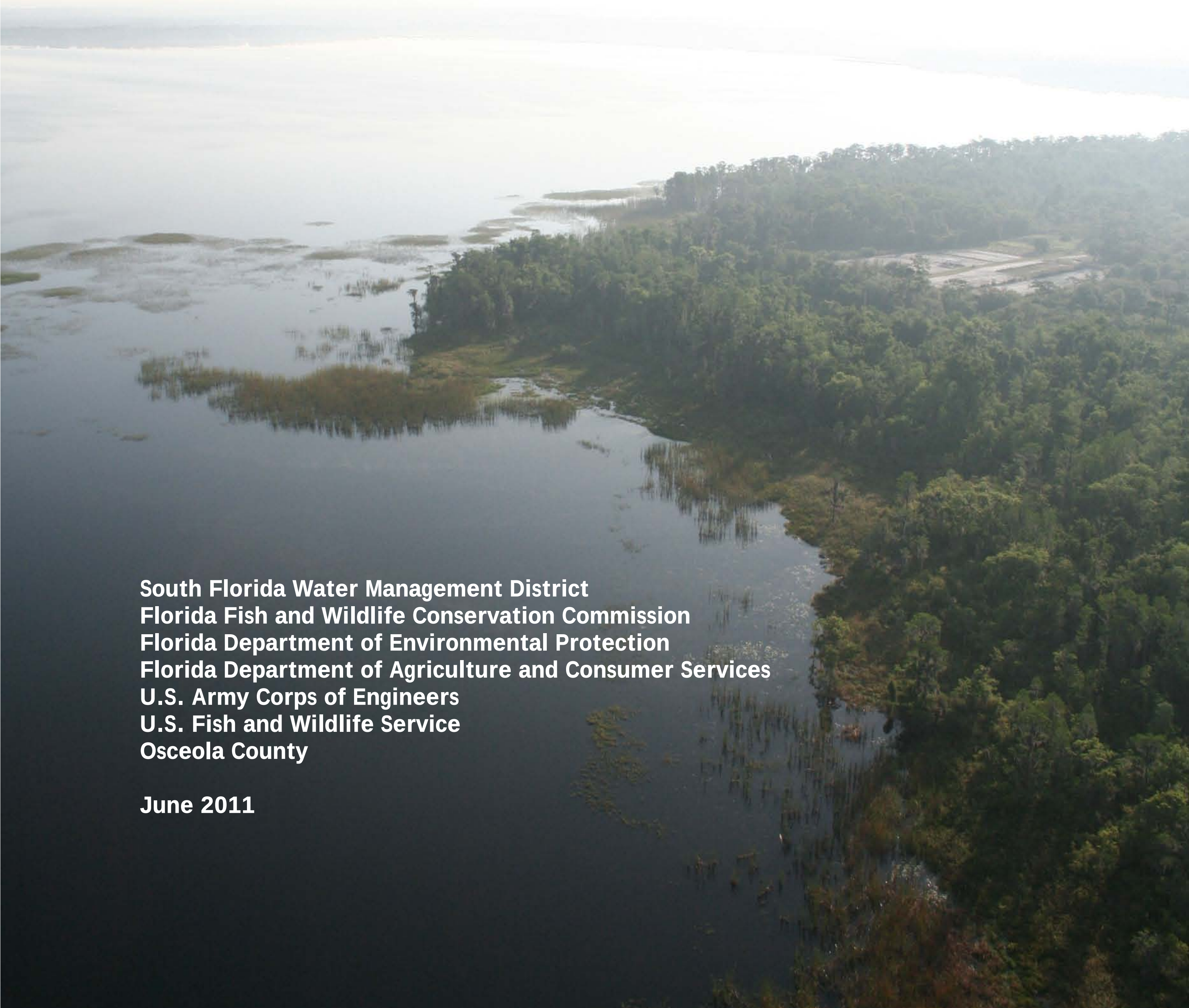
2011 Interagency Draft Kissimmee Chain of Lakes Long-Term Management Plan



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Florida Fish and Wildlife Conservation Commission
Florida Department of Environmental Protection
Florida Department of Agriculture and Consumer Services
U.S. Army Corps of Engineers
U.S. Fish and Wildlife Service
Osceola County

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The SFWMD also acknowledges all the other stakeholders who have provided valuable insights into and perspectives on the value of the resource and the need for federal, state, and local government agencies to work together to preserve and protect the natural resources of central Florida.

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Acronyms and Abbreviations

ac-ft	acre-feet
AIM	assessment indicator measure
ALK	alkalinity
ALCHA	Alligator Chain-of-Lakes Homeowners Association
APM	assessment performance measure
AHRES	FWC-Aquatic Habitat Resource Enhancement Section
BMAP	TMDL Basin Management Action Plan
BMP	best management practice
C&SF Project	Central and Southern Florida Project
CARL	Conservation and Recreation Lands Program
CEM	Conceptual Ecological Model
CERP	Comprehensive Everglades Restoration Plan
cfs	cubic feet per second
Ch.	Chapter (generally used to refer to a legal document)
Chl*a*	chlorophyll *a*
cm	centimeter
Cond	specific conductance
DBHYDRO	SFWMD monitoring database
District	South Florida Water Management District
DO	dissolved oxygen
DRI	Development of Regional Impact
DWMP	SFWMD's Water Management Plan
E	endangered
EAR	Evaluation and Appraisal Report
EIS	Environmental Impact Statement
EPM	Evaluation Performance Measure
ERP	Environmental Resource Permit
ESA	Endangered Species Act
ET	evapotranspiration
EUP	Experimental Use Permit
F.A.C.	Florida Administrative Code
FAS	Floridan aquifer system
FAV	floating aquatic vegetation
FDACS	Florida Department of Agriculture and Consumer Services
FDCA	Florida Department of Community Affairs
FDEP	Florida Department of Environmental Protection
FLUCCS	Florida Land Use and Cover Classification System
FQD	Florida Quality Developments
FRESP	Florida Ranchlands Environmental Services Project

F.S.	Florida Statutes
FWC	Florida Fish and Wildlife Conservation Commission
FWRA	Florida Water Restoration Act
FY	fiscal year
FYN	Florida Yards & Neighborhoods Program (FDEP)
GIS	geographic information system
ha	hectare
hr	hour
HRT	Hydraulic Retention Time
HSPF	Hydrologic Simulation Program-Fortran
IAS	Intermediate Aquifer System
IAT	Interagency team
IBA	Important Bird Area
ICU	intermediate confining unit
IFAS	Institute of Food and Agricultural Sciences
IPMS	Invasive Plant Management Section (part of FWC)
IWR	Impaired Waters Rule
KB	Kissimmee Basin
KB Plan	Kissimmee Basin Regional Water Supply Plan
KBMOS	Kissimmee Basin Hydrologic, Modeling and Operations Study
KCOL	Kissimmee Chain of Lakes
km	kilometers
KRRP	Kissimmee River Restoration Project
Lake Toho	Lake Tohopekaliga
LC/LU	land cover and land use
LFA	Lower Floridan aquifer
LMA	Lake Management Area
LOER	Lake Okeechobee and Estuary Recovery
LOPA	Lake Okeechobee Protection Act
LOPP	Lake Okeechobee Protection Program
LPA	Local Planning Agency
LTMP	Long-Term Management Plan
m	meter
MGD or mgd	million gallons per day
mg/L	milligrams per liter or parts per million
mm	millimeter
mo	month
mpn	most probable number
MS4	Municipal Separate Stormwater System Program
MSL or msl	mean sea level
mt	metric ton
MWI	Midwinter Waterfowl Inventory
NA	not available
N/A	not applicable
NEEPP	Northern Everglades and Estuaries Protection Program
NEPA	National Environmental Policy Act
NGVD	National Geodetic Vertical Datum of 1929

NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NWI	National Wetlands Inventory
NWIS	National Water Information System
OAWP	FDACS Office of Agricultural Water Policy
OIP	FDEP Office of Intergovernmental Programs
P	phosphorus
P2TP	NEEPP Phase II Technical Plan
PCU	platinum cobalt unit
PLRG	pollutant load reduction goal
PMP	Project Management Plan
ppb	parts per billion or µg/L
ppm	parts per million or mg/L
PREC	University of Florida Program for Resource Efficient Communities
PVI	percent of volume infested
RCID	Reedy Creek Improvement District
RPC	Regional Planning Council
SAS	**s**urficial aquifer system
SAV	**s**ubmerged aquatic vegetation
SD	Secchi Disk Depth
SFWMD	South Florida Water Management District
SJRWMD	St. Johns River Water Management District
SOR	Save Our Rivers
sp	a single unidentified species
spp	multiple unidentified species
SRP	soluble reactive phosphorus
STA	Stormwater Treatment Area
SWCD	Soil and Water Conservation District
SWFWMD	Southwest Florida Water Management District
SWIM	Surface Water Improvement and Management
T	threatened
TAC	Technical Advisory Committee
TBD	to be determined
TDS	total dissolved solids
TMDL	total maximum daily load
TN	total nitrogen
TP	total phosphorus
TSI	Trophic State Index
TSS	total suspended solids
UF	University of Florida
UFA	Upper Floridan aquifer
UGB	urban growth boundary
µg/L	micrograms per liter or parts per billion
UKB	Upper Kissimmee Basin
UKISS	Upper Kissimmee Chain of Lakes Routing Model
µS cm^{-1}	microsiemens per centimeter
U.S.	United States

USACE	United States Army Corps of Engineers
USACE-WES	U.S. Army Corps of Engineers - Waterways Experiment Station
USDA	United States Department of Agriculture
USDA-NRCS	United States Department of Agriculture, Natural Resources Conservation Service
USDOI	United States Department of Interior
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WCA	Water Conservation Area
WCC	water control catchment
WCU	water control unit
WMD	water management district
WMIS	Water Management Information System
WOD	Works of the District (SFWMD permit)
WRAC	Water Resources Advisory Commission
WRDA	Water Resources Development Act
WWF	World Wildlife Fund

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Overview

Introduction

The Kissimmee Chain of Lakes (KCOL) is a system of interconnected waterbodies that were historically linked by streams and sloughs. The KCOL is located in a 1,620 square mile watershed that forms the upper portion of the Kissimmee Basin and discharges to the Lower Kissimmee Basin at the Lake Kissimmee outlet structure, S-65. The movement of water through the KCOL is regulated by nine water control structures that are part of the Central and Southern Florida Project (C&SF Project). Since implementation of the C&SF Project, the quality of lake water and wildlife habitat in the KCOL has declined. This deterioration is attributed to a number of factors, including stabilized lake water levels, landscape changes within the lake's watersheds, increased nutrient runoff, and invasion of exotic species. In order to address these emerging management challenges, the KCOL Long-Term Management Plan (LTMP) was initiated through a South Florida Water Management District (SFWMD) Governing Board resolution adopted in April 2003 (Appendix A). This resolution directed SFWMD staff to work with the U.S. Army Corps of Engineers (USACE) and other interested stakeholders to develop a plan to manage the KCOL system. This document is the 2011 interagency draft of the LTMP.

The geographic scope of the LTMP is limited to the 19 KCOL waterbodies regulated by C&SF Project structures and hydrologically connected adjacent lands. The watersheds associated with KCOL waterbodies and adjacent lands are also of interest from a management perspective because activities in the larger watershed can have an adverse effect on the lakes and lake dependent resources. KCOL waterbodies include:

1. Lakes Kissimmee, Lake Hatchineha, and Cypress Lake;
2. Lake Tohopekaliga;
3. East Lake Tohopekaliga, Fell's Cove, and Ajay Lake;
4. Lakes Hart and Mary Jane;
5. Lakes Joel, Myrtle, and Preston;
6. Alligator Chain of Lakes (Alligator, Brick, Lizzie, Coon, Center, and Trout); and
7. Lake Gentry.

For the purposes of the LTMP, these KCOL water bodies were organized into lake management areas (LMAs) described in Chapter 2 and shown in Figure 2.6.

SFWMD staff has coordinated the development of the LTMP with the following partner agencies: Florida Fish and Wildlife Conservation Commission (FWC), Florida Department of Environmental Protection (FDEP), Florida Department of Agriculture and Consumer Services (FDACS), U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service (USFWS), and Osceola County. The partner agencies have met regularly since August 2003 to develop: the scope and goal of the document, a draft conceptual ecological model, assessment performance measures, management objectives and assessment targets and to propose, a monitoring and assessment program, adaptive management process, management framework, and agency action plan. The public has also been encouraged to participate in the planning process. Communication and information gathering was facilitated through email, interagency workshops, and public meetings. Local stakeholder group participants include: Alligator Chain of Lakes Home Owners Association (ALCHA), Audubon of Florida, Deseret Ranch, Lake Mary Jane Alliance, Osceola County Lake Management Advisory Committee, The Nature Conservancy, and the water supply utilities in the Upper Kissimmee Basin.

The results of this collaborative, interagency process are presented in this document, which proposes a strategy for managing the KCOL for the benefit of the fish and wildlife resources and the stakeholders in the region. The participating agencies and stakeholders have defined a shared vision for enhancing and/or sustaining the KCOL resources through cooperation and coordination of federal, state, and local agency resources. This vision cannot be realized without increased agency funding to support the proposed agency action plan presented in Chapter 7. The intent of this plan is to define management objectives and assessment targets, increase awareness of the complicated management challenges facing the KCOL and justify the allocation of more resources to the region to implement the proposed agency action plan.

Participating Agency Guiding Policies

The participating agencies have provided guiding policies for participation in the LTMP. Agency mission statements supporting these guiding polices are presented in Appendix B.

