion on the recovery and prevention strategies for Lake Istokpoga and a description of research needs.
- The **Glossary** contains definitions and explanations of technical terms used in the present study.
- The **Literature Cited** section provides a listing of the informational resources and other reference materials used in the preparation of the present document.
- **Appendices A** through **E** include technical information such as descriptions and analyses of methods and tools, supplemental data and analyses, literature, related correspondence, laws, rules and results of the peer review and other activities in the watershed.

List of Tables

List of Figures

List of Appendices

Acronyms and Abbreviations

°C or C	degree(s) Celsius
°F or F	degree(s) Fahrenheit
ac-ft	acre-foot (feet)
ASR	Aquifer Storage and Recovery
C&SF Project	Central and Southern Florida Project
CERP	Comprehensive Everglades Restoration Plan
cfs	cubic foot (feet) per second
Ch.	Chapter (generally used to reference a legal document)
cm	centimeter(s)
CPUE	Catch per Unit Effort
CUP	Consumptive Use Permit
CWMP	Comprehensive Water Management Plan
DBHYDRO	SFWMD's corporate environmental database
District	South Florida Water Management District
DWMP	District Water Management Plan
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
ET	Evapotranspiration
F.A.C.	Florida Administrative Code
FAS	Floridan Aquifer System
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
F.S.	Florida Statute(s)
ft	foot (feet)
FWC	Florida Fish and Wildlife Conservation Commission
GIS	geographic information system
GLO	General Land Office
GPM	gallon(s) per minute
ha	hectare(s)

IAS	Intermediate Aquifer System
Km	kilometer(s)
LOW	Lake Okeechobee Watershed
m	meter(s)
MFLs	Minimum Flows and Levels
mi	mile(s)
MSL	mean sea level
NA	not applicable or not available
NGVD	National Geodetic Vertical Datum
NRCS	Natural Resources Conservation Service
POR	period of record
Ppm	parts per million
SAS	Surficial Aquifer System
SAV	submerged aquatic vegetation
SFWMD	South Florida Water Management District
SJRWMD	St. Johns River Water Management District
SWFWMD	Southwest Florida Water Management District
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WPB	West Palm Beach

CHAPTER 1
Introduction

BACKGROUND

This report documents the methods and technical criteria used by staff of the South Florida Water Management District (SFWMD or District) to develop minimum level criteria for Lake Istokpoga. The District Water Management Plan for south Florida (SFWMD 2003a) includes a schedule for establishing minimum flows and levels (MFLs) for priority water bodies within the District. Section 373.042(2), F.S., requires the water management districts to review annually the priority list schedule and make any necessary revisions (see **Appendix A**). This list identified the need to establish MFL criteria for Lake Istokpoga. The Minimum Flows and Levels Priority List and Schedule were modified in March 2005, and the deadline for establishing these criteria and for developing associated rules was listed as December 2005 (letter from Henry Dean, SFWMD, to Colleen Castille, Florida Department of Environmental Protection, dated April 1, 2005) (see **Appendix A**).

These MFLs are being developed pursuant to the requirements contained within the Florida Water Resources Act, specifically sections 373.042 and 373.0421 (see **Appendix A**), as part of a comprehensive water resources management approach geared toward assuring sustainability of water resources. The proposed minimum level for Lake Istokpoga is not a "stand-alone" resource protection tool but should be considered in conjunction with all other resource protection responsibilities granted by law to the water management districts, such as consumptive use, environmental resource permitting, water shortage management and water reservations. A model framework identifying the relationship among these tools was used in developing the proposed minimum level and is discussed in the present document. In addition, pursuant to Chapter 373.0361, F.S., the District has completed Regional Water Supply Plans that include recommendations for establishing recovery and prevention strategies and minimum flows for those water bodies not expected to meet the MFL criteria within the water supply planning horizon (SFWMD 2000a, b and c).

Establishing *minimum* flows and levels alone will not be sufficient to maintain a sustainable resource or protect it from *significant harm* during the broad range of water conditions occurring in the managed system. Setting a minimum level is viewed as one point to define the total water needs for sustainability. For Lake Istokpoga, stabilized water levels relative to historic conditions also impact the resource. The necessary hydrologic regime for restoration of the Lake Istokpoga ecosystem must also be defined and implemented through regional water supply plans, lake and watershed management plans, reexamination of the current regulation schedule, and the use of water reservations and other water resource protection tools.

As a component of the Comprehensive Everglades Restoration Plan (CERP), the Lake Okeechobee Watershed Project will examine the Lake Istokpoga basin with a view toward enhancing fish and wildlife benefits and developing a long-term comprehensive management plan that will create a balance among water supply, flood control, and environmental needs (USACE and SFWMD 1999). That effort will identify seasonal variability requirements and maximum water levels that can be sustained by this system without causing damage to the resource or to nearby properties.

As a first formal step to establish a minimum level for Lake Istokpoga, this report includes the following:

- Description of the framework for determining a minimum level based on best available information (an approach applied to other surface and groundwater within the SFWMD).
- Development of methodology and technical criteria for establishing a minimum level for Lake Istokpoga.
- Supporting data and analyses.

The present document will receive independent scientific peer review pursuant to Section 373.042, F.S. (see **Appendix B**), and rule development workshops will be held to discuss MFL concepts proposed for Lake Istokpoga. Persons who wish to receive results of the scientific peer review process and notice of future workshops and other public meetings should notify the SFWMD.

PROCESS AND BASIS FOR ESTABLISHMENT OF MINIMUM FLOWS AND LEVELS

Process Steps and Activities

The process for establishing minimum levels for Lake Istokpoga is summarized as follows:

1. Through the development of the Kissimmee Basin Water Supply Plan and concurrent staff research and analysis, a methodology and technical basis were developed for establishing the minimum level.

2. A first draft of the technical criteria document was completed and distributed in May 2005.

3. Scientific peer review of the technical document was conducted in June 2005 to verify the criteria pursuant to Section 373.0421, F.S.

4. Revisions to the draft document, as recommended by the peer review panel, were incorporated into the criteria; a revised draft of the technical report is scheduled for completion in November 2005.

5. Further public consideration of the technical basis and methodology for establishing the minimum level and a review of the first draft of the rule were conducted during a rule development workshop in August 2005.

6. A final rule is scheduled to be presented to the Governing Board for adoption in December 2005.

Legal and Policy Basis for Establishment of Minimum Flows and Levels

Florida law requires the water management districts to establish MFLs for surface waters and aquifers within their jurisdiction (Section 373.042[1], F.S.) (see **Appendix A**). Typically, minimum *flows* are developed for rivers and springs, and minimum *levels* are developed for lakes and aquifers. The minimum flow is defined as the "... limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area." The minimum level is defined as the "… limit at which further withdrawals would be significantly harmful to the water resources of the area ..." (Section 373.042[1], F.S.). The statute further directs water management districts to use the best available information in establishing the MFL. Each water management district must also consider, and at its discretion may provide for, the protection of nonconsumptive uses in the establishment of MFLs (Section 373.042, F.S.). In addition, a baseline condition for the protected resource functions must be identified through consideration of changes and structural alterations in the hydrologic system (Section 373.042[1], F.S.).

The following sections outline the legal and policy factors relevant to establishing MFLs under Florida law. In summary, the following questions are addressed:

A. What are the priority functions of each water resource, and what are the baseline conditions for the functions being protected?

B. What level of protection for these functions is provided by the MFL standard of protection, the avoidance of *significant harm*?

Relevant Water Resource Functions

Each surface water body or aquifer serves an array of water resource functions that must be considered when establishing a MFL designed to prevent *significant harm*. The term "water resource" is used throughout the Florida Water Resources Act (Chapter 373, F.S.). Water resource functions protected under the Florida Water Resources Act are broad, as illustrated in Section 373.016, F.S., and include flood control, water quality protection, water supply and storage, fish and wildlife protection, navigation and recreation.

The State Water Resource Implementation Rule, Section 62-40.405, F.A.C, outlines specific factors to consider, including protection of natural seasonal changes in water flows or levels, water levels in aquifer systems, and environmental values associated with aquatic and wetland ecology. Other specific considerations include the following:

- Fish and wildlife habitat and the passage of fish.
- Maintenance of freshwater storage and supply.
- Water quality.
- Estuarine resources.
- Transfer of detrital material.
- Filtration and absorption of nutrients and pollutants.
- Sediment loads.
- Recreation in and on the water.
- Navigation.
- Aesthetic and scenic attributes.

The District's Governing Board has the purview to determine which resource functions to consider in establishing MFLs, an analysis that requires a comprehensive look at the sustainability of the resource itself and at the resource's role in sustaining overall regional water resources. **Chapter 3** examines how these provisions apply to the minimum levels proposed for Lake Istokpoga.

Considerations and Exclusions: Baseline Conditions to Protect Water Resource Functions

Once the water resource functions to be protected by a specific minimum flow or level are defined, the baseline resource conditions for assessing *significant harm* must be identified. Considerations for making this determination are set forth in Section 373.0421(1)(a), F.S., which requires water management districts, when setting a MFL, to consider changes and structural alterations that have occurred to a water resource. Likewise, Section 373.0421(1)(b), F.S., (see **Appendix A**) recognizes that certain water bodies no longer serve their historical function and that recovery of these water bodies to historical conditions may not be feasible. These provisions are discussed in **Chapter 3,** to examine their applicability to the minimum level proposed for Lake Istokpoga.

Level of Protection for Water Resource Functions Provided by the MFL Standard of *Significant Harm*

The overall purpose of the Florida Water Resources Act is to ensure the sustainability of state water resources (Section 373.016, F.S.). To carry out this responsibility, Chapter 373 provides the SFWMD with several tools consisting of varying levels of resource protection standards. MFLs play one part in this framework. Determination of the role of MFLs and of the protection that they offer versus other water resource tools available to the SFWMD is discussed next.

The scope and context of MFL protection revolve around the goal of preventing *significant harm*. The following discussion provides some context to the MFLs statute, including the *significant harm* standard, vis-à-vis other water resource protection statutes.

Resource sustainability is the overarching objective of all water resource protection standards (Section 373.016, F.S.). Each water resource protection standard must fit into a statutory function to achieve this overall goal. For instance, pursuant to parts II and IV of Chapter 373, programs regulating surface water management and consumptive use permitting must prevent *harm* to the water resource. Water shortage statutes dictate that permitted water supplies must be restricted from use to prevent *serious harm* to the water resources. Other resource protection tools include reservation of water for fish and wildlife or health and safety purposes (Section 373.223(3), F.S.) and aquifer zoning to prevent undesirable uses of the groundwater (Section 373.036[4–5], F.S.). By contrast, MFLs are set at the point at which *significant harm* to the water resources or ecology would occur. The levels of *harm* cited above—*harm*, *significant harm* and *serious harm*—are relative resource protection terms, each playing a role in the ultimate goal of achieving a sustainable water resource. The SFWMD has proposed that the conceptual relationship among the terms *harm*, *significant harm* and *serious harm* can be represented as shown in **Figure 1**.

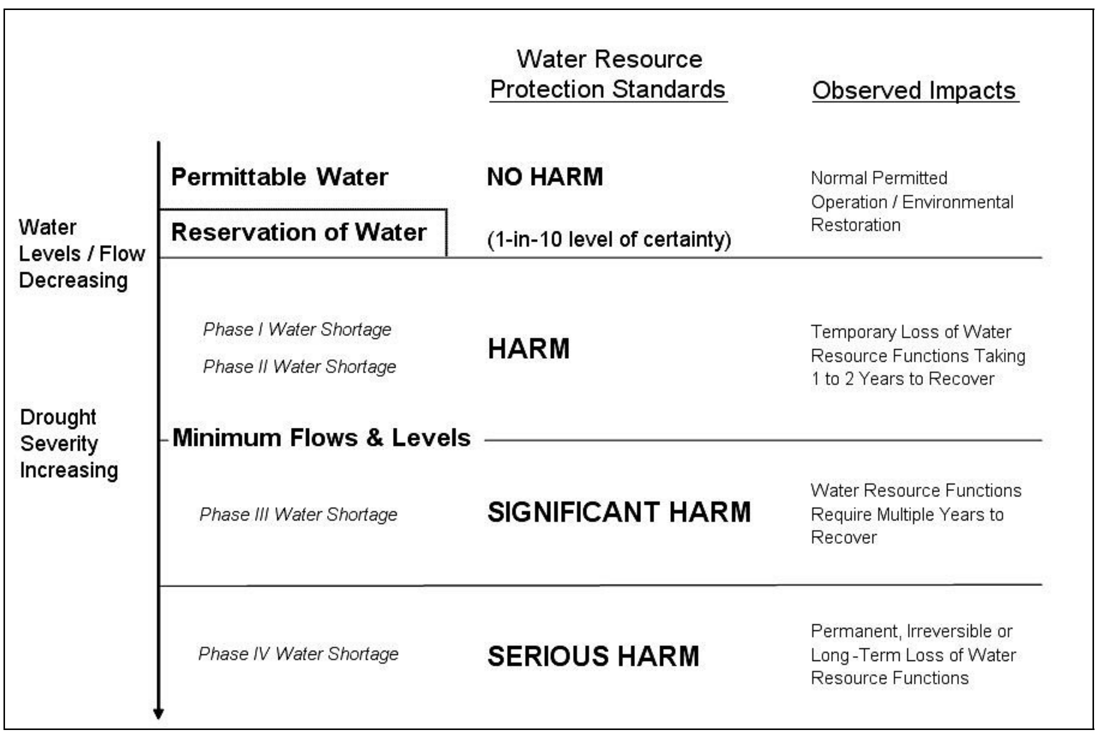


Figure 1. Conceptual Relationships among the Terms Harm, Significant Harm and Serious Harm (from 40E-8.421[1][b], F.A.C.).

The general narrative definition of *significant harm* proposed by the SFWMD and contained in the Florida Administrative Code (F.A.C.) for the water resources of an area is as follows:

> (Chapter 40E-8.021(24), F.A.C.) Significant Harm means the temporary loss of water resource functions, which result from a change in surface or ground water hydrology, that takes more than two years to recover, but which is considered less severe than serious harm. The specific water resource functions addressed by a MFL and the duration of the recovery period associated with significant harm are defined for each priority water body based on the MFL technical support document.

Other Levels of *Harm* Considered in Florida Statutes

A discussion of the other levels of *harm* identified in the conceptual model for consumptive use permitting and water shortage is provided below to give context to the proposed *significant harm* standard.

Harm Standard in the Consumptive Use Permitting Role

The resource protection criteria used for consumptive use permitting (CUP) are based on the level of impact considered harmful to the water resource. These criteria are applied to various resource functions to establish the range of hydrologic change that can occur without *harm*. The hydrologic criteria include level, duration and frequency components and are used to define the amount of water that can be allocated from the resource. Together, the criteria on saltwater intrusion, wetland drawdown, pollution and aquifer mining in Chapter 40E-2, F.A.C., define the *harm* standard for purposes of consumptive use allocation. These *harm* criteria are applied using climate conditions that represent an assumed level of certainty. The level of certainty used in the Kissimmee Basin, Lower West Coast, Lower East Coast and Upper East Coast Regional Water Supply Plans (SFWMD 1998 and 2000a, b and c) is a 1-in-10-year drought frequency, as defined in the SFWMD's permitting rules. The 1-in-10-year drought level of certainty is also the water supply planning goal established in Section 373.0361, F.S. The standard for *harm* used in the CUP process is considered as the point at which adverse impacts to water resources can be restored within a period of one to two years of average rainfall conditions. These short-term adverse impacts are addressed for the Consumptive Use Permitting Program, which calculates allocations to meet demands for use during relatively mild dry season events, defined as the 1-in-10 year drought.

Serious Harm Standard in the Water Shortage Declaration Role

Pursuant to Section 373.246, F.S., water shortage declarations are designed to prevent *serious harm* from occurring to water resources. *Serious harm*, the ultimate *harm* to the water resources contemplated under Chapter 373, F.S., can be interpreted as long-term, irreversible or permanent impacts. Impacts associated with *serious harm* occur during drought events more severe than the 1-in-10 year level of drought used in the CUP criteria.

When drought conditions exist, water users increase withdrawals to supplement water not provided by rainfall, typically for irrigation or outside use. In general, the more severe the drought, the more supplemental water is needed. These increased withdrawals increase the potential for *serious harm* to the water resource.

The SFWMD has implemented its water shortage authority by restricting consumptive uses on the basis of the concept of equitable distribution between users and the water resources (Chapter 40E-21, F.A.C.). Under this program, different levels or phases of water shortage restrictions are imposed relative to the severity of drought conditions. The four phases of current water shortage restrictions are based on relative levels of risk posed to resource conditions leading up to *serious harm* impacts. Under the District's program, Phase I and Phase II water shortage restrictions are designed primarily to prevent *harm* such as localized but recoverable damage to wetlands and short-term inability to maintain water levels needed for resource protection; associated actions that may be taken include restrictions on water use through conservation practices and restrictions on minor uses such as car washing and lawn watering. Phases III and IV, however, require the use of cutbacks such as agricultural irrigation restrictions entailing some level of economic impact to users.

MFL RECOVERY AND PREVENTION STRATEGY

MFLs are implemented through a multifaceted recovery or prevention strategy. Section 373.0421(2), F.S., provides that if it is determined that that water flows or levels are presently below the MFL or that water flows or levels will exceed the established MFL criteria within the next 20 years, the water management district must develop and implement a suitable recovery or prevention strategy. The 20-year period should coincide with the regional water supply plan horizon for the area, and the strategy is to be developed in concert with that planning process.

The general goal of the recovery and prevention strategy is to take actions to satisfy the MFL criteria while continuing to provide sufficient water supplies for all reasonable-beneficial uses (*reasonable-beneficial uses* entail water use in such quantity as is necessary for economic and efficient utilization for a purpose and in a manner that is both reasonable and consistent with the public interest). If the existing condition of the resource is below the MFL, recovery to the MFL must be achieved "as soon as practicable." Many different factors influence a water management district's ability to implement proposed actions punctually, including funding availability, detailed design development, permittability of regulated actions, land acquisition and implementation of updated permitting rules.

From a regulatory standpoint, depending on the existing and projected flows or levels, either water shortage triggers or interim consumptive use permit criteria (or both) may be recommended in the recovery and prevention strategy. The approach varies depending on whether the MFL is currently exceeded and the cause of the MFL exceedance (e.g., consumptive use withdrawals, poor surface water conveyance facilities or operations, overdrainage or a combination of these).

Incremental measures to achieve the MFL must be included in the recovery or prevention strategy, along with a timetable for the provision of water supplies necessary to meet reasonable-beneficial uses. Such incremental measures to achieve the MFL include development of additional water supplies, construction of new or improved storage facilities and implementation of conservation or other efficiency actions. The measures must make water available "concurrent with, to the extent practical, and to offset, reductions in permitted withdrawals, consistent with the provisions of this chapter [Chapter 373]." The determination of what is "practical" in identifying measures for concurrently replacing water supplies will likely be made through consideration of the economic and technical feasibility of potential options. Additional information about a recovery and prevention strategy for Lake Istokpoga is provided in **Chapter 6**.

CHAPTER 2
Description of the Water Body

INTRODUCTION

The Lake Istokpoga basin is located northwest of Lake Okeechobee in central Florida and is within the Kissimmee Basin Planning Area (SFWMD 2000a) (**Figure 2**). The Lake Istokpoga basin drains an area of approximately 920 mi^2 (2,383 km^2) (Milleson 1978) within Highlands and Polk counties. Approximately two-thirds of the basin is within the Southwest Florida Water Management District (SWFWMD), while the remaining portion of the basin and all of the lake itself are within the SFWMD. Lake Istokpoga resides within the Kissimmee/Okeechobee Lowland Region, and the Lake Wales Ridge borders it to the west (White 1970).

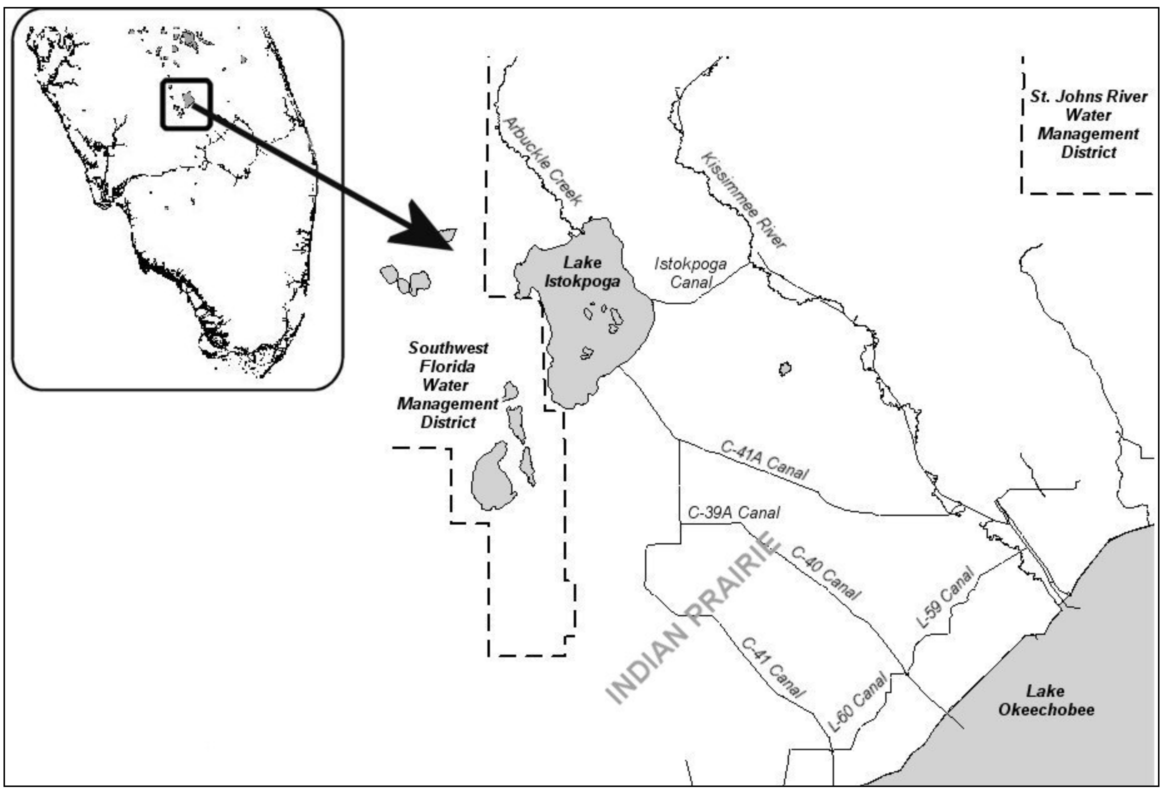


Figure 2. Major Landscape Features in the Lake Istokpoga Vicinity.

Lake Istokpoga is Florida's fifth-largest lake, at approximately 44 mi^2 (114 km^2); the lake is shallow, with an average depth of roughly 4 feet (1.2 m) (McDiffett 1981). Direct rainfall, combined with tributary inflows from Josephine and Arbuckle creeks, provides the bulk of its surface water inputs (Walker and Havens 2003). Outflows from Lake Istokpoga are directed either to the Kissimmee River or Lake Okeechobee through a system of canals and water control structures—the S-68 and the G-85—providing control of Istokpoga's water levels (**Figure 3**). The S-68, which was constructed in 1962 and became operational that same year, is a gated water control structure that discharges outflows into the C-41A Canal to the south, whereby the water is generally routed to the Kissimmee River and/or Lake Okeechobee (**Figure 2**). The G-85 Structure discharges water eastward into the Istokpoga Canal, which flows into the Kissimmee River. Historically, Istokpoga Creek, paralleling today's Istokpoga Canal, provided the only means for channelized outflow from the lake, and significant quantities of overland (sheet) surface water once flowed toward the Kissimmee River and Indian Prairie during times of high water levels.

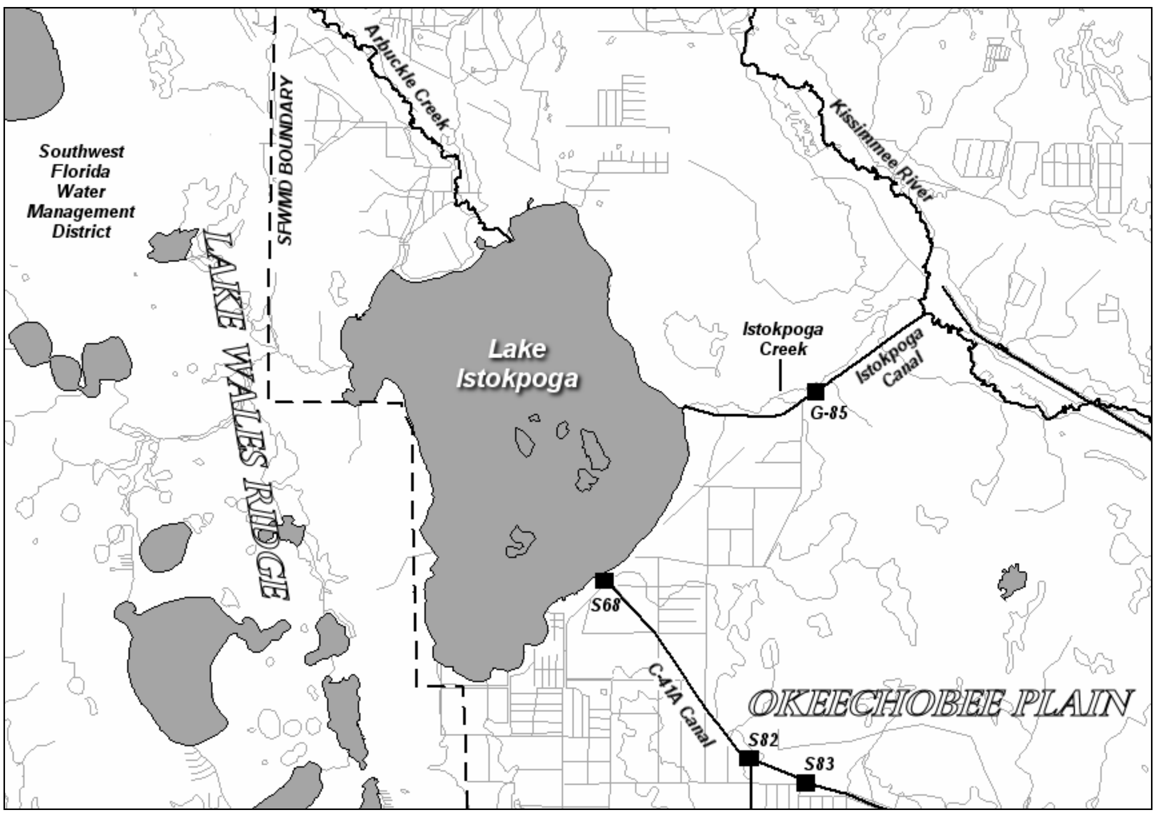


Figure 3. Major Drainage Features of Lake Istokpoga.

Lake Istokpoga is a unique regional resource in several ways. It is an important source of water supply for agricultural lands located southeast of the lake (Indian Prairie). The scenic beauty of the lake has encouraged the establishment of waterfront residences along the northern and eastern shores. The lake is recognized as one of the top fishing lakes in the state of Florida, and several annual bass fishing tournaments are held there, providing significant benefit to the local economy. Fowl hunting is a popular sport on the lake and its fringing marshes. Remnant cypress swamps are found along the western half of the lake, providing important habitat for wildlife. Bird watching is also a significant recreational activity: the two larger islands in the southern end of the lake support a large rookery of wading birds, bald eagles are routinely seen in the area, and some of the highest concentrations of nesting osprey ever documented have been recorded in wetlands fringing the lake (Stewart 2001).

The preservation and enhancement of Lake Istokpoga's outstanding natural and cultural values are the goals of several other ongoing projects besides the MFL project—namely, the reexamination of the Lake Istokpoga regulation schedule as part of the Comprehensive Everglades Restoration Plan (CERP) and the examination of water supply concerns and issues as part of the Kissimmee Basin Water Supply Plan (SFWMD 2000a). A review of these and other enhancement projects is provided later in this chapter.

WATERSHED

Climate, Rainfall and Seasonal Weather Patterns

The climate in the Lake Istokpoga watershed is subtropical, with an average summer daily temperature of 85.5° F (29.7° C) and an average winter daily temperature of 61.4° F (16.3° C). The average annual temperature is 75.5° F (24.2° C). August is typically the warmest month (SFWMD 2000a), and winters are mild, with warm days and moderately cool nights that may dip to near freezing after the passing of a cold front.

There are two defined seasons—namely, a hot, humid, rainy summer season (June through September) and a cool dry season (November through April). May and October are regarded as transitional months that vary from year to year in rainfall and temperature levels. During the rainy summer season, afternoon thundershowers are common and provide most of the total annual rainfall; in addition, tropical storms or hurricanes during the summer and early fall can produce 6 to 10 inches (15 to 25 cm) of rainfall in one day. During the cooler dry season, in contrast, rainfall is much less abundant and is associated typically with the passing of continental cold fronts; some years have long periods of little or no rainfall at all during the winter and early spring, resulting in a regional drought condition.

Rainfall at Avon Park, within the Lake Istokpoga watershed, ranged from 34 inches (86 cm) one year to more than 80 inches (203 cm) another year during the 1902–1998 period (**Figure 4**). Besides this interannual variability in the same place, there also exists considerable spatial variability of rainfall across the region. Near Avon Park (northwest of Lake Istokpoga), for instance, the long-term average annual rainfall is 52.3 inches (132.8 cm), but near Sebring (near the north shore of Lake Istokpoga) the annual average is 45.1 inches (114.6 cm) and at the S-68 Structure (south shore of Lake Istokpoga) it is 39.9 inches (101.3 cm) (**Table 1**, **Figure 5**). The heaviest precipitation occurs from June to September (the wet season), when monthly averages range from 7.5 to 8.6 inches (19.1 to 21.8 cm) (**Figure 6**); on average, the highest average monthly total rainfall of 8.6 inches (21.8 cm) occurs in June with the onset of the rainy season, while the lowest monthly average total rainfall occurs in December, at 1.8 inches (4.6 cm).

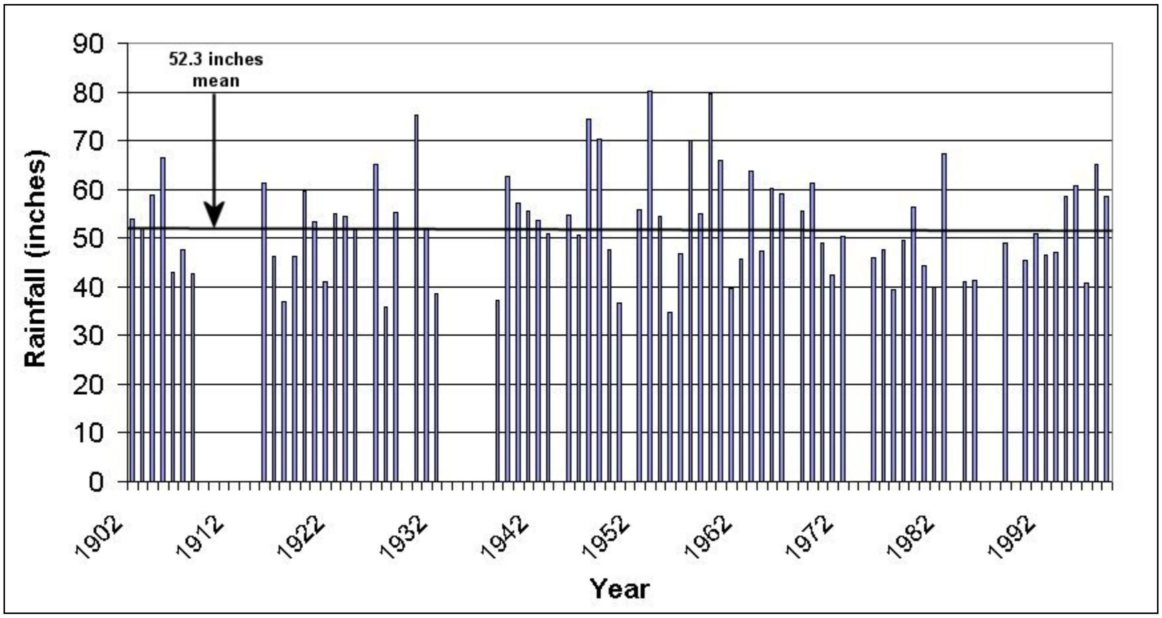


Figure 4. Total Annual Rainfall in Avon Park Station (1902–1998) (for years with complete records) (Source: SFWMD's DBHYDRO Database).

Table 1. Long-Term Mean Rainfall Data for Rainfall Stations in Highlands County (locations indicated in Figure 5) (Source: SFWMD's DBHYDRO Database).

Rainfall Station	Average Annual Rainfall (inches)	Number of Years and Period of Record	Maximum Monthly Rainfall		Minimum Monthly Rainfall		% Rain Falling in Wet Season	Primary DBKEY
			Inches	Month	Inches	Month		
Archbold	49.2	53 1929–1995	7.8	Jun	1.6	Dec	65.7	06205
Avon Park	52.3	82 1902–1995	8.3	Jun	1.7	Nov	66.2	06136
Lake Placid	49.7	50 1933–1995	8.1	Jun	1.5	Dec	65.8	06150
Sebring	45.1	26 1972–2002	7.1	Jun	1.5	Dec	63.2	05855
S-68	39.9	26 1966–1998	6.0	Aug	1.3	Dec	62.6	06066

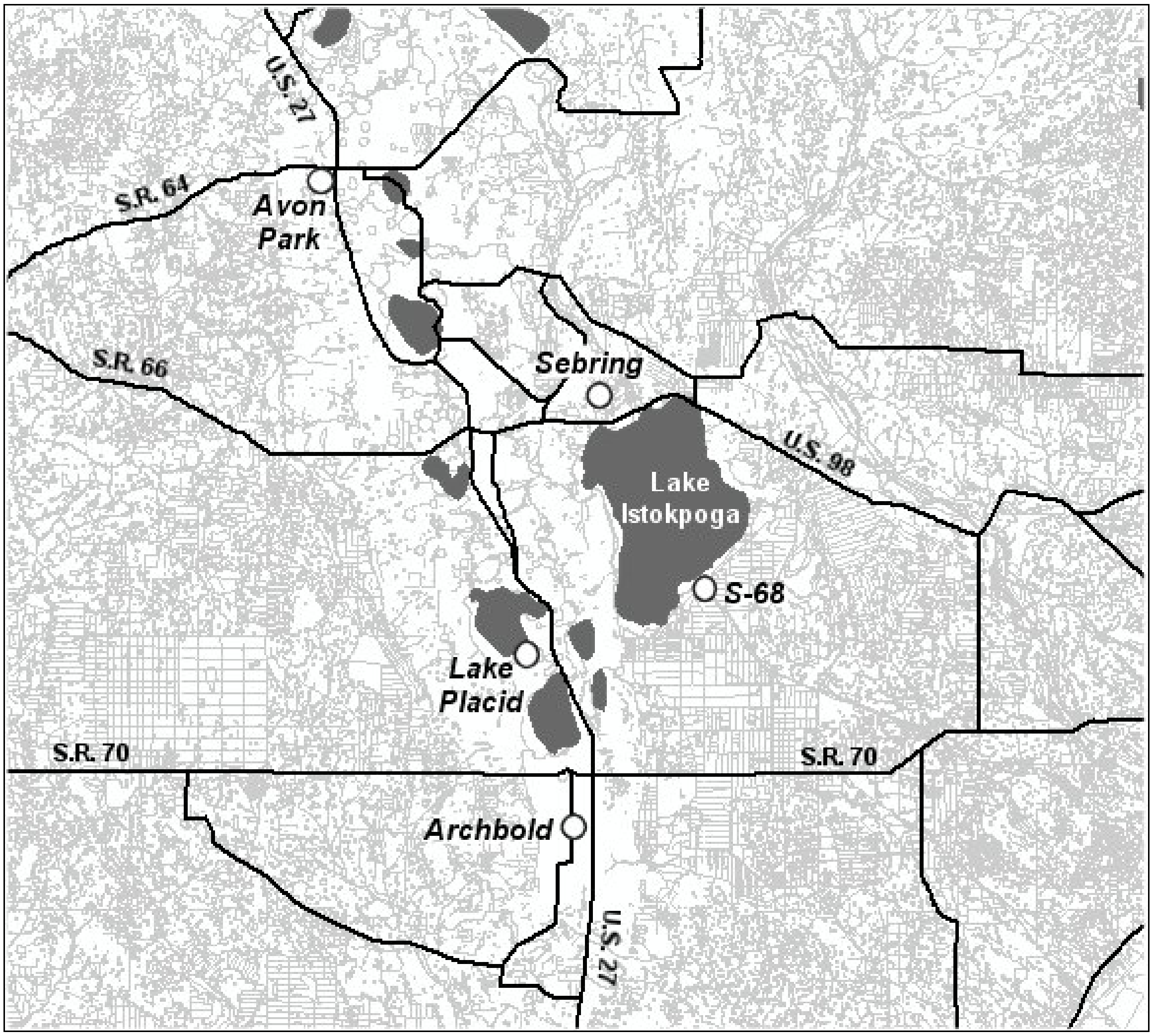


Figure 5. Rainfall Stations in the Lake Istokpoga Area (locations indicated by circles).

Review of the distribution of annual rainfall data from the Avon Park station over time shows that a variance of approximately 10 percent of the mean (± 5.23 inches) occurs about once every three years on average (36 percent of the 75-year period of record). Extreme dry and wet periods can be defined as a variance of more than 20 percent of the mean (± 10.46 inches). Based on this definition, the long-term record shows that an extreme dry or wet period occurs within the basin about once every three years. Hence, the probability of having a "wet," a "dry" or an "average" year is about the same.

Evapotranspiration (ET) is the sum of evaporation and transpiration. Like rainfall, ET is generally expressed in terms of inches of water per year. For the Lake Istokpoga area, ET returns approximately 50 inches (127 cm) of water per year to the atmosphere (Visher and Hughes 1969). The excess of average precipitation over average ET is equal to the combined amounts of average surface water runoff and average groundwater recharge.

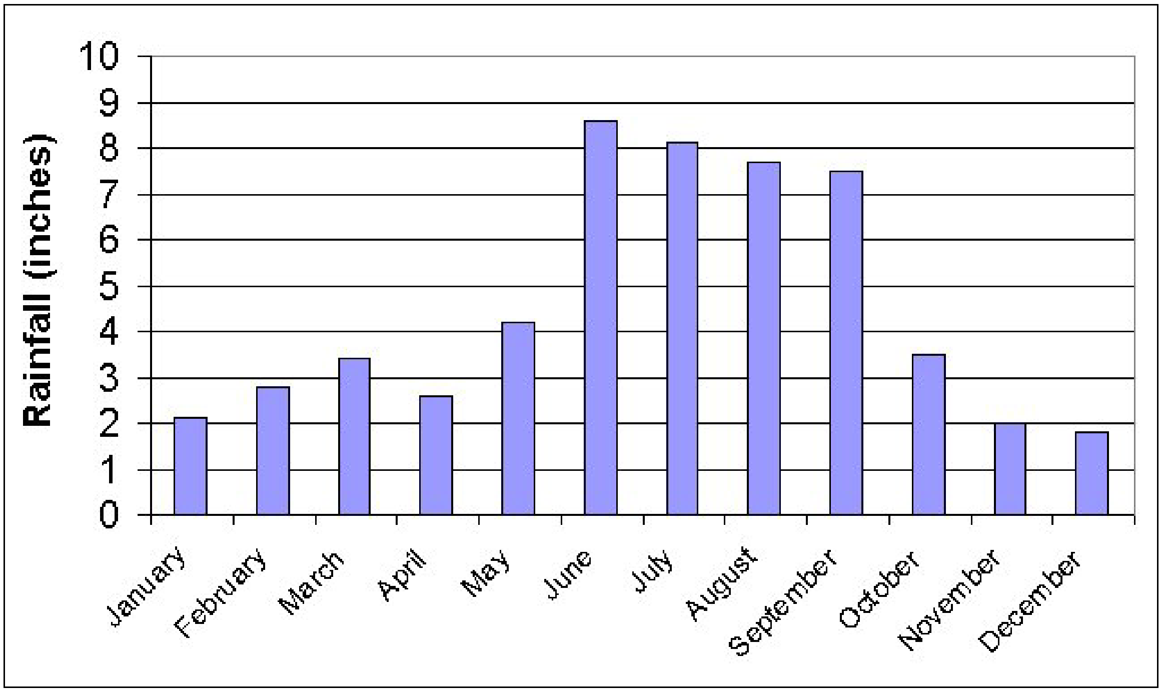


Figure 6. Average Total Monthly Rainfall, Lake Istokpoga Basin (1947–1990) (Source: Searcy 1994).

Physiography

Three major physiographical zones exist within the Lake Istokpoga region. In general, they were formed as the Florida peninsula land mass gradually emerged from a retreating sea. These three zones are described by White (1970) and Scott (1997) as the Lake Wales Ridge, the Okeechobee Plain and the Osceola Plain. The Lake Wales Ridge traverses the western edge of the historic Lake Istokpoga water body (**Figure 3**) and is bounded on the east by the Okeechobee Plain and the Osceola Plain. The Osceola Plain is found mostly northward in Osceola County and has a smaller geographic distribution than do the other two zones. Lake Istokpoga is situated on the western Okeechobee Plain adjacent to the Lake Wales Ridge.

The Lake Wales Ridge is a relic beach ridge/dune system that generally formed during the Pliocene Epoch (c. 5 million to 1.8 million years ago) and has elevations exceeding 100 feet (30 m) NGVD (Scott 1997). The crest of the ridge forms the water divide between the SFWMD and the Southwest Florida Water Management District (SWFWMD). Most of the surface water to the east of this ridge historically drained to the Kissimmee River.

The Okeechobee Plain, which formed with the Osceola Plain during the Paleogene epochs (c. 65 million to 23 million years ago), gradually slopes southward from an elevation of 30 to 40 feet (9 to 12 m) NGVD near the top of its boundary to about 20 feet (6 m) at the north shore of Lake Okeechobee (Scott 1997). The Okeechobee Plain is about 30 miles (48 km) wide and long, with little local relief.

Soils

The overlying sediments in this region are from approximately 10,000 years to 1.6 million years old (Tibbals 1990). Three dominant soil types exist in Highlands County, each with different composition and properties and each found in distinct physiographical regions: 1) very well drained pure sands are found on the high dunes of the Lake Wales Ridge, 2) flatwood soils are distributed throughout the lowlands between the ridge and the Kissimmee River, and 3) organic soils are associated with historical floodplain wetlands (SCS 1989).

The soils characteristic of the Lake Wales Ridge are deep, pure sands that are relatively sterile, very well drained to excessively drained, and having a low water retention capacity (SCS 1989). These soils are found within the undulating landscapes of Florida's central ridge, which has some of the highest elevations found in central and south Florida. These soils compose a relic dune ridge that runs generally southeast to northwest along the western half of the county, providing a stark contrast to the generally level landscape that surrounds it. Historically, xeric vegetation communities developed on these soils, but a significant area has been cleared and irrigated to support citrus and other agriculture.

Flatwood soils are the most abundant soil type found within Highlands County. These soils are composed mostly of sand and are found on level and often poorly drained sites (SCS 1989). In many cases there is standing water for up to a couple of months a year. These soils typically have a spodic layer that can influence the drainage, leaching and runoff characteristics of the site (USDA-NRCS 1999). Flatwood soils can be somewhat acidic.

The third major soil type found in Highlands County, organic soil (peats and mucks), was formed in poorly drained lowland sites in which organic matter (leaf litter, dead plant material) collected to form the usually porous and dark-colored soil (SCS 1989). These soils are hydric, meaning they are associated with wetlands normally inundated with water for a significant portion of the year (USDA-NRCS 1999). The distribution of hydric soils is a useful indicator of the historic extent of wetlands and reveals the interconnected nature of these features (**Figure 7**). The channels along the major drainage areas are evident as darker tones in the illustration and indicate that most of the wetland systems in this region were highly interconnected. Also evident is a large area to the southeast of Lake Istokpoga where a large wetland once provided periodic surface water connection to Lake Okeechobee and the Kissimmee River. A large portion of the organic soils south of Lake Istokpoga has been drained and converted to agriculture.

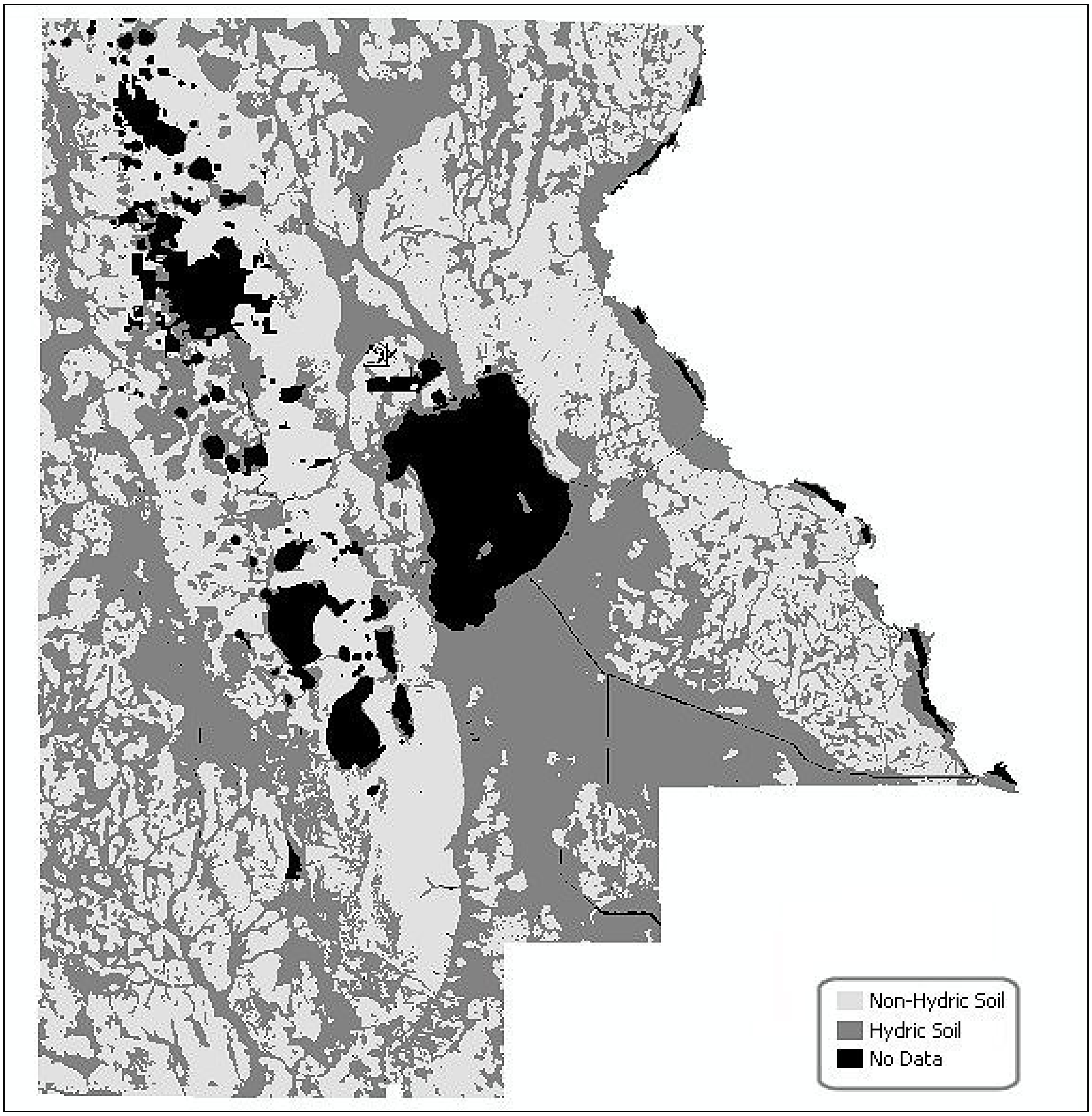


Figure 7. Map of Hydric Soils in Highlands County (Source: Zahina *et al.* 2001a).

Land Use

The existing land use in the Kissimmee Basin Planning Area is generally more urban in the north than in the south. Continued urbanization is anticipated in the north, while in the south, agriculture land use in Highlands, Glades and Okeechobee counties is projected to increase through 2020 (SFWMD 2000a). This projection reflects the general migration of the citrus industry to more southerly locations following the severe freezes of the 1980s.

Land use within Highlands County and the Lake Istokpoga watershed is predominantly agricultural (**Figure 8**). The main agricultural types are pasture lands (including rangeland, which typically is not irrigated), citrus, cropland (including row crops and some sugarcane production), and ornamental landscape plants ("other") (**Table 2**). Sugarcane, which was almost nonexistent in this basin 20 years ago, increased to roughly 3,300 acres (1,335 hectares) in 1995, and sugarcane production is expected to increase to 15,300 acres (6,192 hectares) by 2020. Urbanization is occurring primarily on the Lake Wales Ridge along U.S. Highway 27, an area just outside of the SFWMD jurisdictional boundary.

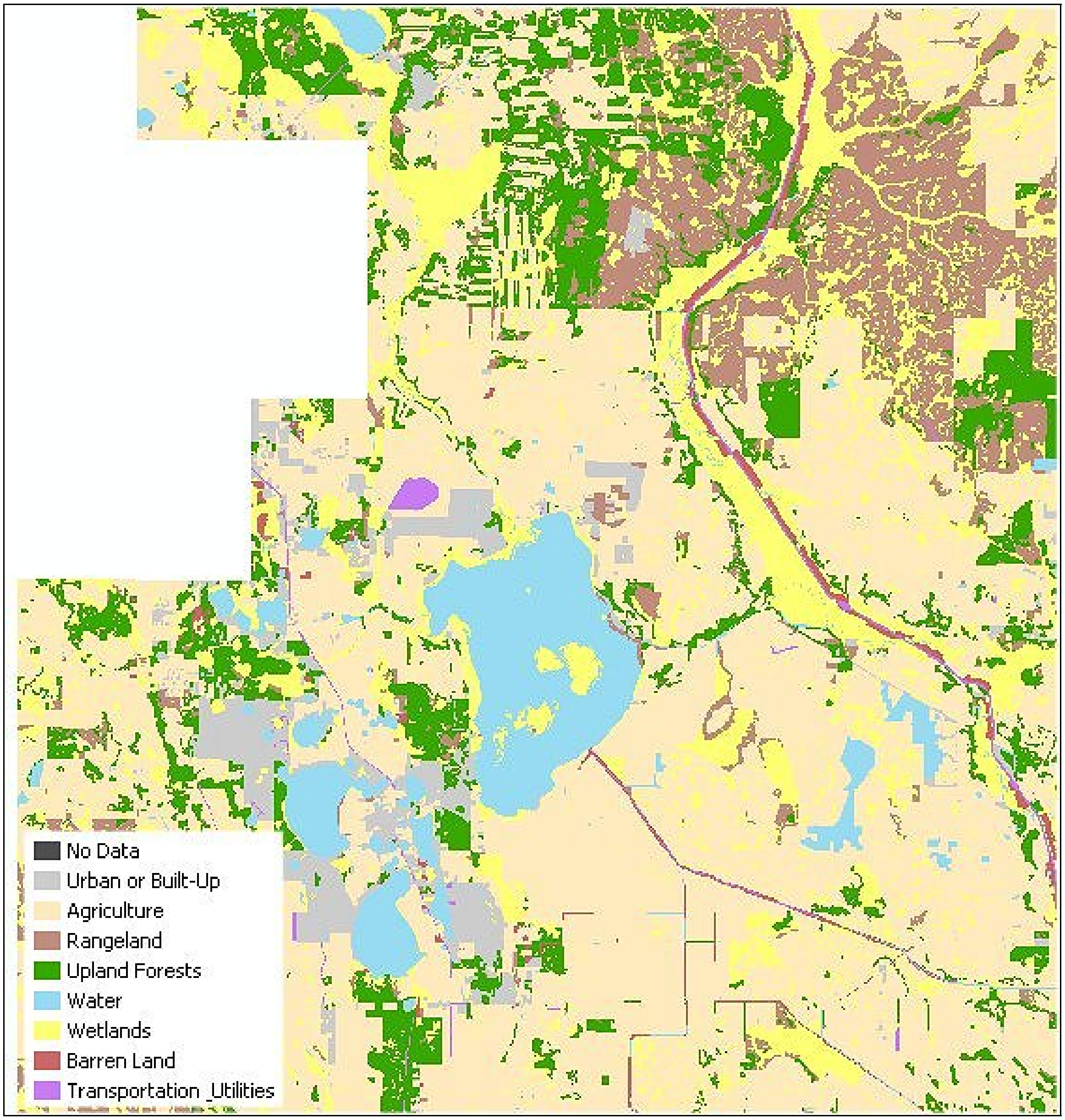


Figure 8. Major Land Use Types in the Lake Istokpoga Area (Source: FDOT 1995).

Table 2. General Land Use Types in Highlands County (Source: FDOT 1995).

Land Use Type	Area (acres)	Percentage of Area
No Data	0.4	<0.1
Urban and Built Up (Total)	31,233	5.1
Urban Housing	20,221	3.3
Commercial	984	0.2
Industrial	290	<0.1
Institutional	1,212	0.2
Recreational	672	0.1
Open Land (Urban)	7,854	1.3
Agriculture (Total)	321,949	52.7
Pastureland	231,927	38.0
Cropland	7,835	1.3
Citrus	72,453	11.9
Other Groves	1,022	0.2
Other Agriculture	8712	1.3
Rangeland	36,429	6.0
Upland Forests	71,024	11.6
Water	43,113	7.1
Wetlands (Total)	98,970	16.2
Swamp	41,260	6.8
Marsh	57,711	9.5
Barren Land	4,742	0.8
Transportation and Utilities	3,171	0.5

South of Lake Istokpoga, in Glades County, lies the Brighton Reservation, one of several Seminole Tribe reservations in Florida. Land use within the reservation includes agriculture, such as rangeland, citrus, aquaculture and sugarcane. Water for crop irrigation is supplied to these agricultural lands from Lake Istokpoga.

Hydrologic Features

Pre-Development Hydrology

SFWMD staff conducted an analysis of historical hydrologic conditions in the Lake Istokpoga watershed based on available landscape level information. The analysis examined early documents from General Land Office (GLO) surveys conducted along Lake Istokpoga (GLO 1870) and used this information to determine historical hydrologic conditions. Products of this analysis included a map of the pre-drainage landscape identifying prominent features, a determination of the extent of pre-drainage plant communities and a determination of hydrologic conditions across the landscape. The methods and results of this analysis are presented in **Appendix C**. Surface water inflows to Lake Istokpoga originated from tributaries to the north and west: Arbuckle Creek, Josephine Creek (called "Leslie Creek" in the original maps), Apthorp Creek and Cram Creek. A fringe of wetlands surrounded the lake, ranging from "boggy swamp" and "bay galls" along the western shore to sawgrass marsh from Istokpoga Creek to the south end of the lake (**Figure 9**).

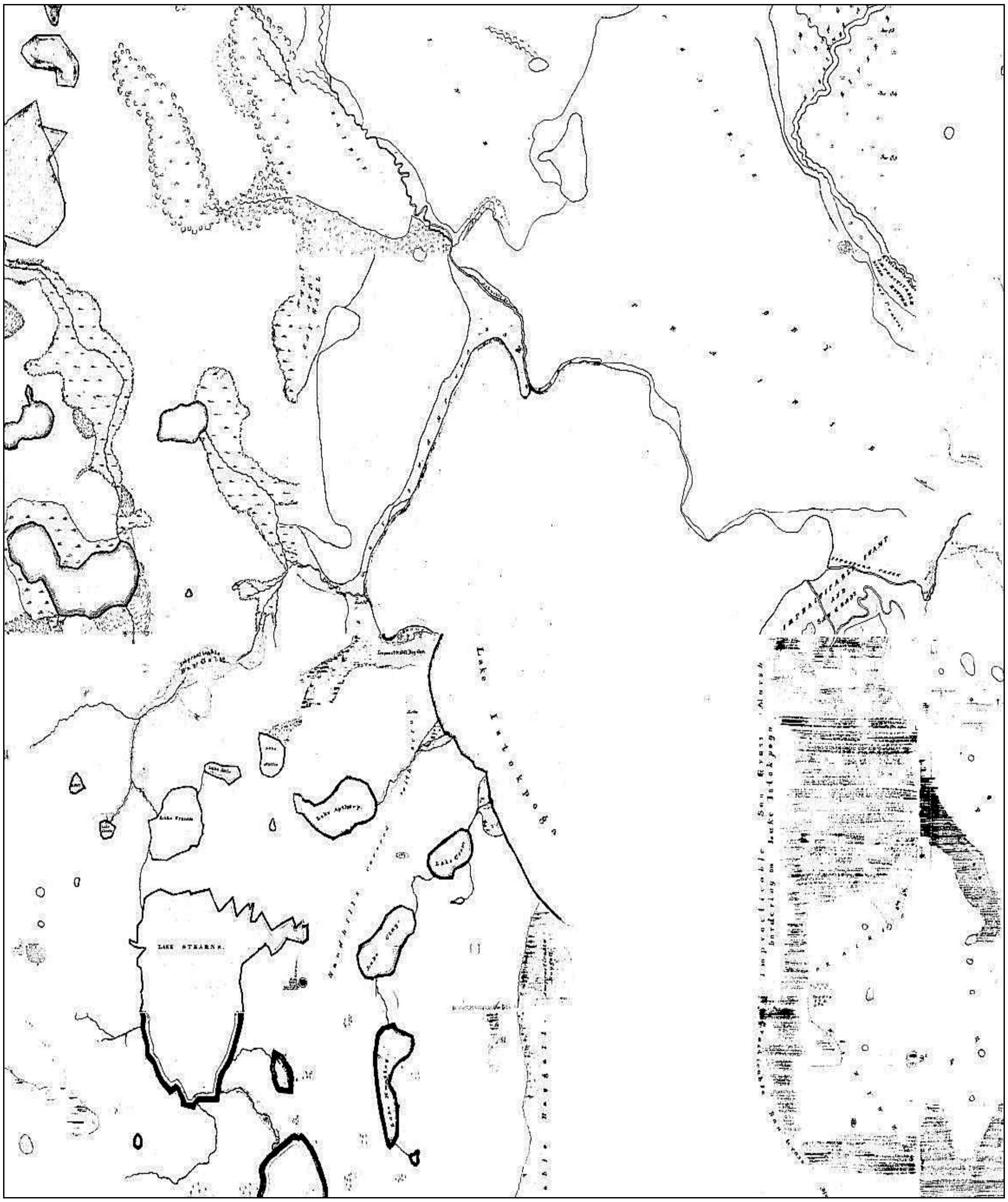


Figure 9. Nineteenth-Century Map of the Lake Istokpoga Watershed (Source: GLO 1870).

Current Hydrology

Major Aquifer Systems

Three major aquifer systems occur in Highlands County—the Surficial (SAS), the Intermediate (IAS), and the Floridan (FAS)—each with a different potential for use as a water resource (**Table 3**).

Table 3. Groundwater Systems in Highlands County (Source: SFWMD 2000a).

Hydrogeologic System	Geologic Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Undifferentiated Clastic Deposits and Tamiami Formation	40–200	Except for isolated areas with high iron and organics, produces small to moderate amounts of good-quality water. Furnishes residential self-supplied and livestock watering locally throughout the county.
Intermediate Aquifer System	Hawthorn Group	300–650	Confining unit for the Floridan Aquifer System. Isolated beds of sand and gravel yield large amount of water locally along the ridge, but they are discontinuous. Not an important source of water over most of the county.
Floridan Aquifer System	Suwannee Limestone Ocala Limestone Moody's Branch Formation Avon Park Limestone Lake City Limestone --------------------------- Oldsmar Limestone Cedar Keys Limestone	0–80 150–250 50–150 200–300 >400 ---------- >600 >670	Most important source of water in Highlands County. Productivity tends to increase with depth. Total dissolved solids, sulfates and chloride concentrations increase with depth and distance to the south from the Highlands Ridge, but water of a quality acceptable for most uses can be found as deep as the Lake City Limestone. --- Water is too highly mineralized for most purposes.

The potential freshwater yields from the SAS vary with location but are usually less than 100 gallons per minute (GPM). In Highlands County, the SAS is used to provide water for cattle lots and residential self-supply. Generally the SAS produces water of potable quality, although some isolated areas may contain high iron and organic concentrations.

The IAS contains isolated beds of sand and gravel, which yield large amounts of good-quality water. These beds are important water supply sources to localized areas along the upland ridge. Since the producing zones are discontinuous, the IAS is not considered to be an important potential source of public or large-scale agricultural water supply for Highlands County. The main use of this aquifer is for residential supply.

The FAS is the most important source of water in Highlands County. It is composed of several zones with varying productivity. Wells tapping the most productive zones of the FAS are capable of yielding from 500 to 1,500 GPM (SFWMD 2000a). Water quality varies with depth and location, becoming increasingly mineralized with depth and distance to the south. With the exception of the southeast corner of the county, water quality suitable for most uses can be found as deep as the Lake City Limestone . All major potable water systems in Highlands County withdraw from the FAS, except for the city of Lake Placid, which withdraws water from Lake Sirena. The FAS is also the primary source of water for citrus irrigation.

Relationship between Groundwater and Surface Water

The relationship between a surface water feature and the underlying groundwater system is often one of the most difficult hydrologic elements to characterize. This relationship depends in part on the hydraulic characteristics of each aquifer and the thickness and nature of the intervening soils involved. When a surface water body (such as a river, canal, wetland, or ephemeral post-rainfall pond on the soil surface) has a higher water elevation than the surrounding water table, that surface water body provides seepage into the local shallow groundwater system; conversely, when the water level of the surface water body is lower than the water table, groundwater discharge may occur into the surface water body. The rate at which this transfer occurs is dependent on the difference in these two levels and on the permeability and thickness of the separating materials.

The FAS experiences both natural and artificial recharge. Natural recharge of the FAS within the Lake Istokpoga Watershed occurs along the Lake Wales and Bombing Range ridges. These areas represent locations where the differences in surface level and FAS level are greatest and the IAS is thinnest or is breached by karst activity. Recharge areas are often evident as potentiometric highs on the surface of the FAS.

Surface Water Hydrology

Lake Istokpoga is located within the Lower Kissimmee River Basin, which also includes the tributary watersheds of the Kissimmee River between the outlet of Lake Kissimmee (S-65) and Lake Okeechobee. The general movement of surface water within the Lake Istokpoga area includes inflow from areas adjacent to the subbasins, storage within the basin and outflow to the Kissimmee River and Lake Okeechobee. In general, rainfall on the basin is directed to one of the main surface water hydrologic features and passes through Lake Istokpoga. Because of the large size and shallow dimensions of the lake, rainfall may be lost by evapotranspiration; it is also routed to the Kissimmee River, or to Lake Okeechobee, or to Indian Prairie for agricultural withdrawals. Water stored within Lake Istokpoga or in lakes within the Lake Wales Ridge may also provide groundwater recharge.

The subbasins that drain into Lake Istokpoga (**Figure 10**) cover some 920 mi^2 (2,383 km^2) and contain more than 50 lakes (Milleson 1978). Several S-65 subbasins lie along the length of the Kissimmee River and C-38 Canal, but only the S-65C subbasin may influence Lake Istokpoga since some water from the lake enters this basin via the Istokpoga Canal when lake levels are high. The C-40/C-41 subbasins receive water from Lake Istokpoga and pass it on to the Kissimmee River and Lake Okeechobee. Lake Istokpoga contributes from 10 percent to 15 percent of the total flow into Lake Okeechobee (Davis and Marshall 1975, SFWMD 2003b).

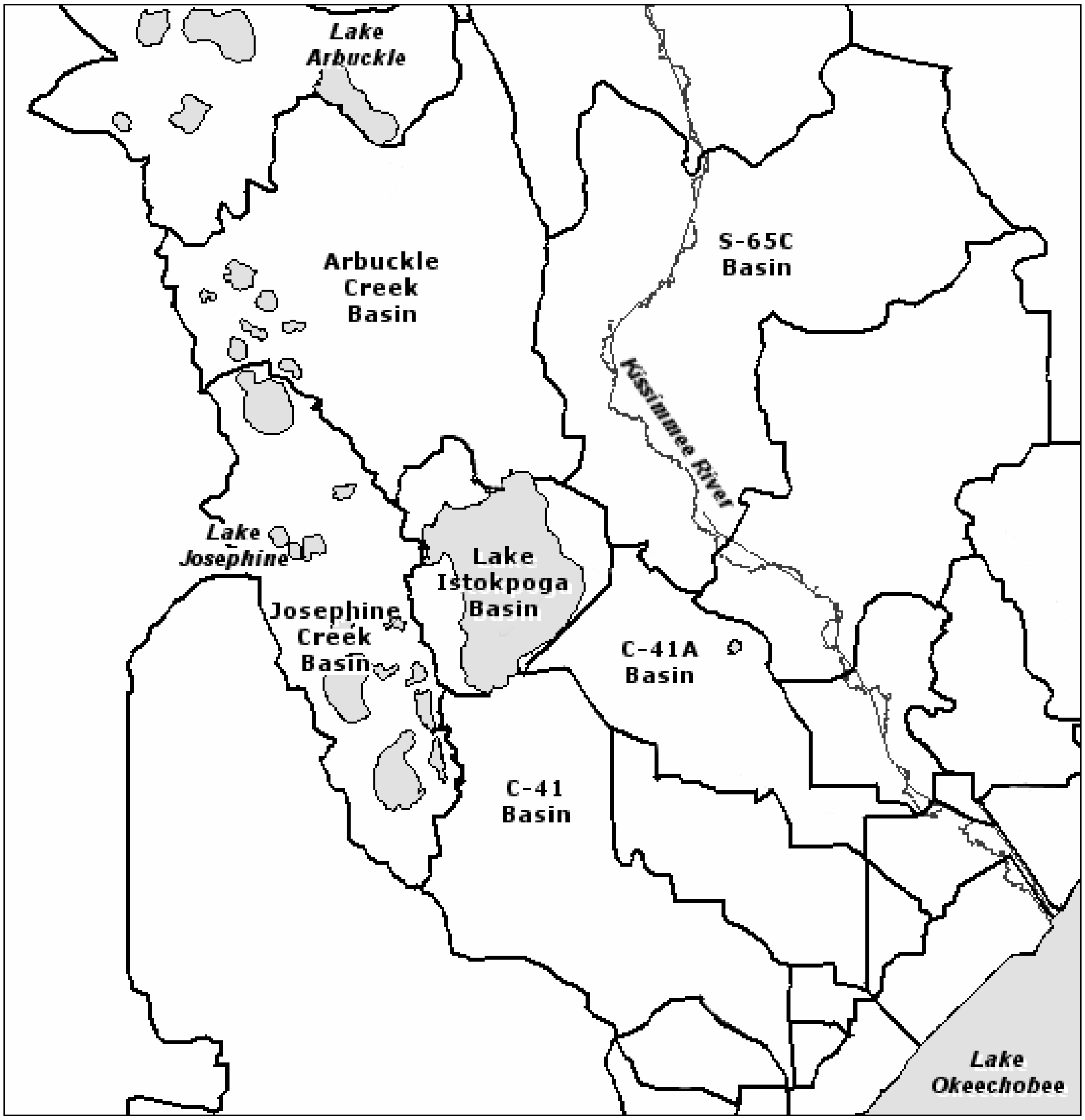
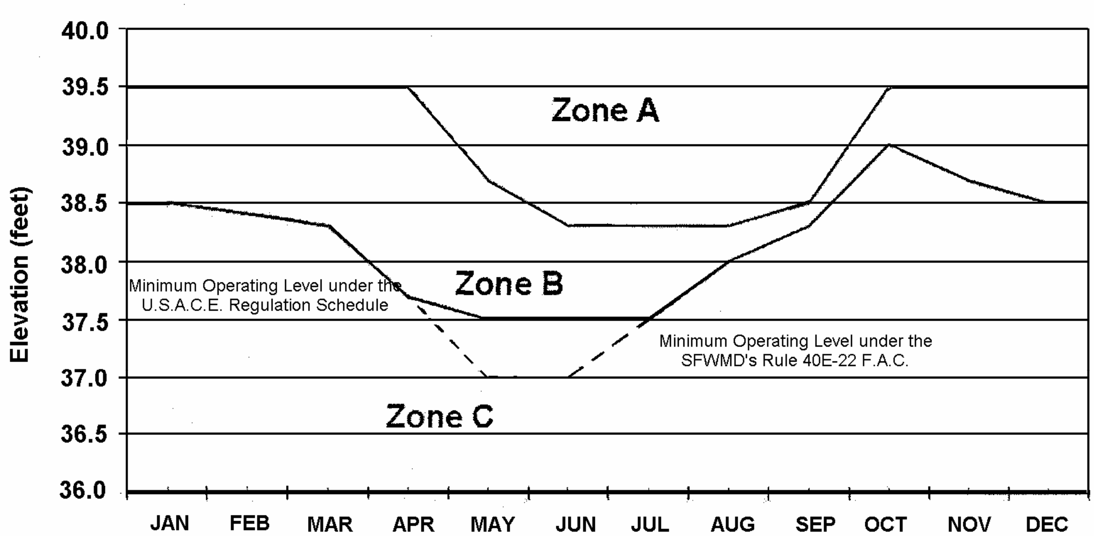


Figure 10. Watershed Basins in the Lake Istokpoga Vicinity.

There are several primary features of the Lake Istokpoga watershed that provide surface water drainage. Tributary inflows to Lake Istokpoga include Arbuckle Creek, Josephine Creek and smaller inputs provided by drainage canals from surrounding lands. Arbuckle Creek, which originates at Lake Arbuckle, drains a large agricultural tract to the north (McDiffett 1981). The Arbuckle Creek subbasin is mostly within the SFWMD jurisdiction but crosses the SFWMD/SWFWMD boundary along its western area. Josephine Creek receives water from Josephine Creek and Yellow Bluff Creek subbasins, both of which are almost entirely in the SWFWMD. Josephine Creek carries water from more than 30 lakes on the Lake Wales Ridge to Lake Istokpoga (McDiffett 1981).

The Lake Istokpoga subbasin includes the lake and lands to the west-southwest of the lake. Most of the land portion of this subbasin lies within the SWFWMD. Water levels in Lake Istokpoga are controlled by regulating outflows through water control structures (S-68 on the south end of the lake and the G-85 on Istokpoga Canal) as guided by a regulation schedule adopted by the U.S. Army Corps of Engineers (USACE) and the SFWMD (**Figure 11**).



Zone	Releases
A	Through all outlets
B	For agricultural demands only
C	No releases to be made

Figure 11. Regulation Schedule for Lake Istokpoga.

The relative position of soil types within the landscape provides an indication of historical floways and drainage features that otherwise would not be apparent (Zahina *et al.* 2001a). A map of natural soils landscape positions within Highlands County (**Figure 12**) shows several prominent features, including the Arbuckle Creek floodplain to the north of the lake and the lowlands to the south that formed a wet-season flowway to Indian Prairie, Lake Okeechobee and the Kissimmee River, an area now crossed with numerous drainage canals and converted to agriculture.

Lake Istokpoga

Lake Istokpoga (27° 23 N, 81° 17 W) is the fifth-largest natural lake in Florida. The lake area is approximately 27,692 acres (11,207 hectares), a figure that varies considerably with surface water elevation. In addition to supporting a vast variety of fish and wildlife resources, the lake also acts as a source of water supply to the Indian Prairie basin via the C-41/C-41A canal system, which drains to the Kissimmee River and Lake Okeechobee. Recreational boating, fishing and hunting are the primary lake activities.

Using a depth contour (bathymetric) map of Lake Istokpoga (**Figure 13**), the stage-to-area and stage-to-volume relationships were determined (**Figure 14**). The stage-to-area relationship indicates an asymptotic relationship between lake stage and lake surface area, with a leveling off to the 40 feet (12.2 m) contour. Surface area is approximately 24,508 acres (9,918 hectares) at a surface water level of 36.5 feet (11.1 m) NGVD and increases to 27,809 acres (11,254 hectares) at 39.5 feet (12.0 m) NGVD. The relationship between lake stage and volume is somewhat more linear as it increases from approximately 81,806 acre-ft (101 million m^3) at a water level of 36.5 feet (11.1 m) NGVD to 161,343 acre-ft (199 million m^3) at 39.5 feet (12.0 m) NGVD.