Partner Agency	Brief Summary of Guiding Policy
South Florida Water Management District	Manage and protect water resources of the South Florida region by balancing and improving water quality, flood control, natural systems, and water supply.
Florida Fish And Wildlife Conservation Commission	Manage, conserve, and regulate the Kissimmee Chain of Lakes fish and wildlife resources, including their habitats, for the benefit of the public and in cooperation with other state and federal agencies and manage aquatic plants, especially invasive aquatic plants, to conserve the various combined uses and functions of public lakes.
Department of Environmental Protection Water Quality	Maintain and restore water quality through development of total maximum daily loads (TMDLs) for verified impaired water bodies and development of Basin Management Action Plans. Review and permit restoration projects to ensure compliance with the Northern Everglades and Estuaries Protection Program.
Florida Department of Agriculture and Consumer Services, Division of Ag Water Policy	Work with agricultural landowners to develop land management plans and implement site-specific agricultural Best Management Practices within the geographical boundaries of the Northern Everglades and Estuary Protection Program
U.S. Army Corps Of Engineers	Provide guidance for operations of authorized C&SF projects; investigate operational modifications for flood damage reduction, water supply, navigation, and environmental enhancement; and manage invasive plants in navigable waterways
U.S. Fish and Wildlife Service	Ensure that fish and wildlife resources receive full consideration and necessary protection in water resource planning activities. Review and influence development activities to ensure impacts to wetlands and other habitats are avoided, minimized or compensated through mitigation. Advise and support federal, state, tribal, and local entities to further the conservation and recovery of listed species.
Osceola County	Support FWC, USACE, and SFWMD lake habitat enhancement and aquatic plant management projects and programs. Modify Land Development Codes to be consistent with lake management goals and objectives. Develop environmental community outreach/involvement programs. Pursue alternative sources of funding for the eradication of exotic or pest plants. Continue land acquisition programs designed to preserve lakeshore habitats and marshes that protect dependant species and provide water quality enhancement benefits.

Long-Term Management Plan Structure

Plan Purpose

The overall purpose of the document is to present a plan to enhance and/or sustain lake ecosystem health through interagency cooperation and coordination. A healthy lake ecosystem, as defined for the LTMP, is a sustainable system capable of maintaining its structure and function over time (Haskell et al. 1992). For the KCOL, "sustainable" refers to a sustainably managed system, since the plan partners recognize that these lakes cannot be returned to their historic or pre-regulation condition.

Management Objectives

The objectives presented in this document define the intended outcomes from interagency management actions. Management objectives are defined for hydrologic management, water quality, fish and wildlife resources, aquatic plant management, water supply, and recreation and public use. Assessment targets associated with these objectives are identified in Chapter 5.

Hydrologic Management

Manage C&SF Project water control structures in the KCOL watershed to:

1. Promote plant diversity, quality lake littoral substrate, and fish and wildlife productivity within lake littoral zones;
2. Maintain current C&SF Project flood reduction benefits;
3. Provide flow releases necessary to meet Kissimmee River Restoration hydrologic criteria; and
4. Reduce undesirable inflows to Lake Okeechobee.

Water Quality

Manage water quality in the KCOL watershed to:

1. Meet or maintain state water quality standards and trophic state criteria including total maximum daily loads (TMDLs);
2. Reduce phosphorus runoff from properties exceeding phosphorus discharge limitations (Lake Okeechobee Works of the District);
3. Reduce municipal storm water nutrient inputs to lakes;
4. Reduce non-nutrient contaminant inputs to lakes; and
5. Protect/enhance water clarity and lake swimability.

Fish and Wildlife

Manage lakes and littoral habitats in the KCOL watershed to:

1. Support the life cycle requirements of KCOL dependent fish and wildlife resources;
2. Conserve and/or enhance aquatic and littoral habitats;
3. Protect lake-associated listed species; and
4. Minimize development encroachment on lakeshore habitats.

Aquatic Plant Management

Manage invasive aquatic plants and nuisance growth of native plants within the KCOL to:

1. Conserve or enhance the multiple uses and functions identified for each water body;
2. Eradicate pioneer infestations of invasive plant species before they become large-scale environmental and economic problems; and
3. Contain established invasive aquatic plant populations at minimal levels that current technology, funding, and environmental and biological conditions will allow.

Water Supply

Manage water resources within the KCOL watershed to:

1. Maintain the quantity of water necessary for the protection of fish and wildlife;
2. Provide opportunities for surface water uses consistent with Kissimmee Basin Water Reservations; and
3. Sustain and/or enhance the quantity and quality of watershed wetlands throughout the UKB.

Recreation and Public Use

Manage public lakes and state lands for multiple recreational purposes within the KCOL watershed to:

1. Sustain existing recreational opportunities and land uses without increasing conflicts between lakefront owners and recreational users;

2. Establish public use opportunities compatible with protection of natural resources; and
3. Manage airboat, ATV, mud truck, and boat traffic to reduce ecological and noise impacts.

Management Concerns, Targets, Priorities, and Challenges

In addition to identifying management objectives for the KCOL system, management concerns, targets, and priorities were identified at management objective (system) level and LMA level (Chapter 3). The LMAs ranking is based on: resource size, fish and wildlife resources and habitats, economic value, recreational uses and opportunities, and management challenges facing the resource.

Monitoring and Assessment

The proposed monitoring and assessment program for the LTMP is a critical component of the adaptive management process described in Chapter 5. The program is comprised of three types of monitoring activities: long-term monitoring to assess current conditions, monitoring to assess the effectiveness of management actions, and monitoring to improve understanding of ecosystem functions and processes. These three types of monitoring are intended to provide the information needed to identify whether a problem exists, to assess what types of management intervention may be needed, and to determine the effectiveness of deployed management tools. Results and assessments from these three types of monitoring activities will be assembled into an annual system assessment report intended to assist resource managers in making appropriate adjustments to management and monitoring programs. The report will be prepared annually. Key findings and concerns will highlight areas where management intervention or correction is required.

Adaptive Management and the Proposed Management Framework

Adaptive management is a systematic approach for improving resource management by learning from management outcomes. It requires a set of clearly defined management objectives (Chapter 3) and associated targets (Chapter 5) that can be evaluated to determine whether the system is responding as expected. An adaptive management approach is being proposed for the LTMP because knowledge and understanding of the system is incomplete and data on the linkages between management actions and ecosystem responses are limited. It is also an appropriate approach because the stakeholders invested in the long-term health of these lake ecosystems represent a large and diverse group of interests.

The proposed management framework defines the players, roles, responsibilities, and relationships required for successful implementation of the adaptive management process. The players include the stakeholders, agency representatives, and decision makers. The stakeholders are in the field and are generally the first to see emerging issues and concerns or where current management tools are not well aligned with management objectives. The agency representatives have primary responsibility for implementing the adaptive management process and proposed management framework and have formal roles and responsibilities for implementing the LTMP and aligning their agency's mandates and resources with the stated management objectives. The decision makers have long-term responsibility for the management tool set and the authority to add and modify tools, allocate resources, initiate new projects and programs, and ensure compliance with laws and regulations.

The proposed framework is intended to provide a coordinated, multi-disciplinary framework for achieving management objectives in the KCOL. The success of the framework will depend on the partner agencies' ability to: 1) build partnerships between stakeholders, managers, and scientists; 2) obtain resource commitments and policy guidance from federal, state, and local partners; and 3) make science-based decisions on how to apply and/or modify management actions to meet stated management objectives.

Assessment Targets

Assessment targets define specific values, threshold values (minimum or maximum), ranges of values, or directions of change and are associated with metrics used to evaluate change in the state of the system relative to management objectives. They are defined in the assessment performance measures developed for the LTMP. Chapter 5 presents assessment targets and links them to management objectives, and existing and proposed monitoring and assessment activities. Assessment targets and related materials are organized by the major system attributes: hydrology, vegetation, birds, fish and other aquatic fauna, and water quality.

Plan Proposal (a.k.a Proposed Path Forward)

Chapter 7 presents the proposed agency action plan for the LTMP. The proposed action plan has four parts.

Part 1: Become a Plan Partner

Plan partners must be committed to the adaptive management process, acknowledge that uncertainty exists, and be willing to accept the risks associated with our limited knowledge and understanding of the system and the system's responses to management actions. Plan partners are expected to:

- Allocate agency staff to serve on an interagency team and a science team;
- Adopt the LTMP management objectives presented in Chapter 3; and
- Allocate resources and/or realign existing resources to support implementation of the LTMP monitoring and assessment program.

Part 2: Fill Management Gaps

To achieve all the management objectives defined in Chapter 3, gaps in the management tool set need to be addressed through policy revisions.

Part 3: Near-Term Coordination

The TMDL Basin Management Action Plan (BMAP), Basin Rule, Statewide Unified Storm Water Rule, and the Kissimmee Basin Water Reservation are currently under development. The partner agencies consider these important initiatives that need to be vetted within the interagency team to ensure that the BMAP and new regulatory criteria are appropriately aligned with the KCOL management objectives.

Part 4: Develop an Integrated Watershed Management Plan specific to the KCOL

Because conditions within the KCOL are dependent upon and influenced by conditions within the watershed, integrated watershed management solutions are needed to achieve the management objectives outlined in Chapter 3. Current programs are designed either to address a single and/or narrow objective or are focused on meeting the requirements of a downstream resource (e.g., nutrient loads to Lake Okeechobee, flows to the Kissimmee River). A strategy for managing the KCOL watershed for multiple objectives needs to be initiated and prioritized.

Document Structure

The LTMP document is divided into seven chapters and includes an acronym list, references, and a glossary. Specific chapter content is described as follows:

- **Chapter 2** provides a description of the physical features of the KCOL watershed; the population growth, land use trends, and recreational and public use opportunities within the watershed; and a summary of recent stakeholder and economic value surveys.
- **Chapter 3** describes the management objectives, concerns, targets, and priorities for enhancing and/or sustaining lake ecosystem health.
- **Chapter 4** describes the proposed monitoring and assessment program.
- **Chapter 5** identifies assessment targets and links them to management objectives and existing and proposed monitoring and assessment activities.
- **Chapter 6** defines the proposed management framework and adaptive management process.
- **Chapter 7** presents the proposed agency action plan.

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Basin Description

Introduction

Located in south-central Florida, the Kissimmee Basin is the northernmost basin in the South Florida Water Management District. The St. Johns River Water Management District (SJRWMD) lies to the north and east of the basin, and the Southwest Florida Water Management District (SWFWMD) lies to the west. The basin extends from the city of Orlando southward to Lake Okeechobee. In addition to the southern portion of Orlando, major urban areas in the Kissimmee Basin include the city of Kissimmee on Lake Tohopekaliga (Lake Toho), the city of St. Cloud on East Lake Tohopekaliga (East Lake Toho), and Disney World and its surrounding areas in the northwestern part of the basin.

For management purposes, the Kissimmee Basin is commonly separated at the outlet of Lake Kissimmee (the S-65 water control structure) into an Upper Kissimmee Basin (UKB) of 1,620 square miles in area and a Lower Kissimmee Basin (LKB) of approximately 760 square miles (See Figure 2.1).

THE C&SF PROJECT IN THE KISSIMMEE BASIN

Prior to the Central and Southern Florida Project (C&SF Project), water from the lakes and wetlands in the Kissimmee Chain of Lakes (KCOL) overflowed natural drainage divides during wet periods and moved slowly southward through the Kissimmee River to Lake Okeechobee.

In 1948, the U.S. Congress authorized the U.S. Army Corps of Engineers to build the C&SF Project to provide flood control and water supply, among other purposes. In 1954, flood control works were authorized for the Kissimmee Basin as an addition to the C&SF Project. Constructed between 1960 and 1971, the project included the dredging of canals between lakes and construction of nine water control structures to regulate lake levels and outflows. The Kissimmee River portion included the channelization of the Kissimmee River (C-38 Canal) and construction of five water control structures. For management purposes, the Kissimmee Basin is commonly divided into the Upper Kissimmee Basin and the Lower Kissimmee Basin at the outlet of Lake Kissimmee’s S-65 Structure.

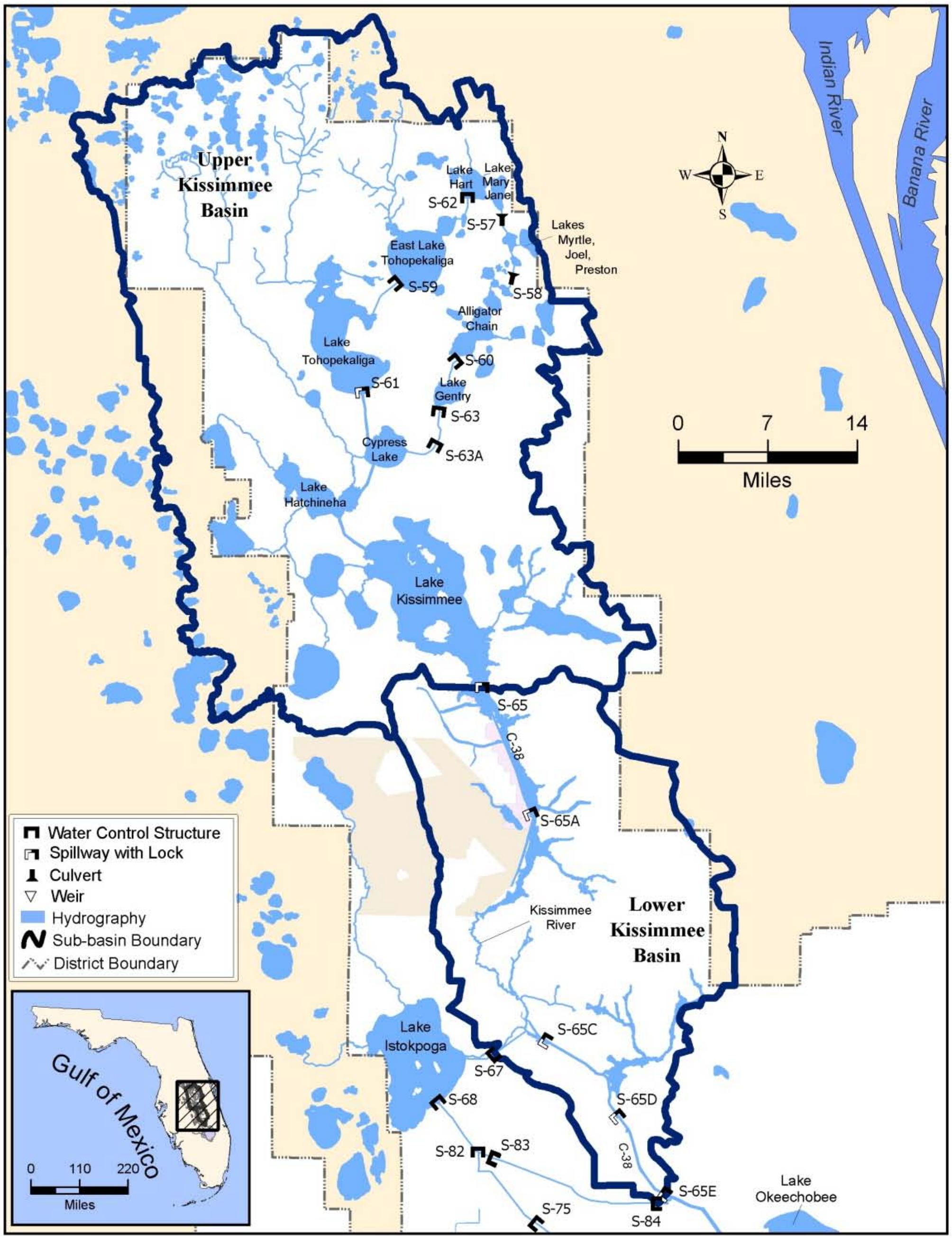

Figure 2.1 – Upper and Lower Kissimmee Basins.