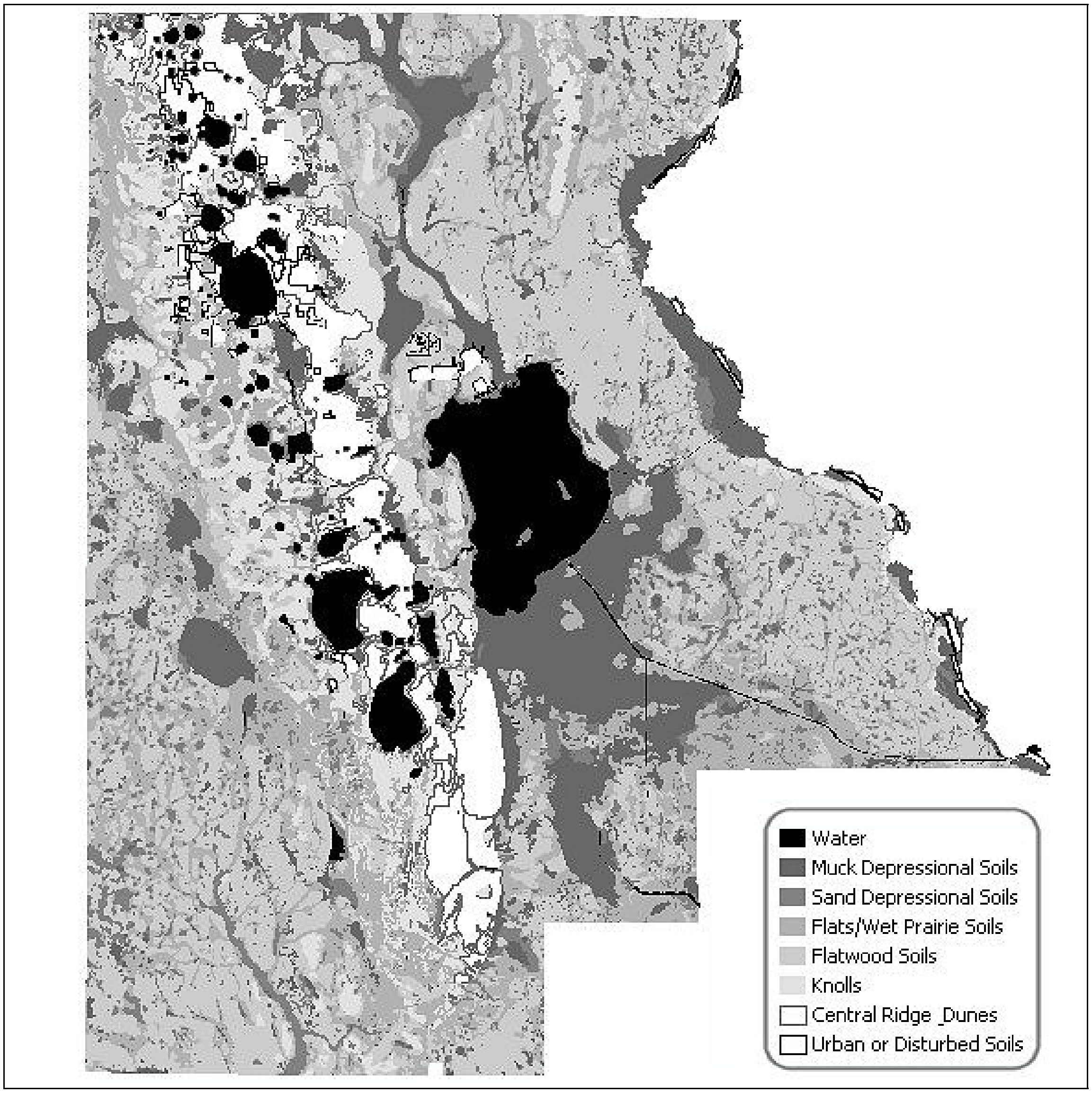


Figure 12. Natural Soil Landscape Positions Map of Highlands County (darker tones indicate soil types that are lower in the landscape, revealing a general topographical gradient) (Source: Zahina *et al.* 2001a).

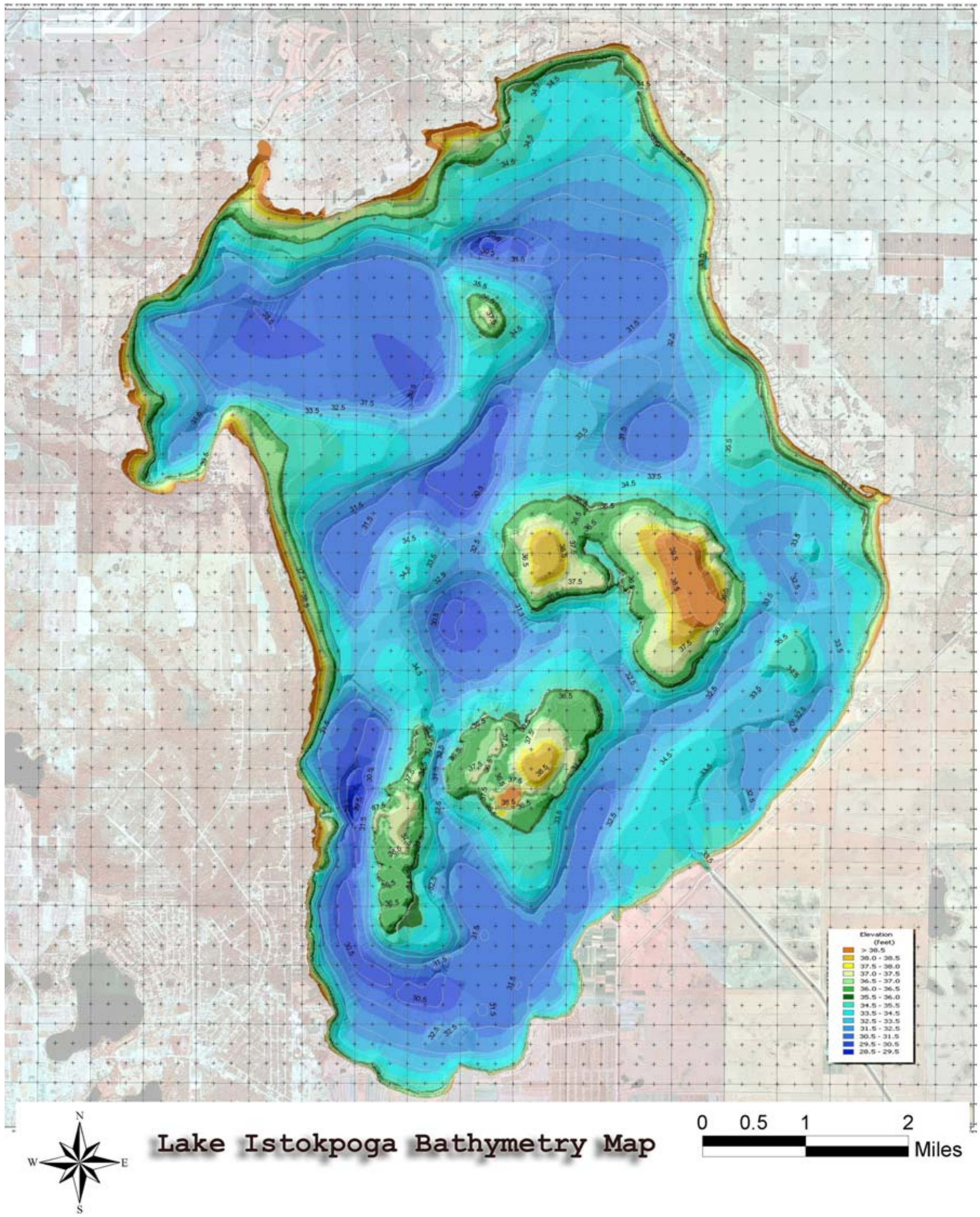


Figure 13. Lake Istokpoga Bathymetric Map (Source: ReMetrix 2003).

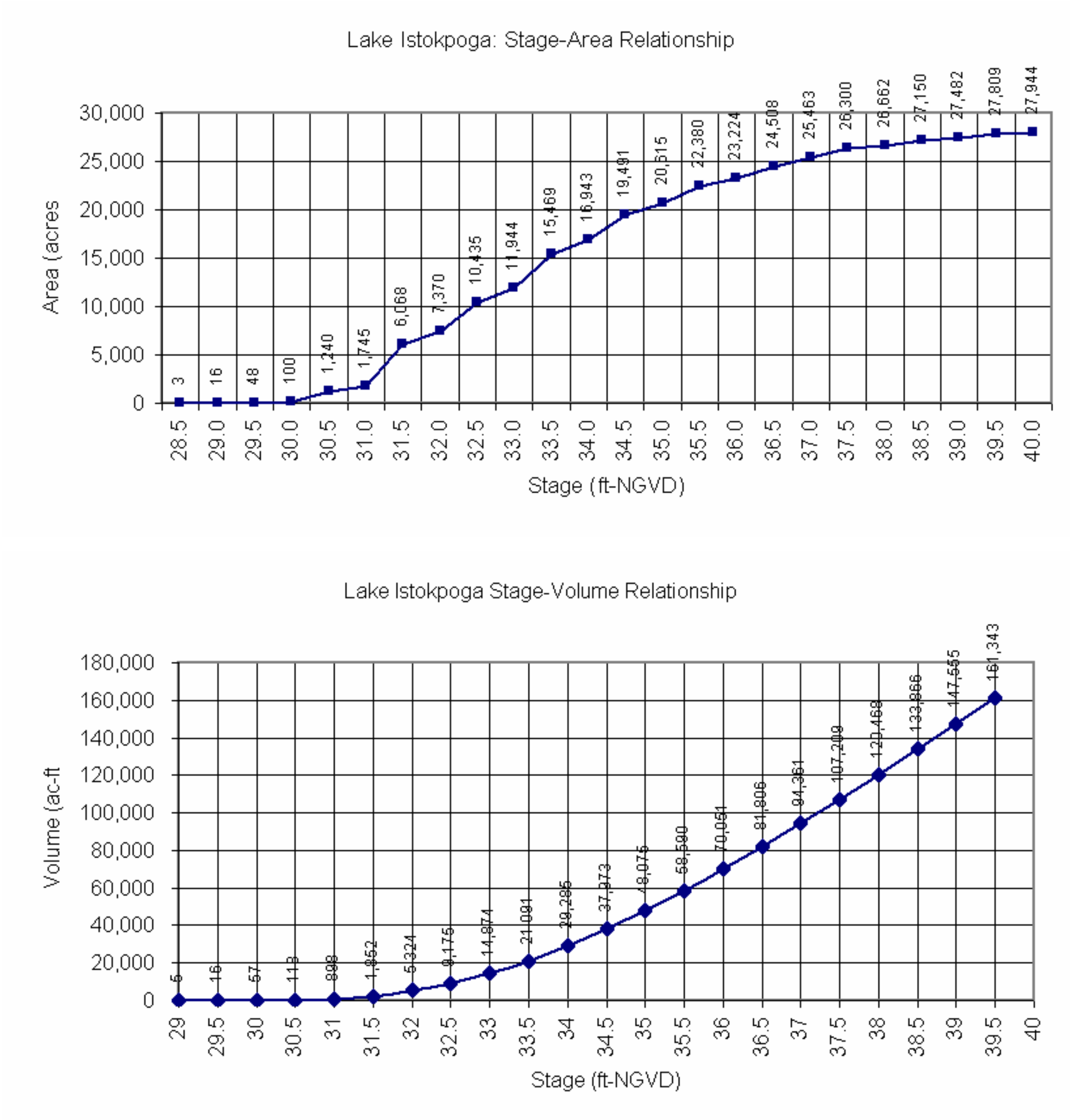


Figure 14. Stage vs. Area and Stage vs. Volume for Lake Istokpoga (Source: derived from bathymetry developed by ReMetrix 2003).

Lake Istokpoga Hydrologic Budget

A simplified water budget was calculated for Lake Istokpoga from existing data sources and is presented in **Appendix D**. **Figure 15** provides a graphic summary of the water budget for Lake Istokpoga for an 11-year period of record (1990 to 2000) based on a water year (water year = May through April). Long–term measured flow data from Arbuckle Creek are available (1939–2004), but flow data from Josephine Creek may underestimate total inputs as flow measurements are collected a considerable distance upstream of Lake Istokpoga and do not include some potential contributions from groundwater and other surface flows. Evapotranspiration (ET) constitutes the least-known component of the water budget, and a standard annual loss of 50 inches (Visher and Hughes 1969) was used. A better understanding of the temporal and spatial variations in rainfall and ET over the watershed is needed in order to improve this preliminary estimate.

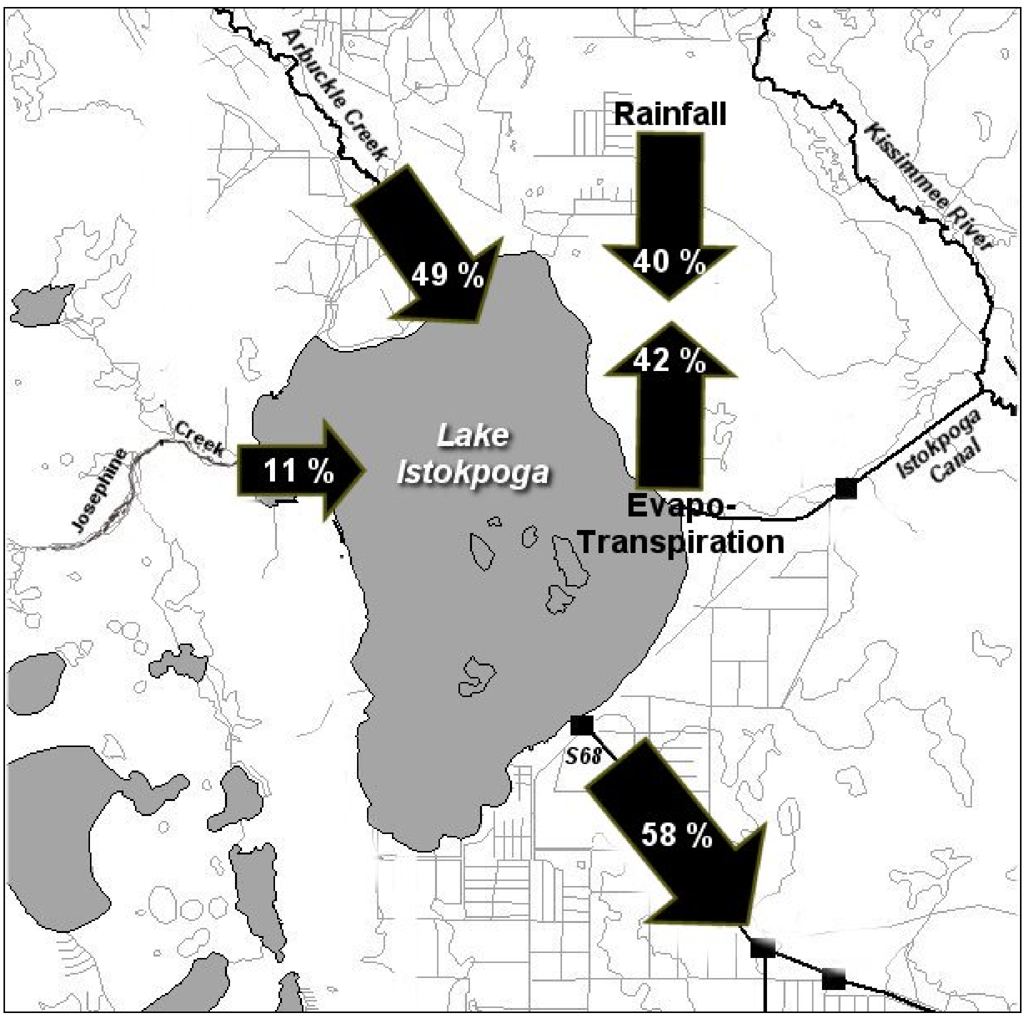


Figure 15. Major Sources of Water Inputs and Water Losses of Lake Istokpoga.

Tributary inflows (Arbuckle and Josephine creeks) are the largest source of water for the lake, representing an average of 60 percent (approximately 218,000 acre-ft) of all measured water entering Lake Istokpoga. Additional water is contributed by unmeasured flows entering from drainage ditches, direct surface water runoff and groundwater seepage/inflows from areas surrounding the lake. Walker and Havens (2003) have estimated that up to 17 percent of total inflow to the lake may be from ungauged sources. Rainfall accounts for most of the remaining input.

The primary outflow from Lake Istokpoga is through the S-68 to the south, accounting for 58 percent (approximately 233,000 acre-ft) of water losses. Evapotranspiration returns an estimated 118,000 acre-ft of water to the atmosphere each year (42 percent of water losses) (Walker and Havens 2003). Other unmeasured water losses occur through the Istokpoga Canal and may also occur through groundwater. A comparison of seasonal water budgets indicates that a surplus of water exists during the wet season and a deficit of water during the dry season (see **Appendix D**).

Consumptive use types that depend directly on Lake Istokpoga include self-supplied residential (groundwater) withdrawals and releases to agricultural users in the Indian Prairie through the S-68. Self-supplied residential withdrawals are not considered significant groundwater and surface water users within the Lake Istokpoga area, but agricultural withdrawals can be significant (**Table D-5, Appendix D; Table 4**). An analysis of permitted consumptive use withdrawals and of the actual pumpages reported for selected permits was conducted (**Appendix D**). The total annual maximum volume of water permitted to flow to the Indian Prairie is 126,380 acre-ft, with actual usage typically less than one-third of the amount of water permitted (**Table 4**). A comparison of the maximum annual allocation for all permits for the Indian Prairie with the volume of water discharged to it through the S-68 indicates that there is typically enough water to meet maximum demands in most years, although that may not be the case in below-average rainfall years.

Table 4. Annual Pumpages Reported for Indian Prairie Users (1998–2003) (units are water volume expressed as acre-ft.).

Permit	Annual Permitted	Average Actual Pumpage	Percentage Used
19-W	49,625	15,021	30
332-W	3,288	682	21
49-W	5,670	1,765	31
117-W	1,707	278	16
23-W	3,684	980	27
120-W	5,331	273	5
129-W	5,988	1,140	19

Drainage and Hydrologic Alteration of Lake Istokpoga

Vegetation communities surrounding Lake Istokpoga originally developed in response to a natural hydrologic cycle that maintained these systems for hundreds of years. Changes to the lake's hydrologic regime in recent decades have resulted in impacts to this important resource.

Istokpoga Creek was channelized into Istokpoga Canal and the G-85 Structure was constructed (1948–1949) to control discharge from the lake to the Kissimmee River in order to help prevent periodic high water from harming adjacent agricultural and residential development within and outside the lake's floodplain. In 1962, natural high and low stages were eliminated from the lake as a result of construction of the S-68 Structure, which drains Istokpoga into the C-41A Canal. These flood control projects reduced the lake's average annual fluctuations from 6 feet to less than 2 feet (**Figure 16**). The annual regulation schedule requires lowering the lake during summer to provide storage for seasonal high rainfall and tropical weather events. Yearly high levels are allowed during the winter when flooding potential is low. This schedule is opposite from the natural annual cycle, in which the lake historically rose to its highest level in the summer and receded during drier winter months.

Lake Istokpoga Regulation Schedule

The S-68 discharges water from Lake Istokpoga southwest into the C-41A Canal, then into associated downstream canals where it becomes available for consumptive use or is discharged to the Kissimmee River or Lake Okeechobee. Water releases from the S-68 have followed an operational schedule since the structure's 1962 construction. This operational schedule was reexamined in the early 1990s as part of a modeling study funded by the U.S. Army Corps of Engineers (Searcy 1994), and water releases from the lake are now made in accordance with a regulation schedule (**Figure 11**) that has been adopted as part of the SFWMD's water shortage rule (40E-22, F.A.C.). This regulation schedule recognizes three water level bands or management zones that vary by month and season, each with its own water release guidelines: when Istokpoga's water levels are within the Zone A band, water is discharged through all controlled lake outlets; when water levels are within Zone B, water discharge is discretionary and may be made for agricultural demands; when lake levels fall into Zone C, no releases are to be made.

The final *Central and Southern Florida Flood Control Project Comprehensive Review Study* (Restudy) (USACE and SFWMD 1999)—submitted to Congress in April 1999—recommended that the SFWMD and the USACE review the current regulation schedule for Lake Istokpoga and reexamine the basin with the idea of enhancing fish and wildlife benefits and developing a long-term comprehensive management plan. This project has since been combined with the CERP Lake Okeechobee Watershed Project.

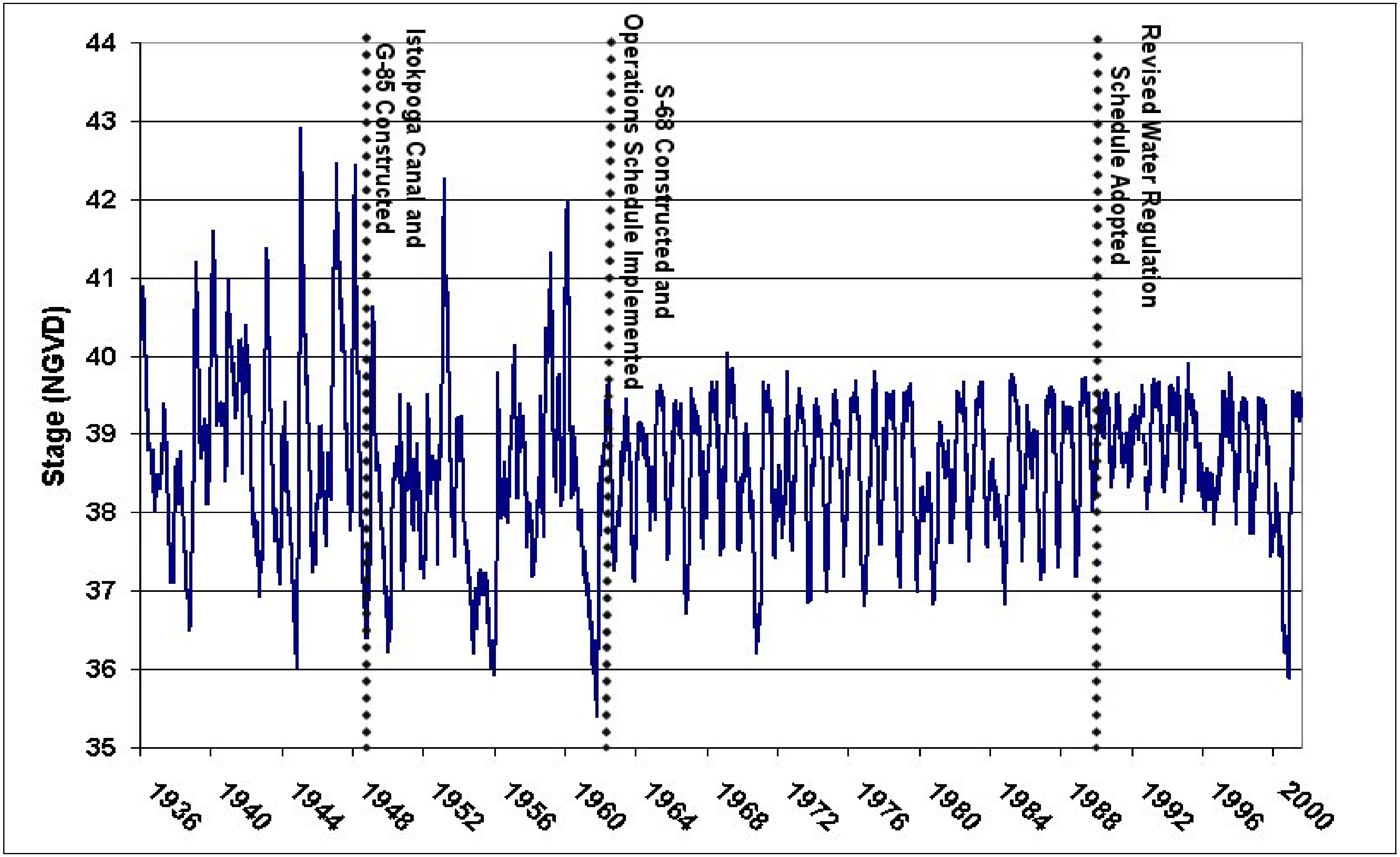


Figure 16. Water Level Stage on Lake Istokpoga at the S-68 Structure Site (1936–2000) (Source Data: SFWMD's DBHYDRO Database).

BIOLOGICAL RESOURCES

Major Vegetation Communities

The current (1995) distribution of major plant communities in Highlands County (**Figure 8)** can be compared with the historical distribution of major plant communities (pre-development) inferred from soil characteristics (**Figure 17**). Pine flatwoods, remnants of which persist today in their natural state and as pastureland and rangeland, historically covered most of the county. Xeric communities, in turn, are associated generally with the Lake Wales Ridge, which runs from southeast to northwest in the county. Wetlands cover more than 15 percent of Highlands County (**Table 2**), or almost 99,000 acres, primarily along the Kissimmee River and Arbuckle Creek floodplains. Within the county's wetlands, marshland associated with riverine habitats predominates, and swampland is also well represented.

Marshland and swampland are found along the Lake Istokpoga shoreline, as well as shrub wetlands and wet prairies(**Figure 18**). Littoral zone marsh is the most abundant Istokpoga wetland type (**Table 5**), encompassing more than 3,400 acres (1,400 ha) and containing large amounts of emergent vegetation and cattail. Forested wetlands (swamps) are also a dominant feature along Lake Istokpoga, covering about 1,700 acres (685 ha) and including bald cypress and mixed hardwoods. Wetland types of minor extent include wet prairie as well as shrub wetland, which usually contain wax myrtle or willow. These diverse ecological communities represent important sources of wildlife habitat.

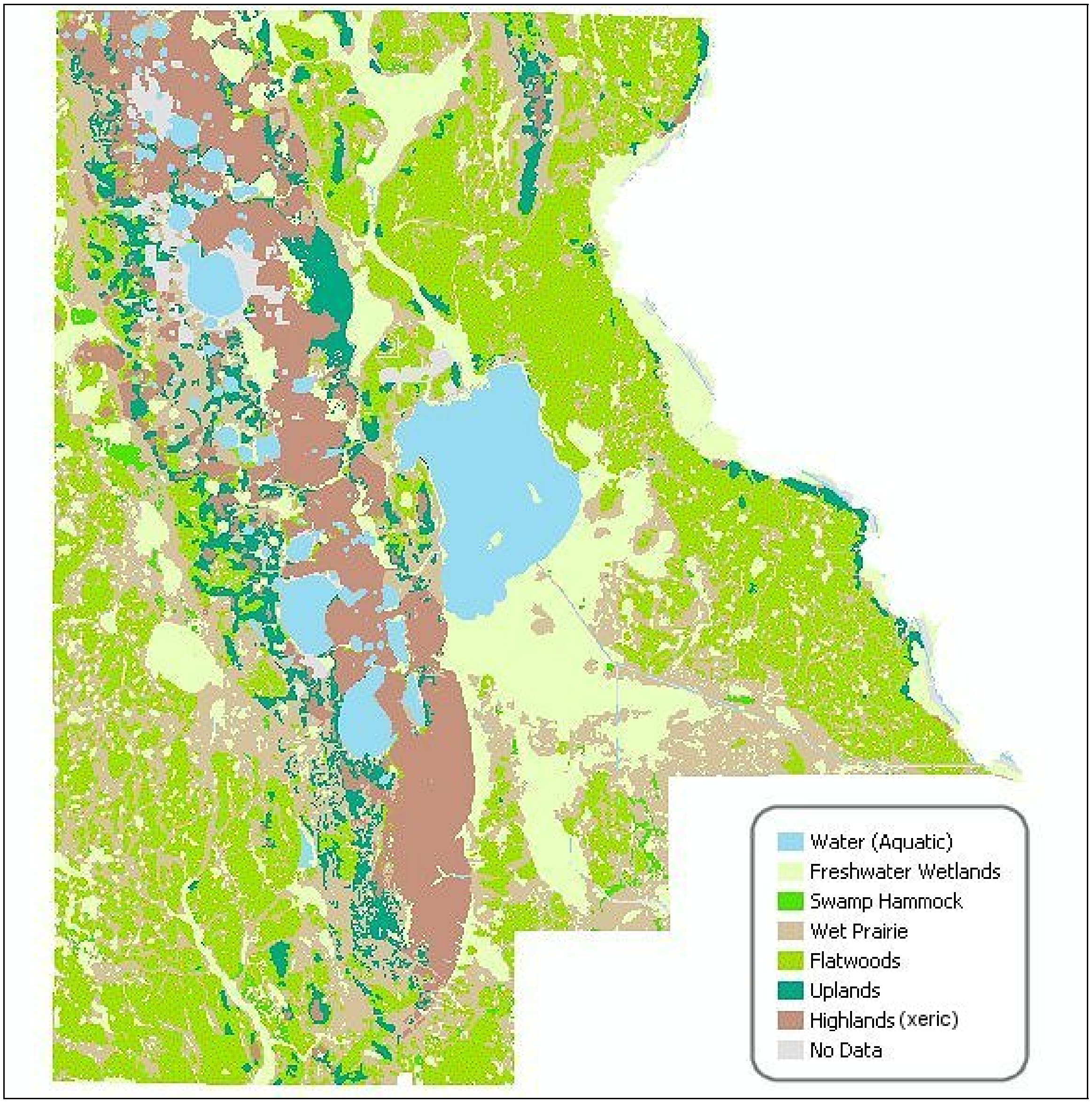


Figure 17. Historic Plant Communities in Highlands County based on Soil Types (Source: Zahina *et al.* 2001a).

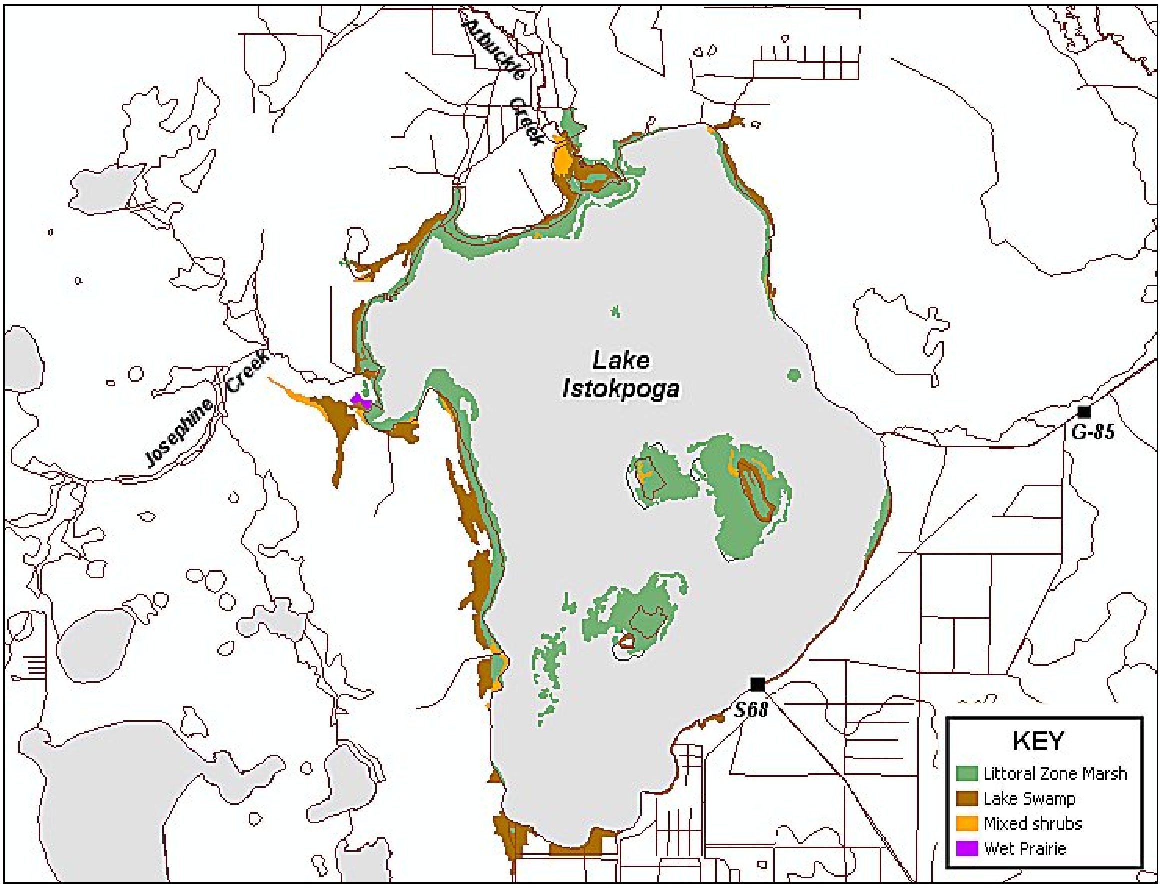


Figure 18. Lake Istokpoga Wetlands (Source Data: FDOT 1995).

Table 5. Floodplain, Littoral and Fringing Wetlands along Lake Istokpoga (Source Data: FDOT 1995).

Wetland Type	Area (acres)	Area (hectares)	Percentage of Total Wetland Area
Littoral Zone Marsh All vegetated nonforested wetlands, including emergent marsh, sloughs and cattails	3,480	1,411	64
Lake Swamp All forested wetlands, including cypress, mixed and hardwood-dominated swamps	1,700	686	31
Mixed Shrubs Wetlands dominated by shrubby vegetation	260	105	5
Wet Prairie Seasonally inundated wetlands dominated by grasses	20	8	less than 1
Total	5,460	2,210	100

Submerged Aquatic Vegetation

Common aquatic plants present in Lake Istokpoga include cattail (*Typha latifolia*), giant bulrush (*Scirpus californicus*), duck potato (*Sagittaria lancifolia*), pickerel weed (*Pontederia cordata*), spatterdock (*Nuphar luteum*), Illinois pondweed (*Potamogeton illinoensis*), eelgrass (*Vallisneria americana*) and bladderwort (*Utricularia sp.*) (Alam *et al.* 1996). Aquatic vegetation within Lake Istokpoga has changed significantly over the past several decades. Stabilized lake water levels have contributed to the expansion of invasive and nonnative aquatic plants. Hydrilla (*Hydrilla verticillata*) was introduced into the lake in the early 1980s; over the past decade hydrilla coverage on the lake has fluctuated, peaking in 1996–1997, when it covered approximately 94 percent (26,000 acres) of the lake's surface (**Figure 19**). Vegetation control projects—including lake level drawdown, sediment scraping, chemical treatment, mechanical harvesting and the introduction of triploid grass carp (*Ctenopharyngodon idella*)—have been somewhat successful in controlling some undesirable aquatic weeds but have not eliminated them altogether (VanArman *et al.* 1993, FWC 2000). A large-scale vegetation management and treatment project in 2001 reduced Istokpoga's hydrilla coverage from an estimated 19,384 acres (70% coverage) to an estimated 475 acres (2% coverage) (**Figure 19**).

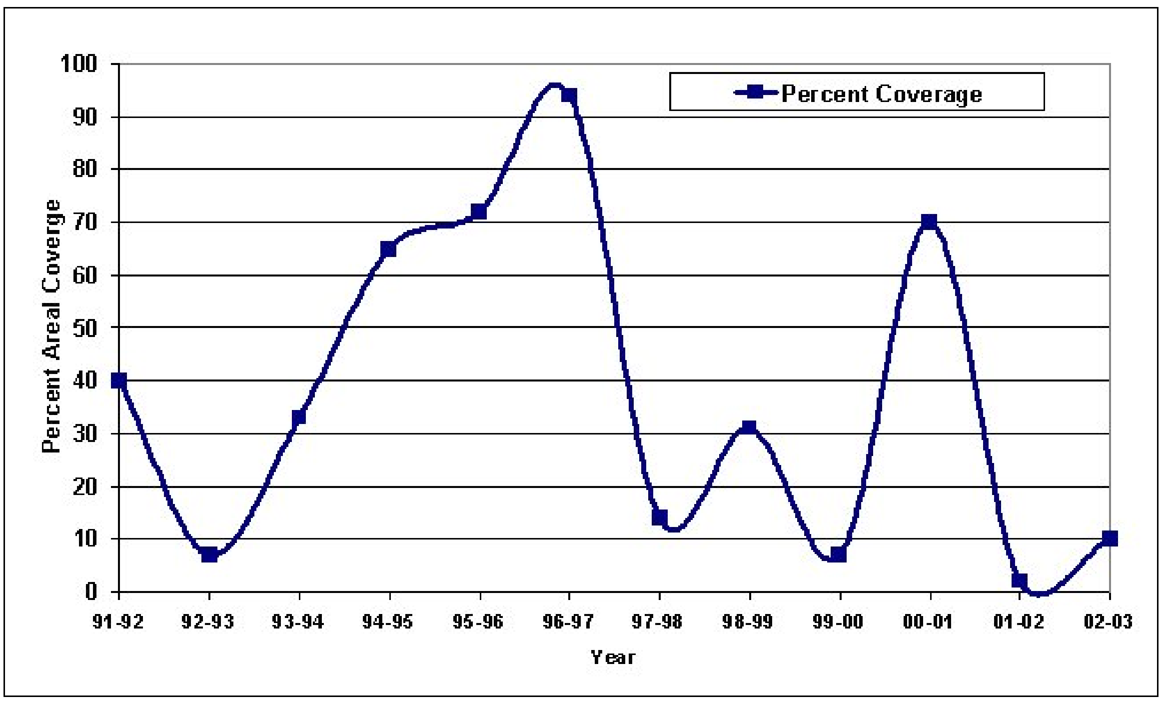


Figure 19. Hydrilla Coverage on Lake Istokpoga 1991–2003 (Source: FWC 2002).