Hydrology

Within the UKB, the KCOL is the dominant hydrologic feature. Historically, the KCOL and the Kissimmee River were an integrated system comprised of headwater lakes connected by broad shallow wetlands and creeks. Inter-annual water-level fluctuations in the KCOL ranged between 2 and 10 feet during the recorded pre-regulation period. The lakes had limited outflow capacities and functioned as natural detention areas that provided storage in the wet season and continuous discharge to the Kissimmee River throughout the year (USFWS 1959). Under these natural conditions, lake levels would rise in the wet season and overflow to adjoining lands, creating broad, marshy connections between the lakes. During these periods, the hydrology could be characterized by slow changes in stage, low flow velocities, and long gradual recessions in the dry season (Bogart and Ferguson 1955). The flooded marshes were used by fish and wildlife for spawning and foraging. Flows would peak in October and November and then decrease through the dry season (Obeysekera and Loftin 1990). During dry periods, characterized by low water levels, connections between the lakes would disappear and littoral zones would become exposed. This process allowed the bottom sediments to oxidize and prevented the accumulation of organic material along the lake edge (USACE 1996). Pre-regulation hydrology played a critical role in maintaining fish and wildlife populations and highly diverse marsh habitats (USFWS 1959).

The KCOL has been substantially altered from this historical condition through the dredging of canals, installation and operation of water control structures, increased development, and proliferation of problematic plant and animal species. These alterations have contributed to the loss of desirable native species and reduction in overall plant and animal diversity and abundance (Perrin et al. 1982). The most dramatic alteration is in water level fluctuations. Lake level fluctuation has been reduced from 2–10 ft (0.6–3.0 m) to about 2–4 ft (0.6–1.2 m) annually (Obeysekera and Loftin 1990). In addition, regulation has changed the seasonality and variability (frequency, duration, and timing) of high and low lake stages and regulated discharges have increased recession and ascension rates. This altered hydrology has eliminated the natural flooding and drying cycles essential to maintaining quality lake littoral habitats. Current conditions promote the growth of dense vegetation and the accumulation of organic material in the lake littoral habitats, which negatively impact fish and wildlife resources dependent upon these areas (SFWMD et al. 2004).

Surfacewater Resources

The hydrologic modification of the KCOL watershed began in the 1880s. During that time, Hamilton Disston began excavating canals between the lakes to improve navigation and drainage of the surrounding lands. In 1902, flood control works for the Kissimmee Basin were authorized by the Federal Rivers and Harbors Act of 1954 as an addition to the C&SF Project. The primary purposes were to relieve flooding and minimize flood damage within the Kissimmee Basin and to improve navigation opportunities originally provided in the Rivers and Harbors Act of 1902. The project was constructed between 1960 and 1971. The UKB portion, constructed between 1964 and 1970, included construction of nine water control structures (S-57, S-58, S-59, S-60, S-61, S-62, S-63, S-63A, and S-65) to regulate lake levels and outflows. A number of canals between the lakes were enlarged, and new canals were dredged to connect Alligator Lake with Lake Gentry, and to connect Lake Gentry with Cypress Lake. In 1972, the SFWMD became project owner of the entire C&SF Project. Under an agreement between the USACE and the SFWMD, the SFWMD is required to operate and maintain all completed portions of the C&SF Project pursuant to regulations prescribed by the Secretary of the Army.

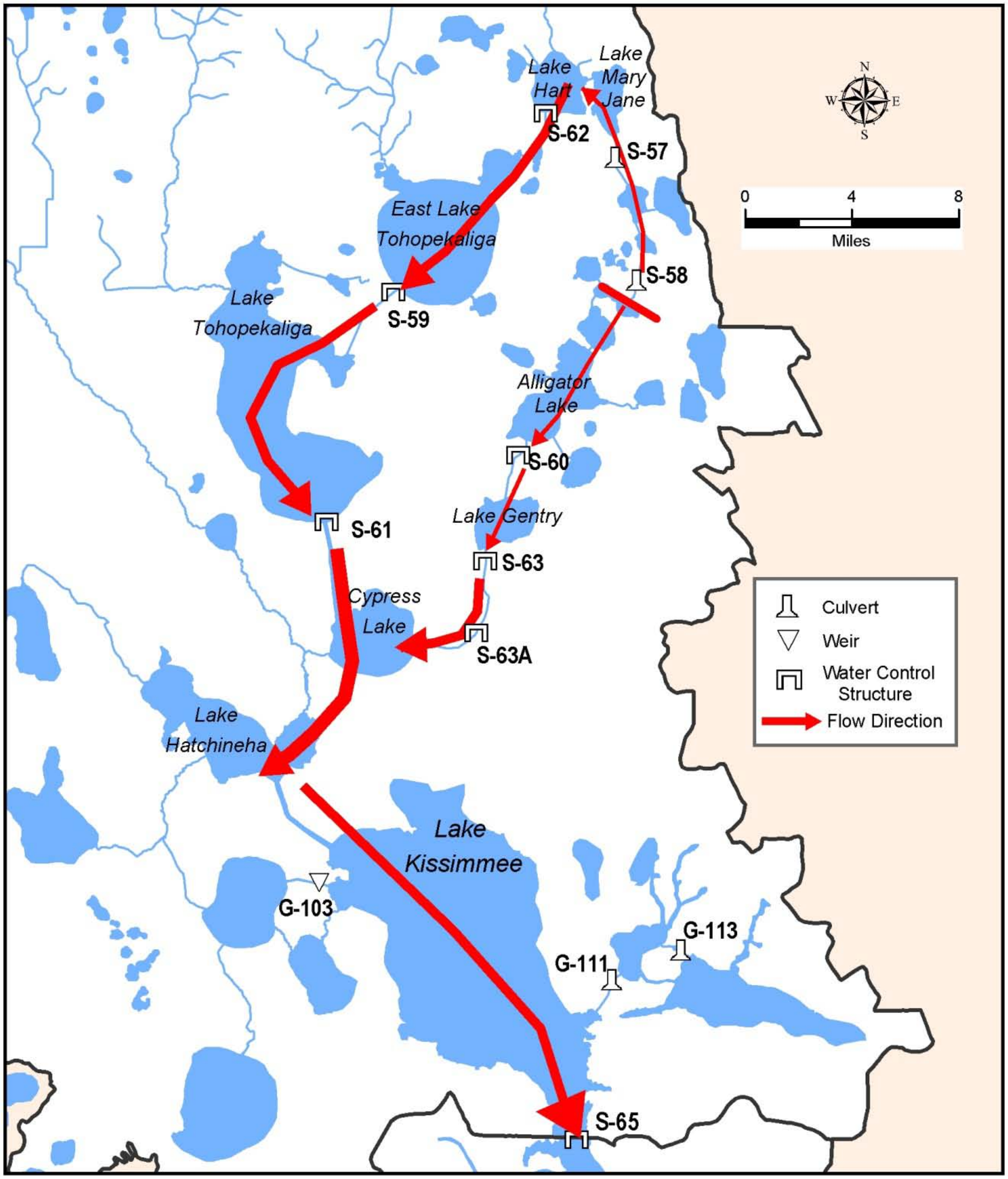

Figure 2.2 – Water control structures and direction of flow of water through the Kissimmee Chain of Lakes.

Figure 2.2 shows the water control structures and the primary direction of flow through the KCOL. The S-58 water control structure just north of Alligator Lake acts as the drainage divide. Although water can be released under very high stages either to the north or to the south, flow is predominantly to the south. North of the S-58 water control structure, water flows through several canals and small lakes to Lakes Mary Jane and Hart and then south through East Lake Toho and Lake Toho to Cypress Lake, where it joins flow from the southern portion of the eastern chain. Southward flow from the S-58 water control structure travels a shorter route through the Alligator

Chain of Lakes and Lake Gentry to Cypress Lake. From Cypress Lake, water flows southward to Lake Hatchineha and then to Lake Kissimmee, where it is discharged to the Kissimmee River through the S-65 water control structure. Although the KCOL consists of dozens of lakes, the LTMP scope is limited to the 19 water bodies with water levels and flow directly controlled by C&SF Project water control structures and operating criteria. All of the lakes in the KCOL are shallow, with mean depths varying from 5 feet to 10 feet with a median depth of 6.6 feet (Table 2.1). Maximum depths range from 9 to 32 feet (Alligator Lake).

Table 2.1 – Central and South Florida Project water bodies in the Kissimmee Chain of Lakes (Source: SFWMD GIS files)

Lake Name	**Lake Area** (acres)	**Maximum Regulatory Stage** (ft-NGVD)	**Max Depth** (ft)	**Mean Depth** (ft)
Cypress Lake	5,470	52.5	10.5	4.8
Lake Hatchineha	11,273	52.5	11.5	4.5
Lake Kissimmee	44,405	52.5	18.5	7.4
Lake Tohopekaliga	22,019	55	13	6.1
Ajay Lake	*	*	*	*
Fells Cove	1,232	58	10	4.2
East Lake Tohopekaliga	11,667	58	18	9.9
Lake Mary Jane	1,376	61	12	4.5
Lake Hart	2,434	61	20	6.6
Lake Preston	1,238	62	10	4.3
Lake Myrtle	715	62	10	2.5
Lake Joel	797	62	10	4.2
Trout Lake	609	64	11	3.5
Lake Center	556	64	9	3.4
Coon Lake	271	64	*	*
Lake Lizzie	897	64	21	5.5
Alligator Lake	3,775	64	25	8.0
Brick Lake	1,292	64	18	6.1
Lake Gentry	1,947	61.5	18.5	7.8

* Data not available.

The major tributaries feeding the KCOL are Shingle Creek, Reedy Creek, and Boggy Creek (see Figure 2.1). The headwaters for the three creeks are located in urbanized portions of metro-Orlando. The creeks flow southward through wetlands into Lake Toho, Cypress Lake, and East Lake Toho, respectively. The Econlockhatchee Swamp, a blackwater swamp located along the eastern boundary of the KCOL, also is believed to be an important water source for the small lakes immediately west and southwest of the swamp. Hydrogeologic investigations are proposed for this area to gain a better understanding of the inter-relationship and/or interdependency between these water resources.

The headwaters of Shingle Creek form in the city of Orlando. The creek runs southward for 24 miles through Shingle Creek Swamp and the city of Kissimmee before discharging into Lake Toho. Natural flow in Shingle Creek was substantially modified by of the channelization of 13 miles of the watercourse in the 1920s and subsequent transection by utility transmission lines and access roads

(SFWMD et al. 2007a). Shingle Creek is the largest tributary discharging into Lake Toho and represents 34 percent of the total inflow into that lake.

Reedy Creek in Osceola County represents the least disturbed of the three major creeks. Originating in Walt Disney World, Reedy Creek runs southeast for 29 miles before splitting into two branches near Cypress Lake. One branch enters Cypress Lake and the other enters Lake Hatchineha. During most of its course, the creek flows through Reedy Creek Swamp. Reedy Creek also receives water from the Butler Chain of Lakes when these lakes are high enough (SFWMD et al. 2007b). Reedy Creek makes up approximately 19 percent of the total inflows into Lake Kissimmee, Lake Hatchineha, and Cypress Lake.

Boggy Creek has two main branches: east and west. The east branch, which is 12 miles long, is the main watercourse of Boggy Creek. The headwaters of this branch form in the city of Orlando northwest of Orlando International Airport. The headwaters of the west branch originate in another highly urbanized area of Orlando, Lake Jessamine. The east and west branchs of the Creek unite and run through Boggy Creek Swamp before emptying into a cove in northwestern East Lake Toho. Boggy Creek contributes approximately 69 percent of the total inflows into East Lake Toho.