Littoral Zone Vegetation

A map of littoral zone vegetation communities is shown in **Figure 18**. As with submerged aquatic vegetation, littoral zone vegetation has undergone a transformation over the past several decades. Milleson (1978) documented an increase in littoral vegetation from 2,177 acres (881 hectares) in 1944 to 3,198 acres (1,294 hectares) in 1975, believed to be caused by persistently lower lake levels and a reduction of the natural frequency of seasonal drying and inundation. Once dominated by duck potato and bulrush, the shoreline now supports dense cattail or pickerel weed. From 1977 to 1991, cattail coverage had increased by 87 percent (Alam *et al.* 1996).

Hydrologic alterations (the lack of adequate seasonal water level fluctuations and the unnatural reversal of seasonal high and low water levels) and increases in nutrient inputs from tributaries have also promoted the development and expansion of floating mats of water hyacinths (*Eichhornia crassipes*) and other species common to tussock communities (O'Dell *et al.* 1995, Alam *et al.* 1996). Tussocks are thick clumps of growing vegetation, usually coarse grass or sedge and other plants, generally located in shallow water (less than two feet) with expansion occurring out from the shallow fringe of the lake. In 2000, before a major tussock removal project was implemented, the rate of tussock expansion was estimated at approximately 100 acres every year (FWC 2000). Vegetation management projects have focused on reduction of tussock formation and on removal of undesirable littoral zone vegetation and replanting with desirable native species.

Development and expansion of tussocks have negative impacts on Lake Istokpoga in several ways. Because of their rapid growth characteristics, these plants deposit organic matter that forms a substrate for future tussock formation. This organic muck, which averages 1.5 feet in depth, is devoid of dissolved oxygen and is not capable of aerobic decomposition. Eventually tussock mats form a substrate for more-terrestrial plant species, and the lake's shallow littoral zone becomes transformed into a marsh. Tussock expansion generally leads to loss of native littoral zone plants and a reduction of sandy benthic substrate. Loss of these native plant communities has the potential to impact fish spawning and foraging and to reduce waterfowl feeding areas and juvenile-fish habitat. Dense tussocks, which can extend as far as 400 yards into the lake, impact public access and navigation, degrade aesthetics and devalue lakeside property. Although some animals exploit tussocks for nesting and protective areas, the overall ecologic and economic impacts to Lake Istokpoga are strongly negative (FWC 2000).

Fringing Swamp Vegetation

Swamp habitat along the shoreline of Lake Istokpoga (**Figure 18**) is currently less abundant than in the past. Lake Istokpoga was once surrounded by extensive bald cypress swamp (one of the largest in the interior of Florida) and by mixed swamp forest dominated by several additional tree species, located mainly to the south and east of the lake (Brandt 1924). Those forests were almost entirely cleared by timber operations, canal construction and agricultural development (McNair *et al.* 2001), primarily from the late 1940s to the early 1960s, with smaller areas cleared as recently as the 1970s. The fringing swamp dominated by bald cypress (*Taxodium distichum*) and the mixed swamp have remained mostly unchanged in area since the 1970s. But with the stabilization of water levels over the past several decades, the swamp community is not reproductive (FWC 2000). Unless a suitable water regime is restored to the lake, the swamp community will eventually be replaced with other habitat types.

Upland Vegetation Communities

Upland communities account for approximately 12 percent (75,766 acres) of the Highlands County land area (**Table 2**). These are mostly forested lands covered with pine flatwoods, oak hammock and scrub (oak and pine). Much of the historic extent of this community type has been converted to rangeland and pasturelands. Xeric communities are associated with the well-drained dunes of the Lake Wales Ridge, which support a number of unique and federally protected species (SCS 1980).

Major Wildlife Communities

Bird Communities

The Lake Istokpoga area and associated wetlands support a large number of bird species. A comprehensive list of bird species documented in Highlands County has been compiled from a number of sources (**Table E-1**, **Appendix E**). At least 75 species are believed to be breeding in Highlands County, 26 of which are associated with wetland or lake habitats (**Table E-2**, **Appendix E**). Many bird species in Highlands County, such as the Florida scrub jay (*Aphelocoma coerulescens),* depend on a specific type of habitat for feeding and/or successful reproduction. Many other of the county's bird species require more than one habitat type in order to feed, nest and rear chicks to adulthood successfully (Ehrlich *et al.* 1988). Wading birds, for instance, typically forage for food in marshes or in shallow open-water areas but roost and nest in trees (Bird 1999). Of the 26 known species of birds associated with Lake Istokpoga habitats, 21 use more than one habitat type (**Table E-2**, **Appendix E**). A disturbance, whether natural or man-induced, can have a significant impact on birds' population distribution and reproductive success.

Lake Istokpoga contains three major types of habitats important for a variety of bird species—namely, aquatic habitat, littoral zone marsh, and swamp. **Figure 18** shows the distribution of these habitat types around Lake Istokpoga. The *aquatic habitats* are open-water areas that may contain submerged vegetation; aquatic habitats also contain a wide variety of fish and numerous species of invertebrates that are important prey for birds. The *littoral zone marsh* is found on the broad flats surrounding the lake and may be used for foraging, shelter and nesting sites. Fringing lake *swamps* are found mostly along the southern area of the lake behind the littoral zone, and swamp trees can be important roosting and nesting sites for wading birds and many raptors. A significant wading bird rookery is found on the islands in the south central area of the lake (FWC 2000). Bald eagles and very high numbers of osprey nest in the fringing swamp (Stewart 2001).

Migratory birds use the lake during the winter, and waterfowl such as ducks and coots are common seasonal inhabitants.

Fish Communities

The fish communities within Lake Istokpoga are important components of the lake's ecologic community and the local economy. Small fish are important food sources for wading birds and raptors, supporting one of the largest known concentrations of osprey ever documented (Stewart 2001). Fishing and associated activities support a significant recreation-based economy, ranging from sales of fishing-related equipment (from bait to boats) to fishing guide services and year-round fishing camps. The local ecologic community and economy both rely on the maintenance of a healthy and productive fish community.

Fish surveys conducted by the Florida Fish and Wildlife Conservation Commission (FWC) during 2002 recorded 38 fish species from Lake Istokpoga (**Table 6**). Most of the species depend on the littoral marsh for habitat. Largemouth bass (*Micropertus salmoides*), black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*) and redear sunfish (*Lepomis microlophus*) are the four most popular species sought by recreational anglers on Lake Istokpoga and are the primary species managed by the FWC. More-detailed descriptions of bass and crappie population surveys are provided below. With the exception of redear sunfish, the sport fish population of Lake Istokpoga has been described recently as being in "good to excellent shape" (Champeau *et al.* 2004).

From January through April, largemouth bass spawn in bulrush and other vegetation around Big Island and Bumblebee Island and along shallow-water areas. Electroshock and creel surveys show that the largemouth bass population was in excellent condition with strong 1996, 1998 and 2000 year-classes (FWC 2002). Results of fish surveys conducted during 2002 show the largemouth bass fishery on the lake to be strong two years after implementation of a slot limit and one year following a lake drawdown and habitat enhancement project (**Figure 20**). As expected, the 2001 year-class was weak following the spring 2001 drawdown of the lake, but age and growth analysis conducted during 2002 indicated fast-growing, robust fish (FWC 2002).

During winter as water temperatures stabilize at around 65° F (18° C), black crappie will move into bulrush and spatterdock areas along the shoreline to spawn. Trawl data indicate a crappie population dominated by fish four years old and younger, with relatively few older than five years (FWC 2002). Trawl net and angler harvest data show strong year-classes for 1999 and 2000 (**Figure 21**), while the 2001 year-class was expectedly weak because of low water levels recorded during the 2001 drawdown. Crappie reach "harvestable size" (8 in or 20.3 cm) within three years and "preferred size" (10 in or 25.4 cm) within four years (FWC 2002, Gabelhouse 1984).

Table 6. List of Fish Species Recorded from Lake Istokpoga through Electrofishing and Wegener Ring Catch Methods (Source: FWC 2002).

Common Name (Scientific Name)	Primary Habitat Type
Atlantic needlefish (*Strongylura marina*)	Open water and deep marsh
Black crappie (*Pomoxis nigromaculatus*)	Open water, deep marsh and shallow marsh
Blue tilapia *(Oreochromis aurea)*	Deep and shallow marsh
Bluefin killifish (*Lucania goodei*)	Deep and shallow marsh
Bluegill (*Lepomis macrochirus*)	Open water, deep marsh and shallow marsh
Bluespotted sunfish (*Enneacanthus gloriosus*)	Shallow marsh
Bowfin (*Amia calva*)	Deep and shallow marsh
Brook silversides (*Labidesthes sicculus*)	Deep and shallow marsh
Brown bullhead (*Ameiurus nebulosis*)	Open water, deep marsh and shallow marsh
Brown hoplo *(Hoplosternum littorale)*	Deep and shallow marsh
Chain pickerel (*Esox niger*)	Deep and shallow marsh
Channel catfish (*Ictalurus punctatus)*	Open water and deep marsh
Dollar sunfish (*Lepomis marginatus*)	Deep and shallow marsh
Eastern mosquito fish (*Gambusia holbrooki*)	Deep and shallow marsh
Everglades pygmy sunfish (*Elasoma evergladei*)	Shallow marsh
Flagfish (*Jordanella floridae*)	Shallow marsh
Florida gar (*Lepisosteus platyrhincus*)	Open water, deep marsh and shallow marsh
Gizzard shad (*Dorosoma cepedianum*)	Open water and deep marsh
Golden shiner (*Notemigonus crysoleucas*)	Deep and shallow marsh
Golden topminnow (*Fundulus chrysotus*)	Deep and shallow marsh
Inland silversides (*Menidia beryllina*)	Open water and deep marsh
Lake chubsucker (*Erimyzon sucetta*)	Deep and shallow marsh
Largemouth bass (*Micropertus salmoides*)	Deep and shallow marsh
Least killifish (*Heterandria formosa*)	Shallow marsh
Okefenokee pygmy sunfish (*Elassoma okefenokee*)	Shallow marsh
Pugnose minnow (*Opsopoeodus emiliae*)	Deep and shallow marsh
Redear sunfish (*Lepomis microlophus*)	Deep and shallow marsh
Sailfin molly *(Poecilia latipinna)*	Shallow marsh

Seminole killifish (*Fundulus seminolis*)	Deep and shallow marsh
Spotted sunfish (*Lepomis punctatus*)	Deep and shallow marsh
Swamp darter (*Etheostoma fusiforme*)	Deep and shallow marsh
Tadpole madtom (*Noturus gyrinus*)	Deep and shallow marsh
Tailight shiner (*Notropis maculatus*)	Deep and shallow marsh
Threadfin shad (*Dorosoma petenense*)	Open water and deep marsh
Walking catfish *(Clarias batrachus)*	Deep and shallow marsh
Warmouth (*Lepomis gulosus*)	Deep and shallow marsh
White catfish *(Ameiurus catus)*	Open water and deep marsh
Yellow bullhead (*Ameiurus natalis*)	Deep and shallow marsh

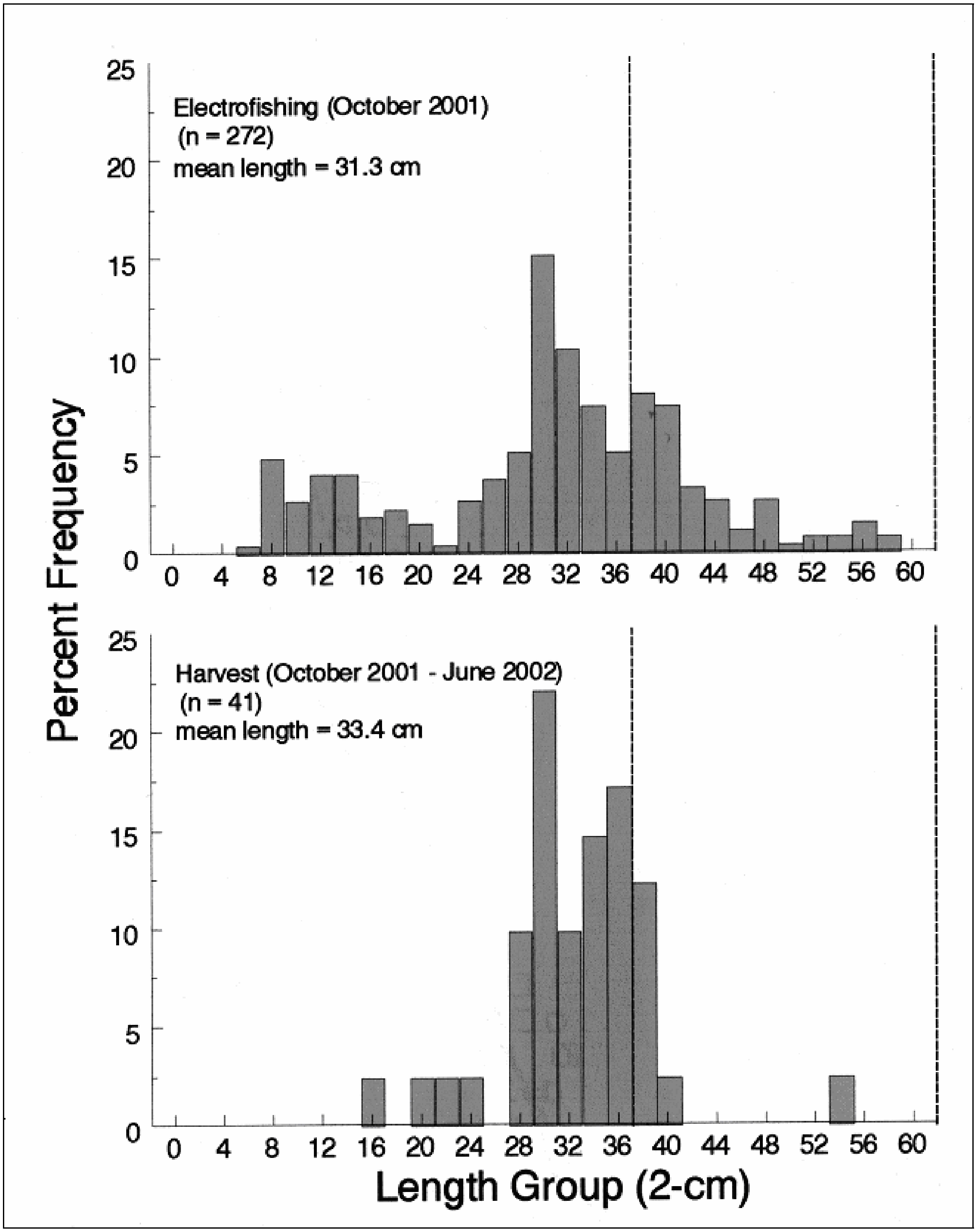


Figure 20. Length-Frequency of Largemouth Bass Distributions (percentage, 2 cm groups) Obtained from Electrofishing Sampling and Angler Harvest: Lake Istokpoga 2001–2002 (area within the dotted lines represents fish prohibited from harvest under the protective slot limit on Lake Istokpoga) (Source: FWC 2002).

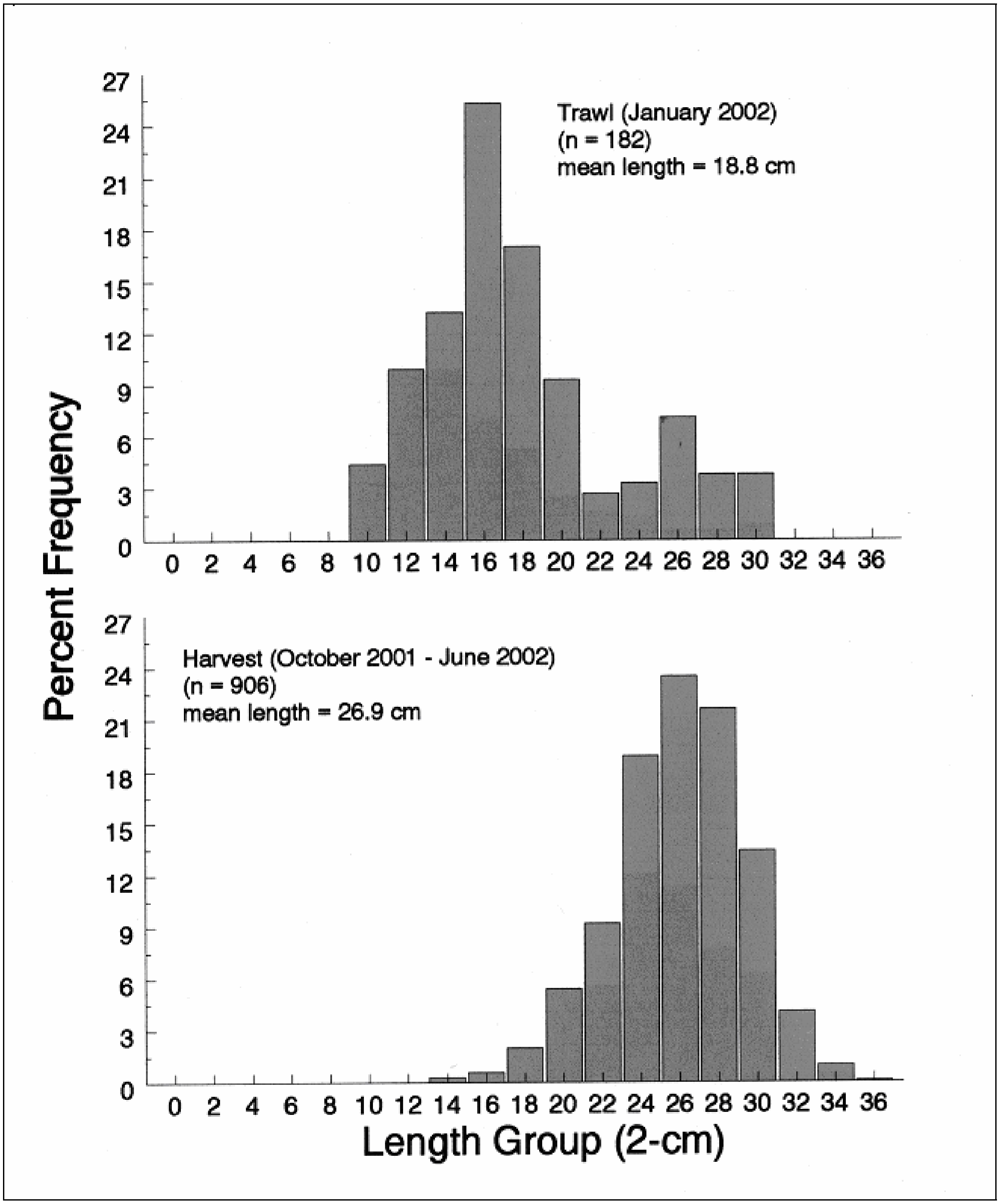


Figure 21. Length-Frequency of Black Crappie Distributions (percentage, 2 cm groups) Obtained from Trawl Sampling and Angler Harvest, Lake Istokpoga 2001–2002 (Source: FWC 2002).

Plants and Animals of Special Concern

A number of species listed by the Florida Committee on Rare and Endangered Plants and Animals (Rodgers *et al.* 1996) have significant populations within Lake Istokpoga and the surrounding uplands. The lake supports populations of aquatic avian species, including limpkins and other wading birds, and is believed to contain one of the greatest concentrations of osprey nests in the world (Stewart 2001, Pranty 2002). Additional species of importance that nest along Lake Istokpoga include the least bittern, great egret, bald eagle and short-tailed hawk (McNair *et al.* 2001, Pranty 2002).

Other significant habitats for rare, threatened and endangered species are found within the Lake Istokpoga watershed. Along the western boundary of the historic Lake Istokpoga floodplain lies the Lake Wales Ridge. During the recent ice ages this unique formation was periodically isolated from the North American continent by rising sea levels. The plants and animals living in the harsh environment of those dunes were also physically and genetically isolated from the parent populations from which they descended. These isolation events allowed the development of differences that persisted when the sea levels receded and the island ridge was rejoined with North America. Many of these dune plants and animals remain restricted to the ridge habitats today, and the Lake Wales Ridge has one of the highest concentrations of endemic species in North America. As of 2000, the ridge is host to 19 plant, three reptile and one bird species federally listed as threatened or endangered (SFWMD 2000a).

WATER QUALITY

Water quality within the Lake Istokpoga watershed can vary considerably by site. Isolated wetlands may contain water of relatively high quality, for instance, but significant water quality problems may be found in water bodies that receive runoff from agricultural lands or from land use types associated with high pollution loading rates. High levels of nutrients have been implicated as the cause of the rapid growth and proliferation of aquatic weeds (such as cattails, water hyacinth and hydrilla) and tussocks in Lake Istokpoga. Water quality in the lake is occasionally degraded by nutrient runoff from adjacent agricultural lands (Hand *et al.* 1988).

Besides the SFWMD (for instance, Milleson 1978, Walker and Havens 2003), other groups that have conducted water quality studies in Lake Istokpoga include LAKEWATCH (Florida LAKEWATCH 2003) and the United States Environmental Protection Agency (USEPA 1977).

Sources of Water Quality Degradation in Lake Istokpoga

Water quality in Lake Istokpoga has been affected by runoff from land uses in areas surrounding the lake, as well by lake level regulation and aquatic plant management activities. Lake Istokpoga's two primary tributaries, Josephine and Arbuckle creeks at the north end of the lake, provide significant inputs of nutrients from upstream sources.

An analysis of the potential risk of pollution from land use types in Highlands County was conducted by Zahina *et al.* (2001b) (**Figure 22**). The pollution risk was calculated by the use of a pollution load screening model developed for the St. Johns River Water Management District. In this method, annual potential pollution loads were estimated using average annual rainfall, the presence or absence of on-site treatment systems, soil type, and mean annual loads for land use types. The pollution risk analysis identified much of the area surrounding Arbuckle Creek and Lake Istokpoga southward toward Indian Prairie as having a moderate risk for nutrient pollution (nitrogen and phosphorus) from surrounding land uses. A relatively high risk for pesticide pollution exists, based on the large extent of agricultural lands within the basin.

Nutrients

Nutrient loading, concentrations and in-lake cycling are influenced by inputs from tributaries, stabilization of historic water level fluctuations and the extent of hydrilla. Phosphorus and nitrogen concentrations in Lake Istokpoga were studied by several authors and agencies over the past decades (**Table 7**). The combined volume of water inflow to the north end of Lake Istokpoga from Arbuckle and Josephine creeks is approximately equal to the outflow through the S-68 at the south end, but these inflows provide 1.5 times more nitrogen and 3 times more phosphorus to the lake than is discharged out of the lake through S-68 (VanArman *et al.* 1993, O'Dell *et al.* 1995; also see Florida LAKEWATCH 2003). This is most likely the result of uptake by littoral and submerged vegetation, planktonic algae and sediments. In general, phosphorus levels at the southern end of Lake Istokpoga are reduced as compared to measurements at the north end of the lake (O'Dell *et al.* 1995). As water originating from tributaries moves south through the lake, nutrients are depleted and chlorophyll α concentrations increase (**Table 8**). Generally, nutrient levels in the northern portion of the lake have increased since LAKEWATCH began monitoring in 1996. This is of greater importance because water from Lake Istokpoga flows into Lake Okeechobee, which has a target total daily maximum load for phosphorus from upstream sources.

According to LAKEWATCH data, phosphorus levels at the north end of the lake range from 40 mg/m^3 to 102 mg/m^3 and average 66 mg/m^3, while in-lake phosphorus levels range from 16 mg/m^3 to 85 mg/m^3 and average 51 mg/m^3 (**Table 7**). Total nitrogen in Lake Istokpoga averaged from 753 mg/m^3 to 2,587 mg/m^3. Surface water data indicate that nutrient levels increase and water clarity decreases in Lake Istokpoga following a whole-lake treatment to control hydrilla (O'Dell *et al.* 1995).

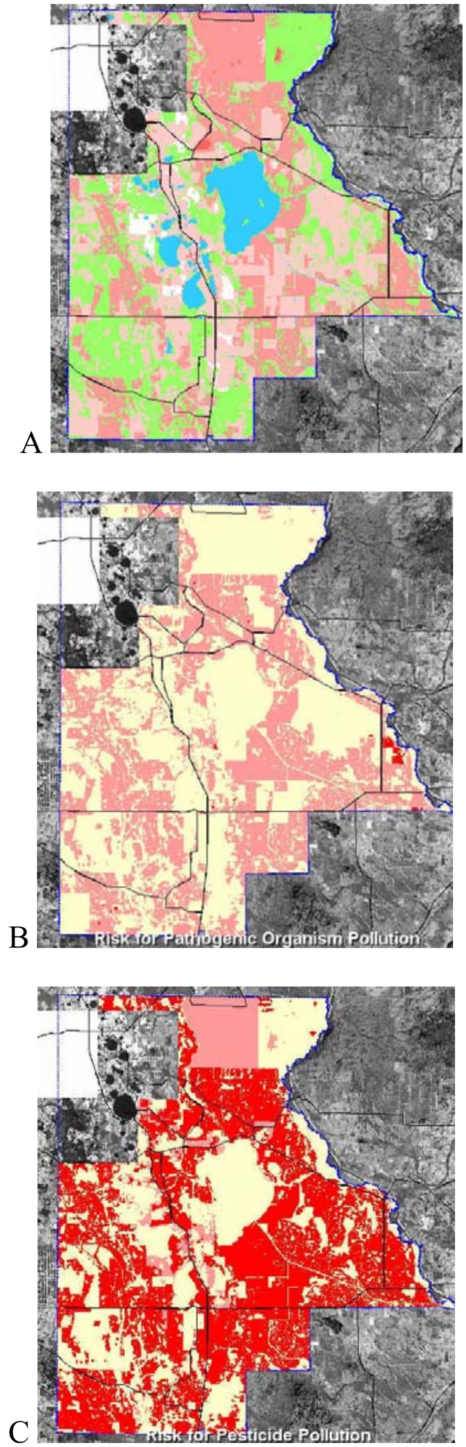


Figure 22. Analysis of Pollution Risk from Land Use Types in Highlands County; dark red indicates high risk for the pollutant, light red or yellow indicate low risk, green indicates no risk, and blue indicates areas with no data; (A) shows potential for Nitrogen, Phosphorus, Suspended Solids, Lead and Zinc Pollution, (B) shows potential for pathogenic organism pollution, and (C) shows potential for pesticide pollution (Source: Zahina *et al.* 2001b).

Table 7. Total Nitrogen and Phosphorus in Lake Istokpoga: Results of Present and Past Water Quality Studies.

Author and Study Period	**Total N (mg/m^3)**	**Total P (mg/m^3)**
USEPA, 1977 (Source: USEPA 1977)	938–1,535	37–57
Florida Dept. of Environmental Regulation, 1970–1987 (Source: Hand *et al.* 1988)	1,490*	60*
Florida Dept. of Environmental Regulation, 1982–1987 (Source: Hand and Paulic 1992)	975*	60–70
Milleson (SFWMD) 1973–1976 (Source: Milleson 1978)	1,028*	46*
SFWMD, 1988–1992 (Fluridone Treatment Study) (Source: VanArman 1993, O'Dell *et al.* 1995)		
1988 (pre-treatment)	841*	43*
1989–1992 (post-treatment)	978*	50*
SFWMD DBHYDRO Database, 1988–2003 (Data available from: http://www.sfwmd.gov/)	500–4,230 (1,020*)	1–477 (53*)
LAKEWATCH, 1996–2002 (Source: Florida LAKEWATCH 2003)		
Lake Istokpoga	753–2,587 (1,249*)	16–85 (51*)
North Lake Istokpoga	830–1,160 (1,160*)	40–102 (66*)

*Indicates mean for period of record.

Table 8. Water Clarity in Lake Istokpoga: Results of Present and Past Water Quality Studies.

Author and Study Period	**Chlorophyll α (mg/m^3)**	**Secchi Disc (m)**
US EPA, 1977 (Source: US EPA 1997)	3.6–11.4	0.5–1.5
Canfield and Hodgson, 1983 (Source: Canfield and Hodgson 1983)	31.2*	0.50*
Florida Dept. of Environmental Regulation, 1970–1987 (Source: Hand *et al.* 1988)	12*	0.60*
Florida Dept. of Environmental Regulation, 1982–1987 (Source: Hand and Paulic 1992)	11–12*	0.70–0.80
Milleson (SFWMD) 1973–1976 (Source: Milleson 1978)	16.5*	0.4–0.9 (0.7*)
SFWMD, 1988–1992 (Fluridone Treatment Study) (Source: VanArman 1993, O'Dell *et al.* 1995)		
1988 (pre-treatment)	6.9*	1.22*
1989–1992 (post-treatment)	14.5*	0.96*
SFWMD DBHYDRO Database, 1988–2003 (Data available from: http://www.sfwmd.gov/)	0–209 (18*)	0.1–4.3 (0.9*)
LAKEWATCH, 1996–1999 (Source: Florida LAKEWATCH 2003)	Total Chlorophyll:	
Lake Istokpoga	2.0–89.3 (34.5*)	0.4–2.0 (0.9*)
North Lake Istokpoga	5.3–74.0 (33.9*)	0.5–1.2 (0.8*)

*Indicates mean for period of record.

Turbidity and Color

The concentrations of planktonic algae (that is, algae living in free-floating form within the water column) are often used as indicators of nutrient enrichment of surface waters. Excessive algae concentrations reduce water clarity and in extreme cases can lead to oxygen depletion and fish kills. Algae levels, which are usually estimated from chlorophyll α concentrations in water samples (**Table 8**), typically fluctuate with nutrient levels. Chlorophyll α levels in Lake Istokpoga, as reported by LAKEWATCH, were slightly higher in northern Lake Istokpoga than in the rest of the lake, indicating an effect from tributary inputs. Chlorophyll α levels increased following Fluridone treatment of the lake to control hydrilla, most likely because of degradation of plant materials and the release of nutrients.

Water clarity is often measured by the "Secchi Disk" method, whereby a standardized disk is lowered into the water to the greatest depth at which markings on the disk can still be distinguished. Water clarity, as measured by LAKEWATCH and determined by Secchi depths, is not as good in the northern area of the lake (**Table 8**). A decrease in water clarity was also observed following treatment of the lake with Fluridone. These observations can be attributed to decreases in water quality as a result of tributary inputs, proliferation of planktonic algae and the decay of aquatic vegetation following treatment.

Oxygen, pH and Temperature

Table 9 shows the measured values for oxygen, pH and temperature for Lake Istokpoga and its main tributaries. These data are available from the SFWMD's corporate environmental database called DBHYDRO and were acquired by a monitoring program for the lake. Generally, dissolved oxygen levels were higher in the lake than in the tributaries. These differences may stem from the high amount of phytoplankton, submerged vegetation and algal epiphytes found within the shallow Lake Istokpoga. Arbuckle and Josephine creeks have relatively little submerged aquatic vegetation, they may be sites for groundwater inflows, and they tend to have poorer water quality—conditions that would support lower oxygen concentrations. Measured pH values were circum-neutral for both the lake and tributary waters, probably because most Florida surface waters tend to be well buffered. Temperature varied little among water bodies.

Table 9. Oxygen and pH in Lake Istokpoga and Its Tributaries: Mean Values for the Period of Record (1989–2003) with Standard Deviation (Source: SFWMD's DBHYDRO Database).

	Oxygen (mg/L)	pH	Temperature (Celsius)
Lake Istokpoga	8.2 ± 1.4	7.6 ± 0.8	24.9 ± 4.9
S-68	7.8 ± 1.5	7.6 ± 0.7	25.1 ± 5.1
Arbuckle Creek	4.9 ± 2.0	6.5 ± 0.6	24.9 ± 4.5
Josephine Creek	5.2 ± 1.6	6.1 ± 0.6	24.5 ± 4.1

WATER RESOURCE ISSUES

Overview of Consumptive Uses within the Watershed

The driving force behind urban water demand is population. Population in the Kissimmee Basin Planning Area is projected to increase by almost 90 percent by 2020 (SFWMD 2000a). Most of this population increase is projected to occur within the northern urban areas of this planning area (Orange and Osceola counties), and the southern portion (including Lake Istokpoga) is projected to have only a modest increase in residents. The Kissimmee Basin Water Supply Plan (SFWMD 2000a) projects an increase in Highlands County residents from 7,700 (1995) to approximately 11,600 (2020). The Highlands County area (meaning the area of Highlands County within the SFWMD jurisdiction) contains no municipalities.

Agricultural activity represents the single largest water use type in the Lake Istokpoga area. The primary land use in the Lake Istokpoga basin is agricultural, dominated by citrus groves, improved pasture, and truck farming (McDiffett 1981). Citrus and ornamental-plant farms are typically found on the Lake Wales Ridge to the west and on drained lands to the south of Lake Istokpoga. Land coverage by irrigated citrus in the Highlands area is expected to increase from 39,324 acres (1995) to more than 61,000 acres (2020) (SFWMD 2000a).

The Brighton Indian Reservation (Seminole Tribe) is located south of Lake Istokpoga within the Lake Istokpoga–Indian Prairie basin and is supplied with water mostly from Lake Istokpoga through the C-41/C-40 Canals. The reservation was established in 1938 and currently has a population of about 500. It covers almost 36,000 acres, primarily agricultural, including improved pasture, citrus, sugarcane and aquaculture. The Lake Istokpoga–Indian Prairie basin has historically experienced water shortages. The 1987 Water Rights Compact signed by the Seminole Tribe of Florida, the State of Florida and the SFWMD establishes, among other things, the Tribe's water entitlement for the Brighton Reservation. A subsequent agreement (number C-4121) was executed in the early 1990s and further defined the Tribe's water rights (see **Appendix A** for details on this agreement).

Lake Istokpoga–Indian Prairie Basin Surface Water Analysis

For the past decade, the use of additional surface water from the Lake Istokpoga–Indian Prairie basin has been restricted as a result of several water shortages that occurred in the area during the 1980s. As part of the Kissimmee Basin Water Supply Plan planning effort, an evaluation of the water use problems of the Lake Istokpoga–Indian Prairie basin and recommendations regarding alternate water supply sources were completed (SFWMD 2000a). Under that analysis the Lake Istokpoga–Indian Prairie basin was defined as the area having access to the C-40, C-41 and C-41A canals or access to Lake Istokpoga, either directly or via other canals. The analysis included statistical and empirical methods to estimate discharges from the control structures. The statistical approach attempted to develop a mathematical correlation between rainfall patterns and releases from the control structures. The empirical approach reviewed 20 years of records to find years that matched the seasonal rainfall conditions of a 1-in-10 year drought. The statistical approach was found to track the trends in discharge relatively well but had less success in matching month-to-month values and extreme discharge events.

The analysis evaluated water availability in the basin during a 1-in-10 year drought condition. The analysis assumption was that the drought was preceded by an average rainfall year and that the water level of Lake Istokpoga was at or near its average level at the end of the wet season in October. A presumption in the analysis was that water currently released from the basin to either Lake Okeechobee or the Kissimmee River south of S-65D could be used as the first source in meeting the projected demands. In the first part of this analysis, the discharge leaving the basin through water control structures S-68, S-71, S-72 and S-84 was quantified for the 1-in-10 year drought condition. The second effort of the analysis determined if additional supplies could be released from Lake Istokpoga while maintaining the required minimum operational schedule and minimum canal levels set forth in the Water Shortage Rule 40E-22, F.A.C.