C&SF Project Water Level Regulations

The water management infrastructure in the KCOL consists of canals that connect lakes and water control structures that regulate water levels and the movement of water between lakes. The C&SF Project lakes are organized into Water Control Units (WCUs) and Water Control Catchments (WCCs). WCUs are comprised of a water body or a set of interconnected water bodies (for example, a lake and its adjoining canals) that convey water. WCUs are regulated as a single unit by a downstream water control structure in accordance with operating criteria codified in the USACE Water Control Manual for Kissimmee River – Lake Istokpoga Basin (USACE 1994). WCCs are comprised of a WCU and its associated watershed. The nine WCCs in the KCOL and their associated land uses are presented in Appendix C.

The operating criteria for WCUs define seasonal and monthly water level limits required to meet the flood protection, water supply, recreational, and environmental objectives of the C&SF Project. The current set of rules was created in the mid-1980s by the USACE and SFWMD. They are currently being reevaluated as part of the SFWMD Kissimmee Basin Modeling and Operations Study (KBMOS).

Groundwater Resources

The Kissimmee Basin has a complex groundwater system that includes three major hydrogeologic units: the surficial aquifer system (SAS), the intermediate confining unit (ICU), and the Floridan aquifer system (FAS). The SAS generally consists of fine-grained unconsolidated materials and yields low quantities of water to wells. In general, water in the SAS is unconfined and the altitude of water levels in wells tapping the aquifer system represents the water table. Given the close proximity of the water table to the surface over much of the basin, there is generally a high degree of interconnection between groundwater and surface waters in the region. When a river, canal or wetland has a higher water level than the water table, these surface water bodies provide seepage into the local shallow groundwater system. Conversely, when the water level of the surface water bodies is lower than the water table, groundwater discharge may occur. The rate at which this transfer occurs depends on the difference in these two levels and the permeability and thickness of the materials separating the two systems. The ICU consists primarily of low-permeability sediments rocks and, with the exception of a few isolated areas within the basin, is not an important source of water.

Virtually all of the water currently used to meet municipal, industrial, and agricultural needs within the region of the Kissimmee Basin comes from the FAS (SFWMD 2000a). The FAS consists of two distinct high-permeability production zones: the Upper Floridan aquifer (UFA) and Lower Floridan aquifer (LFA). The two zones are separated by the less permeable middle semi-confining unit. The UFA is the most important source of potable water in the majority of the counties that encompass the Kissimmee Basin (SFWMD 2000a).

The magnitude and direction of water interchange between the different aquifers depends on the relative altitude of the potentiometric surfaces of the aquifers and the thickness and vertical permeability of the intervening confining units. Aucott (1988) has mapped the regional-scale areal variations in water exchange between the SAS and UFA in Florida. The UFA in the northern portion of the basin is recharged by direct downward leakance (e.g., through sinkholes) from the SAS, and where present, through the ICU (Adamski and German 2004, Aucott 1988, Shaw and Trost 1984). Recharge to the FAS is high along the Lake Wales, Mount Dora, and Bombing Range ridges where the confining layer is either thin or breached and the elevation differences between the SAS and FAS are greatest (SFWMD 2000a). The potential also exists for groundwater to flow vertically between the UFA and the LFA across the middle semi-confining unit that separates the two units of the FAS (Adamski and German 2004, SFWMD 1999).

Water Quality

Lakes in the Kissimmee Chain of Lakes (KCOL) are designated as Class III water bodies by the State of Florida, for which the designated uses are "recreation and propagation and maintenance of healthy, well-balanced populations of fish and wildlife". The lakes are highly valuable for these purposes, although nutrient enrichment threatens to diminish their recreational, economic, and ecological value. The magnitude of enrichment varies from lake to lake; some lakes have a long history of impact (e.g., Lake Toho) and ecological changes are apparent, while a few others have been impacted very little. Symptoms of nutrient enrichment include frequent algal blooms, high rates of organic sedimentation, extensive stands of dense aquatic vegetation, and changes in populations of fish and other aquatic fauna. Water level stabilization and the spread of invasive aquatic plants may be the primary causes of some of these symptoms, particularly vegetation growth and organic matter build-up, but they are exacerbated by the eutrophication process.

The SFWMD and various other state and local agencies have undertaken many projects to reduce or prevent nutrient enrichment in the KCOL. One of the most significant of these efforts was the diversion of wastewater treatment effluents away from Lake Toho in the 1980s. Nonpoint-source nutrient runoff continues to be a concern, however, and the SFWMD is cooperating with FDEP, FDACS, and local governments to reduce runoff from agricultural and non-agricultural sources.

Currently, several lakes are identified as nutrient-impaired by the Florida Department of Environmental Protection. Lakes Kissimmee and Cypress were listed as impaired in 2006 (CDM 2008). The FDEP added Lake Toho, East Lake Toho and Lake Hatchineha to this list in 2010 (http://www.dep.state.fl.us/water/watersheds/assessment/adopted_gp4-c2.htm). The final impairment status of Lake Toho is currently under discussion between FDEP and local stakeholders. Originally the waterbody was being considered as being impaired and needing a

TMDL. However, a restoration planning process is underway that may move the water body into a category known as "impaired, but recently completed or on-going restoration activities are underway to restore the designated uses of the waterbody." The restoration planning and potential listing modification are expected to be completed by December 2011.

In total, the FDEP verified 34 water bodies in the Kissimmee Basin as impaired for one or two constituents. Of these water bodies, 9 lakes were identified as having impairments for nutrients, lead, and mercury in fish tissue (Table 2.2). However, the absence of a given lake from this list does not mean that it is secure. Land use changes in a rapidly urbanizing landscape could impact some lakes that are so far well-preserved. These lakes have lower levels of nutrients (are mesotrophic) and may require more strict levels of protection than the more nutrient-rich (eutrophic) lakes. Also, some lakes may not be on the FDEP's list because an inadequate amount of data is available to evaluate them.

Control of KCOL eutrophication is very important for the health of Lake Okeechobee. The Kissimmee Basin supplies nearly a third of the phosphorus that enters Lake Okeechobee, and over half of this phosphorus is discharged from the KCOL. Although the concentration of phosphorus in KCOL discharge is relatively dilute (78 ppb) compared to concentrations in discharges from other watersheds around Lake Okeechobee, the volume of water released from these lakes results in a large amount of phosphorus flowing downstream through the Kissimmee River. The average annual amount is 91 metric tons, which is over half the Lake Okeechobee TMDL of 140 metric tons. With such a huge dilute source of phosphorus at hand, an increase in concentration of just a few parts per billion or a year of above-average rainfall in the Upper Kissimmee Basin can make a large difference in the total phosphorus load to Lake Okeechobee. Achievement of the Lake Okeechobee TMDL is very challenging, and to a large extent depends on reducing KCOL phosphorus concentrations to historical levels and retaining more water in the Upper Kissimmee Basin.

Table 2.2 – Impaired water bodies in the Kissimmee Chain of Lakes.

Water Body	Nutrients	Mercury in Fish Tissue	Iron
Alligator Lake		X	
Brick Lake		X	
Cypress Lake	X	X	
East Lake Tohopekaliga	X	X	
Lake Hart		X	
Lake Hatchineha	X	X	
Lake Kissimmee	X	X	
Lake Mary Jane		X	X
Lake Tohopekaliga	X	X	
Lake Gentry		X	

Fish and Wildlife

Fish and wildlife resources have thrived in the KCOL for generations and are one of the most aesthetically and economically valued assets in the region. Fish and wildlife depend on KCOL lakes and littoral habiats for foraging, refuge, and reproduction. Enhancing and sustaining the quality of littoral habitats has been identified by the LTMP partner agencies as the top fish and wildlife priority. Agency mandates for the protection and management of fish and wildlife in the KCOL specify management for existing resources in the basin.

Several lakes within the KCOL are designated by the FWC as fish management areas (see discussion below) and are well known for their largemouth bass (*Micropterus salmoides floridanus*), black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), and redear sunfish (*Lepomis microlophus*) fisheries valued in the millions of dollars to the local economy.

Resident and migratory wading birds that depend upon the KCOL lakes and wetlands include the endangered wood stork (*Mycteria americana*), great white egret (*Ardea alba*), great blue heron (*Ardea herodias*), little blue heron (*Egretta caerulea*), anhinga (*Anhinga anhinga*), snowy egret (*Egretta thula*), white ibis (*Eudocimus albus*), tricolored heron (*Egretta tricolor*), black-crowned night heron (*Nycticorax nycticorax*), yellow-crowned night heron (*Nyctanassa violacea*), glossy ibis (*Plegadis falcinellus*), and cattle egret (*Bubulcus ibis*). The primary waterfowl species using the KCOL are ring-necked duck (*Aythya collaris*), mottled duck (*Anas fulvigula*), and blue-winged teal (*Anas discors*). During some years large concentrations of lesser scaup (*Aythya affinis*) will use some areas of the KCOL and large numbers of American coot (*Fulica americana*) are common during the overwinter period (FWC 2008).

Two subspecies of sandhill crane (Florida sandhill crane, *Grus canadensis pratensis*, and eastern greater sandhill crane, *G. c. tabida*) and whooping cranes (*G. americana*) inhabit KCOL wetland and littoral habitats. The eastern greater sandhill cranes are migratory and occur during winter (November-February), while the other subspecies are permanent residents.

Lakes, such as Lake Toho, serve as primary nesting and foraging habitat for resident populations of the endangered Everglades snail kite (*Rostrhamus sociabilis plumbeus*) and also function as a refuge for the Everglades snail kites during drought conditions in southern Florida.

Florida has the third-largest nesting population of Bald Eagle in the lower 48 states, and the KCOL supports an area of concentrated nesting within the state (FWC 2005a, FWC Eagle Nest Locator http://myfwc.com/eagle/eaglenests/Default.asp).

There is a resident population of American alligator (*Alligator mississipiensis*) in the KCOL that FWC actively monitors and manages. The 2010 FWC survey estimated alligator populations on: Hatchineha 2,296 - Kissimmee 6,522 - Toho 4,183 - East Lake Toho 129. East Lake Toho has served as a commercial alligator egg collection area since 2007.

Aquatic and Wetland Vegetation

Aquatic and wetland habitats are a dominant land feature in the UKB. For the purposes of the LTMP, aquatic and wetland habitats were classified using a method adapted from Cowardin et al. (1979) and other publications. While this planning document does not consistently follow any one source, the UKB wetlands have been classified into three primary types: lacustrine, palustrine, and riverine. More detailed definitions for each wetland type and associated subgroups are available in Appendix D.

The focus of the LTMP is on littoral and submerged wetlands in C&SF Project water bodies. Palustrine and riverine wetlands are included because they are important to fish and wildlife resources. Wetland quality within the KCOL varies by LMA but is similar among the eutrophic (high nutrient level) and mesotrophic (moderate nutrient level) lakes. As previously stated, one of the top priorities of the LTMP partner agencies is to enhance and sustain lake littoral habitats to support existing populations of KCOL fish and wildlife resources.

A typical littoral plant community begins on the openwater's edge with bulrush (*Scirpus* sp.) in the deepest areas of the littoral zone. Eelgrass (*Vallisneria Americana*), Illinois pondweed (*Potamogeton illinoensis*), water lily (*Nymphaea odorata*), spatterdock (*Nuphar lutea*), spike rush (*Eleocharis* sp.), knotgrass (*Paspalum distichum*), and maidencane (*Panicum hemitomon*) would be seen farther landward followed by willow (*Salix* sp.) and buttonbush (*Cephalanthus occidentalis*) at the landward extent of the system. These habitats have been extensively invaded by wetland and aquatic weeds including: water hyacinth (*Eichhornia crassipes*), water lettuce (*Pistia stratiotes*), torpedo grass (*Panicum repens*), and hydrilla (*Hydrilla verticillata*).

Water Supply

The upper portion of the KCOL lies within areas designated and planned by Orange, Osceola, and Polk counties for future urban growth and development. Although the plan designations for each county vary, from Osceola's Urban Growth Boundary to Polk County's Urban Development Area, the common denominator is that future growth will be managed to produce higher density and compact development that is more efficient to serve with public facilities and services. This regional focus is a direct response to the level of population growth that is expected to occur over the next 20 to 30 years. For example, the population of Orange County within the UKB is expected to double over the next two decades, and Osceola County's population is expected to increase by a factor of 1.85, or 261,000 people, between 2008 and 2028 (Orange County 2008, Osceola County

2008). In addition, the area within the UKB portion of Polk County's is expected to more than triple by 2030 (Purcell 2008).

Public Use and Recreation

Land use

Population growth and urbanization trends within the UKB are dramatically changing the land use characteristics of the region. It has been estimated that the population will increase to 1.1 million by 2025 (SFWMD 2006a). While this growth is projected to occur within planned urban growth areas, the conversion of lands from agricultural and rural uses to urban uses and densities poses a variety of challenges for the long-term management of the basin.

This trend toward dramatic land use changes is underscored by data obtained for the Osceola County Urban Growth Boundary (UGB) area (Osceola County 2007). The UGB illustrated on Figure 2.3 encompasses much of the Lake Toho and East Lake Toho watershed area, as well as the Reedy Creek, Boggy Creek, and Shingle Creek watersheds (SFWMD 2006b). By 2025, the remaining 40,722 acres of undeveloped lands within the UGB are expected to be converted to residential and commercial land uses. Table 2.3 summarizes the 14 major land use categories from the year 2000 within each of the LMAs. Figure 2.4 illustrates the land use distribution for the KCOL watershed area. Only land use categories representing more than 1 percent of the total area are represented.

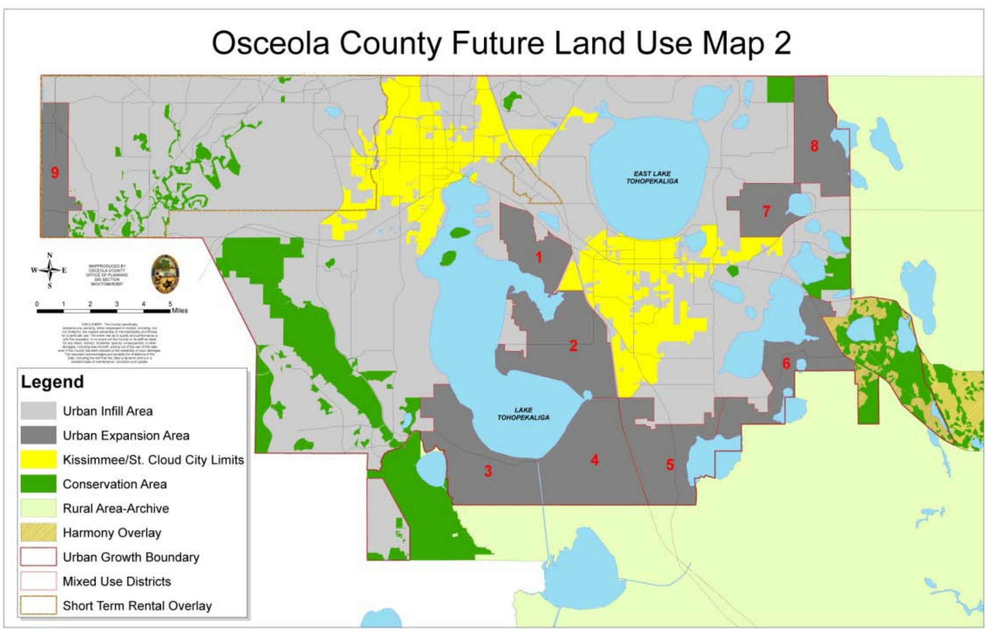

Figure 2.3 – Osceola County future land use plan map depicting urban growth boundary.

Table 2.3 – Year 2000 land use acreage in 14 major categories presented by Lake Management Areas.

LMA	Lakes Cypress, Hatchinea & Kissimmee (S-65 Structure)			Lake Tohopekaliga (S-61 Structure)	East Lake Tohopekaliga, Fell's Cove, & Lake Ajay (S-59 Structure)	Lakes Hart and Mary Jane (S-62 Structure)	Lakes Myrtle, Preston and Lake Joel (S-57 Structure)	Alligator Lake, Lake Center, Coon Lake, Trout Lake, Lake Lizzie, and Brick Lake (S-58 and S-60 Structures)	Lake Gentry (S-63 and S-63A Structures)
WCU	**Lake Kissimmee**	**Lake Cypress**	**Lake Hatchineha**	**Lake Tohopekaliga**	**East Lake Tohopekaliga, Fell's Cove, & Lake Ajay**	**Lakes Hart and Mary Jane**	**Lake Joel, Myrtle and Preston**	**Alligator Chain of Lakes**	**Lake Gentry**
Land Use Type	**Land Use Area (acre)**								
Agricultural	87,278	69,194	46,235	30,016	13,596	6,095	494	18,450	8,776
Barren Land	365	1,904	814	1,362	1,629	278	20	160	85
Commercial	248	3,589	40	7,623	3,575	49		37	
Communications and Utilities	55	2,424	266	1,135	368	642		58	
Industrial	912	2,105	516	3,616	3,326	176	1	9	111
Institutional	94	378	78	1,772	1,075			52	9
Open Land	4,736	2,239	4,189	1,709	489			173	
Recreational	773	5,184	987	2,009	881	235		10	
Residential	7,422	19,598	10,353	33,444	22,093	1,352	654	4,272	646
Transportation	1,087	3,540	242	6,487	6,581	454		103	8
Upland Forests	42,497	28,684	17,547	15,106	8,425	8,828	3,591	6,276	5,503
Upland Non-Forested	21,914	11,254	4,433	1,950	2,371	2,033	2,805	2,159	1,373
Water	47,333	18,348	13,505	21,221	16,042	4,494	1,286	8,791	1,764
Wetlands	55,159	74,665	33,608	25,592	11,301	9,773	5,089	18,880	11,669
Total Area (acre)	269,872	243,108	132,813	153,040	91,750	34,408	13,939	59,430	29,943

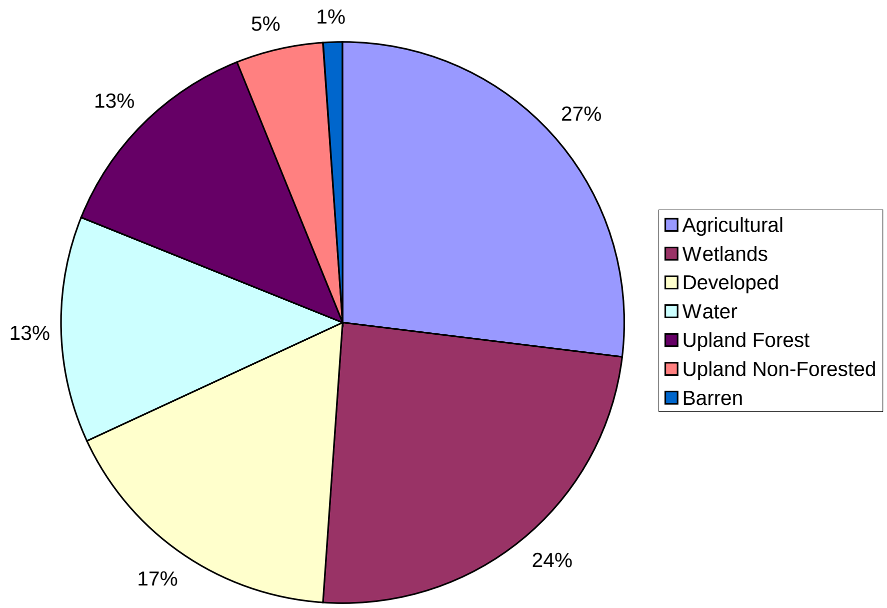

Figure 2.4 – Land use in the Upper Kissimmee Basin in the year 2000 (SFWMD 2006b).

Parks, Marinas, and Boat Ramps

The KCOL is rich with recreational opportunities such as fishing, hunting, boating, wakeboarding, water skiing, jet skiing, wildlife viewing, sightseeing, and camping, and are considered a precious natural and economic resource for both Osceola County and the state of Florida. There are over 20 public boat ramps throughout the basin to provide access to the KCOL. These facilities along with other park and recreational facilities are managed by Osceola County, Orange County, and the cities of Kissimmee and St. Cloud. These facilities offer various recreational opportunities including recreational pathways for walking and jogging, sports fields for baseball and soccer, nature trails for wildlife observation, and lakefront vistas for fishing, swimming and boating. Examples include Mac Overstreet Regional Park, Lake Toho Community Park, Partin Triangle Neighborhood Park, Southport Park, Makinson Island, Moss Park, and the Ralph V. Chisholm Regional Park.

Conservation Lands

Approximately 120,000 acres of publicly owned lands are in the basin. The majority of these lands are part of the SFWMD's Save Our Rivers Program, which began in 1981 with the enactment of Water Management Lands Trust Fund, Chapter 373.59, Florida Statues (F.S.). The Save Our Rivers Program allows water management districts to purchase lands needed for conservation, flood control, and water supply. These lands are managed and designated for a wide range of uses, including water resource protection, wildlife habitat, and various recreational uses (SFWMD 2005). Of the 120,000 acres, 52,000 surround Lake Kissimmee, Lake Hatchineha, and Cypress Lake. These lands were acquired by the SFWMD under the Headwaters Revitalization Project to provide additional water storage for the Kissimmee River Restoration Project (KRRP). Nearly all of this land is open to the public and to recreational activities that are compatible with the land's primary purpose of water-resource protection.

Other public lands within the basin are managed by the FDEP and the FWC. These include the Lake Kissimmee State Park, Three Lakes Wildlife Management Area, Split Oak Forest/Preserve, Lake Lizzie Nature Preserve, and Lake Runnymede Conservation Area. Although not public, a large parcel of land (The Disney Wilderness Preserve) on the north side of Lake Hatchineha is managed by The Nature Conservancy. Figure 2.5 delineates the publicly owned lands in the UKB.

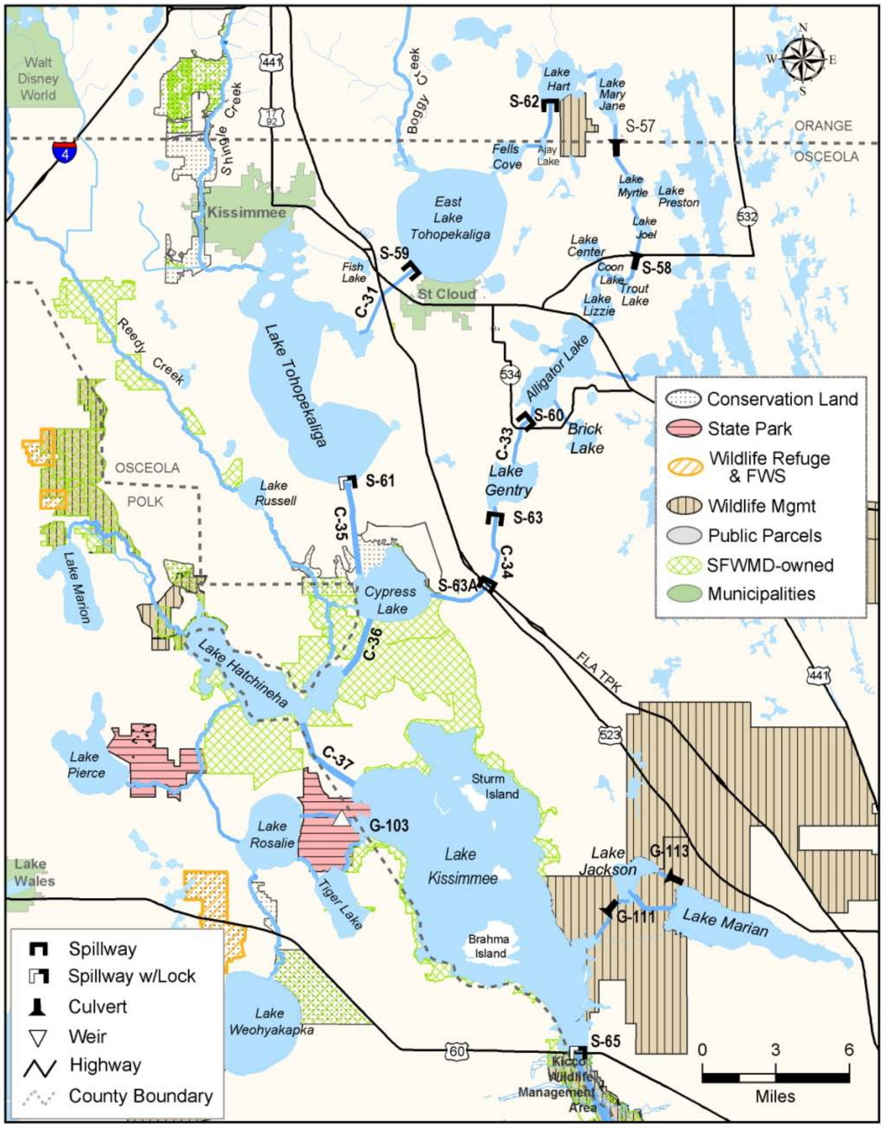

Figure 2.5 – Publicly owned lands in the Upper Kissimmee Basin.

Fish Management Areas

Cypress Lake, Lake Toho, East Lake Toho, Lake Hatchineha, and Lake Kissimmee are designated as Fish Management Areas. The FWC monitors the population density and community structure within these Fish Management Areas. The KCOL fish populations are relatively stable and need very little management. None of the KCOL lakes except Lake Jackson are stocked and that lake is stocked only after low water years. Automatic fish feeders and fish attractors are often used to concentrate sport fish for bank anglers. There are some brush piles in KCOL lakes to attract black crappie and there is a fish feeder on the Brinson Park pier at the north end of Lake Toho to help improve fishing success at this highly used area. There are no specific restrictions on KCOL lakes other than the normal statewide restrictions.

Stakeholder Value Survey

The SFWMD conducted a stakeholder value survey in 2004-2005 (Tolley 2005, Appendix E). The survey was conducted to assess the values residents and visitors in Osceola, Polk, Highlands, and Okeechobee counties associate with the Kissimmee Chain of Lakes. Results showed that a significant number of people use the lakes and associated uplands for leisure time activities and that protecting water quality is a high priority relative to their continued enjoyment of these activities. In addition, results showed that fish and wildlife habitat preservation was thought to be a higher priority than recreation and access to areas for recreation, suggesting that respondents of the survey place an intrinsic value rather than a utilitarian value on the environment.

The top five lakes visited in the KCOL in descending order were identified as Lake Tohopekaliga, Lake Kissimmee, East Lake Tohopekaliga, Cypress Lake, Lake Hatchineha, Alligator Lake, and Lake Lizzie. The top recreational uses in the KCOL in decreasing priority were picnicking, boating, hiking and fishing (tie), swimming, and bird watching. Seven stakeholder groups were listed for respondents to characterize themselves as and included homeowner/resident, business/tourism interests, developers/planners, agricultural interests, consumptive recreational users, non-consumptive recreational users, and environmental groups.

Lake Management Areas

For the purposes of the LTMP, the C&SF Project lakes/WCUs have been organized into the seven Lake Management Areas (LMAs) shown in Figure 2.6. Table 2.4 lists the LMAs and their associated water control structures, watershed areas, and secondary lakes. LMA descriptions are provided below.