The analysis contained three major components: estimation of the 1-in-10 year water demands, determination of 1-in-10 year drought discharges from the basin under the existing operation/management, and analysis of alternative sources. Water use estimates were made for two major categories of water use: urban and agriculture. Urban use was divided into five categories, with all except public water supply considered self-supplied. Agricultural water use is water used for crop irrigation and cattle watering, as well as water used in facilities supporting these activities. All water use demands were calculated on a monthly basis using a statistically derived 1-in-10 year drought condition.

The results of the analysis showed the need for the release of an additional 17,069 acre/feet of water from Lake Istokpoga in 2020, above the historic 1-in-10 year releases, to meet additional needs for the Indian Prairie basin during a 1-in-10 year drought. This release, in combination with back pumping from Lake Okeechobee, was projected to be able to meet the 2020 demands for this planning area. During average rainfall conditions, no additional releases from Lake Istokpoga beyond those currently delivered are anticipated. Anticipated water supply needs are addressed in the Kissimmee Basin Water Supply Plan (SFWMD 2000a).

Input of Nutrients and Pollutants

Water quality in Lake Istokpoga has been directly affected by runoff from land uses surrounding the lake and less directly affected by lake level regulation and aquatic-plant management activities. The relationship between lake stage and water quality is not well understood because of a number of confounding factors, including the following:

- Extent of hydrilla coverage.
- Recent hydrilla or invasive weed treatment.
- Inflow volume.

- Discharge volume.
- Type of water quality parameter.
- Water quality sampling location.

Water quality monitoring programs are ongoing, and efforts to deal with point-source pollution have been initiated. Examples of projects studying water quality relationships in Lake Istokpoga are the Phosphorus Study (described later) and the studies supporting the development of Total Daily Maximum Loads (TMDLs). Water quality in Lake Istokpoga has implications for controlling nutrient levels in the Kissimmee River and Lake Okeechobee, the latter having a total daily maximum load established for phosphorus. A summary of Lake Istokpoga area projects that examine water quality issues can be found in the "Lake Istokpoga Resource Protection Projects" section concluding the present chapter.

Navigation and Recreation

Navigation and recreation in Lake Istokpoga can be affected by low water levels and by water level stabilization. Boating access to the lake from spur canals can be hampered by low water levels, and serious physical barriers to free movement of motor-powered crafts can result from the proliferation of cattail, tussocks and hydrilla promoted by water level stabilization. Recreation on Lake Istokpoga is affected by water level stabilization because the resultant formation of tussocks and proliferation of hydrilla can have negative impacts on the quality of fish habitats. Periodic drawdowns and control of nuisance vegetation, as on other Florida lakes, have been shown to improve the quality of aquatic habitats and can benefit the long-term viability of fish communities (see Florida Game and Freshwater Fish Commission 1994).

Aquatic Habitat Management Program

An aquatic habitat enhancement program was conducted on Lake Istokpoga by the FWC during the winter and spring of 2001. Objectives of the project were to restore fish and wildlife habitat, improve water quality and enhance flood protection and navigation within the lake. **Figure 23** provides a fish management area map showing the location of cattail and bulrush tussocks targeted for reduction or elimination prior to the lake's drawdown (FWC 2002).

A window of opportunity for enhancing lake vegetation presented itself during the drought of 2000–2001. Low lake stages favored implementation of an aquatic habitat management drawdown project two years earlier than originally planned. The SFWMD provided $3 million to fund this project. Aggressive collaboration by the FWC, SFWMD, USACE, FDEP, Highlands County Board of County Commissioners and other cooperating agencies allowed the FWC to put this plan into operation less than two months after the opportunity arose. Using earth-moving equipment, workers restored an estimated 1,309 acres (530 hectares) of fish and wildlife habitat through scraping and removal of 2,463,797 yards^2 (1,883,708 m^2) of tussock and organic sediments from the dry lake bottom. The project resulted in restoration of about two-thirds of the lake's shoreline littoral zone (**Figure 24**). One third of the harvested material was removed from the lake and placed at 16 upland storage sites. Thirty-six "wildlife islands" (in-lake disposal sites) were constructed during the project. The project focused on removal of 100 acres (40.5 hectares) of cattail tussocks and associated organic sediments around Big Island marsh and the northwest shoreline using mechanical weed harvesters. This material was consolidated on the in-lake wildlife islands.

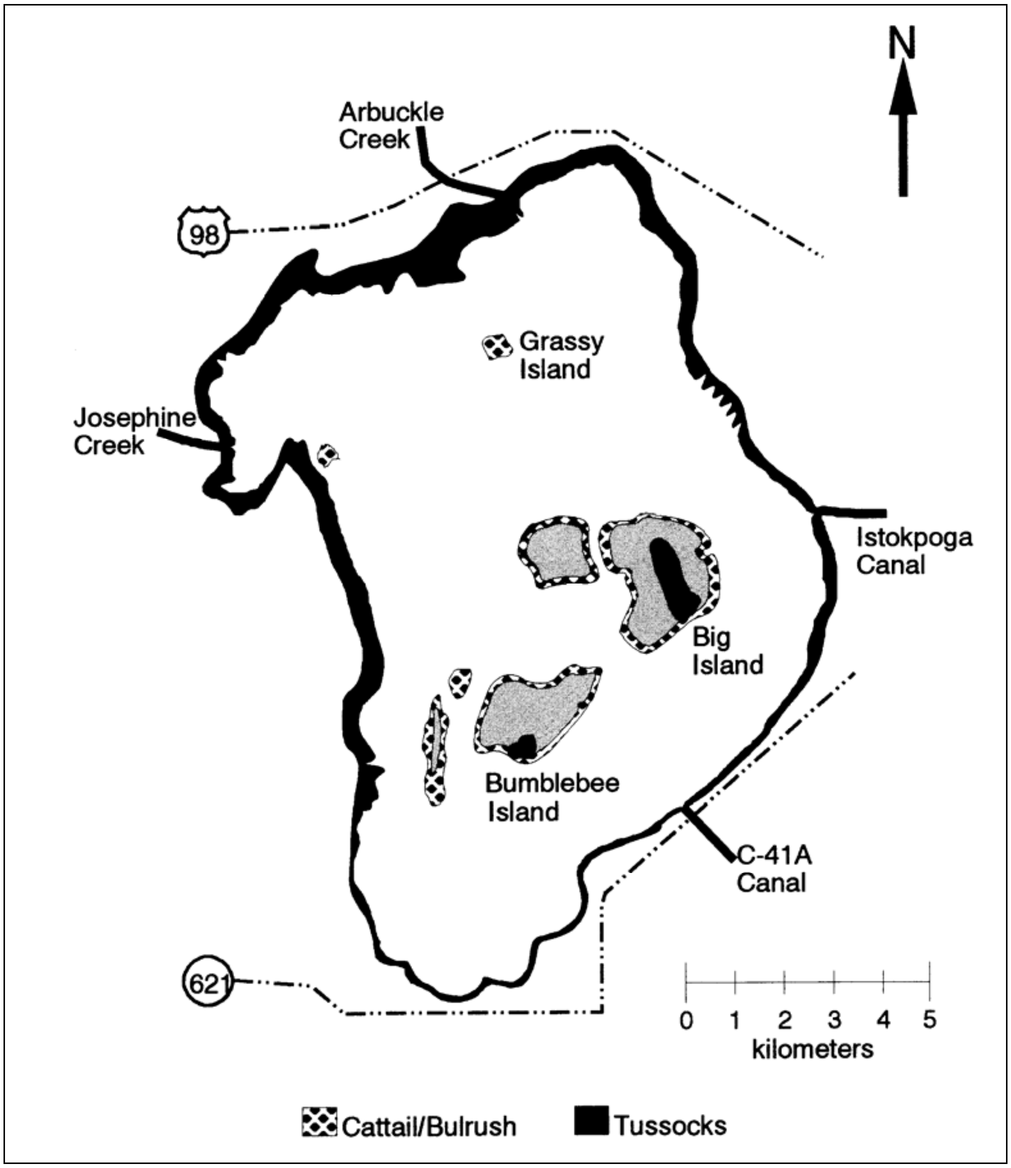


Figure 23. Lake Istokpoga Fish Management Area (Source: FWC 2002).

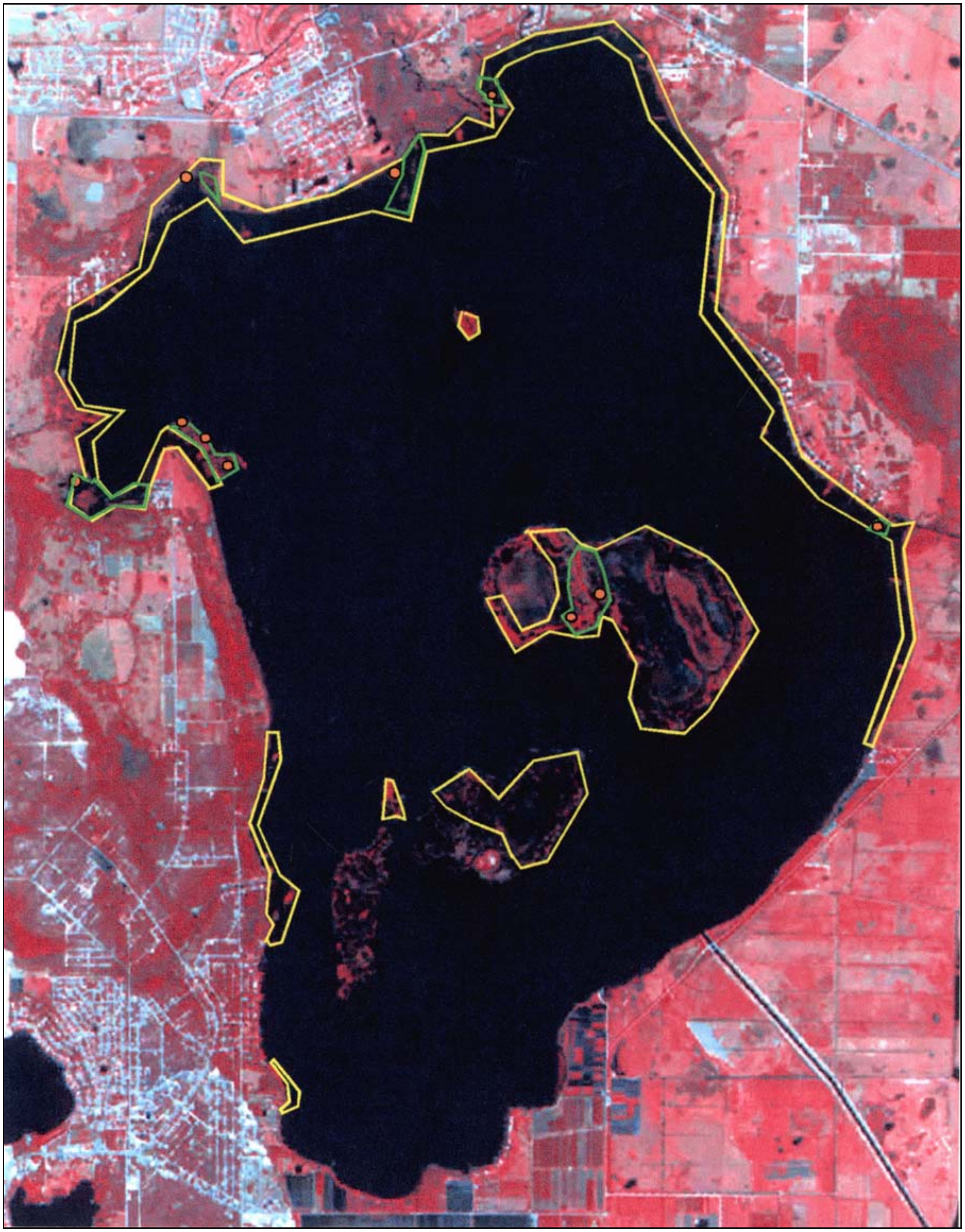


Figure 24. Satellite Image of Lake Istokpoga (areas outlined in green represent sites with tussock harvesting by aquatic weed harvesters; areas outlined in yellow represent sites with herbicide treatment of invasive aquatic plants; orange dots represent in-lake consolidation islands) (Source: FWC 2002).

In addition to mechanical harvesting, chemical treatment was used to reduce the extent of undesirable plants. Whole-lake treatment with Fluridone was used to control hydrilla. Dense stands of cattail, pickerel weed and burhead sedge (*Oxycaryum cubense*) or Cuban bulrush *(Scirpus cubensis)* were treated with herbicides; this included an area of 2,450 acres (991.5 hectares) located around Big Island and Bumblebee Island marshes. Dense cattail stands were sprayed by helicopter, with some sparse cattail bands left intact for use by fish, wading birds and waterfowl. **Figure 24** shows those areas of the lake enhanced by herbicide treatment.

Follow-up studies conducted by the FWC during 2002 showed that the enhanced areas of the lake had contained pickerel weed, duck potato, torpedo grass (*Panicum repens*), eelgrass, coontail (*Ceratophyllum demersum*) and hydrilla. The chemical treatment reduced hydrilla coverage from an estimated 19,384 acres (70 percent coverage) recorded in 2000–2001 to an estimated 475 acres (2 percent coverage) recorded during the post-drawdown/post-treatment period of 2001–2002 (**Figure 19**). Fish surveys conducted within the enhanced areas showed increases in fish abundance and in diversity and richness of fish species in response to the colonization by emergent and submersed aquatic macrophytes (FWC 2002).

Overall, the aquatic habitat enhancement program has been recognized as an excellent example of interagency teamwork. Many local, state and federal agencies worked together, along with citizen groups, to help ensure the health of Lake Istokpoga's wildlife habitat and its associated $6 million annual sport fishery (Champeau *et al.* 2004). The total cost of the project was $2,740,320 (FWC 2002).

Fisheries Management

The Division of Fisheries Management of the FWC lists Lake Istokpoga as one of Florida's top ten lakes for catching largemouth bass, black crappie and bluegill (http://www.floridafisheries.com/). The black crappie fishery has peak catch rates during the winter months. Bluegill fishing is also popular, with late spring and summer producing the best results. The Florida Game and Freshwater Fish Commission (now the Florida Fish and Wildlife Conservation Commission or FWC) conducts fish studies on Lake Istokpoga; details of the sampling methods and data available are shown in **Table 10**.

Table 10. Fish Sampling Conducted by the FWC on Lake Istokpoga (Source: FWC).

Sampling Method	**Species Targeted**	**Data Type**
Electrofishing	Largemouth bass; all species	Largemouth bass: Catch per unit effort (CPUE, fish/minute), size composition, length-weight relation, growth rate, annual mortality; data are collected from "historical" sites (>1m, 1987–present) and "enhanced" sites (<0.75 m, 2001–present)[1] All species: species composition (relative abundance), CPUE (fish/min), length frequency, biomass; data are collected from "enhanced" sites (2001–present)
Trawl (4.9 m footrope with 38 mm stretch mesh)	Black crappie are primary target; all species are collected	Black crappie: CPUE, length frequency, age composition, sex composition, length-weight relation, growth rate, annual mortality; 1998–present All species: species composition (relative abundance), CPUE (fish/min), length frequency; 1998–present
Wegener Ring (4 m^2)	All species	Species composition (relative abundance), CPUE (fish/hectare), length frequency, biomass; 2001–present
Recreational Angler Survey	Largemouth bass, Black crappie, Bluegill, Redear sunfish, Miscellaneous species typically not targeted by anglers	Effort (angler-hours), catch/harvest (no. of fish), catch success/harvest success (fish/hour), size composition of harvested fish, age composition of harvested fish, sex composition of harvested fish, largemouth bass tournament effort, size composition of "tournament" bass; 1990–1995, 1997–present
Radiotelemetry	Largemouth bass	Objectives of the project are to document/evaluate use of the littoral habitat (specifically, areas enhanced during the 2001 drawdown), response to aquatic habitat management strategies (for instance, hydrilla treatment) and response to changes in water levels under the current water management regime. Metrics include home area, primary habitat used, water quality (dissolved oxygen, temperature, turbidity) in "present location" and "previous location" sites. Data collected October 2002–June 2005.

[1] Prior to the 2001 drawdown, electrofishing could be conducted only at the lakeward edge of the littoral zone. Currently, sampling is conducted at those "historic" sites and in "enhanced" sites (that is, littoral area opened up after the 2001 drawdown).

On July 1, 2000, the FWC implemented a protective slot limit on the size and number of largemouth bass harvested from the lake. In order to maintain the lake's high-quality largemouth bass fishery, the FWC instituted a 15-inch to 24-inch (38 cm to 61 cm) protective slot limit, with a bag limit of three fish, of which only one bass may exceed 24 inches (61 cm). The objective of this regulation was to manage for a high-quality largemouth bass fishery, allowing the harvest of more-abundant smaller bass while still allowing for "catch of a lifetime" trophy-sized fish to be harvested as well (FWC 2000).

The FWC has issued a mercury warning for Lake Istokpoga. Consumption of largemouth bass should be limited by women of childbearing age, and children under age ten should not eat more than 8 ounces of bass over a four-week period. All others should limit consumption of bass from these areas to no more than 8 ounces a week (http://www.floridafisheries.com/). The FWC conducted an analysis of the mercury content of Lake Istokpoga fish in 1989; during that sampling effort, bass had an average mercury level of 0.60 parts per million (ppm). Average mercury levels in bass in 2002 (one year after the lake drawdown) were 0.44 ppm; the amount in bass less than 15 inches long was 0.39 ppm, and in bass greater than 14 inches (standard used in mercury advisories) it was 0.51 ppm. These sampling studies indicate an overall reduction in mercury content since 1989. The lake, however, will remain on the "Limited Consumption" list because of the 0.51 ppm mercury levels detected in bass exceeding 14 inches in length (FWC 2002).

Creel surveys conducted during 1991 and 1992 documented an hourly catch rate of 0.41 bass per hour, which was nearly double the statewide average (FWC 2002). Fish community sampling data collected in restored wetland habitat (**Tables 11** and **12**) indicate a viable and healthy fish community. These restored wetland areas represent an addition of fish habitat unavailable before the drawdown. In 2002 and 2003, the recreational fishery was strong, with high angler effort and success observed for both the largemouth bass and black crappie. Black crappie age classes 1 and 2 were strong in the two years following the 2001 drawdown (**Figure 25**). Angler catch success rates of 0.45 fish/hour were recorded (**Table 13**). Catches of high-quality and trophy bass were also very good. "High-quality" bass continue to make up a large proportion of tournament-caught fish since implementation of the July 2000 protective slot limit (**Table 14** and **Table 15**). Fish sampling in areas enhanced by the drawdown was indicative of quality fish habitat and a diverse fish community. These areas exhibited oxygen levels and hard sand substrate necessary for good spawning habitat. The economic value of the fishery in those areas of the lake enhanced by the drawdown was estimated to average $25,961.42 per hectare during the autumn of 2001 and $39,269.70 per hectare during the spring of 2002 (FWC 2002).

Additional fish monitoring studies currently under way on Lake Istokpoga include 1) bass habitat utilization studies employing radiotelemetry devices implanted in more than a dozen bass and 2) a bass natality, growth and feeding study being conducted by the University of Florida.

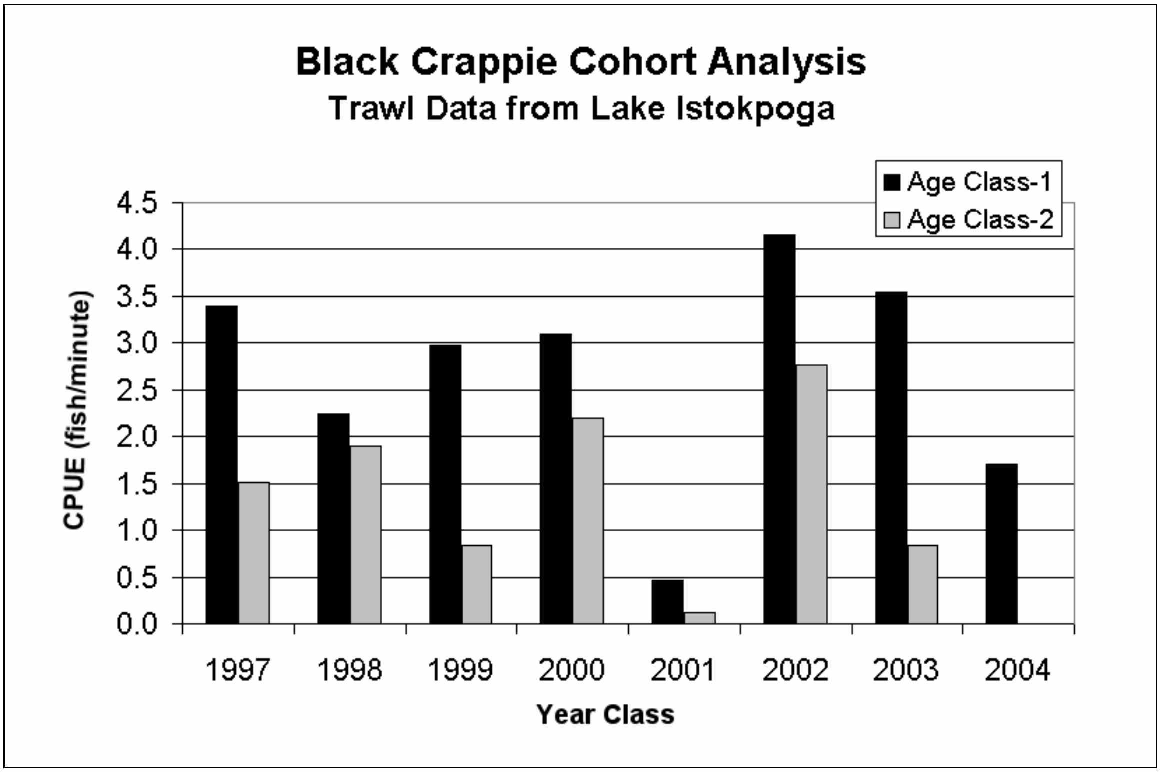


Figure 25. Lake Istokpoga Black Crappie Cohort Analysis (no age class-2 data available for 2004) (Source: FWC).

Table 11. Fish Community Sampling Data in Lake Istokpoga Enhancement Sites[1] Using the Wegener Ring Method (n = 24/sample quarter) (Source: FWC).

	November 2001	April 2002	November 2002	April 2003	November 2003
Total Species	18	26	22	27	21
Species Diversity	2.74	3.43	2.85	2.95	3.57
Density (number/acre)	18,511	39,594	56,545	75,858	62,712
Economic Value (US$ per acre, per Ch. 62-11, FDEP Statutes)	10,506	16,310	16,333	20,350	22,253

[1]Enhancement sites are locations along the lake littoral zone that were dominated by tussocks and dense plant growth before the 2001 drawdown; these areas were restored to littoral wetlands during the drawdown and represent habitat areas not available before restoration.

Table 12. Fish Community Sampling Data in Lake Istokpoga Enhancement Sites[1] Using Electrofishing Method (n = 12 transects; 10-minute treatment) (Source: FWC).

	October 2001	April 2002	October 2002	April 2003	October 2003
Total Species	21	24	23	28	25
Species Diversity	2.29	2.57	2.46	2.95	2.75
CPUE[2] (all species)	11.4	9.7	11.1	13.5	12.7
Largemouth Bass CPUE	0.43	0.30	0.23	0.73	0.62

[1]Enhancement sites are locations along the lake littoral zone that were dominated by tussocks and dense plant growth; these areas were restored to littoral zone wetlands during the drawdown and represent areas not available before habitat restoration.

[2]CPUE = catch per unit effort, expressed as number of individual fish per minute.

Table 13. Lake Istokpoga Angler Creel Data for Sport Fish Species (Source: FWC 2003) (ND= no data collected).

Year (November–March)	Angler Success (fish/hour)			
	Largemouth Bass	**Black Crappie**	**Bluegill**	**Redear Sunfish**
1991–1992	0.37	1.60	ND	ND
1992–1993 (Post-treatment)	0.30	1.85	ND	ND
1993–1994	0.30	1.44	ND	ND
1994–1995	0.22	1.90	ND	ND
1995–1996	ND	ND	ND	ND
1996–1997	ND	ND	ND	ND
1997–1998	0.50	2.71	5.05	2.18
1998–1999	0.51	2.12	3.03	1.25
1999–2000 (Post-treatment)	0.46	2.72	5.63	1.29
2000–2001 Drawdown and slot limit implemented	0.74	2.53	2.67	0
2001–2002 Post-drawdown Post-treatment	0.45	2.07	3.11	0.37
2002–2003 Hydrilla treatment	0.45	1.75	4.91	1.71

Table 14. Lake Istokpoga Largemouth Bass Catch Data (Source: FWC).

	Baseline	**2002**	**2003**
Bass Angler Effort (hours/acre)	5.2	4.2	5.8
Angler Success (fish/hour)			
All bass	0.50	0.50	0.47
Slot bass	0.22	0.21	0.21
Tournament Catch Size (>18 inches)	23%	28%	27%
Bass Size Structure (electrofishing)			
>18 inches	5%	10%	16%
15–24 inches	23%	36%	41%

Table 15. Lake Istokpoga Largemouth Bass Tournament Data (Source: FWC).

	1998	**1999**	**2000**	**2001**	**2002**	**2003**
Total Reports	31	32	64	25	82	94
Total Bass	2,053	1,330	4,267	1,187	4,010	5,161
Mean Weight (lbs)	2.25	1.72	1.44	2.22	2.26	2.54
Mean Big Bass (lbs)	6.79	4.58	6.61	5.41	6.63	7.31

LAKE ISTOKPOGA RESOURCE PROTECTION PROJECTS

Kissimmee Basin Water Supply Plan Update (2005)

Water supply plans are water resource planning efforts designed to identify water needs over a 20-year time frame and projects that are proposed to meet those needs. The SFWMD completed the first Kissimmee Basin Water Supply Plan (KB Plan) in 2000, and a 2005 update is currently being compiled.

The Kissimmee Basin is one of four regional planning areas in the SFWMD. The Kissimmee Basin Planning Area covers approximately 3,500 square miles and includes parts of Glades, Highlands, Okeechobee, Orange, Osceola, and Polk counties and also shares some boundaries with adjacent water management districts— the SJRWMD (St. Johns River Water Management District) along the east and north and the SWFWMD (Southwest Florida Water Management District) along the west.

Each of the three water management districts involved has identified relevant areas that may experience *harm* to natural resources as a result of future water withdrawals. In the Kissimmee Basin Planning Area's northern counties shared with the SJRWMD, groundwater withdrawals by municipalities are the largest risk. In portions of Highlands (shared with SWFWMD) and Glades counties, surface water supplies from Lake Istokpoga are limited (see **Appendix D** for dry season water availability and consumptive use permit allowances). And the SWFWMD has identified several stressed lakes along the Lake Wales Ridge that have been linked to declines in Floridan Aquifer levels.

The goals of the KB Plan are to provide a framework for future water use decisions and to ensure adequate water supply for urban areas, agriculture and the environment over the next 20-year planning horizon. The plan estimates the future water supply needs of urban areas and agriculture, weighs those demands against historically used water sources and identifies areas in which these demands cannot be met without possible *harm* to the resource and environment, including wetlands. The plan evaluates the potential of several alternative water source options to meet any unmet demand and makes recommendations for their development.

The plan's objectives include the following:

- Optimize use of all water sources.
- Protect natural systems from *harm* stemming from water uses.
- Identify options that will provide a 1-in-10 year level of certainty for all existing and projected reasonable-beneficial uses.

- Promote compatibility of the KB Plan with tribal and local-government land use decisions and policies.
- Promote compatibility and integration with other related regional water resource efforts.
- Promote water conservation and efficient use of water sources.
- Refine water supply demand projections for all reasonable-beneficial uses for average-year and the 1-in-10–year levels of certainty.
- Identify adequate sources of funding to support water resource development and water supply development options identified in the plan.
- Protect water resources from *harm* stemming from water uses.

The SFWMD's water supply planning functions are guided by the directives and policies of the SFWMD's Water Supply Policy Document (SFWMD 1991); State Water Policy (Chapter 62–40, F.A.C.); Chapter 373, F.S.; the State Comprehensive Plan (Chapter 187, F.S.); and delegation of authority from the Florida Department of Environmental Protection (FDEP). In addition, the plan meets the legislative requirements of the 1996 Governor's Executive Order 96-297 and the 1997 water supply planning provisions of Section 373.0361, F.S.

Southern Indian Prairie Canal Basin Operation Plan

The purpose of the Southern Indian Prairie Canal Basin Operation Plan is to implement several of the recommendations from the Kissimmee Basin Water Supply Plan. The project will evaluate the installation of additional pumps to move water from Lake Okeechobee to provide water supply upstream of S-82 and S-83 in the southern Indian Prairie canal basin. The operation of existing pumps will be evaluated to determine the need for new pumps in light of Seminole water rights/needs, operational levels, potential land acquisition requirements, monitoring requirements, first-cost and operating costs, and related issues, such as water quality, flood control and environmental concerns. This project will not modify the SFWMD-Seminole agreement, address TMDL requirements, recompute irrigation demands, investigate water availability from Kissimmee or evaluate other water supply sources.

Lake Istokpoga Aquifer Storage and Recovery

The Lake Istokpoga Aquifer Storage and Recovery project will investigate the feasibility of aquifer storage and recovery (ASR) for Lake Istokpoga. The project is a response to Recommendation 5.2 of the Kissimmee Basin Water Supply Plan and is expected to be completed in cooperation with the SWFWMD. Initial stages of the feasibility study are looking toward the water quality and hydrologic studies being completed for Lake Okeechobee.

Lake Okeechobee Watershed CERP Project

The Lake Okeechobee Watershed (LOW) Project is part of the greater Comprehensive Everglades Restoration Plan (CERP), which is a group of projects designed to be a framework and guide for restoring, protecting and preserving the water resources of central and southern Florida. The CERP has been described as the world's largest ecosystem restoration effort and includes more than 60 major components.

The purposes of the LOW Project are to improve the water quality of Lake Okeechobee, provide for better management of lake water levels and reduce damaging releases to the estuaries. Water from the watershed and the lake will be detained in large storage areas during wet periods for later use during dry periods. The project envisions implementation of water quality treatment facilities that, together with source control measures, will meet the Lake Okeechobee TMDL (total maximum daily loads) norms on nutrient loading.

The LOW Project study area was initially divided into four interconnected planning areas. The evaluation criteria previously developed were focused on issues associated with these four hydrologically distinct regions. A fifth planning area, the Lake Istokpoga Watershed, was subsequently added to the project study area. As part of the LOW project, the Lake Istokpoga Regulation Schedule will reexamine the Lake Istokpoga basin, focusing on creating a balance among the environmental, water supply and flood control needs in the drainage basin. The plan will address the need for flood protection for the perimeter and upstream tributaries and for downstream areas west and east of the C-41A Canal. The plan will also address water supply needs of agricultural users and the Seminole Tribe of Florida. An assessment will be performed for the Lake Okeechobee northern watershed to identify sites where water quality treatment and storage facilities would provide optimum benefits to Lake Okeechobee. This may or may not include a reservoir or a stormwater treatment area (STA) in the Lake Istokpoga basin.

Kissimmee River Restoration Project

The Kissimmee River Restoration Project is a joint U.S. Army Corps of Engineers–SFWMD project to restore large areas of the historic Kissimmee Lakes and River wetland system. The upper-basin portion of the project consists of water regulation schedule modifications, canal and structure improvements and land acquisition. This effort will reestablish natural timing and volumes of flows into the Kissimmee River and will provide more-natural fluctuations of water levels to enhance the peripheral marshes of the lakes. Backfilling C-38 in Pools B, C and D and the restoration of flows through the meandering river channel will create historic hydrologic conditions in the floodplain to enhance fish and wildlife habitat.

The Kissimmee River Restoration will result in higher water levels in Pool C, downstream of G-85. As a result, flood discharge capacity from Lake Istokpoga to the Kissimmee River could be reduced. In order to maintain the existing Lake Istokpoga flood discharge capacity, G-85 is slated to be replaced with S-67 and a portion of the

Istokpoga Canal will be improved. Additionally, S-68, S-83 and S-84 will be modified to provide additional discharge capacity (**Figure 3**).

Phosphorus Budget and Loading Analysis for Lake Istokpoga and the Upper Kissimmee Watersheds

The Phosphorus Budget and Loading Analysis for Lake Istokpoga and the Upper Kissimmee Watersheds will assess the sources of phosphorus from Lake Istokpoga (and Upper Kissimmee Lakes) and the relative contribution to the water quality status of Lake Okeechobee, as required by the Lake Okeechobee Protection Act. The project will do the following: identify contributing basins (including Lake Istokpoga) and define the drainage boundaries, conduct a mass balance analysis of phosphorus for each land use at the basin and watershed scale, analyze possible relationships between net phosphorus imports and basin characteristics (land use, soil type, and the like) and prepare relevant documentation.

Lake Istokpoga Phosphorus Study

The Lake Istokpoga Phosphorus Study, which is being monitored jointly by the SFWMD and USGS, will determine whether reductions in external phosphorus loading to Lake Istokpoga will result in corresponding reductions to phosphorus loads to Lake Okeechobee. The study will determine the following: physical and chemical characteristics of in-lake sediment; assimilative capacity of the sediment; how long the assimilative capacity will last; the current contribution of phosphorus from sediments to the water column; and the effect that a reduction in external loading may have on phosphorus discharges.

Total Maximum Daily Loads (TMDLs)

The FDEP is developing a maximum daily load (TMDL) for the Northern Tributaries to Lake Okeechobee, including Lake Istokpoga. In 1999, the Department initiated the development of a phosphorus TMDL for Lake Okeechobee. This TMDL, adopted by rule in May 2001, proposes an annual load of 140 metric tons of phosphorus to Lake Okeechobee to achieve an in-lake target phosphorus concentration of 40 ppb in the pelagic zone of the lake. This restoration target will support a healthy lake system, restore the designated uses of Lake Okeechobee and allow the lake to meet applicable water quality standards. The annual load was calculated using computer models developed with guidance from the Lake Okeechobee TMDL Technical Advisory Committee. The entire load is allocated to the sum of all nonpoint sources. Additional information on this project can be found at: http://www.dep.state.fl.us.

CHAPTER 3
Resource Functions and Considerations

INTRODUCTION

The present chapter identifies the primary water resource functions of Lake Istokpoga that are to be protected by the proposed minimum level, and it discusses related resource protection issues, policies and procedures. The chapter also identifies the baseline resource conditions for assessing *significant harm,* as set forth in Section 373.0421(1)(a), F.S., which allows the water management districts, when setting a MFL, to consider changes and structural alterations that have occurred to a water resource.

WATER RESOURCE FUNCTIONS

Water resources within the Lake Istokpoga watershed serve a variety of functions that need to be considered in MFL development, including water supply, flood control, water quality, wildlife habitat, navigation and recreation. The Lake Istokpoga watershed can be divided into different hydrologic components, each associated with a different water body having unique characteristics (**Figure 10**). A discussion of these hydrologic units is provided in the Surface Water Hydrology subsection of **Chapter 2**.

Water Supply and Flood Control

Flows of surface water in the upper Lake Istokpoga watershed may be stored in Lake Arbuckle or Lake Josephine or directed toward Lake Istokpoga generally through two major tributaries: Arbuckle Creek and Josephine Creek. These water inflows into Lake Istokpoga may then be stored or passed downstream for water supply or released to the Kissimmee River or Lake Okeechobee.

Lake Istokpoga water levels are regulated within a narrow range ($\pm$ 2 ft) to support two primary goals: flood protection and water supply. The annual regulation schedule requires lowering the lake during the summer to provide storage and flood protection during the rainy season. The regulation schedule also requires increasing lake levels during the winter when flooding potential is low and water supply needs are highest (**Figure 11**). This schedule is opposite the natural annual cycle in which lake levels rise to their highest in the summer and decline during drier winter months.