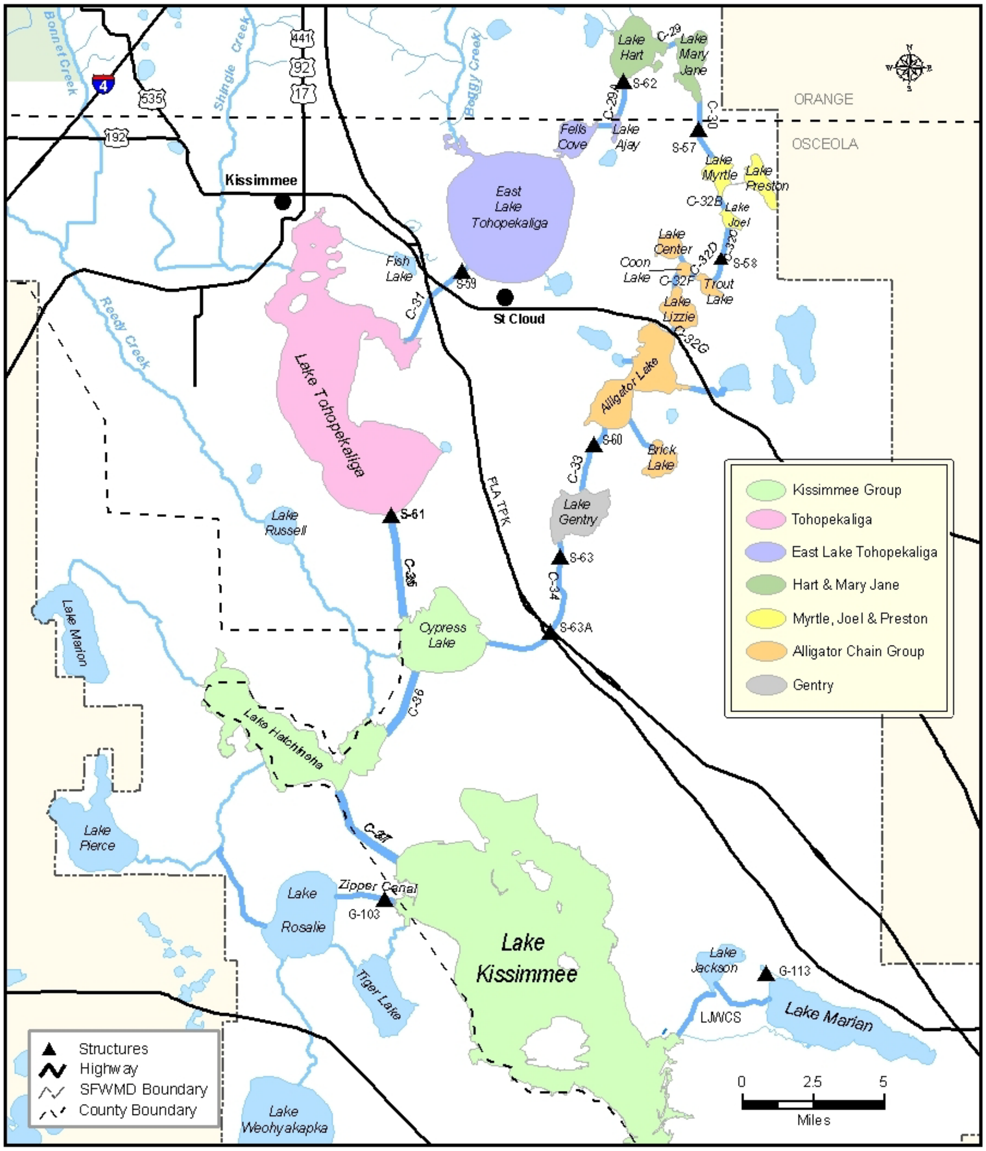

Figure 2.6 – The Kissimmee Chain of Lakes grouped by Lake Management Areas.

Table 2.4 – Lake Management Area structures, watersheds, and secondary lakes.

Lake Management Area	Water Control Structure	Contributing Watershed Area (acres)	Secondary Lakes
Lake Kissimmee, Lake Hatchineha, and Cypress Lake	S-65	645,793	Lake Russell, Tiger Lake, Lake Marion, Lake Pierce, Lake Rosalie, Lake Weohyakapka, Lake Jackson, Lake Marian
Lake Tohopekaliga	S-61	153,040	Fish Lake
East Lake Tohopekaliga, Fells Cove, and Ajay Lake	S-59	91,750	Lake Conlin, Lake Runnymede
Lake Hart and Lake Mary Jane	S-62	34,408	N/A
Lake Myrtle, Lake Joel, and Lake Preston	S-57, S-58	13,939	N/A
Alligator Chain of Lakes (Alligator, Brick, Lizzie, Coon, Center, and Trout)	S-58, S-60	59,460	Live Oak Lake, Buck Lake
Lake Gentry	S-63, S-63A	29,943	

Lake Kissimmee, Lake Hatchineha, and Cypress Lake LMA (S-65 Structure)

The Lake Kissimmee, Lake Hatchineha, and Cypress Lake LMA is the largest of the seven LMAs and contributes 52.8 percent of the total discharge from the UKB. The S-65 water control structure, located at the outlet of Lake Kissimmee, regulates the water levels in these lakes and governs releases from the UKB to the Kissimmee River. Secondary lakes within the LMA (Lake Russell, Tiger Lake, Lake Marion, Lake Pierce, Lake Rosalie, Lake Weohyakapka, Lake Jackson, and Lake Marian) are connected to Lakes Kissimmee, Hatchineha, and Cypress through both natural and man-made conveyances. The largest tributary to these lakes is Reedy Creek. Reedy Creek extends north into the Disney Resort area and contributes approximately 19 percent of the total inflows into the LMA.

The KRRP will increase the high pool stage on Lakes Kissimmee, Hatchineha, and Cypress from 52.5 ft to 54 ft NGVD and modify the S-65 water control structure operating criteria to meet the hydrologic requirements of the restored Kissimmee River. The secondary purpose of this project is to increase the quantity and quality of lake littoral wetland habitat for the benefit of fish and wildlife. The majority of land surrounding these lakes is held in public ownership and is managed as conservation lands.

Lakes Kissimmee, Hatchineha, and Cypress have been identified as having the greatest fish and wildlife value within the KCOL and are managed by state agencies to maintain the economic contribution to the region. These lakes are designated by the FWC as fish management areas and are well known for their largemouth bass, black crappie, bluegill, and redear sunfish fisheries valued in the millions of dollars to the local economy (Bell 2006). The endangered Everglades snail kite and whooping crane are among the species that use the lakes for nesting and foraging. Recreational uses include fishing, boating, hunting (duck, frog, alligator, turkey, etc.), picnicking, and wildlife viewing.

All three lakes are located within the Kissimmee/Okeechobee Lowland region (see discussion in Chapter 5), are considered eutrophic, and have been identified by FDEP as being impaired for nutrients.

Lake Tohopekaliga LMA (S-61 Structure)

Lake Toho, the second largest lake in the KCOL, is the only waterbody within the Lake Tohopekaliga LMA (Lake Toho LMA) and contributes approximately 26.1 percent of the total discharge from the UKB. The S-61 water control structure, located at the outlet of Lake Toho, regulates water levels in Lake Toho and discharges water into the Lake Kissimmee, Lake Hatchineha, and Cypress Lake LMA through the Southport Canal (C-35). The East Lake Tohopekaliga LMA (discussed below) discharges through the St. Cloud Canal (C-31) into the northeastern portion of the Lake Toho called Goblet's Cove. Shingle Creek is the largest tributary discharging into the Lake Toho, contributing approximately 34 percent of the total inflow.

The entire Lake Toho LMA is located within the Osceola County Urban Service Area and the city of Kissimmee is located on the northwestern shore of the lake. Although undeveloped areas remain along the southeastern and southern shores of the lake, all of these lands reside within the boundaries of proposed developments of regional impact (see "Management Tools" discussion in Chapter 4).

Recreational uses of Lake Toho include fishing, hunting (duck, frog, alligator, turkey, etc.), boating, canoeing, wildlife viewing, ecotourism, picnicking, and sightseeing. The lake is designated by the FWC as a fish management area and is world renowned for its largemouth bass, black crappie, bluegill, and redear sunfish fisheries. These fisheries attract numerous fishing tournaments and are valued in the millions of dollars to the local economy (Bell 2006). The lake is recognized around the world as a destination for bird watching and is the primary nesting and foraging habitat for resident populations of the Everglades snail kite and endangered whooping crane in the KCOL. Lake Toho can also function as a refuge for the Everglades snail kites when drought conditions in southern Florida impact habitat quality for this speices.

Lake Toho is located within the Kissimmee/Okeechobee Lowland region, is considered eutrophic, and has been identified by FDEP as being impaired for nutrients.

East Lake Tohopekaliga, Fells Cove and Ajay Lake LMA (S-59 Structure)

The East Lake Tohopekaliga, Fells Cove, and Ajay Lake LMA (East Lake Toho LMA) is the third largest of the LMAs and contributes approximately 8.4 percent of the total discharge from the UKB. The S-59 water control structure, located at the outlet of East Lake Toho, regulates water levels in East Lake Toho, Fells Cove, and Ajay Lake and discharges water into the St. Cloud Canal (C-31) and the Lake Toho LMA. The two major inflows into East Lake Toho are Boggy Creek and the Ajay-East Tohopekaliga Canal (C-29A). Boggy Creek enters at the northwestern corner of the lake and contributes approximately 69 percent of the total inflows into this LMA. The Ajay-East Tohopekaliga Canal discharges water into the lake from the Lakes Hart and Mary Jane LMA (discussed below). Additional minor inflows from Lake Runnymede occur along the southeastern shore of East Lake Toho. The East Lake Toho LMA is bounded on the southern side by the Osceola County Urban Service Area and the city of St. Cloud.

East Lake Toho is an urban recreational lake with extensive residential shoreline development. Recreational uses include fishing, boating, hunting (alligator and duck), boat racing, canoeing, water skiing, jet skiing, kayaking, ecotourism, and sightseeing. The lake is designated by the FWC as a fish management area and is well known for its largemouth bass, black crappie, bluegill, and redear sunfish fisheries. The lake supports a stable population of approximately 129 alligators (2010 estimate) and has served as a commercial alligator egg collection area since 2007. It is also used by numerous bird species for nesting and foraging, including: snail kites, Florida sandhill cranes, and whooping cranes.

Waterbodies of the East Lake Toho LMA are within the Osceola Slope region and are considered mesotrophic. East Lake Toho has been identified by FDEP as being impaired for nutrients.

Alligator Chain of Lakes LMA (S-58 and S-60 Structures)

The Alligator Chain of Lakes LMA consists of Alligator Lake, Lake Center, Coon Lake, Trout Lake, Lake Lizzie, and Brick Lake, which are linked together by C&SF Project canals. The Alligator Chain of Lakes contributes 4.1 percent of the total discharge from the UKB. In addition, the LMA includes Live Oak Lake, Bay Lake, Sardine Lake, Buck Lake, and Lake Pearl, which are linked to the C&SF Project lakes through private canals. Two control structures (S-60 and S-58) regulate water levels on these eleven lakes, which are refered to as the Alligator Chain of Lakes. The two water control structures are jointly operated by a single regulation schedule. The S-60 water control structure, located at the southern outlet of Alligator Lake, is the primary structure and discharges water into the Lake Gentry LMA through the C-33 canal. The smaller S-58 water control structure located at the northern end of Trout Lake generally acts as the drainage divide for the KCOL, except under very high water conditions when water can be released northward through the C-32C canal into the Lakes Preston, Myrtle, and Joel LMA.

Historically, a surface water connection did not exist between the Alligator Chain of Lakes and Lake Gentry. The Alligator Chain of Lakes discharged to the north into the Lakes Preston, Myrtle, and Joel LMA. The C&SF Project excavated the canals that connect the Alligator Chain of Lakes to Lake Gentry and Lake Gentry to Cypress Lake.

The Alligator Chain of Lakes supports stable populations of bass and alligator and is used for nesting and foraging by a variety of wading birds. The Lake Lizzie Nature Preserve is located on the southern end of Lake Lizzie and is designated as an Important Bird Area by the Audubon Society. The preserve is noted for its Florida scrub jay (*Aphelocoma coerulescens*) population and its proximity to the undeveloped, private land holding to the north called the Deseret Ranches. Lake Lizzie is the southern terminus of a mosaic of natural communities that provide habitat to threatened and endangered species, including the: wood stork, Florida sandhill crane, red-cockaded woodpecker (*Picoides borealis*), Florida scrub jay, and Bachman's sparrow (*Aimophila aestivalis*).

Recreational uses for this LMA include fishing, hunting (alligator, frog, and duck), boating, sightseeing, canoeing, kayaking, wakeboarding, jet skiing, and waterskiing.

Waterbodies of the the Alligator Chain of Lakes LMA are within the Osceola Slope region and are considered mesotrophic.

Lake Gentry LMA (S-63 and S-63A Structures)

Lake Gentry is the only lake within the Lake Gentry LMA and contributes 2.9 percent of the total discharge from the UKB. This lake receives surface water inflows from the Alligator Chain of Lakes LMA through the C-33 canal to the north and from the Big Bend Swamp along its southern shore. Lake Gentry discharges through the C-34 canal into the Lake Kissimmee, Lake Hatchineha, and Cypress Lake LMA.

Historically, Lake Gentry did not have a surface water connection to either the Alligator Chain of Lakes LMA or Cypress Lake, suggesting that historically it was a closed basin lake. The S-63 water control structure is located 200 feet downstream from Lake Gentry on the C-34 canal. A second water control structure, S-63A, is approximately halfway between the S-63 water control structure and Cypress Lake. The S-63A water control structure is used to step down the stages in the C-34.

The shoreline of Lake Gentry is predominantly undeveloped, with some rural lakeside residences on the northern side of the lake. Big Bend Swamp is located along the southern and western shores. Big Bend Swamp is a large cypress-dominated strand swamp with depressional marshes, wet prairies, and hydric hammocks. The Big Bend Swamp area has been identified on the Conservation and Recreation Lands Program (CARL) 2000 priority list and is considered to be important habitat for up to 30 rare animal species that require large areas of flatwoods, prairie, and wetlands, such as red-cockaded woodpeckers, Florida sandhill cranes, Florida grasshopper sparrows (*Ammodramus savannarum*), Sherman's fox squirrels (*Sciurus niger)*, swallow-tailed kites (*Elanoides forficatus*), and crested caracaras (*Polyborus plancus audubonii*) (FDEP 2010).

Recreational uses of the lake include fishing, hunting (alligator, frog, and duck), boating, sightseeing, canoeing, and kayaking.

Lake Gentry is within the Osceola Slope region and is considered mesotrophic.

Lakes Hart and Mary Jane LMA (S-62 Structure)

The Lakes Hart and Mary Jane LMA is the northernmost LMA in the KCOL and contributes 2.4 percent of the total discharge from the UKB. The S-62 water control structure at the outlet of Lake Hart regulates water levels of these two lakes. The LMA receives inflows from the Lakes Preston, Myrtle, and Joel LMA through the C-30 canal and discharges through the C-29A canal to the East Lake Toho LMA. Lake Mary Jane also discharges through the Disston Canal to the Econlockhatchee River located within the St. Johns River Water Management District (SJRWMD).

While some rural residential developments surround portions of each lake, the majority of the shorelines along Lakes Hart and Mary Jane remain undeveloped. There is urban growth pressure in the LMA, however, the majority of areas around both lakes are parts of rural settlements with covenants intended to preserve the rural/agricultural nature of these areas. The northern side of Lake Hart is bounded by the Orange County urban growth boundary.

Moss Park and Split Oak Preserve are located between Lakes Hart and Mary Jane. The Split Oak Preserve is a 1,800-acre mitigation area managed by the FWC. Moss Park is the largest Orange County Park (1,551 acres) with an estimated 200,000 visitors per year (Personal communication, J. Paradise 2008). The Bird Island Rookery, located on an island in Lake Mary Jane, has been designated as an Important Bird Area (IBA) by the Audubon Society. Many species of wading birds nest on the rookery island, including the endangered wood stork, great white egret, great blue heron, little blue heron, anhinga, snowy egret, white ibis, tricolored heron, black-crowned night heron, yellow-crowned night heron, glossy ibis, American coot, and cattle egret.

Historically, Lake Mary Jane had water levels that were maintained approximately 3 feet higher than Lake Hart. Water flowed from Lake Mary Jane to Lake Hart through two major slough systems between the lakes and a stream/creek located where the current Lake Mary Jane (C-29) canal exists today. An escarpment existed along the stream/canal between the lakes. When the canal was dredged between the lakes, the escarpment was removed and Lake Mary Jane's water levels dropped by approximately 2 feet to match Lake Hart. There are deep holes in Lake Mary Jane that are the result of the dredging that was done to connect the islands in the Isle of Pines. All of the lakeshore homes around Lake Mary Jane were built after the the hydrology was altered (Arnold 2007). The historic slough systems between the lakes remain today and are important wetland systems. They are also used as fire breaks by Split Oat Preserve land managers who routinely use fire to maintain habitat values within the preserve.

Recreational uses of the lakes include wildlife viewing, horseback riding, hiking, camping, boating, fishing, swimming, wakeboarding, water skiing, and hunting (frog, alligator, duck, and turkey).

Lakes Hart and Mary Jane are within the Osceola Slope region and are considered mesotrophic. Florida LAKEWATCH (a volunteer water quality monitoring program coordinated by the University of Florida) data indicate their current water quality is good.

Lakes Joel, Myrtle, and Preston LMA (S-57 Structure)

The Lakes Preston, Myrtle, and Joel LMA is located at the topographic top of the chain of lakes on the northern side of the S-58 water control structure and contributes 3.2 percent of the total discharge from the UKB. The S-57 water control structure, located on the C-30 canal north of Lake Myrtle, regulates water levels within the LMA and discharges to the Lake Hart and Mary Jane LMA. Although the S-57 water control structure is the primary control, outflow can occur under very high stages through the S-58 water control structure to the south. The S-58 water control structure regulates the outflow from Lake Joel through the C-32 canal to the Alligator Chain of Lakes LMA.

The lands surrounding Lakes Preston, Myrtle, and Joel are owned and managed by Deseret Ranches. The Ranch owns approximately 290,000 contiguous acres of land starting at the Lakes Preston, Myrtle, and Joel LMA and extending east into the SJRWMD. The Lakes Preston, Joel, and Myrtle LMA is within a portion of the ranch called Sungrove. The watershed and shoreline of these lakes is undeveloped and remains in near natural condition. Lake habitats and water quality are very good. The littoral zone is intact and has experieinced only minor invasion from nuisance vegetation. There is no history of aquatic plant management.

The Osceola County urban growth boundary is adjacent to the western edge of these lakes. A conceptual master plan has been developed for a 17,150-acre parcel within Deseret Ranches that includes areas surrounding Lakes Preston, Myrtle, and Joel. The Osceola County Board of County Commissioners has adopted a comprehensive plan amendment for the area. The eastern shoreline of Lake Preston is near the SFWMD/SJRWMD boundary. Recreational uses include private boating, fishing, and hunting since there is no public access to these lakes.

Lakes Preston, Myrtle, and Joel are within the Osceola Slope region and are considered mesotrophic.

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3
Management Objectives, Concerns, Targets, Priorities, and Challenges

Introduction

This chapter presents management objectives, concerns, targets, priorities, and challenges for the KCOL and provides the foundation for the proposed monitoring and assessment program (see discussion in Chapter 4). The proposed monitoring and assessment program will provide a basis for identifying appropriate lake management activities that can be implemented to improve lake conditions and address emerging issues or concerns (see discussion in Chapters 5 and 6).

Management Objectives

As previously stated, the purpose of the LTMP is to enhance and/or sustain lake ecosystem health. Although management objectives and assessment targets for the KCOL system have been developed, this effort has been constrained by limited availability of data for the establishment of reference and baseline conditions. The information presented in this chapter was compiled from interactions with the partner agencies and other stakeholder groups (e.g. KCOL residents). The assessment targets for the six managment objectives (hydrologic management, water quality, fish and wildlife resources, aquatic plant management, water supply, and recreation and public use) presented in this version of the LTMP will be refined and updated as new data become available and as new issues and concerns emerge.

Hydrologic Management

The current set of prescribed water control structure operating criteria for the management of water levels and flows through the KCOL are generally out of sync with the life cycle requirements of fish and wildlife and have degraded habitat quality within the lake littoral zones. An Interagency Team defined a set of performance measures for use during the KBMOS that describe the desired hydrology needed to enhance and sustain habitat within the lake littoral zones and in turn maintain the productivity of KCOL dependent fish and wildlife populations. While KBMOS will be used to identify a preferred set of new water control structure operating criteria for the KCOL, it is apparent from the modeling completed to date that these changes alone will not achieve all the Study operating objectives defined in the KBMOS (SFWMD 2009). Of particular concern are the quantity impacts associated with the development that occurred within the KCOL watershed prior to implementation of current environmental resource regulations. Innovative, multi-objective, multi-stakeholder solutions are needed to achieve the desired characteristics of KCOL hydrology that will not be addressed through KBMOS or the existing and proposed ERP regulations.

The major concerns associated with the current hydrology of the KCOL are: stabilized water levels, short duration low water levels, no prescribed extreme low water events, prolonged duration high water events, poor transitions between high and low water levels, and volume and rate of watershed runoff.

Stabilized Water Levels

Lake water levels in the KCOL are generally stabilized within a narrow range. These conditions degrade habitat within the littoral zones and require management intervention to maintain suitable habitat. Stabilization in this case refers to both intra- and inter-annual water level fluctuations. Under current C&SF project operating criteria, there is little variability in seasonal high or low water levels. All lakes except Kissimmee, Hatchineha, and Cypress are managed to achieve a single target low water level by May 31. Water levels after May 31 are allowed to rise in response to rainfall or upstream flood control releases. Seasonal high lake stages are prescribed to occur at the same level each year from November to March.

Short Duration Low Water Levels

Current operating criteria do not provide the durations in seasonal low water levels needed to dry and compact bottom sediments and stimulate growth of aquatic plants. In addition, seasonal low water levels and their antecedent recessions occur out of sync with the nesting and foraging requirements of fish and wildlife that benefit from prey exposure and concentration.

No Prescribed Extreme Low Water Events

Current operating criteria do not provide operational guidance for implementing extreme low water levels. Although these events should not occur frequently, they should occur periodically.

Prolonged Duration High Water Levels

In the majority of lakes (exceptions are Preston, Joel, Myrtle, Kissimmee, Hatchineha, and Cypress), seasonal high water levels are held for prolonged durations (approximately 135 days). These hydroperiods result in dense growth of aquatic vegetation, reduce the number of wetland community types within the lake littoral zones, and reduce overall plant diversity. Prolonged inundation of the woody aquatic plants (e.g., willow, buttonbush and cypress) that generally occur at higher elevations in lake littoral zone reduces germination and increases mortality with an overall effect of reducing desirable nesting habitat for snail kite and wading birds (FWC 2005b).

Poor Transitions between High and Low Water Levels

The prescribed transitions between high and low lake water levels are at rates and times not compatible with fish and wildlife requirements. The transitions between seasonal high and low water levels under current operating criteria are specified to occur over two and half months. These transitions are less problematic on the smaller lakes that have limited current and historic ranges in water level fluctuations. On the larger lakes with greater ranges, rates tend to be too rapid and out of sync with the life cycle requirements of fish and wildlife and aquatic vegetation.

Volume and Rate of Watershed Runoff

The volume and rate of runoff from the lake watersheds causes lake water levels to rise quickly in response to rainfall. This "flashiness" is not a characteristic of the pre-regulation basin hydrology and is undesirable from a fish and wildlife perspective. It is especially undesirable during the spring months that are critical to snail kite, apple snail, wading bird, and fish reproductive success and recruitment.

While current and proposed environmental resource permitting (ERP) regulations are intended to prevent water quantity impacts associated with new development, they are not designed to address existing quantity impacts associated with the development that occurred in the KCOL prior to ERP regulations. To achieve the desired characteristics of lake and watershed hydrology that will not be addressed through KBMOS or through existing and proposed ERP regulations, innovative, multi-objective, multi-stakeholder solutions are needed.

Table 3.1 presents the four water hydrologic management objectives along with the associated management concerns, management targets and management priorities needed to achieve those objectives.

Table 3.1 – Hydrologic management objectives, concerns, targets and priorities.

Management Objective	Management Concern	Management Targets	Management Priority
Promote plant diversity, quality substrate, and fish and wildlife productivity within littoral zones.	Water control structure operating criteria have degraded the quality of littoral wetlands.	Meet habitat and fish and wildlife assessment targets (define in Chapter 5).	Implement preferred water control structure operating criteria identified through KBMOS. Establish water reservations to maintain quantities of water within the system needed for the protection of fish and wildlife.
Maintain current C&SF Project flood reduction benefits.	Increased runoff volumes into the lakes cause rapid increases in water levels that negatively impact fish and wildlife resources.	Future lake water levels should not exceed current condition lake water levels under the same design storm events.	Implement Basin Rule, increase storage and retention within the watershed, and modify land development codes and ordinances.
Provide flow releases necessary to meet Kissimmee River restoration hydrologic criteria.	The KRRP is dependent upon discharges from the KCOL to meet the river restoration hydrologic criteria.	Meet hydrologic targets defined for KRRP.	Implement preferred water control structure operating criteria identified through KBMOS. Establish water reservations to maintain quantities of water within the system needed for the protection of fish and wildlife.
Reduce undesirable inflows to Lake Okeechobee.	Kissimmee Basin inflows to Lake Okeechobee have the potential to positively and/or negatively effect Lake Okeechobee water levels.	Meet Lake Okeechobee desired inflow envelope target.	Implement Basin Rule, increase storage and retention within the watershed, and modify land development codes and ordinances.

Water Quality

Lakes in the KCOL are designated as Class III water bodies by the State of Florida, for which the designated uses are "recreation and propagation and maintenance of healthy, well-balanced populations of fish and wildlife". Lakes Kissimmee, Hatchineha, Cypress, and Toho are considered eutrophic while the remainder of the C&SF water bodies in the Chain are considered mesotrophic. Preservation of lake trophic state throughout the KCOL is perhaps the most critical water quality concern because these lakes are of significant ecological, economic, and recreational value to the region. In addition, the trophic status of the KCOL is critical to the health of Lake Okeechobee since these lakes form the headwaters of Lake Okeechobee and supply a large portion of water to the lake. If these lakes become more eutrophic, the chance of meeting the phosphorus TMDL for Lake Okeechobee will become an even bigger challenge.

The lakes in the KCOL receive runoff from a variety of sources, including agricultural lands, the urban and suburban areas of the cities of Orlando, Kissimmee, Poinciana and St. Cloud, and numerous natural forested and wetland areas. In general, nutrient concentrations in the KCOL are moderate, but the FDEP has identified several lakes as impaired for nutrients. Symptoms of nutrient enrichment include frequent algal blooms, high rates of organic sedimentation, extensive stands of dense aquatic vegetation, and changes in populations of fish and other aquatic fauna. Water bodies on the verified list for nutrient impairment include lakes Cypress, Hatchineha, Kissimmee, Toho, and East Lake Toho and tributaries to these lakes including Lake Marion Creek, Southport Canal, and Dead River.

Table 3.2 presents the five water quality management objectives along with the associated management concerns, management targets and management priorities needed to achieve those objectives.

Table 3.2 – Water quality management objectives, concerns, targets and priorities.