Water from Lake Istokpoga is released through two primary routes. The G-85 Structure discharges water from Lake Istokpoga into the Istokpoga Canal, which flows eastward to the Kissimmee River. And at the south end of Lake Istokpoga is S-68, a gated water control structure that discharges into the C-41A Canal; water releases from the S-68 are generally routed into the Kissimmee River and/or to Lake Okeechobee. An extensive network of drainage ditches to the south of Lake Istokpoga drains agricultural lands and provides a source of irrigation water during the dry season. The ability to pass water quickly through drainage canals is necessary for flood protection during the rainy season, when frequent localized heavy rains occur.

Indian Prairie and the Brighton Indian Reservation, in Glades County south of Lake Istokpoga, are supplied with water mostly from Lake Istokpoga. The Brighton Reservation's primary land use is agriculture, and the Lake Istokpoga–Indian Prairie basin has historically experienced water shortages. The 1987 Water Rights Compact signed by the Seminole Tribe of Florida, the State of Florida and the SFWMD establishes the Tribe's water entitlement for the Brighton Reservation (see **Appendix A**). Although water supply releases from Lake Istokpoga may affect lake level decrease rates, the current regulation schedule does not allow water releases to below 37.0 feet NGVD (see **Figure 11**), and in this sense this agreement is not expected to affect the proposed minimum level.

Water Quality

Water quality within the Lake Istokpoga watershed can vary considerably by site. Isolated wetlands may contain water of relatively high quality, but water bodies associated with or downstream of agricultural lands can have significant water quality problems. The proliferation of weedy plant species, which can affect fish and wildlife habitats, is supported by elevated nutrient inputs from upstream sources and also by unnatural hydropatterns.

The primary sources of water to Lake Istokpoga are rainfall and tributary inflows. Tributary inflows, especially from Arbuckle Creek, are typically of lower quality (O'Dell *et al.* 1995). The results of a pollution risk analysis indicate that many areas surrounding Arbuckle Creek and Lake Istokpoga as well as many areas lying southward toward Indian Prairie have a moderate risk for causing nutrient pollution (nitrogen and phosphorus) (**Figure 22**). Results from monitoring efforts in Lake Istokpoga indicate that water quality has been affected by land uses of areas surrounding the lake and also by lake level regulation and aquatic-plant management activities (**Tables 7**, **8** and **9**).

Recreation and Navigation

Lake and river recreation are important activities in the Lake Istokpoga watershed. The many wetlands and surface waters in the watershed provide extensive opportunities for recreational boating (including canoeing), camping, fishing, wildlife observation, hunting and swimming. Many of these uses depend on the ability of water levels, water flow and water quality to support healthy plant and animal communities. Recreation on the many lakes, wetlands and creeks within the watershed provides a significant economic base for the region.

Fish and Wildlife Habitat

The Lake Istokpoga watershed contains some relatively undeveloped creeks and lakes. The watershed also borders the Kissimmee River Basin, which is currently undergoing a comprehensive restoration effort. The remaining water bodies and wetlands provide important wildlife habitat for a large array of birds, including osprey, bald eagles, sandhill cranes, wading birds, ducks, migratory birds and other species of concern (FWC 2000, Stewart 2001). Aquatic habitats support a fishery that has significance for wildlife and for recreational fishing. Maintenance of sufficient water depths and hydroperiods within these water bodies is required in order to protect existing plant and animal communities. The larger lakes in the watershed provide important habitat for freshwater fish—including largemouth bass, bluegill, crappie and catfish—that are important to recreational fishing interests, wading birds and raptors. Aquatic beds within lakes provide important habitat for freshwater organisms, many of which are a food source for fish and other wildlife. Swamps along the lake margins contain a number of species of trees and shrubs that provide important specialized wildlife habitats.

The Division of Fisheries Management of the FWC lists Lake Istokpoga as one of Florida's top ten lakes for catching largemouth bass, black crappie and bluegill. Overall, the FWC estimates Lake Istokpoga's sport fishery to be valued at $6 million annually (FWC 2002). Lake Istokpoga is also known for its significant bird population, which includes a number of federally designated threatened and endangered species. The wading bird rookery on Bumblebee Island in Lake Istokpoga is one of the most important rookeries in the area, and studies of osprey along the lake have documented one of the largest concentrations of active nests ever found (Stewart 2001).

ALTERATIONS

Hydrologic Changes

During the past century, changes made to provide drainage, water supply and flood protection for homes and farms and to improve lake access have irreversibly altered the structure and biological resources of Lake Istokpoga. These changes include the following:

- Alterations of natural hydrologic patterns and variability, which have allowed increased residential development along the lake, encouraged the expansion of undesirable weedy plant species into habitats important to fish and wildlife, and promoted the proliferation of floating vegetation mats that interfere with navigation (and can clog water control structures).
- Reduction of water tables, which has reduced the extent of wetlands, stressed remaining wetlands, and encouraged development into areas that were previously flooded.

- Drainage of wetlands within the historic Lake Istokpoga floodplain for development purposes.
- Diversion of natural water flows.
- Alteration of natural watercourses and shorelines.
- Construction of drainage ditches and canals.
- Changes to seasonal flooding patterns to provide maximum water levels during the dry season and minimum water levels during the wet season.

Water Quality and Biological Changes

Water quality changes in the Lake Istokpoga subbasin during the past 50 years are associated mostly with the expansion of agriculture in the region. The effects of fertilizer and pesticide runoff from agricultural croplands in this region are reinforced by the general sterility and high leaching capacity of the sandy soils and by the relatively high annual rainfall amounts across the region (**Table 1**). Runoff from feedlots and from other intensive cattle-raising operations is a significant source of nutrients and pathogenic organisms (see Zahina *et al.* 2001b). Lake Istokpoga was historically a sandy-bottom lake (FWC 2000), but today many areas have extensive organic substrate deposits. Flattening of natural water level fluctuations has stimulated the production of vegetation communities and the deposition of nutrient-rich organic sediments and has inhibited the natural historical cycle of degradation, compaction and oxidation.

Eutrophication of Lake Istokpoga has supported the expansion of weedy plant species that were once much less common along the lakeshore, including cattail and pickerel weed, which have replaced much of the littoral marsh community and have filled in the lake’s shallow open-water areas. In addition, hydrilla has expanded explosively within Istokpoga’s aquatic habitats and has displaced entire native communities of desirable vegetation (FWC 2000).

CONSIDERATIONS AND EXCLUSIONS

Once identification has been made of the functions and features of the water resource slated for protection by a specific minimum flow or level, determination must be made of the water resource’s baseline conditions upon which the assessment of *significant harm* will be based. The basis for making this determination of baseline conditions is set forth in Section 373.0421(1)(a), F.S., which requires the water management districts setting the MFL to consider changes and structural alterations that have occurred over time to the original water resource. Section 373.0421(1)(b), F.S., provides for exclusions from that requirement by recognizing that certain water bodies no longer serve their historical function and that recovery of these water bodies to historical conditions may not be feasible.

Considerations

Lake Istokpoga has a variety of features and functions that affect, or are affected by, the need to establish a minimum level and that therefore must be considered when defining the minimum level, including the following:

- Natural systems, including aquatic vegetation communities, wetlands, fish and wildlife.
- Hydrology.
- Water supply.
- Flood protection.
- Water quality.
- Navigation and recreation.

Natural Systems

During the past century, natural systems in Lake Istokpoga have been significantly altered by human activities. Some areas of the lake do remain in fairly good condition, although many of these areas have to be maintained artificially through vegetation control projects. Maintenance of aquatic communities, littoral zone marsh and lake swamp is important for many reasons—namely, the provision of habitat for wildlife use; recreation and support for the local economic base; and aesthetic values. Significant areas in the watershed have been permanently changed from natural landscapes to urban and agricultural land uses.

Hydrology

Activities associated with drainage, water supply and flood control have occasioned major hydrologic changes in Lake Istokpoga, including the stabilization of water level fluctuation, the elimination of extreme events and the alteration of the timing of high/low water periods. These hydrologic changes have significantly modified the frequency, timing and duration of the lake's natural water level variations, they have led to alteration of biological communities within the lake, and they have negatively affected natural physical processes that once served to improve and maintain water quality.

Water Supply

Management of the lake as a water supply source is one factor incorporated into the current operational schedule. Water supply releases from the S-68 are not allowed when water levels fall below a minimum lake level (**Figure 11**). Section 373.042(a), F.S., prohibits that any water supply withdrawal, whether existing or future, cause *significant harm* to the water resource or to the ecology of the area. Once the minimum level is established, the need to meet existing and future reasonable-beneficial water supply requirements must be factored into a recovery and prevention strategy, as explained in Section 373.0421(b), F.S.

Flood Protection

The construction and management of numerous drainage canals and associated water control structures upstream and downstream of Lake Istokpoga have significantly altered the natural drainage and flooding patterns of the area. Water levels in Lake Istokpoga are managed so as to reduce the potential for flooding of surrounding private lands and residences. Any proposed minimum level will meet or exceed existing levels of flood control.

The need to protect developed lands adjacent to the lake from flooding is a constraint preventing the lake from achieving historic high water levels. Some areas of former wetland forests adjacent to the lake can never be effectively reflooded and represent a permanent change from wetland to upland resources.

Water Quality

Water quality is most directly affected by continuous inputs of pollutants from upstream runoff sources; efforts are under way to reduce these inputs over time. The relationship between water levels and water quality is less direct, associated with deposition of organic sediments, proliferation of tussocks and management of aquatic weeds. These indirect effects will be considered during development of minimum level criteria.

Navigation and Recreation

Navigation and recreation on Lake Istokpoga are negatively affected by low water levels, which restrict boat access to the lake. Any proposed minimum level will consider this impact of low water levels on lake recreational activities and will keep in mind the need for lake access.

Exclusions

As described in **Chapter 1**, Section 373.0421(1)(b), F.S., recognizes that in certain cases a water body may no longer serve its historical function and recovery of this water body to its historical condition may not be practical or feasible. But District staff determined that it was not appropriate to apply this exclusion to Lake Istokpoga relative to establishment of a minimum level. Lake Istokpoga and its associated habitats have indeed been, and continue to be, greatly altered by economic development in the basin and by needs for flood protection and water supply, so much so that full recovery of historic water level characteristics of the lake and of its associated tributaries and wetlands may not be technically or economically feasible. Nevertheless, the need to protect and enhance the remaining natural features in the system is clearly identified, and the consideration in Section 373.0421(1)(a), F.S., seems to address adequately the changes and alterations in water resource functions applicable to these areas. As a result, there is no apparent basis to invoke the exclusion in Subsection 373.0421(1)(b)1, F.S. The remaining exclusions in Subsections 373.0421(1)(b)(2–3), F.S., pertain to water bodies less than 25 acres in size or to constructed water bodies and therefore do not apply to Lake Istokpoga.

In summary, the SFWMD will establish a minimum level for Lake Istokpoga based on consideration of structural alterations to the resource, as allowed pursuant to Section 373.042(1)(a), F.S. Section 373.042(a), F.S., prohibits allowing *significant harm* to be caused to the water resources or ecology of the area by existing or future water supply withdrawals. Once the minimum level is established, the need to meet existing and future reasonable-beneficial water supply requirements must be factored into the recovery and prevention strategy.

CHAPTER 4

Methods for Developing Minimum Level Criteria

CONCEPTUAL BASIS FOR MINIMUM LEVELS: MANAGEMENT CONCERNS AND OBJECTIVES

Management of a natural resource is a complex process requiring consideration of a number of variables. Establishment of a minimum level is an important component of this process; a minimum level, however, is only one aspect of a whole range of variation that must be considered as part of management efforts. Other aspects include average levels, maximum levels, and seasonal variability and frequency of flooding and drought events. To focus on only one aspect of the lake's hydrology would be an overly simplistic treatment of the whole range of complex ecosystem interactions that need to be considered in order to protect this water body.

Because of the intrinsic ecologic complexity of many natural water bodies, disagreement is common regarding the nature of the role of the MFL within the larger picture of resource management. The MFL marks a point at which a water supply withdrawal will cause *significant harm* to a surface water body, aquifer, or area ecology (see MFL rule definitions in **Chapter 1**). The MFL rule provides for setting an MFL on the basis of "best available information," and typically an MFL is set for a water body despite the clear recognition that more studies are required in order to understand fully some of the more complex relevant hydrologic/ecologic interactions. Rather than waiting until all information is available before making a management decision, MFL development is based on "best available information." This process also includes an adaptive approach that 1) sets water inflows and levels based on best available information, expert opinion and assumptions and analyses derived from conceptual and mathematical modeling, 2) monitors the results for success or failure, 3) identifies research needs and reevaluates water level and flow targets and 4) provides for adjustment of water level and inflow as needed, on the basis of results from monitoring and research.

Historical data and accounts provide a means for identifying ecologic changes to the system during the previous century. **Chapter 2** describes the pre-development watershed conditions. The most notable changes to Lake Istokpoga over the past half-century include the following:

- Stabilization of water levels, thereby eliminating periodic occurrences of extreme high and low water levels characteristic of historic Lake Istokpoga hydrology.

- Alteration of the natural seasonal pattern of rainy-season high water levels and dry-season low water levels (current lake management tends to maintain higher lake levels during the dry season, for water supply, and lower levels during the rainy season, for flood control).
- Alteration of natural flowways out of Lake Istokpoga (this function has been largely assumed by canals and is regulated by water control structures).
- Draining of lands within the historic floodplain for development of agriculture and homesites.
- Large increases in loading of pollutants, mostly nitrogen and phosphorus, from upstream sources.
- Proliferation of nonnative and nuisance plant species that disrupt natural systems in the lake and littoral wetlands and negatively affect navigation and recreation.
- Accumulation of organic sediments that impact fish and wildlife resources.

Several projects currently address these resource management issues in the Lake Istokpoga watershed. The establishment of a minimum level for Lake Istokpoga will define low water levels that cause *significant harm*. Efforts such as the Kissimmee Basin Water Supply Plan, the Comprehensive Everglades Restoration Plan (CERP) and the FWC's wildlife habitat management programs provide the means to manage high-water events, to address water storage needs and to restore some of the lake's lost hydrologic and ecologic functions.

Considering impacts to Lake Istokpoga from alterations in hydrology, water chemistry and ecology, District specialists suggest that management objectives for Lake Istokpoga should address the following concerns:

- Provision of periodic drawdowns designed to approximate historic low water level conditions more closely, thereby providing an opportunity for sediment consolidation and control of nuisance vegetation.
- Reevaluation of the current regulation schedule to incorporate a more natural pattern and timing of water levels to reflect seasonal and other historical fluctuations.
- Protection and enhancement of remaining littoral zone and fringing swamp wetlands through improved management practices, including maintenance of more appropriate water levels.
- Improvement of water quality in the lake and tributaries by identifying and managing sources of inflows of pollution and storm water runoff.

Development of minimum level criteria provides an additional tool needed for addressing these goals and objectives. The minimum level criteria will specifically identify the range of water levels in the lake that will cause *significant harm* to the resource.

METHODS STUDIED IN DEVELOPING MFL CRITERIA FOR LAKE ISTOKPOGA

Methods Used in Other Florida Lakes

Lake Okeechobee (SFWMD)

Lake Okeechobee is a large, shallow, eutrophic lake located in south central Florida that serves as a multipurpose reservoir to meet regional water management needs. In 2000, the SFWMD established a MFL for Lake Okeechobee based on achieving balanced protection of the following four water resource functions: 1) preventing saltwater intrusion into the Biscayne Aquifer, 2) meeting water storage and supply needs, 3) providing habitat for fish and wildlife and 4) supporting navigation and recreational use. Lake Okeechobee water depth is controlled by a regulation schedule, and allocations of lake water during drought periods are based on a drought management plan.

Defining the criteria for Lake Okeechobee minimum water levels involved the examination of drought management plans, historical data and ecologic research results. Drought management plans indicated that total annual rainfall in south Florida is highly variable. Historical data showed that when lake water levels fell below 10.5 feet, limitations of outlet structures made it difficult to provide water to protect coastal wellfields against saltwater intrusion. Ecologic research showed that, in regard to water level, a 1-foot decline in lake levels from 12 feet to 11 feet brought a 20 percent loss of aquatic habitat and other significant impacts, which became worse as water levels declined below 11 feet. In regard to determining a minimum duration and return frequency for declaration of a violation of the minimum water level, little pertinent ecologic information existed, so the minimum duration and return frequency components were estimated on the basis of analysis of historical records from 1952 to 1995.

The *significant harm* criteria for Lake Okeechobee were based on the relationship between water levels in the lake and the ability to 1) protect the coastal aquifer, 2) supply water to Everglades National Park, the Everglades Agricultural Area, Seminole Indian Tribe Reservation lands and the Caloosahatchee and St. Lucie basins, 3) provide littoral zone habitat for fish and wildlife and 4) ensure navigational and recreational access. *Significant harm* to navigation and recreation was determined on the basis of 1) water depths needed for safe navigation of the Okeechobee Waterway, 2) bathymetry maps and 3) discussions with marina operators and boat captains. Minimum level criteria for Lake Okeechobee are as follows:

> A MFL violation occurs in Lake Okeechobee when an exceedance, as defined herein, occurs more than once every six years. An exceedance is a decline below 11 feet NGVD for more than 80 nonconsecutive or consecutive days during an eighteen-month period. The eighteen-month period shall be initiated following the first day Lake Okeechobee falls below 11 feet NGVD and shall not include more than one wet season, defined as May 31st through October 31st, of any given calendar year (Chapter 40E-8.221 [1], F.A.C.)

Southwest Florida Water Management District Lakes

In 1996, the Southwest Florida Water Management District convened a Technical Advisory Committee to develop minimum flows and levels methodologies. The Committee was composed of SWFWMD staff, representatives of local governments and interested citizens. Separate subcommittees were formed to develop specific methodologies for aquifers, lakes and wetlands. As a result of work performed by the Lake Level Subcommittee, the SWFWMD Governing Board adopted in 1998 a methodology for establishing minimum lake levels. Three categories of lakes were identified in this methodology: Category 1 lakes (with fringing bald cypress wetlands and water levels that currently rise to an elevation expected to maintain fully the integrity of the wetlands), Category 2 lakes (with fringing bald cypress wetlands that have been structurally altered such that lake water levels do not rise to levels formerly attained) and Category 3 lakes (with no fringing bald cypress) (see SWFWMD 1999, 2001 and 2002).

Establishment of minimum levels for lakes fringed with bald cypress wetlands (as is Lake Istokpoga) is preceded by the compilation of lake stage data, the calculation of stage-duration percentile statistics, the characterization of the data as "historic" or "current," the determination of normal pool and control point elevation, and the development of a region-specific reference lake water regime. Minimum levels are established based on a series of dichotomous choices concerning the type of stage data available and the relative elevations of the suite of descriptive stage-duration statistics. The definition of a "minimum level" for those SWFWMD lakes is as follows:

- The "minimum level" is the long-term level of a surface water, water table or potentiometric surface at which further withdrawals would be significantly harmful to the water resources of the area and which may provide for the protection of nonconsumptive uses (e.g., recreational, aesthetic and navigation). Such level shall be expressed as an elevation in feet relative to the National Geodetic Vertical Datum (1929) or in feet relative to the North American Vertical Datum (1988) and includes Minimum Wetland Levels, High Minimum Lake Levels, Minimum Lake Levels and Saltwater Intrusion Minimum Aquifer Levels.

A "high minimum lake level" (HMLL) and "minimum lake level" (MLL) are further defined as follows:

- The "high minimum lake level" is the minimum level that corresponds to the elevation that the lake water level must equal or exceed 10 percent of the time on a long-term basis. For evaluation of hydrologic data for the purpose of establishing minimum levels, "long-term" means a period that spans the range of hydrologic conditions that can be expected to occur, based on historical records. Typically, a period of six or more years is considered sufficient for establishment of long-term conditions; however, shorter periods may be considered to be representative of long-term conditions, based on reasonable scientific judgment.

- The "minimum lake level" is the minimum level that corresponds to the elevation that the lake water level must equal or exceed 50 percent of the time on a long-term basis.

The term *significant harm* was deemed by the SWFWMD Governing Board to be equivalent to "significantly altered." As such, the standards and methods associated with the definition of "significantly altered" wetlands, as originally developed by the Wetland Subcommittee to identify isolated wetlands that have been "significantly altered" as a result of reduced hydroperiods (SWFWMD 1999), would be applied to lakes with fringing bald cypress wetlands.

The SWFWMD approach to MFLs differs from that of the SFWMD, especially in the basic definition of *significant harm* (see SFWMD definition outlined in **Chapter 1**, specifically **Figure 1**). Furthermore, the types of lakes found within the SWFWMD are different from those typically found within the SFMWD. For these reasons, direct application of the SWFWMD methodology is not appropriate here. Use of the rationale for protection of fringing wetlands, however, is an important and applicable consideration included in the MFL concept developed for Lake Istokpoga.

St. Johns River Water Management District Lakes

The St. Johns River Water Management District (SJRWMD) defines MFLs as the minimum water levels and/or flows necessary to prevent *significant harm* to the water resources or ecology of an area resulting from water withdrawals permitted by the SJRWMD. These MFLs define how often and for how long the high, average and low water levels and/or flows should occur in order to prevent *significant harm*. The SJRWMD defines *significant harm* as "unacceptable long-term changes to ecosystem structure or the long-term or short-term unacceptable decline of important ecosystem functions caused by anthropogenic alteration of system hydrology" (SJRWMD 2001). The hydrologic (water level and/or flow) conditions defined by the MFLs are similar to, but are usually lower than, existing hydrologic conditions (see **Figure 26**) (SJRWMD 2001). Three to five MFL criteria are usually defined for each aquatic system: minimum infrequent low, minimum frequent low, minimum average, minimum frequent high and minimum infrequent high (**Figure 27**). These MFL categories directly correspond to community types typically found along the hydrologic gradient upslope from the water body, each with different minimum hydroperiod requirements. These communities include aquatic (open water), slough, marsh, swamp, wet prairie and hydric hammock.

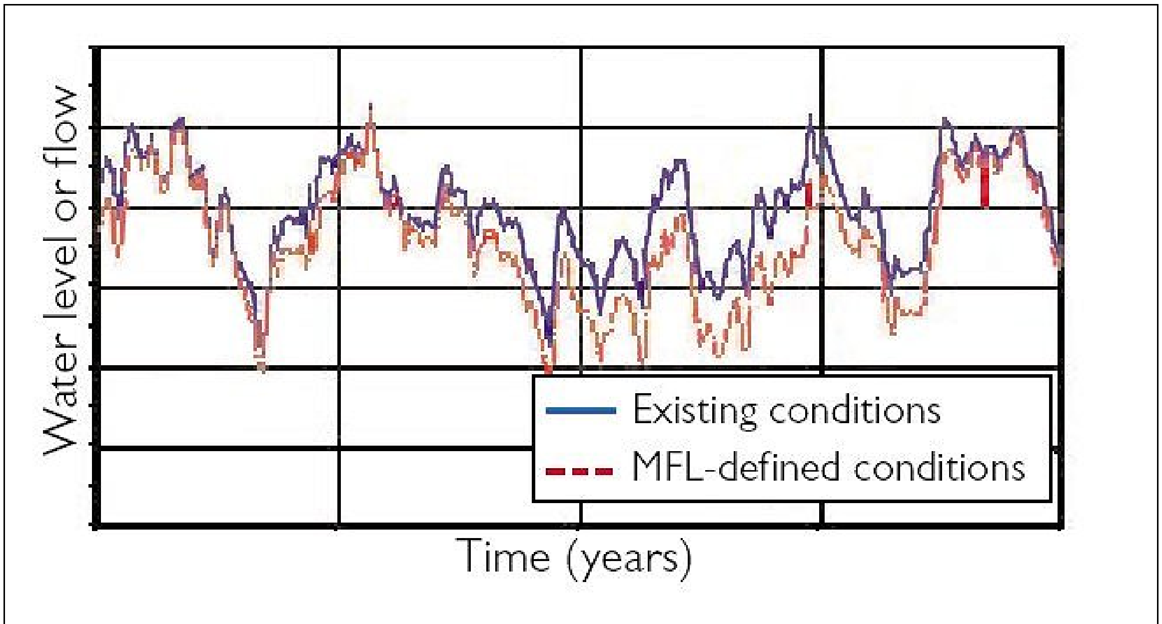


Figure 26. Comparison of Typical Hydrograph and MFL-Defined Minimum Level Hydrograph as Established by the St. Johns River Water Management District (Source: SJRWMD 2001).

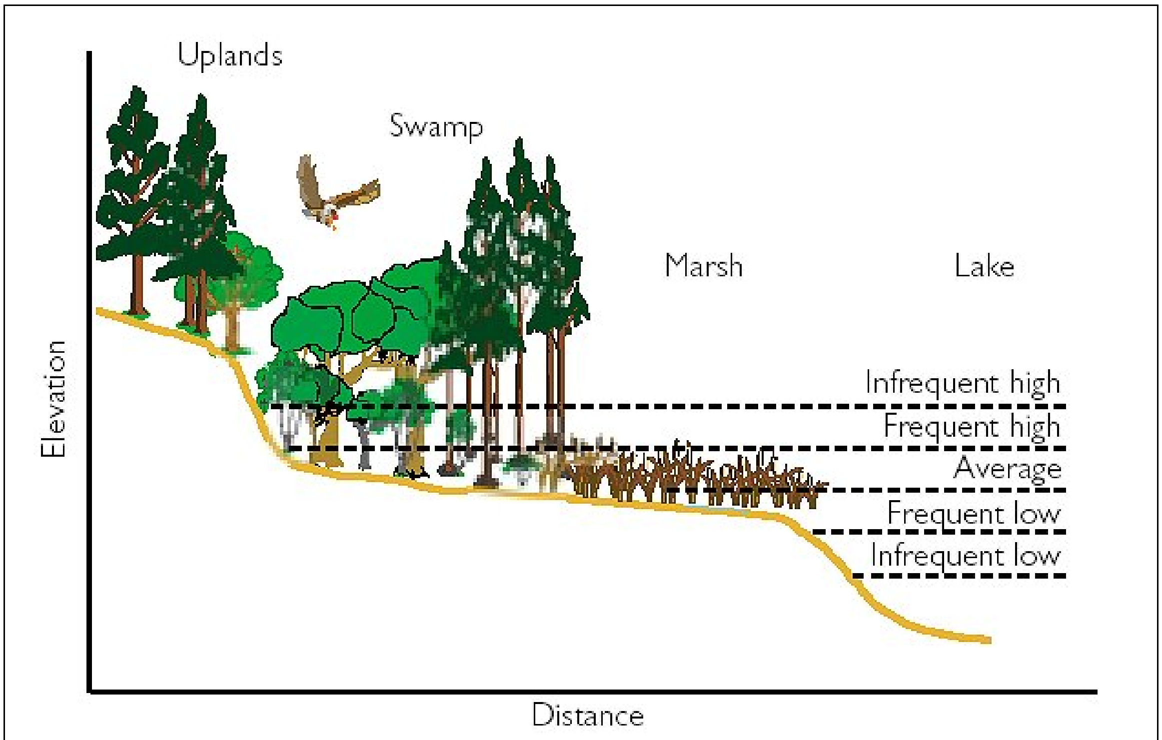


Figure 27. Five Different Potential MFLs as Defined by the St. Johns River Water Management District (Source: SJRWMD 2001).

The SJRWMD defines these categories as follows:

- The "minimum infrequent low" means an acutely low surface water level or flow with an associated frequency and duration that may occur during periods of extreme drought. Below this level there will be a significant negative impact on the biota of the surface water, which includes associated wetlands.
- The "minimum frequent low" means a chronically low surface water level or flow that generally occurs only during periods of reduced rainfall. This level helps prevent deleterious effects to the composition and structure of floodplain soils, to the species composition and structure of floodplain and instream biotic communities, and to the linkage of aquatic and floodplain food webs.
- The "minimum average" means the surface water level or flow necessary over a long period to maintain the integrity of hydric soils and wetland plant communities.
- The "minimum frequent high" means a chronically high surface water level or flow with an associated frequency and duration. This level allows for inundation of the floodplain at a depth and duration sufficient to maintain wetland functions.
- The "minimum infrequent high" means an acutely high surface water level or flow with an associated frequency and duration. This level is expected to be reached or exceeded during or immediately after periods of high rainfall so as to allow for inundation of a floodplain at a depth and duration sufficient to maintain biota and the exchange of nutrients and detrital material.

The SJRWMD approach to MFLs differs significantly from that of the SFWMD, both in the basic definition of *significant harm* (**Chapter 1** and **Figure 1**) and in the derivation of the MFL from existing conditions. Direct application of the SJRWMD methodology to Lake Istokpoga is not feasible, but consideration of lake wetlands will be included in the development of the minimum level for Lake Istokpoga.

Additional Methods

Additional approaches that were considered during the development of MFL criteria for Lake Istokpoga are the following:

- <u>Analysis of historic and current hydrologic conditions.</u> A fairly robust set of 1936–2003 water level data for Lake Istokpoga is available from the SFWMD's DBHYDRO database. This record includes several decades of figures from the periods before and after alteration of the lake's natural hydropattern. A comparison of pre-alteration and current conditions is useful for understanding the hydrologic changes that have occurred.

- Study of low water levels' impact on water supply, navigation, recreation and water quality. The needs of the Istokpoga basin are examined in order to determine if there is a point at which these resource functions are significantly harmed.
- Study of natural systems' hydrologic requirements. Analysis of the hydrologic requirements of littoral zone and fringing swamp vegetation communities can be conducted from existing bathymetry and land use datasets. Most wildlife and fish are ultimately dependent on these vegetation communities as their vital habitat, and therefore the health of the aquatic and surrounding wetland vegetation communities is considered essential.

Because each of these three approaches is able to focus on a unique resource function and because sufficient data exist to conduct each analysis, all three have been used to provide a result that most effectively considers the overall Lake Istokpoga system. The following section discusses in more detail each of these three approaches.

METHODS USED IN DEVELOPING MFL CRITERIA FOR LAKE ISTOKPOGA

Analysis of Historic and Current Hydrologic Conditions

A long-term time series of measured water level data on Lake Istokpoga is available from the SFWMD's DBHYDRO Database (this database is available at: http://www.sfwmd.gov/org/ema/dbhydro/). Specific information about the files containing relevant water level data is presented in **Table 16**.

The graph of this time series of water levels (**Figure 16**) shows three distinct, partially overlapping periods starting in 1936 and corresponding to three different water management practices, as follows: 1936 to 1963; 1963 to the present; and 1989 to the present. In 1963 lake levels began to be managed for flood control; in 1989 lake levels began to be managed for navigation, recreation and water supply purposes. An analysis of water levels during these three periods was conducted in order to characterize the different water level regimes: 1) no controls, 2) flattened highs, and 3) flattened highs and lows. Then descriptive statistics for these three periods were compared so as to determine changes resulting from lake management.

- During the 1936–1963 period, lake levels were unconstrained; this period theoretically reflects a "historic" condition.
- From 1963 to the present—the period following construction of the S-68 Structure—high water events were essentially eliminated as lake levels become managed for flood control.
- From 1989 to the present—the period following the commencement of lake management for navigation, recreation

and water supply—low water levels (water levels less than 36.5 feet NGVD) did not occur (excluding the period of a controlled drawdown for environmental enhancement).

Table 16. Water Level Data in the SFWMD's DBHYDRO Database.

DBHYDRO Element	Element Description	Value	Value Description
DBKEY	Station number in DBHYDRO Database	00231	Station number
STATION	Station name in DBHYDRO Database	S68_H	Sample collected at the headwater (lake) side of the S-68 Structure
AGENCY	Source of the data	USGS	United States Geological Survey
COUNTY	County where monitoring station resides	HIG	Highlands
TYPE	Data type	STG	Surface water stage
UNITS	Data units	FT NGVD29	Feet, NGVD29 Datum
STAT	Statistic	MEAN	Mean for time unit
FQ	Frequency (time-unit) of reported datum	DA	Time unit of one day
START	First day of record	1936	Year of 1936
END	Last day of record	2002	Note: this is periodically updated as more data are processed and made available
LAT	Latitude of monitoring station	271948	27.1948 North
LONG	Longitude of monitoring station	811515	81.1515 West
SECTION	Section where monitoring station resides	20	Section block 20 within the Township/Range
TOWN	Township where monitoring station resides	36	Township 36 South
RANGE	Range where monitoring station resides	31	Range 31 East
ALTERNATE ID	Alternate station number in DBHYDRO Database	2271700	Alternate station number

Evaluation of Low Water Levels' Impact on Supply, Navigation/Recreation and Water Quality

Water Supply Issues and Constraints

Unlike urban areas within the Istokpoga basin, agricultural areas south of Lake Istokpoga depend on the lake for water (for irrigation) during dry periods. The agricultural operations within the Lake Istokpoga–Indian Prairie basin have experienced a series of water shortages related to a lack of supply from Lake Istokpoga and of runoff from the basin. During the late 1980s and early 1990s, several actions were taken by the SFWMD to correct these problems. An analysis of the Lake Istokpoga–Indian Prairie system, completed as part of the Kissimmee Basin Water Supply Plan (SFWMD 2000a), suggests that although there appears to be sufficient water to meet the current water supply demands, surface water from the Lake Istokpoga–Indian Prairie basin is not sufficient to meet all of the projected future (2020) water needs. The recommendations considered as part of the KB Plan were aimed at the development of alternative supplies to meet the projected future needs.

To address the projected future surface water deficits more fully, the KB Plan advisory committee formed a subcommittee to identify issues within the Istokpoga basin and to review an analysis developed in responses to these concerns. The group also identified and discussed several water resource options specific to the Istokpoga basin for addressing the projected shortfalls in water supply. Two types of options were identified as ways to make additional water available or to reduce projected demand. Water source options that were identified as having the greatest potential for meeting future demands included backpumping from Lake Okeechobee, importing water from the Kissimmee River at S-84, changing the minimum operational flows from Lake Istokpoga and constructing regional reservoirs.

The ability to increase storage in Lake Istokpoga by maintaining water levels above current levels was also considered. This option received the largest amount of debate from the KB Plan focus group. Concerns were raised about the proper regulation schedule and the minimum operational levels for the lake. Some committee members thought the existing level of 37.5 feet was too low from the viewpoint of resultant navigational constraints. Others thought that the lake did not fluctuate enough and should be allowed to drop to 36.5 feet on occasion. Concerns were also expressed about the time of the year at which these levels should be achieved. The majority of participants agreed that maximizing the range of annual water level fluctuations while maintaining navigation and flood protection constraints would be beneficial.

Water supply within the Lake Istokpoga basin is not a concern at this time; nevertheless, water supply projects are under way to investigate the potential future needs and supply shortfalls (SFWMD 2000a). These issues will be further discussed and addressed by future KB Plan updates and the Lake Okeechobee Watershed (LOW) CERP Project. Lake Istokpoga's water supply function is therefore not considered a constraint in developing MFL criteria at this time. But a comparison of the proposed minimum level with the current Regulation Schedule for Lake Istokpoga will be conducted to determine if the proposed minimum level could potentially affect water supply. Future updates to the MFL criteria will consider water supply issues and any related need for adjustments to MFL criteria.

Recreational Use and Navigation

Lake Istokpoga's large size permits a wide range of recreational activities such as fishing, hunting, waterskiing, wildlife observation and boating. Arbuckle Creek is a favorite canoeing and kayaking route and includes the lake's northern shore. Many of these recreational/navigational uses depend on the existence of adequate lake levels, flow and water quality to support healthy plant and animal communities within the lake. Therefore, maintenance of minimum levels is important for access to and enjoyment of the resource.

In 1974, the SFWMD's Governing Board adopted a rule (Part I, Chapter 40E-22, F.A.C) that contains a Regional Water Shortage Plan for the Lake Istokpoga–Indian Prairie Area. The plan established a minimum permissible schedule for Lake Istokpoga and the project canals into which the lake discharges. This Governing Board action was based on a 1974 report entitled *Report on Surface Water Availability in Lake Istokpoga–Indian Prairie Area* (SFWMD 1991). This report does not provide a detailed ecologic-impact analysis associated with the minimum level recommendations, and it appears that the lake's ecology was not a determining factor. The report's justification for the recommended Lake Istokpoga minimum level focused on recreational boating and aesthetic values. The report states that "…based on staff knowledge of recreational navigation access problems in the lake and lake residents' views of desirable lake stages as expressed at public meetings and in correspondence to the SFWMD, a judgment determination was made setting minimum lake stage at 37.0 feet mean sea level…" (SFWMD 1991).

Stakeholder comments and input at public meetings indicate that problems with localized access to the lake may appear when water levels drop below 38 feet NGVD. In addition, the impacts of low water levels on navigation and recreational access are transient and are eliminated when water levels rise. The effects of prolonged low water events on navigation and recreational access are included as a consideration in MFL development.

Relationship between Water Quality and Lake Levels

The relationship between water quality and water levels in Lake Istokpoga is largely undefined. It is assumed, however, that internal cycling mechanisms and nutrient loading from tributaries are the dominant factors controlling water quality.

The primary origin of nutrient inputs to the lake is storm water runoff from upstream sources. The magnitude of these inputs is independent of water levels in Lake Istokpoga, since the inputs are controlled by rainfall patterns within the basin. Generally, water quality is poorer in the northern end of the lake, where Arbuckle and Josephine creeks empty into Lake Istokpoga. Water quality measurements in the southern end of the lake (near the S-68 Structure outflow) indicate that high amounts of nutrients are removed from the water column through uptake by aquatic and littoral zone vegetation.

One activity that may temporarily affect water quality is the chemical treatment of aquatic vegetation (such as hydrilla) (O'Dell *et al.* 1995). This effect, however, is not the direct result of lower water levels, although vegetation control is usually exercised during low water periods. Death and decay of the chemically treated vegetation can lead to release of nutrients stored in the plant tissue, raising water column nutrient levels. The severity of such treatments' impact on water quality depends on the extent of the treatment area and on the type of herbicide applied. Fluridone, which is used for large-scale and whole-lake treatment of hydrilla, is slow-acting and typically has a response time of several weeks or longer. Studies of water quality after treatment generally indicate a temporary increase in phosphorus and chlorophyll concentrations and a decrease in Secchi depths (O'Dell *et al.* 1995). This increase in nutrients has not been associated with algal blooms or other environmental degradation, and some released phosphorus may have been lost from the lake through outflows.

Because of the assumed indirect or weak relationship between water quality and water levels, as well as the lack of data relating water levels to water quality, this factor was not included in the development of MFL criteria for Lake Istokpoga.

Analysis of Natural Systems' Hydrologic Requirements

Aquatic and Wetland Vegetation Communities

Lake Istokpoga's littoral zone and aquatic vegetation communities provide critical habitat for fish and wildlife. Protection of aquatic and littoral zone vegetation is essential because this habitat affords needed spawning and nesting areas and protective cover and serves as a nursery for organisms that are food for fish and wildlife.

Because littoral zone wetland hydropatterns are related to lake levels, consideration of the hydroperiod requirements of these littoral zone wetland communities was a key factor in MFL criteria development for Lake Istokpoga. Fish and wildlife communities rely on in-lake and adjacent wetlands as critical habitats, and thus the analysis of aquatic and wetland vegetation communities' hydrologic requirements can provide a basis for examining lake levels' potential impact on the local ecology. It is assumed that if the average hydroperiod for a wetland type is shortened for several years in succession, then the community will begin to shift to another community type more characteristic of drier habitats. With this change comes an altered function within the landscape and altered value to fish and wildlife.

The point at which these wetlands experience *significant harm* associated with lake level changes was determined by using the typical water level and hydroperiod ranges reported for the various wetland types. By comparing lake levels and wetland elevations, water depths within littoral wetlands were determined. The extent of lake wetlands was obtained from land use maps (FDOT 1995), and the natural range of wetland hydrologic conditions was obtained from a review of the scientific literature. Ground elevations within these wetlands were determined from a recent bathymetry study conducted for the FDEP (ReMetrix 2003) and were used to specify the average lake levels required to sustain each community type.

Fish Communities

Lake Istokpoga's fish communities are important components of the local ecologic community and economy. Small fish are important food sources for wading birds and raptors, supporting one of the largest known concentrations of osprey (Stewart 2001). Fishing and associated activities support a significant recreation-based economy, ranging from sales of fishing-related equipment (from bait to boats) to fishing guide services and year-round fishing camps. The local ecologic community and the local economy both rely on the maintenance of a healthy and productive fish community.

Fisheries management includes implementation of slot limits for catches, vegetation management and, more recently, drawdown of lake levels to remove accumulated sediments and facilitate treatment of weedy aquatic vegetation. The effects of low water levels on the fishery resource were considered as part of the MFL criteria. Fish survey data were impacts that could be directly related to the 2001 drawdown event and that persisted for more than two years.

Bird Communities

Many bird species depend on a specific type of habitat for feeding and/or successful reproduction. A disturbance, whether natural or human induced, can have a significant impact on population distribution and reproductive success. Some bird species use several habitat types for different purposes. For instance, wading birds typically forage for food in marshes or in shallow open-water areas but roost and nest in trees (usually swamps). Some bird species are directly dependent on water levels for successful feeding (Kushlan 1976, 1986, 1989; Ogden *et al.* 1976). Low water levels can favor fish catches by wading birds and raptors by concentrating prey into smaller spatial areas and shallow water. But excessive and prolonged low water levels may negatively impact littoral zone wetlands, which are vital habitats for some bird species. The health and diversity of aquatic and wetland habitats are essential elements in supporting a vigorous and diverse bird population.

The habitat requirements of a wide range of bird species found within the Lake Istokpoga area were researched in order to help determine the relationships between water levels and the well-being of the various bird communities. An examination was undertaken of the potential impact of low water levels on bird breeding cycles and on plant communities used by birds. The sources of bird habitat information included books, Internet resources and conversations with local bird experts. Low water conditions that would cause reproductive failure of successive year-classes may negatively impact local bird populations. Several successive years of impacts may lead to *significant harm*.

CHAPTER 5

Results: Water Level Requirements of Lake Istokpoga Resources

ANALYSIS OF HISTORIC AND CURRENT HYDROLOGIC CONDITIONS

Historical Water Levels on Lake Istokpoga

Prior to 1962, high water events (above 40 feet NGVD) regularly occurred on Lake Istokpoga. From 1936 to 1962, high water events occurred 14 times (**Table 17, Figure 16**), with a return frequency of approximately once every two years. These periods of high water levels can play an important environmental role by 1) depositing organic matter within the floodplain to be oxidized and decomposed after flood waters recede, 2) inundating swampland, thereby reducing understory growth and 3) transporting viable seeds throughout the area, thereby supporting wetland reproduction and species diversity. Since construction and operation of water control structures, water levels reached 40 feet NGVD only once (briefly) between 1962 and 2002.

Table 17. Lake Istokpoga Water Level Statistics from Various Historic Periods of Record (all values are feet NGVD).

	1936–1962	1962–1989	1989–2000
Mean	38.6	38.5	38.8
Standard Deviation	1.3	0.8	0.56
Count (*n*)	9649	9862	4298
Median	38.5	38.6	39.0
Mode	38.4	39.4	39.4
Minimum	35.4	36.2	37.2
Maximum	42.9	40.1	39.9
Range	7.5	3.9	2.7

After 1962 and especially after 1989, the duration, magnitude and frequency of low water events were reduced from the historic (pre-1962) condition. In the 1936–1962 period, there occurred six natural low water events (at or below 36.5 feet NGVD), with an average duration of seven weeks and a return frequency of once every 3.4 years (**Table 18**). In the 1962–1985 period, two low water events occurred, one associated with a drawdown of the lake for construction of the S-68 in 1962. After 1985, water levels dropped below 36.5 feet NGVD only once, during a controlled vegetation enhancement project in 2001.

Table 18. Frequency and Duration of Low Water Events on Lake Istokpoga for the Period of Record 1939–2002 (the 1962 and 2001 events shown in italics were controlled drawdown events [that is, not naturally occurring]).

Year	Duration[1] (Weeks)	Years since Last Event
1939	less than 1	N/A
1945	5	6
1949	3	4
1950	6	1
1955	7	5
1956	20	1
1962 Drawdown	*18*	*N/A*
1971	6	9
2001 Drawdown	*19*	*N/A*
1939–2000 Mean	8	5
1939–2000 Median	6	5
1939–1963 Mean	9	4
1939–1963 Median	6	5

[1] Event defined as a period of continuous lake levels of 36.5 feet NGVD or less, with fewer than seven continuous days at or above 36.5 feet.

N/A = not applicable, because drawdown was not a natural event.

Extremely low water levels can play an important environmental function by permitting 1) the drying, compaction and oxidation of organic matter in the lake bed and littoral zone, 2) the germination and establishment of swamp and marsh vegetation and 3) the temporary concentration of aquatic prey into smaller areas to support wading bird and raptor foraging and the rearing of chicks. Prior to human suppression of natural fires, flatwood burns would ignite the dewatered lake bottom and consume exposed organic matter (FWC 2000). These periodic drydown episodes were a vital mechanism for maintaining a sandy lake bottom, reducing in-lake storage of nutrients and controlling growth of littoral zone vegetation communities. Extreme lake drydown played an important role in maintaining the shallow character of the lake, and in the future if no sediment removal projects are implemented, the suppression of low water levels could lead to eventual succession of the lake to a marsh (FWC 2000).

Current Regulation Schedule

Water levels in Lake Istokpoga are managed by operation of water control structures (structures S-68 and G-85) as guided by a regulation schedule adopted by the U.S. Army Corps of Engineers and the SFWMD (**Figure 11**). Benefits of the regulation schedule include 1) a reduction in the potential for flooding of lakeside homes and businesses, 2) a reduction in the number and severity of low water level events, thereby aiding navigational access important to the local economy and 3) sufficient dry season water availability for recreation, boating and fishing interests and for supplying water to downstream users. Nevertheless, without natural lake level fluctuations, the germination of aquatic plant seeds is reduced, buildup of organic sediments occurs and the formation and expansion of floating vegetation mats are promoted. The regulation schedule will be reevaluated by the LOW CERP Project as the latter examines the Lake Istokpoga basin with a view toward creating a balance among the environmental, flood control and water supply needs in the drainage basin. The LOW CERP Project will address the need for flood protection for the perimeter and upstream tributaries and for downstream areas west and east of the C-41A Canal, and it will also address water supply needs of agricultural users, including the Seminole Tribe of Florida.

MFLs are concerned with low water levels that cause *significant harm* to the resource, and *significant harm* would be unlikely to occur under the current regulation schedule, because low water events no longer occur to the degree that existed before water level stabilization. But because the regulation schedule will be reviewed by the LOW CERP Project and periodic drawdowns are being proposed to benefit the natural communities within the lake, a definition of the point of *significant harm* to the current resource caused by low water levels will be a useful tool.

IMPACTS OF LOW WATER LEVELS ON NAVIGATION AND RECREATION

In 1974, the SFWMD's Governing Board adopted a Regional Water Shortage Plan for the Lake Istokpoga–Indian Prairie Area (Part I, Chapter 40E-22, F.A.C). This Plan established a minimum permissible schedule (water level) for Lake Istokpoga of 37.0 feet NGVD, based on "…staff knowledge of recreational navigation access problems in the lake and residents' views of desirable lake stages as expressed at public meetings and in correspondence to the District..." (SFWMD 1991). Public and stakeholder comments at public meetings indicated that some problems with lake access began to appear when water levels fell below 38 feet NGVD. A review of Lake Istokpoga's hydrograph (**Figure 16**) indicates that naturally occurring low water conditions (that is, at or below 36.5 feet NGVD) happened infrequently and seldom lasted for more than two months, except during periods of drought (**Table 13**). The longest low water event in the period of record occurred during a two-year span (1955–1956) in which water levels were below 36.5 feet NGVD for a total of 27 weeks (**Table 13**). Prolonged low water levels can impact not only navigation but also the recreation-based businesses along Lake Istokpoga. Under the current regulation schedule (**Figure 11**) these effects are usually temporary and occur only when a controlled drawdown is conducted to enhance shoreline vegetation communities.

The LOW CERP Project is currently reexamining the Lake Istokpoga Regulation Schedule. To develop a navigation access performance measure, local experts were asked to provide input regarding the navigation and recreational access impairment associated with different water levels (Dr. Nellie Morales, personal communication). The findings from this effort are shown in **Table 19**.

Table 19. Proposed Lake Istokpoga Navigation Performance Measure (Source: USACE and SFWMD 2005)

Lake Stage (feet-NGVD)	Private Access Status	Public Access Status
≥ 38.0	Minimum impact	No impact.
37.5 – 37.99	Impaired access	Minimum (start) impact. At these stages, difficulties in getting boats into water and navigating the lake are observed. Hydrilla is also a factor. Boaters would have easier access at any of these stages if no hydrilla were present within the lake. Hydrilla does not impair access; it impairs navigation. This is true at any water level, but the lower the lake level, the greater is the impact hydrilla has on navigation and the more likely it is to affect navigation (shallower water means less water for hydrilla to mat-out).
37.0 – 37.49	Severely impaired	Impaired access. Problems at public boat ramps for large boats.
36.5 – 36.99	No private access	Severely impaired access. All public boat ramps will experience impaired access for pontoon boats and for all non-shallow-draft boats. There is approximately 50% more access impairment than at 37.0 feet. No access from RV parks. Fish camps still have limited access. Navigation is very limited (limit to where you can fish).
36.0 – 36.49		Limited access through fish camps. Public can access the lake through 2 of the fish camps. Pay a boat ramp fee to access the lake. Access at public ramps is limited to non-motorized/electric-motor boats (canoes, etc.), small-engine johnboats that can be manually launched (carried/pushed), and airboats.
<36.0		All public access is impaired.

HYDROLOGIC REQUIREMENTS OF NATURAL SYSTEMS

Requirements of Aquatic and Wetland Communities

Hydrologic conditions in wetland communities fringing Lake Istokpoga are directly controlled by lake levels. These wetlands provide important ecologic functions to the lake and should be protected. Benefits afforded by these wetlands include the following:

- Stabilization of lakeshore sediments and soils.
- Dampening of the effects of wind and wave energy.
- Water quality improvement through pollutant assimilation and processing and through reduction of sediment resuspension.
- Wildlife habitat.
- Aesthetic enjoyment.
- Crucial fish habitat that supports the locally important sport fishing economy.

The general types of wetlands found along Lake Istokpoga include marsh (typically located in the littoral zone), swamp, shrub wetlands and wet prairie (**Figure 18**). Littoral zone marsh is the most abundant wetland type (**Table 5**), encompassing more than 3,400 acres (1,400 hectares), and it includes both emergent and cattail-dominated wetlands. Forested wetlands (swamps) are also a dominant wetland type along Lake Istokpoga, although their extension is only about half that of littoral marsh; forested wetlands include swamps dominated by bald cypress, mixed swamp hardwoods or a mixture of both. Other wetland types of minor extent include shrub wetlands, usually containing wax myrtle or willow, and wet prairie. Typical hydroperiods for some of these wetland types are shown in **Table 20**.

Table 20. Average Inundation Depths and Hydroperiod for Select Wetland Types.

Wetland Type (Reference)	**Mean Annual Low Water Depth**	**Hydroperiod (months)**
Marsh–Shallow		
CH2M Hill 1996a,b	Subsurface	3–7
ESE 1992	Subsurface	4
Marsh		
Duever 2002	0.5–3.8 feet.*	6–10
Ewel 1990	Subsurface	6–9
CH2M Hill 1996a,b	Subsurface	6–10
Marsh–Deep		
Brown and Starnes 1983	Subsurface	12
ESE 1992	Subsurface	10
CH2M Hill 1996a,b	Subsurface	10–12
Lake Marsh		
ESE 1992 (littoral)	Subsurface	6
ESE 1992 (pelagic)	Subsurface	12
Swamp–Mixed, Shallow		
ESE 1992	Subsurface	3
Swamp–Mixed		
Brown and Starnes 1983	Subsurface	6–8
CH2M Hill 1996a,b	Subsurface	3–6
Duever 2002	0.5–3.0 feet. *	8–10
ESE 1992	Subsurface	5
Ewel 1990	Subsurface	6–9
Swamp–Mixed, Deep		
CH2M Hill 1996a,b	Subsurface	5–9
ESE 1992	Subsurface	6
Swamp–Cypress, Shallow		
CH2M Hill 1996a,b	Subsurface	3–7
Swamp–Cypress		
CH2M Hill 1996a,b	Subsurface	6–9
Duever 2002	1.3–3.8 feet.*	6–8
ESE 1992	Subsurface	7
Swamp–Lake Fringe		
Ewel 1990	Subsurface	6–9

*Minimum range indicates depth expected during a 1-in-10-year drought.

Water Level Requirements of Lake Istokpoga Wetlands

Using recent bathymetry data, surface elevation maps for the largest wetland areas around Lake Istokpoga were created (**Figures 28–30**). Examination of these maps indicates that littoral zone emergent vegetation (marsh) communities generally reside between 36.5 and 39.5 feet NGVD and that bald cypress/mixed hardwood swamp is generally found at elevations of 39.5 feet NGVD and higher. The ecotone, or transition area, between aquatic and deep marsh communities lies at approximately 36.5 feet NGVD, and between marsh and swamp it lies at approximately 39.5 feet NGVD. Some variation from these general elevations can exist, because the transition can be gradual, making it difficult at times to discern where one community definitively ends and another begins.

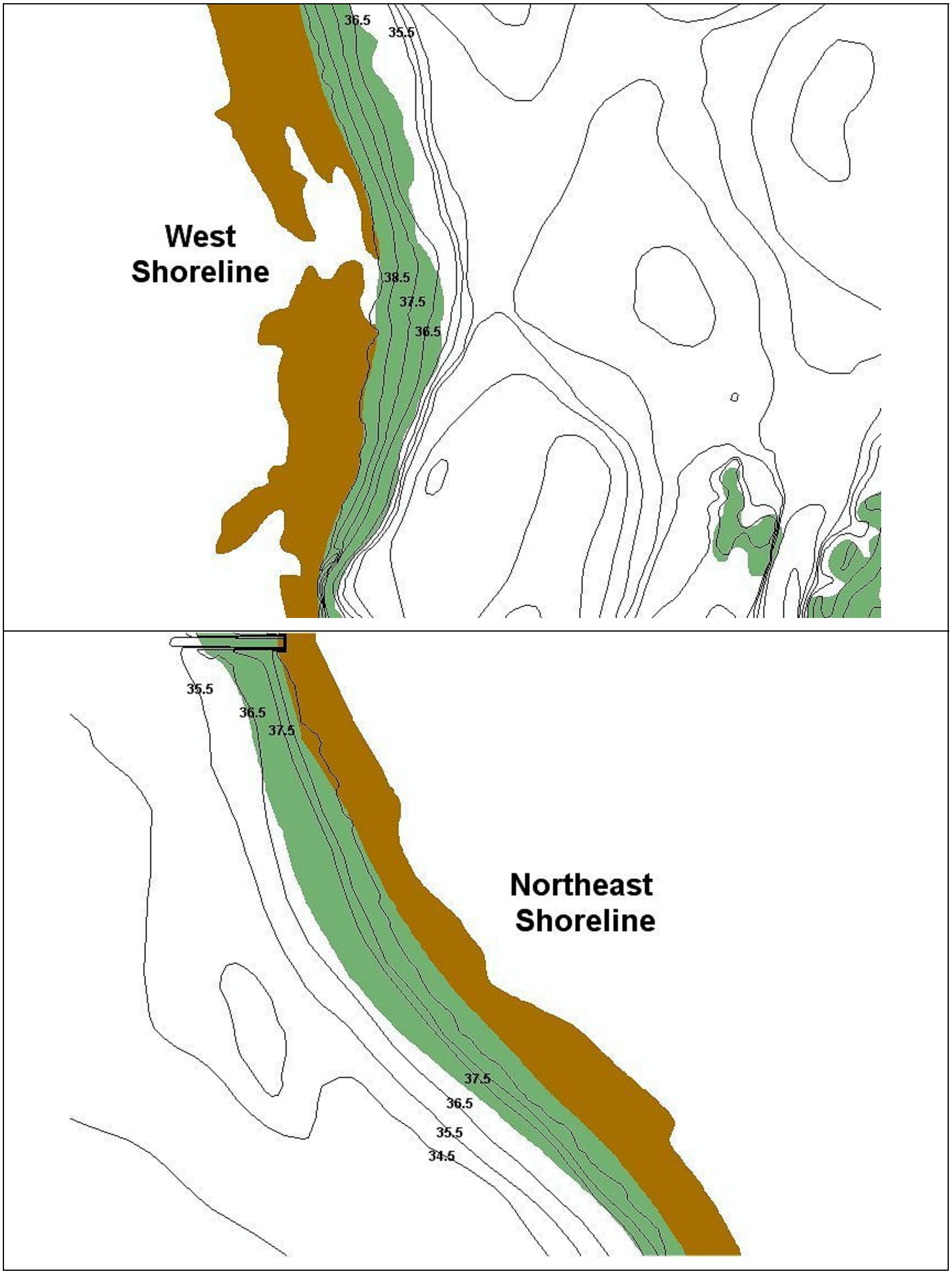


Figure 28. Elevations within Lake Istokpoga Littoral Wetlands along the West and Northeast Shorelines (green areas indicate marsh, and brown areas indicate swamp).

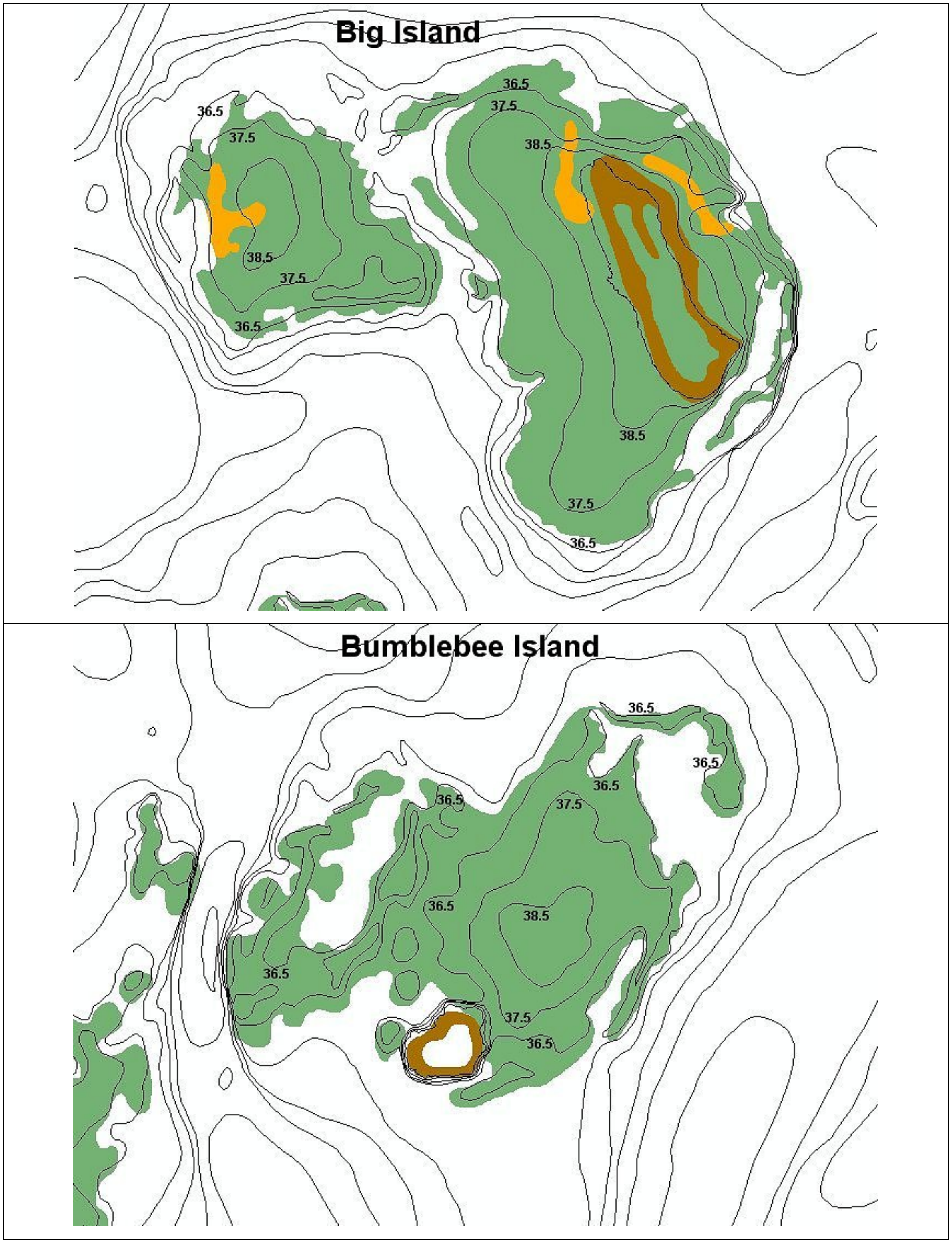


Figure 29. Elevations within Lake Istokpoga Wetlands on Big and Bumblebee Islands (green areas indicate marsh, brown areas indicate swamp and orange areas indicate shrub).

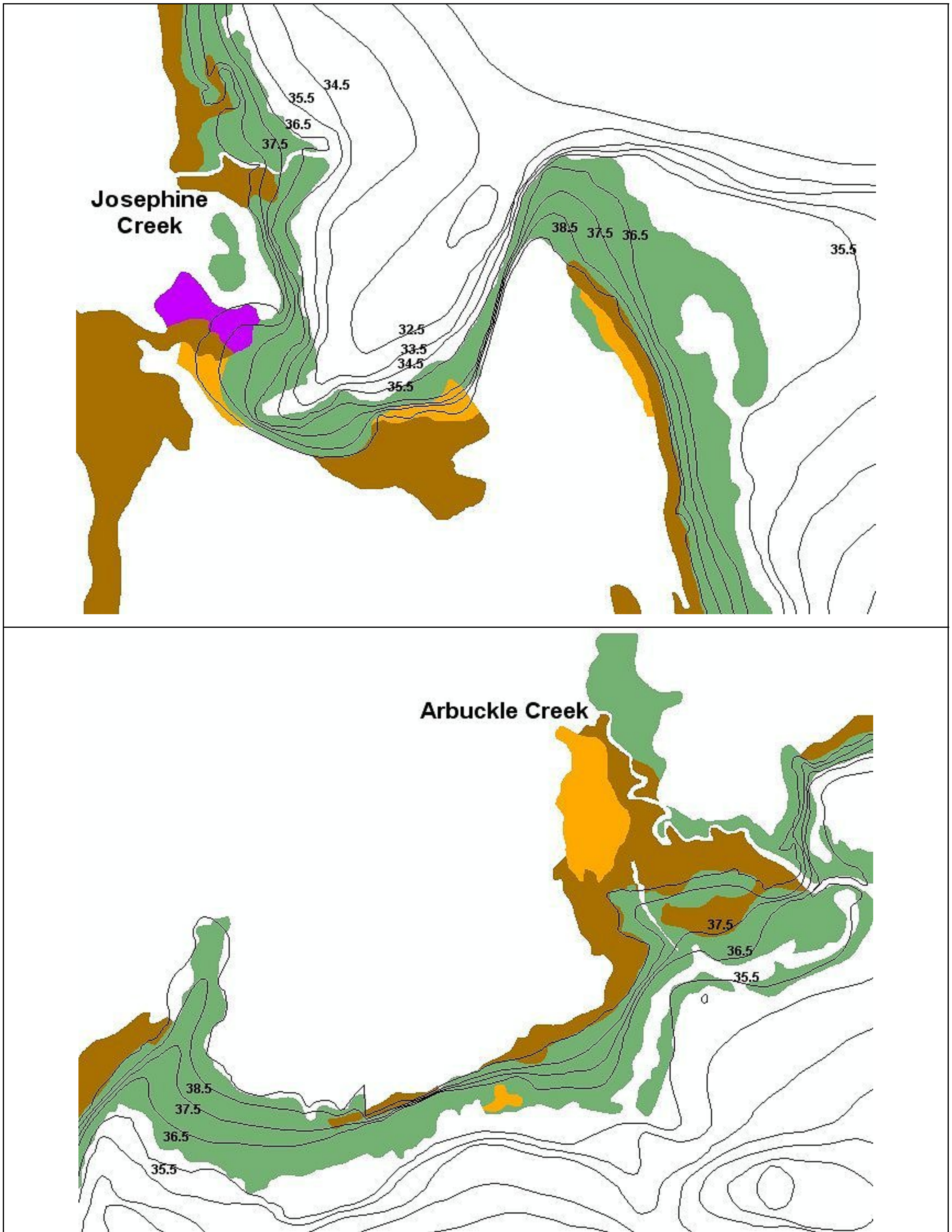


Figure 30. Elevations within Lake Istokpoga Littoral Wetlands at Josephine and Arbuckle Creeks (green areas indicate marsh, brown areas indicate swamp, orange areas indicate shrub and purple areas indicate wet prairie habitats).

The MFL criteria are concerned with protecting the existing resources of the lake and the current extent of natural communities, although the elevation and extent of natural communities may have changed since stabilization of lake levels in the early 1960s. High and low water events occurred more frequently on Lake Istokpoga before the 1960s, and so marsh and aquatic habitats may have occupied different elevations from the elevations they occupy today. Insufficient historical data exist to determine the precise historical extent of these communities. The bald cypress and mixed swamp hardwood communities contain trees of significant age and most likely persist in the same elevations they historically occupied.

The average hydroperiods of major wetland types were obtained from a review of ecologic publications (**Table 20**) and were compared with long-term lake water level data. In addition, average littoral wetland hydroperiods from the historic period (1936–1963) and from the era of the managed system (1963–2001) were compared (**Figure 31**). These results indicate that implementation of lake level management has caused hydroperiods of littoral zone marsh habitats (at current elevations) to increase and those of swamp habitats to decrease. Only infrequently has inundation of the entire fringing swamp occurred since 1963 (the commencement year of lake level regulation for flood control), as the upper level of the water level schedule is close to the ground surface elevation.

Annual average hydroperiods of bald cypress/mixed hardwood swamp are typically longer than three months, and during drought conditions water levels can fall to 3 feet below the soil surface (**Table 20**). If the average hydroperiod is reduced to below the minimum range typical for cypress swamp (that is, approximately three months), the community may come to be dominated over the years by species more characteristic of drier communities. Prolonged or frequently recurring extreme low water periods would cause excessive drying of the soil, damage to swamp vegetation and increased frequency of fire.

At 36.5 feet NGVD, the lake level is approximately 3.0 feet below the swamp's soil surface, which is the low water depth extreme (in a drought condition) reported for bald cypress (**Table 20**). Analysis of historic extreme low water events indicates that, on average, the lake fell below 36.5 feet NGVD for seven weeks once every three years (**Table 18**). During the planned 2001 drawdown, lake levels were below 36.5 feet for 19 weeks. No adverse impact to the lake's swamp community was reported during or following the drawdown event (FWC 2002).

The surface elevation of deep marsh habitat (long-hydroperiod marsh) is approximately 36.5 feet NGVD (**Figures 28–30**), corresponding to a point at which the aquatic beds become exposed. Average annual hydroperiods typical for these same deep marsh habitats are between 10 and 12 months (**Table 20**), such that this community is typically exposed only during drought periods. The drought management criterion of 37 feet NGVD in the regulation schedule (**Figure 11**) protects these wetlands from extreme drying events that may be harmful. The effect of the 2001 drawdown event on the lake's littoral marsh community was generally viewed as beneficial (FWC 2002).

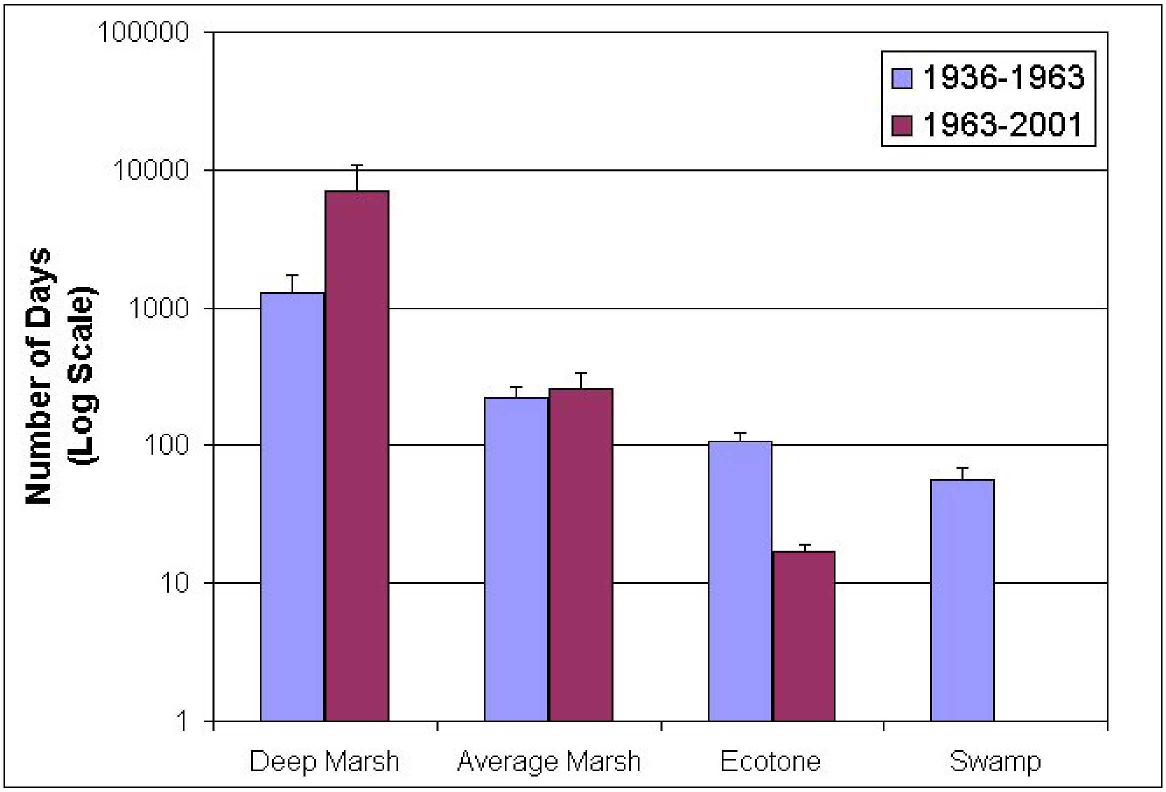


Figure 31. Average Hydroperiod in Wetlands along Lake Istokpoga (period of record excluded the 2001 controlled drawdown) (standard deviation is shown by the error bars).

Water Level Requirements of Fish Communities

The opportunity to study impacts to fish communities as a result of extreme low water events has been rare in Lake Istokpoga because water levels have been managed since the early 1960s so as to hold them within a narrow range of fluctuation. As part of the 2001 drawdown on Lake Istokpoga, lake levels were at or below 36.5 feet NGVD for 19 weeks to allow enhancement of fish habitats, to implement chemical and mechanical control of non-native and invasive vegetation and to remove muck from the lake bed. But because any one of these activities alone can influence the strength of a year-class of fish and because all the activities were conducted simultaneously, the ability to relate a change in the lake's fish populations definitively with a low water event remains problematic.

Research on impacts to fish populations from extreme low water events has been conducted in Florida lakes (for example, Moyer *et al.* 1995, Allen *et al.* 2003, Bonvechio and Allen 2005), in Florida wetlands (for instance, Chick *et al.* 2004, Trexler *et al.* 2004) and in Florida rivers (for instance, Bonvechio and Allen 2005). The existence of significant hydrogeologic differences among some of these water bodies precludes direct comparisons with Lake Istokpoga; nevertheless, these studies can offer some insight into the difficulties of trying to relate fish population changes definitively with low water events.

In 1987 a drawdown of Lake Tohopekaliga was conducted to restore 11.8 miles (19 km) of degraded littoral zone wetlands by mechanically removing approximately 215,812 yards^3 (165,000 m^3) of accumulated organic sediments. Moyer *et al.* (1995) conducted fish sampling in restored and nonrestored (control) sites in the two years following the drawdown to study potential short-term impact to fisheries. Electrofishing data from 1988 and 1989 indicated that median catch per effort for largemouth bass, redear sunfish and forage fish was significantly greater in restored sites than in control sites. Median catch-per-effort values in restored sites also were higher for bluegill, but the differences were statistically significant only in 1988. Sampling in shallow areas with Wegener rings found that age-0 largemouth bass and other sport fish were more abundant in restored areas than in control sites; nonetheless, sport fish reproduction was reduced in restored sites during 1989 and was not detected in control sites. The overall conclusion was that in general, there occurred an immediate positive fishery response to the Lake Tohopekaliga extreme drawdown and removal of organic sediments to restore littoral zone wetlands.

Largemouth bass abundance and angler catch rates were studied following the 1995–1996 habitat enhancement project on Lake Kissimmee (Allen *et al.* 2003). Lake Kissimmee is comparable to Lake Istokpoga in terms of its relatively large size (35,000 acres or 14,143 ha), tropic status, fish populations, vegetation and general management concerns. The goal of the habitat enhancement project was to improve sport fish populations, particularly of largemouth bass, and to remove dense inshore vegetation caused by water level stabilization. Water levels were lowered between November 1995 and March 1996, and the lake was refilled in June. Heavy equipment was used to remove muck from about half of the approximately 50-mile (80-km) shoreline. Recolonization of scraped sites occurred throughout the 1997–2000 period. Improved growth and abundance of age-1 largemouth bass were detected for at least two of the year-classes (the 1997 and 1998 classes) after the habitat enhancement project, but no increase in harvestable largemouth bass abundance or in angler catch rates was demonstrated (Allen *et al.* 2003).

The benefits of a managed drawdown for the purposes of habitat enhancement are multifaceted. Muck removal restores lost fish habitat, opens up littoral areas for fishing and boating activity, improves access to the lake by homeowners and fish camps, increases dissolved-oxygen concentrations in littoral habitats and expands fish diversity in enhanced sites (Allen and Tugend 2002, Tugend and Allen 2004). Minns *et al.* (1996) argued that freshwater habitat enhancement efforts should focus on general ecosystem and multispecies benefits rather than on promotion of a single preferred species. In any case, the responses of different sport fish populations to drawdown and muck removal will probably vary, and the effects on adult fish abundance and angler catch rates may be difficult to detect (Allen *et al.* 2003).

As just noted, a low water event seldom occurs alone without other factors (such as habitat enhancement efforts), and the ability to relate a low water event directly to a negative impact to fisheries is not clear-cut. Furthermore, data from sampling conducted in newly restored habitat is not comparable with pre-drawdown data collected from other areas of the lake. This having been said, however, available fish sampling data are unable to indicate *significant harm* to Lake Istokpoga's fish resource as a result of the drawdown. In other words, comparison of fish sampling data from before and after the drawdown is unable to indicate that any multiyear negative impact to the fishery occurred (see **Figure 25, Table 13).** Data collected after the drawdown indicated a healthy fishery two years after the drawdown event (**Figures 20, 21** and **Tables 11, 12, 14, 15)**.

In fact, because of the restoration and expansion of littoral zone fish habitats, a long-term benefit to the fishery is expected, as was found on Lake Tohopekaliga and Lake Kissimmee following drawdowns. More indirectly, management and protection of the lake's wetland and aquatic plant communities constitute prerequisites for healthy fisheries. The magnitude and duration of the 2001 drawdown event were comparable to those of naturally occurring low water events that took place before management of lake levels (see **Figure 16** and **Table 18**). In this regard, it must be borne in mind that long-lasting low water events have not occurred in close succession historically and that such a scenario should continue to be avoided in order to prevent multiyear negative impacts to year-classes of fish. Excessive prolongation of water levels, or stages, at less than 36.5 feet NGVD may be harmful to fish communities, since littoral zone habitats—important foraging and spawning areas for fish—are dry at this water level. Severe or frequent low water conditions that cause a change from littoral marsh to a more upland community type could reduce the extent or quality of fish habitats and thereby cause declines in fish foraging and spawning success.

Water Level Requirements of Bird Communities

Lake Istokpoga contains three types of habitats important for bird species—aquatic, littoral marsh, and swamp (**Table 21, Figure 18**). Most bird species require more than one habitat type in order to feed, nest and rear chicks to adulthood successfully (Ehrlich *et al.* 1988, Bird 1999). Ospreys, for instance, nest in the swamp adjacent to the lake and feed from the lake's aquatic habitat (Stewart 2001). Of the 26 known species of birds associated with Lake Istokpoga habitats, 21 use more than one habitat type (**Appendix E**).

Table 21. Highlands County Bird Species Associated with Lake Istokpoga Habitats.

Species (Common Name)	Nesting Season[1]	Nesting Habitat[1]	Feeding Habitat[1]
American Kestrel	March through June	Swamp trees (cavity nest)	Littoral, swamp
Bald Eagle	September through May	Swamp trees (high nest)	Aquatic[2], littoral, swamp
Barred Owl	December through April	Swamp trees (cavity nest)	Littoral, swamp
Black-Necked Stilt	April through June	Littoral vegetation	Aquatic, littoral
Common Moorhen	March through September	Littoral vegetation	Aquatic, littoral
Cooper's Hawk	April through July	Swamp trees	Littoral[3], swamp[3]
Fulvous Whistling Duck	March through August	Littoral vegetation	Aquatic, littoral
Great Blue Heron	Extended through the year	Swamp trees	Aquatic, littoral, swamp
Great Egret	Year-round	Swamp trees	Aquatic, littoral, swamp
Green Heron	March through July	Swamp trees or shrubs	Aquatic, littoral, swamp
Limpkin	February through June	Littoral vegetation	Littoral
Mallard		Littoral vegetation	Aquatic, littoral
Mottled Duck	February through September	Littoral vegetation	Aquatic, littoral
Northern Harrier	February through September*	----------------------------	Aquatic, littoral, swamp
Osprey	Year-round	Swamp trees (high nest)	Aquatic, swamp
Pied-Billed Grebe	Year-round	Littoral vegetation	Aquatic
Purple Gallinule	March through September	Littoral vegetation	Aquatic, littoral
Red-Shouldered Hawk	January through May	Swamp trees	Littoral, swamp
Red-Tailed Hawk	January through June	Swamp trees (mature)	Littoral, swamp
Red-Winged Blackbird	March through July	Littoral vegetation	Littoral
Sandhill Crane	December through June	Littoral (often nests in wet areas)	Littoral
Short-Tailed Hawk	February through May	Swamp trees	Littoral[2], swamp[2]
Snail Kite (Everglades Snail Kite)	Year-round	Swamp or littoral vegetation	Littoral
Swallow-Tailed Kite	April	Swamp trees (tall cypress)	Littoral, swamp
Tricolor Heron	February through August	Swamp trees or shrubs	Aquatic, littoral
Wood Duck	January through June	Swamp trees (cavity nest)	Aquatic, littoral

[1]Source: National Geographic Soc. 1987, Ehrlich *et al*. 1988, Poole *et al*. 1992, Bird 1999.

[2]indicates special cases having very long hydroperiods, such as aquatic beds and aquatic mud flats that may occasionally be exposed during drought conditions.

[3]indicates an indirect association.

The primary habitat types used by birds in the Lake Istokpoga area are as follows:

- Aquatic habitats—open-water areas possibly containing submerged vegetation. Many types of fish are found in the water column, and numerous species of invertebrates and other animals live within the vegetation beds.
- Littoral marsh (nonforested wetlands)—found on the broad flats that surround the lake. Marsh vegetation provides shelter and nourishment for a variety of organisms important as food sources for some bird species. In addition, tall wetland plants provide nesting sites and cover for certain birds.
- Swamps (forested wetlands)—found mostly along the southern area of the lake. These areas are located behind the littoral zone, and these forests are important roosting and nesting sites for wading birds and many raptors.

To protect the critical habitats required by many bird species found along Lake Istokpoga, the aquatic, marsh and swamp habitats must be protected from significant changes (that is, from a shift to drier community types, with an associated change or loss of function), which are assumed to equate to *significant harm*. It is assumed that MFL criteria, which protect these natural systems, will also protect the bird communities from *significant harm*.

Data are lacking that might relate the effects of low water events directly to changes in bird populations within Lake Istokpoga, but studies from other areas of Florida can provide some insight into potential impacts. Generally, low water levels in wetland-lake systems are associated with improved feeding and successful rearing of chicks since low water levels concentrate the birds' aquatic prey into smaller areas (Kushlan 1976, 1986, 1989; Ogden *et al.* 1976). The maintenance of higher water levels tends to reduce foraging success. On the other hand, the drying of wetlands (which causes mortality of prey) can be negative; if reduced water levels persist and affect prey habitat or lead to reduction of prey populations, an indirect impact to bird communities may result.

SUMMARY OF ANALYSIS

Two distinct periods are discernible from the water level time series data for Lake Istokpoga. During the historical, or pre-management, period (1936–1962), Lake Istokpoga fell below 36.5 feet NGVD for seven weeks once every 3.4 years, on average (**Table 18**). Since the initiation of the lake management period, the lake has fallen below 36.5 feet NGVD only three times, two of which were associated with controlled drawdowns to build a water control structure (1962–1963) and to undertake an environmental enhancement project (2001).

The need to protect developed lands along Lake Istokpoga from flooding prohibits reflooding of some remnant swamp areas, particularly of those that are situated above 39.5 feet NGVD (the upper range of the regulation schedule—see **Figure 11**). It is recognized that wetland communities require a minimum period of flooding and that alteration and development of lake shore areas constitute a constraint on management of some natural areas along Lake Istokpoga. It is also recognized that an appropriate depth of flooding is required to maintain the swamp's health; that parameter, however, is beyond the scope of the MFL project.

The minimum water level threshold proposed for Lake Istokpoga is 36.5 feet NGVD. This elevation is derived from the water level identified as the point at which surface water is absent in most littoral wetlands along the lake (**Figures 28–30**) and at which access to the lake for navigational and recreational purposes is impaired (**Table 19**). Adverse impacts to fish and bird communities are not expected from periodic, short-duration low water events at (or below) 36.5 feet NGVD, but prolonged events may be undesirable. Management of low water events based on these resource functions is in harmony with the considerations set forth in the MFL rule. Impacts to water supply are considered to be minimal, since the current regulation schedule stops water releases from Lake Istokpoga when water levels fall below the minimum operating level (Zone B), which ranges from 39.0 feet at the end of the wet season to 37.5 feet at the end of the dry season (**Figure 6, Figure 11**).

CHAPTER 6

Proposed Minimum Level Criteria, Monitoring, *Significant-Harm* Prevention and Adaptive Management Plan

PROPOSED MINIMUM LEVEL CRITERIA

Definition of *Significant Harm*

The two primary sources of water inputs into Lake Istokpoga are rainfall and inflows from Arbuckle and Josephine creeks. Water levels in Lake Istokpoga are controlled by the operation of water control structures (structures S-68 and G-85) as guided by a regulation schedule adopted by the U.S. Army Corps of Engineers and the SFWMD (**Figure 11**). *Significant harm* stemming from low water levels is unlikely to occur under the existing regulation schedule, given typical regional weather patterns and present levels of inflows from the creeks. According to an analysis of water level requirements (presented in **Chapters 2, 4** and **5)**, *harm* to the resource functions could occur when water levels fall below the 36.5 feet NGVD criterion, which is below the lower level of the regulation schedule. Water supply releases from Lake Istokpoga are halted when water levels fall below 37.5 feet NGVD during the end of the dry season (**Figure 11**). At this point, lake levels are controlled essentially by local rainfall and evaporation. As long as water levels are within the range specified in the regulation schedule, then the minimum needs of water supply, flood control, navigation and ecologic communities are being met and a *no harm* condition prevails.

For navigational and recreational interests, the duration of water levels below 36.5 feet NGVD that leads to *harm* is not clearly defined. Prolonged low water levels impact navigation and recreation, as well as recreation-based businesses along Lake Istokpoga, by limiting access to lake resources (**Table 19**). Under the current regulation schedule (**Figure 11**), these effects are usually temporary and occur only when a controlled drawdown is conducted to enhance shoreline vegetation communities.

A *significant harm* condition for Lake Istokpoga is based primarily on impacts to the lake's biological communities that last more than two years. Based on examination of technical information, the definition of *significant harm* for Lake Istokpoga is as follows:

> Significant harm is defined to occur to the Lake Istokpoga system when surface water levels fall below 36.5 feet NGVD for 20 weeks (140 days) or longer within a calendar year, more frequently than every four years.

Periodic low water events can provide important environmental benefits to the lake's resources (FWC 2000, 2002), but more-extreme or frequently recurring low water events could potentially have longer-term (>2 years) impacts to littoral zone wetlands, wildlife, and recreation and navigation opportunities, as well as to the local economy. This *significant harm* definition is intended to address three important aspects of a defined low water event on Lake Istokpoga's resources: 1) the definition of a low water event (that is, levels must fall below 36.5 feet), 2) the maximum duration of an event and 3) the maximum return frequency of an event. The rationale for each criterion is provided below.

Rationale for Proposed Criteria

The maximum duration of a low water event was defined on the basis of experience gained from the 2001 drawdown. The 2001 event allowed biologists to observe and document impacts to lake resources and to monitor the time required for these resources to recover to a "pre-drawdown" condition. Biological data collected before and after this event were unable to document a clear impact to fish resources that lasted more than 2 years. During the two years immediately after the drawdown, sport fish catches and catch rates were roughly comparable to pre-drawdown levels (**Tables 13, 14, 15**) and fish sampling data indicated a healthy community (**Figures 20, 21, 25)**. This drawdown also allowed chemical and mechanical hydrilla control, restoration and enhancement of littoral zone wetlands, and removal of accumulated organic sediments, which improved lake vegetation communities and water quality. The magnitude and duration of this drawdown event were comparable to those of naturally occurring low water events experienced before implementation of the regulation schedule (**Figure 16** and **Table 18**). On the basis of this knowledge, the point at which a low water event would cause *significant harm* to the system would be when water levels fall below 36.5 feet for a period longer than the 19-week duration of the 2001 drawdown.

The return frequency of drawdown events (once every four years) was based on consideration of the related requirements of wetland vegetation hydroperiods and fish reproductive success. The current wetland communities residing along Lake Istokpoga range from hardwood and cypress swamp on higher sites to littoral zone wetlands on mesic (medium water requirements) sites to submerged aquatic beds near the shoreline (**Figure 18**). When lake water levels fall below 36.5 feet NGVD, the following occurs: 1) the water table is more than three feet below the soil surface in lake swamp communities, 2) and water levels are near the soil surface in littoral wetlands, exposing submerged aquatic vegetation (SAV) at the shoreline. Typically, deepwater marsh communities have average annual hydroperiods of 10 to 12 months (**Table 20**), while submerged aquatic vegetation beds are always inundated, except during severe drought conditions. If low water events occur more often than once every four years, the annual average hydroperiod for existing lake wetlands may be reduced below the typical range for these community types. When lake levels fall below 36.5 feet NGVD, there is no surface water within the littoral zone marsh, which is an important habitat for fish spawning and juvenile-fish foraging. If extreme low water levels persist throughout the fish spawning season, a year-class of fish may be affected. An impact to two such year-classes within a several-year period would potentially cause multiyear impacts to fish populations. To allow a full recovery of the fisheries resource and a full year of successful reproduction of the restored fish population, a four-year maximum return frequency is proposed to protect the fisheries resource of Lake Istokpoga from *significant harm*.

Basis of Proposed Criteria

Proposed minimum level criteria for Lake Istokpoga are linked to the concept of protecting valued ecologic components from *significant harm*. The specific ecologic resources identified for Lake Istokpoga are wetlands (aquatic beds, marshes and swamps) and their associated fish and wildlife communities. The ecologically and economically important fish and wildlife resources of Lake Istokpoga depend on healthy wetland communities as sources of food, spawning sites, nursery areas for juveniles, nesting sites, shelter and protection, as well as other habitat values. These wetlands also provide other important functions, such as water quality improvement and stabilization of shorelines.

It is recognized that the currently available ecological data may not be sufficient to understand fully the impacts or benefits of low water events. The criteria proposed in the present report are offered as an initial step in defining the point at which *significant harm* may occur, but additional studies may be needed through time to understand ecological functions better and to refine the criteria. A strategy of adaptive management (described later) provides the means to examine new information periodically and to adjust the MFL criteria, if indicated.

Protection from *Significant Harm*

During very dry periods or a managed drawdown, prolonged low water conditions may occur that lead to *significant harm*. No such events caused by low rainfall or drought have occurred in the years since the implementation of the Lake Istokpoga Regulation Schedule, but determination of the point of *significant harm* may be a useful guide for future lake management if demands for water increase.

Technical Criteria

Based on the foregoing information, SFWMD staff proposes the following MFL criteria for Lake Istokpoga:

> A MFL violation occurs within Lake Istokpoga when surface water levels fall below 36.5 feet NGVD for 20 or more weeks within one calendar year, more often than once every four years.

The proposed minimum level for Lake Istokpoga is based on the assumption that *significant harm* can occur to the lake's ecologic resources when water levels fall below 36.5 feet NGVD for the period specified. The MFL criteria are intended to address low water levels resulting from regional drought conditions and/or from withdrawals of water from the lake or adjacent aquifers.

Ability to Meet Proposed Criteria

Analysis of the current regulation schedule and a review of operational policies for Lake Istokpoga indicate that the proposed minimum level criteria will be met under current conditions and for the foreseeable future. Furthermore, the proposed criteria are not expected to affect navigation, recreation, water supply or natural systems since the criteria are well below the current operating schedule for the lake (**Figure 11**). Potential exceedances of these criteria would occur only during a controlled drawdown event. But periodic drawdowns of the lake below 36.5 feet NGVD, as conducted during 2001 by the FWC, are beneficial to the lake and may be required as part of an overall lake management strategy. It is recognized that under certain circumstances, it may be necessary to conduct controlled drawdowns of magnitudes or frequencies that exceed the proposed MFL criteria, in order to enhance the lake's ecologic resources.

The MFL statues and rules do not provide the authority or the legal basis to require that low water events occur. The MFL does provide guidelines 1) as to the magnitude and duration of drawdown events that may occur without causing long-term damage to the resource and 2) as a means to ensure that such damaging low water events do not occur as a result of consumptive use withdrawals. The MFL criteria do not restrict the ability of the SFWMD, FWC and FDEP to lower lake levels as deemed necessary for aquatic weed control, fisheries management, shoreline enhancement or dredging of navigation channels.

Monitoring Strategy

Over the past decades, the SFWMD has continuously monitored water levels at several stations in Lake Istokpoga (**Table 16**). The same stations can be used to track MFL exceedances within the lake. Since implementation of more-conservative water management efforts after 1985, extreme low water events (<36.5 feet NGVD) have occurred only during a managed drawdown event. Furthermore, future low water events are anticipated to occur only under controlled conditions for purposes of environmental enhancement.

During the 2001 vegetation enhancement project, the FWC and the SFWMD carried out biological and hydrologic monitoring, which was required as part of the Environmental Impact Statement and permit from the USEPA. Future managed drawdown events could provide opportunities to conduct pre- and post-drawdown biological and hydrologic monitoring and to measure further the impact of low water events on Lake Istokpoga's resources. The FWC conducts fish catch surveys (**Tables 11, 12, 13, 14, 15)** and performs estimates of the extent of hydrilla in the lake each year. In addition, the distribution of major littoral zone communities is monitored by the FDEP and FWC to gauge the success of ongoing vegetation enhancement projects. These efforts provide a broad range of monitoring data that can be used to address directly the question of low water events' impact on the resource.

It is recommended that vegetation monitoring associated with controlled drawdown events include more emphasis on the multiyear responses of fringing wetland vegetation, especially cypress communities, to low water levels. The current monitoring programs could be expanded or enhanced to incorporate the proposed MFL wetland resource protection concerns.

Prevention Strategy

Since the proposed *significant harm* criteria are not presently being exceeded, a MFL Recovery Strategy (Section 373.0421[2], F.S.) does not need to be developed to protect the resource. Furthermore, under the current operational plan and regulation schedule, *significant harm* to the water body is not expected to occur in the near future, and a MFL Prevention Strategy (Section 373.0421[2], F.S.) is not required.

Low water events play an important role in the overall health of the lake ecosystem, and other projects are planned that may address some of the related issues. These projects include the potential for a reservoir in the Indian Prairie area south of the lake, which may allow more flexibility in the regulation schedule. The Lake Okeechobee Watershed CERP Project will evaluate the existing regulation schedule and will recommend changes to enhance the lake's biological resources for long-term management.

Research Recommendations

The SFWMD and FWC are actively involved in monitoring biological and hydrologic parameters both before and after controlled drawdown events. The SFWMD should continue this partnership with the FWC so that the goals of both projects (the MFL and the environmental enhancement project) are met. Currently birds, fish, and aquatic and littoral zone vegetation communities are being monitored, as well as water quality and lake water levels.

Additional recommended research parameters that could be included in future studies include the following:

- Better monitoring of stream inflow and water use in stream basins.
- Increased attention to groundwater and surface water interactions.
- Further study of evaporation rates on Lake Istokpoga.
- Better understanding of a water budget for Lake Istokpoga.
- Improved understanding of the hydrologic needs for a sustainable fringing lake swamp (bald cypress and mixed hardwood).

Adaptive Management

The proposed minimum level criteria are based on best available information with the understanding that more information is needed in order to refine assumptions used in criteria development. Ongoing and proposed research and monitoring efforts in the Lake Istokpoga watershed will continue to provide more information to improve our understanding of the lake's resources. This information will provide SFWMD staff an opportunity to reevaluate the proposed criteria and to refine the MFL in accordance with regional water supply plan development and implementation activities.

The Lake Okeechobee Watershed Project, a part of the CERP, may potentially affect regulation of water levels in Lake Istokpoga. This project will reevaluate and recommend changes to the Lake Istokpoga Regulation Schedule and will examine the need for additional water storage facilities in the watershed. If significant changes to lake management occur that may require reevaluation of MFL criteria based on new information or altered operational criteria, such changes will be considered in the next Lake Istokpoga MFL update, which is scheduled for 2010, or sooner if significant changes to lake management are proposed.

The criteria developed in the present document should be used as the basis for SFWMD rule development and to evaluate the potential effects of implementation of policy recommendations from watershed planning studies (including modeling). In the issuance of consumptive use permits in the Kissimmee Basin Planning Area, the proposed water use increases should be monitored in terms of their potential individual and cumulative impact on the observance of the MFL guidelines. Current research and monitoring efforts by the SFWMD, FWC, FDEP and local entities should continue, and additional research and monitoring efforts are suggested as a means to provide useful data for refinement of MFL criteria. Monitoring programs associated with drawdown and ecologic enhancement projects are recommended to include an enhanced focus on wetland monitoring that is consistent with the needs of gauging *harm* and *significant harm* to these resources.

Glossary

1-in-10 Year Drought A drought of such intensity that it is expected to have a return frequency of once in ten years (on average). A drought in which below-normal rainfall has a 90 percent probability of being exceeded during a 12-month period, meaning that there is only a 10 percent chance that less than this amount of rain will fall in any given year.

1-in-10 Year Level of Certainty Probability that the needs for reasonable-beneficial uses of water will be fully met during a 1-in-10 year drought.

Acre-foot The volume of water that covers one acre to a depth of one foot; 43,560 cubic feet; 1,233.5 cubic meters; 325,851 gallons.

Algal Bloom Rapid growth of algae on the surface of lakes, streams or ponds; typically stimulated by nutrient enrichment.

Alternative Water Supply A supply of water that has been reclaimed after one or more public supply, municipal, industrial, commercial or agricultural uses, or a supply of storm water, or brackish or salt water, that has been treated in accordance with applicable rules and standards sufficient to supply the intended use.

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

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

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

Average Rainfall Year A year having rainfall with a 50 percent probability of being exceeded during a 12-month period.

Backpumping The practice of actively pumping water leaving an area back into a surface water body.

Baseline Condition (see *Reference Condition*)

Basin (Groundwater) A spatial 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.

Bathymetry The measurement of water depth at various places in a body of water.

Benthos/Benthic The bottom of a lake or sea or the macroscopic organisms that live in the bottom substrate, such as clams and worms.

Biomass The amount of living matter (as in a unit area or volume of habitat).

Biscayne Aquifer A portion of the Surficial Aquifer System that provides most of the fresh water for public water supply and agriculture within Miami-Dade, Broward and southeastern Palm Beach counties. The Biscayne Aquifer is highly susceptible to contamination because of its high permeability and its proximity to land surface in many locations.

Catch per Unit Effort (CPUE) The number of fish caught by an amount of effort. Typically, effort is a combination of gear type, gear size, and length of time gear is used. Catch per unit of effort is often used as a measurement of relative abundance for a particular fish.

Central and Southern Florida Flood Control Project (C&SF Project) A complete system of canals, storage areas and water control structures spanning the area from Orlando south to the Everglades to both the east and west coasts. It was designed and constructed during the 1950s by the United States Army Corps of Engineers (USACE) to provide flood control and improve navigation and recreation.

Central and Southern Florida Project Comprehensive Review Study (Restudy or C&SF Restudy) A five-year study effort that looked at modifying the current C&SF Project to restore the greater Everglades and south Florida ecosystem while providing for the other water-related needs of the region. The study concluded with the Comprehensive Plan presented to Congress on July 1, 1999. The recommendations made within the Restudy—that is, structural and operational modifications to the C&SF Project—are being further refined and will be implemented in the Comprehensive Everglades Restoration Plan (CERP).

Clastic Describes rock or sediment composed of individual grains or fragments from physical breakdown of a larger mass and transported from their place of origin.

Comprehensive Everglades Restoration Plan (CERP) The implementation of recommendations made within the Restudy: structural and operational modifications to the C&SF Project are being further refined and will be implemented through this plan.

Conservation (see *Water Conservation*)

Consumptive Use A type of water use that reduces the amount of water in the source from which it is withdrawn.

Consumptive Use Permit (CUP) A permit issued by the SFWMD under authority of Chapter 40E-2, F.A.C., allowing withdrawal of water for consumptive use.

Control Structure A man-made structure designed to regulate the level/flow of water in a canal or water body (e.g., weirs, dams).

Demand The quantity of water needed to be withdrawn to fulfill a requirement.

Dissolved Oxygen The concentration of oxygen dissolved in water, sometimes expressed as percent saturation, where saturation is the maximum amount of oxygen that theoretically can be dissolved in water at a given altitude and temperature.

District Water Management Plan (DWMP) Regional water resource plan developed by the District under Ch. 373.036, F. S.

Domestic Self-Supplied (DSS) Water Demand (*Same as Residential Self-Supplied Water Demand*) The water used by households whose primary source of water is private wells and water treatment facilities with pumpages of less than 0.1 million gallons per day.

Drawdown The vertical distance a water level is lowered resulting from a withdrawal at a given point.

Ephemeral Surface water body that holds water only during and immediately after periods of rainfall.

Epiphytes Plants that grow on other plants and usually derive their moisture and nutrients from the air and rain.

Eutrophication The increase in nutrients in a body of water. Natural eutrophication is a gradual process, but human activities may greatly accelerate the process.

Evapotranspiration (ET) The combined water losses from the surface of water and soils (evaporation) and plants (transpiration).

Everglades Agricultural Area (EAA) The area of histosoils (organic soils) south of Lake Okeechobee that is used for agricultural production.

Flatwoods (Pine) Natural communities that occur on level land and are characterized by a dominant overstory of slash pine. Depending on soil drainage characteristics and position in the landscape, pine flatwoods habitats can exhibit xeric to moderately wet conditions.

Florida Administrative Code (F.A.C.) The Florida Administrative Code is the official compilation of the administrative rules and regulations of state agencies.

Florida Department of Environmental Protection (FDEP) The SFWMD operates under the general supervisory authority of the FDEP, which includes budgetary oversight.

Florida Statutes (F.S.) The Florida Statutes are a permanent collection of state laws organized by subject area into a code made up of titles, chapters, parts and sections. The Florida Statutes are updated annually by laws that create, amend or repeal statutory material.

Floridan Aquifer System (FAS) A highly used aquifer system composed of the Upper Floridan and Lower Floridan Aquifers. It is the principal source of water supply north of Lake Okeechobee; south of Lake Okeechobee, the aquifer contains saltwater The upper Floridan Aquifer is used for drinking water supply in parts of Martin and St. Lucie counties. From Jupiter to south Miami, water from the Floridan Aquifer System is mineralized (total dissolved solids are greater than 1,000 mg/L) along coastal areas.

Flow The actual amount of water flowing by a particular point over some specified time. In the context of water supply, flow represents the amount of water being treated, moved or reused. Flow is frequently expressed in millions of gallons per day (MGD) or cubic feet per second (cfs).

Food Web The totality of interacting predator-prey relationships (food chains) in an ecologic community.

Geographic Information Systems (GIS) The abstract representation of landscape features (natural or cultural) into a digital geographic database (geodatabase) that describes the world in geographic terms.

Governing Board Governing Board of the South Florida Water Management District.

Groundwater Water beneath the soil surface, whether or not flowing through known and definite channels.

Harm The temporary loss of water resource functions which results from a change in surface or groundwater hydrology and takes a period of one to two years of average rainfall conditions to recover (as defined for consumptive use permitting in Chapter 40E-2, F.A.C.).

Hectare A unit of measure in the metric system equal to 10,000 square meters (2.47 acres).

Hydrologic Alterations The deviation from a natural hydrologic pattern: examples include the lack of adequate seasonal water level fluctuations and an unnatural reversal of seasonal high and low water levels.

Hydropattern The seasonal pattern of an ecosystem's inundation or saturation, which can include aspects such as timing, duration and severity of flooding or drying.

Hydroperiod The frequency and duration of inundation or saturation of an ecosystem. In the context of characterizing wetlands, the term hydroperiod describes that length of time during the year that the substrate is either saturated or covered with water.

Intermediate Aquifer System (IAS) This aquifer system consists of five zones of alternating confining and producing units. The producing zones include the Sandstone and mid-Hawthorn aquifers.

Irrigation The application of water to crops and other plants by artificial means.

Karst A topography formed over limestone, dolomite or gypsum and characterized by sinkholes, caves and underground drainage.

Lake Okeechobee Florida's largest lake, which measures 730 square miles and is the second-largest freshwater lake wholly within the United States.

Level of Certainty Probability that the demands for reasonable-beneficial uses of water will be fully met for a specified period of time (generally taken to be one year) and for a specified condition of water availability (generally taken to be a drought event of a specified return frequency).

Littoral Of, relating to, or situated or growing on or near a shore.

Load A measure of the amount of dissolved material entering a water body, as calculated by multiplying the concentration of dissolved material by flow.

Marsh A frequently or continually inundated nonforested wetland characterized by emergent herbaceous vegetation adapted to saturated soil conditions.

Minimum Flow and Level (MFL) The point at which further withdrawals would cause *significant harm* to the water resources/ecology of the area.

National Geodetic Vertical Datum (NGVD) A nationally established reference for elevation data that is based upon mean sea level measurements taken in 1929.

Natural Resources Conservation Service (NRCS) An agency of the U.S. Department of Agriculture (USDA) that provides technical assistance for soil and water conservation, natural resource surveys and community resource protection. Formerly the U.S. Soil Conservation Service (SCS).

Nuisance (Invasive) Species Native or non-native (typically plant) species that spreads rapidly under disturbed conditions and displaces more-desirable plant communities.

Organics Involving organic life or products of organic life; relating to or composed of chemical compounds containing hydrocarbon groups.

Pelagic Zone Open-water zone.

Permeability Ability of a substrate to transmit fluid.

Planktonic Related to the free-floating or weakly swimming minute animal and plant life of a body of water.

Potable Water Water that is safe for human consumption and with a chloride concentration of less than 250 milligrams/liter.

Potentiometric Head The level to which water will rise when a well is pierced in a confined aquifer.

Potentiometric Surface An imaginary surface representing the total head of groundwater.

Public Water Supply (PWS) Utilities that provide potable water for public use.

Public Water Supply Demand All potable water supplied by regional water treatment facilities with pumpage of 0.1 million gallons per day or more to all customers, not just residential.

Reasonable-Beneficial Use Water use in such quantity as is necessary for economic and efficient utilization for a purpose and in a manner both reasonable and consistent with the public interest.

Reference Condition. A representation of some defined condition in the watershed that is used for the purpose of comparison.

Regional Water Supply Plan (RWSP) Detailed water supply plan developed by the District under Section 373.0361, F.S., providing an evaluation of available water supply and projected demands at the regional scale. The planning process projects future demand for 20 years and develops strategies to meet identified needs.

Reservations of Water (see *Water Reservations*).

Reservoir A man-made or natural water body used for water storage.

Residential Self-Supplied Water Demand (*Same as Domestic Self-Supplied Water Demand*) The water used by households whose primary source of water is private wells and water treatment facilities with pumpages of less than 0.1 million gallons per day.

Restudy (see Central and Southern Florida Project Comprehensive Review Study).

Saline Water or Saltwater Intrusion Movement of saline water laterally inland from the seacoast or vertically upward, to replace fresh water in an aquifer.

Seawater Water that has a chloride concentration equal to or greater than 19,000 milligrams per liter.

Secchi Disk A black and white disk used to measure the transparency or clarity of water by lowering the disk into the water horizontally and noting the greatest depth at which differences between the colors can be distinguished.

Self-Supplied The water used to satisfy a water need that is not supplied by a public water supply utility.

Serious Harm The long-term loss of water resource functions resulting from a change in surface or groundwater hydrology, as addressed in Chapters 40E-21 and 40E-22, F.A.C.

Significant Harm The temporary loss of water resource functions that results from a change in surface or groundwater hydrology that takes more than two years to recover, but which is considered less severe than *serious harm*. The specific water resource functions addressed by a MFL and the duration of the recovery period associated with *significant harm* are defined for each priority water body based on the MFL technical support document.

Slough A channel in which water moves sluggishly, or a place of deep muck, mud or mire. Sloughs are wetland habitats that serve as channels for water draining off surrounding uplands and/or wetlands.

Spodic A dark-colored subsurface soil horizon characteristic of flatwood soils (from Gr. *spodos*, wood ash).

Stage The elevation of the surface of a water body.

Storm Water Surface water resulting from rainfall runoff that does not percolate into the ground or evaporate.

Surface Water Water that flows, falls or collects above the soil or substrate surface.

Surficial Aquifer System (SAS) Often the principal source of water for urban uses within certain areas of south Florida. This aquifer is unconfined, consisting of varying amounts of limestone and sediments that extend from the land surface to the top of an intermediate confining unit.

Swamp A seasonally, frequently or continuously inundated forested wetland.

Truck Farming The horticultural practice of growing one or more vegetable crops on a large scale for shipment to distant markets.

Turbidity The measure of suspended material in a liquid.

Tussock A compact hummock of generally solid ground in a bog or marsh, usually covered with and bound together by the roots of low vegetation such as grasses or sedges.

Uplands An area without a hydric soil and with a hydrologic regime not sufficiently wet to support vegetation typically adapted to life in saturated soil conditions.

Valued Ecosystem Component (VEC) A resource-based management strategy similar to a program developed by the EPA as part of the National Estuary Program. For the purposes of this study, the VEC approach is based on the concept that management goals for a specific water body can best be achieved by providing suitable environmental conditions that will support certain key species, or key groups of species, that inhabit the system.

Water Budget An accounting of total water entering, residing in and leaving a given location or activity.

Water Conservation Reduction of the demand for water through activities that alter water use practices—e.g., improving water use efficiency and reducing water loss, waste, and use.

Water Reservations State law on water reservations, in Section 373.223(4), F.S., defines water reservations as follows: "The governing board or the department, by regulation, may reserve from use by permit applicants, water in such locations and quantities, and for such seasons of the year, as in its judgment may be required for the protection of fish and wildlife or the public health and safety. Such reservations shall be subject to periodic review and revision in the light of changed conditions. However, all presently existing legal uses of water shall be protected so long as such use is not contrary to the public interest."

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

Watershed The drainage area from which all surface water drains to a common receiving water body system.

Water Shortage Declaration If there is a possibility that insufficient water will be available within a source class to meet the estimated present and anticipated user demands from that source or to protect the water resource from *serious harm*, the governing board may declare a water shortage for the affected source class (Rule 40E-21.231, F.A.C.). Estimation of the percentage of reduction in demand required to match available supply is required and identifies which phase of drought restriction is implemented. A gradual progression in severity of restriction is implemented through increasing phases. Once a water shortage is declared, the District is required to notify permitted users by mail of the restrictions and to publish restrictions in area newspapers.

Water Supply Development The planning, design, construction, operation and maintenance of public or private facilities for water collection, production, treatment, transmission or distribution for sale, resale or end use.

Water Year The 12-month period, May 1 through April 30. The water year is designated by the calendar year in which it ends. Therefore, the 2004 water year ends on April 30, 2004

Wetlands Areas inundated or saturated by surface or groundwater at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands typically have hydric soils.

Xeric Of or pertaining to a habitat having a low or inadequate supply of moisture, or of or pertaining to an organism living in such an environment.

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