Management Objective	Management Concern	Management Targets	Management Priority
Meet or maintain state water quality standards and trophic state criteria including Total Maximum Daily Loads (TMDLs).	East Lake Toho, Lake Toho, Cypress Lake, Lake Hatchineha, and Lake Kissimmee are on the FDEP verified list for nutrient impairment. The presence of hydrilla in Lake Toho is potentially masking nutrient impairment. Development within the basin will continue to convert lands surrounding some lakes from natural/agricultural uses to urban/residential uses.	Reduce nutrient loads to water bodies in the KCOL.	Develop restoration plan or TMDLs and Basin Management Action Plans for nutrient impaired water bodies. Initiate the Upper Kissimmee River Feasibility study (SFWMD et al 2011). Acquire rural, lakefront, and other basin lands for water storage and treatment projects. Investigate sediment/water column nutrient interactions in Lake Toho to determine contribution to the overall nutrient load/budget.
Reduce phosphorus runoff from properties that exceed phosphorus discharge limits (Lake Okeechobee Works of the District).	Phosphorus discharges will degrade lake habitat quality and reduce lake assimilation capacities.	Reduce nutrient loads to water bodies in the KCOL.	Initiate the Upper Kissimmee River Feasibility (SFWMD et al 2011). Implement stormwater retrofits and look for opportunities to develop regional facilities to capture, store, and treat storm water for subsequent reuse. Develop an education program for lakeshore property owners to encourage responsible chemical application on private properties. Implement the Statewide Stormwater Rule.

Management Objective	Management Concern	Management Targets	Management Priority
Reduce municipal stormwater nutrient inputs to lakes.	Existing municipal stormwater drainage flows untreated into lakes.	Reduce the amount of untreated storm water draining into the lakes.	Implement stormwater retrofits and look for opportunities to develop regional facilities to capture, store, and treat storm water for subsequent reuse. Develop an education program for lakeshore property owners to encourage responsible chemical application on private properties.
Reduce non-nutrient contaminant inputs to lakes.	Chemical (herbicide, and pesticide) runoff from lakeshore properties runs off directly into the lakes.	Eliminate elevated concentrations of key water quality constituents.	Acquire lakefront lands for water storage and treatment projects. Develop an education program for lakeshore property owners to encourage responsible chemical application on private properties.
Protect and/or enhance water clarity and lake swimability.	Nutrient loads, municipal stormwater, and non-nutrient contaminants are impacting water quality and potentially introducing harmful constituents into the water column.	Reduce nutrient loads to to water bodies in the KCOL. Reduce the amount of untreated storm water draining into the lakes. Eliminate elevated concentrations of key water quality constituents.	Implement stormwater retrofits and look for opportunities to develop regional facilities to capture, store, and treat storm water for subsequent reuse. Develop an education program for lakeshore property owners to encourage responsible chemical application on private properties. Implement Statewide Stormwater Rule.

Fish and Wildlife

The KCOL provide habitat for a diverse array of fish and wildlife species, including threatened and endangered species. These fish and wildlife resources have thrived in the KCOL for generations and are among the most aesthetically and economically valued assets in the region.

These resources depend on KCOL littoral wetlands for foraging, refuge, and reproduction. The quality of these plant communities is dependent on C&SF Project water level regulations, the quality of water flowing into the lakes, and management of invasive plants.

While the FWC and USFWS have mandated responsibilities for fish and wildlife resources, local governments have the greatest potential to positively influence both the quality and quantity of fish and wildlife habitat and resources within the region through coordinated conservation planning and land development codes and ordinances. The USACE has the authority to make proposed modifications to C&SF Project operations but these alone will not address the fish and wildlife management objectives described below. Integrated and coordinated management of the lake system and the watershed for the benefit of the region's fish and wildlife resources should include measures that address upland, wetland, and lake habitat preservation and enhancement, environmental and human water supply demands, and the quality and quantity of inflows to the lakes and tributaries.

Table 3.3 presents the four fish and wildlife management objectives along with the associated management concerns, management targets, and management priorities needed to achieve those objectives.

Table 3.3 – Fish and wildlife management objectives, concerns, targets and priorities.

Management Objective	Management Concern	Management Targets	Management Priority
Support life cycle requirements of KCOL-dependent fish and wildlife resources.	Degradation of littoral wetlands and loss of adjacent wetland habitat will negatively impact fish and wildlife populations and eventually result in the overall deterioration of regional fish and wildlife resources.	Species richness and diversity will be equal to or greater than the current condition.	Implement preferred water control structure operating criteria identified through KBMOS. Establish water reservations to maintain quantities of water within the system needed for the protection of fish and wildlife.
Conserve and/or enhance aquatic and littoral habitats.	Current environmental regulation practices do not provide the necessary mechanisms to conserve aquatic and littoral habitats.	Acreages of aquatic and lake littoral habitats will be equal to or greater than the current condition.	Modify conservation policies associated with land development codes and ordinances.
Protect lake-associated listed species.	The key species of concern is the snail kite and protection of nesting and foraging habitat from recreational boating, lakeshore development, riparian owner vegetation management practices, linear park and lakeshore lighting, incompatible aquatic plant management, and predation.	Reproductive success and recruitment will be equal to or greater than the current condition.	Implement preferred water control structure operating criteria identified through KBMOS. Modify conservation policies associated with land development codes and ordinances. Continue outreach and species protection initiatives at the federal, state, and local level.
Minimize development encroachment on lakeshore habitats.	Preservation of natural buffers between development and fish and wildlife habitat. Potential for conflict between existing and proposed lakeshore land uses and habitat enhancement project activities.	Acreages of natural habitat adjacent to lake littoral zones will be equal to or greater than the current condition.	Modify conservation policies associated with land development codes and ordinances.

Aquatic Plant Management

Aquatic plant management programs in the KCOL are designed and implemented to protect human health, safety, and recreation and to prevent injury to desireable plants, animal life, and property. This management is necessary to effectively meet the operational objectives of the C&SF Project and provide quality habitat for fish and wildlife resources. Although native plants occasionally present problems for lakes, more than 90 percent of the FWC's aquatic plant management expenditures are for the control of invasive exotic plants, especially water hyacinth, water lettuce, and hydrilla. Problems associated with native plants are usually related to access, navigation, or flood control. Examples include cattails (*Typha* spp.) overgrowing boat ramps and trails, or rafts of littoral vegetation breaking loose and jamming against bridges and flood control or navigation structures.

The eutrophic lakes (Lakes Kissimmee, Hatchineha, and Toho and Cypress Lake) have more management challenges associated with invasive species, plant densities, and accumulations of organic sediments. While the same management challenges exist for the mesotrophic lakes (East Lake Toho, Lake Gentry, the Alligator Chain, and Lakes Hart, Mary Jane, Preston, Myrtle, and Joel), these lakes tend to have better quality littoral wetlands that require less management. Overall the mesotrophic lakes tend to be less productive, smaller in size, and having fewer competing management objectives. Lake littoral wetlands within the KCOL generally have dense plant communities (up to 100% cover, Allen and Tugend 2002). It is believed that the primary driver for these conditions is stabilized water levels, although nutrients are a secondary driver. The dense vegetation has led to excessive organic matter deposition and gradual degradation in quality and loss of littoral acreage (Moyer et al. 1995).

The aquatic plant management objectives identified for the LTMP are primarily the responsibility of the FWC's AHRES and the USACE. Aquatic plant management in the KCOL has been complicated by the changing responses of hydrilla to herbicides, evolving lake level management requirements of the KRRP, and snail kites.

Table 3.4 presents three aquatic plant management objectives along with the associated management concerns, management targets, and management priorities needed to achieve those objectives.

Table 3.4 – Aquatic plant management objectives, concerns, targets and priorities.

Management Objective	Management Concern	Management Targets	Management Priority
Conserve or enhance the multiple uses and functions identified for each water body.	Development within lake watersheds and along lake shorelines will increase nutrient inputs, impede the ability to use current management tools, and change management expectations for aquatic plants.	Maintain current water body uses and functions.	Treatment of non-native and nuisance vegetation (i.e., cattail, pickerel weed, torpedo grass).
Eradicate pioneer infestations of invasive plant species before they become large-scale environmental and economic problems.	Nuisance and invasive aquatic plants can quickly dominate the aquatic plant community, resulting in low plant diversity and poor fish and wildlife habitat.	Maintain nuisance (native) aquatic plants at low densities and control new invasive plant species at the lowest feasible levels	Aquatic plant managers should identify when resources are insufficient to address management challenges
Contain established invasive aquatic plant populations at minimal levels that current technology, funding, and environmental and biological conditions will allow.	Invasive aquatic plants can quickly dominate the aquatic plant community, resulting in low plant diversity and poor fish and wildlife habitat.	Maintain current water body uses and functions	Aquatic plant managers should identify when resources are insufficient to address management challenges

Water Supply

The water supply management objectives for the KCOL are intended to address both human and environmental demands. One key challenge for water supply utilities is how to meet the demand for water to support increasing populations in the region. The demand for public water supply is expected to more than double from almost 114 million gallons per day (MGD) in 2000 to over 235 MGD by 2025 (SFWMD 2006b). This additional water supply need exceeds the Kissimmee Basin's available groundwater yield and alternative supplies are being investigated.

Current monitoring is ongoing to determine whether withdrawals are stressing watershed wetland resources. Monitoring is focused on indicators of stress related to chronically-lowered water levels and impaired wetland functions. By identifying the areas that are most sensitive to withdrawals, solutions can be developed that protect these resources while providing for the water needs of the region.

The SFWMD and FDEP have primary responsibility for issuing consumptive use permits. Water supply objectives need to be combined with the hydrologic management objectives for the C&SF Project to develop a framework for integrated watershed management that meets both environmental and human demands.

Table 3.5 – Water supply management objectives, concerns, targets and priorities

Management Objective	Management Concern	Management Targets	Management Priority
Maintain the quantity of water necessary for the protection of fish and wildlife.	Surface and groundwater resources will be overallocated at the expense of the natural system.	Meet flow and stage targets to be defined in the Kissimmee Basin Water Reservations. Maintain target tributary base flows for Shingle, Boggy, and Reedy Creeks.	Establish water reservations to maintain quantities of water within the system needed for the protection of fish and wildlife.
Provide opportunities for surface water uses consistent with Kissimmee Water Reservations.	Surface and groundwater resources will be overprotected and significantly increase costs for water supply stakeholders throughout the region.	Identify feasible quantities of surface and groundwater to meet consumptive use demands.	Develop and implement a regional, long-term strategy to meet future demands.
Sustain and/or enhance the quantity and quality of watershed wetlands throughout the UKB.	Loss of natural storage and detention within the wetland systems in the UKB watershed will reduce the quantity of water available for protection of the natural system and public water supplies.	No degredataion or net loss of wetland acreage in the watersheds of each Lake Management Area.	Develop and implement an integrated watershed management strategy that incorporates management and maintenance of watershed wetlands.

Public Use and Recreation

The KCOL is highly valued by boaters, anglers, hunters, picnickers, and wildlife viewers. The resource contributes approximately $8.5 million/year to the regional economy (Bell 2006). Sustaining recreational opportunities within the KCOL is tightly coupled with sustaining fish and wildlife resources, good water quality, and desirable plant communities. One of the biggest challenges in sustaining recreational opportunities is management of the range of uses. As populations in the region grow and more people visit the KCOL, there is likely to be increased conflicts between these uses. Plan partners must find ways to balance recreational demands with natural resource needs to achieve management objectives and preserve the desireable qualities of the region. More outreach is needed to improve understanding of the uses, rules, and regulations. More law enforcement is needed to deter illegal activities. Recreational use limits may need to be set and more ordinances with tougher penalties may be required. Management agencies should be proactive in developing appropriate measures to preserve both the uses and functions of KCOL water bodies.

Table 3.6 presents three public use and recreation management objectives along with the associated management concerns, management targets and management priorities needed to achieve those objectives.

Table 3.6 – Public use and recreation management objectives, concerns, targets and priorities.

Management Objective	Management Concern	Management Targets	Management Priority
Sustain existing recreational opportunities and land uses without increasing conflicts between riparian owners and users.	Conflicts are increasing between lakeshore residents and recreational uses that have been in place for decades.	Existing recreational uses and regulations will remain the same as current condition.	Increase enforcement presence. Increase community outreach efforts to better inform existing and new residents of uses, rules, management practices, and scheduled recreational activities. Make existing resources more accessible to the public.
Identify public use opportunities compatible with protection of natural resources.	New lakeshore developments will not identify compatible uses for lakeshore public space.	100 percent of lakeshore public space dedicated to compatible uses.	Identify compatible uses of lakeshore public space and incorporate them into the land development code.
Manage airboat, ATV, mud truck, and boat traffic to reduce ecological and noise impacts.	Airboat noise. Impacts caused by driving on lake bottom with mud trucks and ATVs during low water conditions. Wading bird and snail kite nests being run over and destroyed by airboats. Disturbance to nesting birds which causes decreased reproductive success.	Reduction in the number of reported incidents.	Increase enforcement presence.

Prioritization for the Lake Management Areas

The following discussion presents a justification for the prioritization of the LMAs with respect to future management. This ranking is based on the information presented in Chapters 1 and 2, the management objectives presented above, and input from the plan partners. The plan partners developed this prioritization as a guide to the allocation of resources for addressing and resolving management challenges within the KCOL. The ranking is based on: resource size, fish and wildlife resources and habitats, economic value, recreational uses and opportunities, and management challenges facing the resource. Information considered for each of the LMAs is presented below along with the basis for the LMA prioritization.

Highest Priority: Lake Tohopekaliga LMA

The Lake Toho LMA is the top ranked management priority because of the size of the resource, the value of fish and wildlife assets, the financial importance of the recreational activities on the lake, and the number of existing and anticipated management challenges.

Management Goal: Enhance major system components within the LMA.

Key Characteristics:

- **C&SF Water Bodies:** Lake Toho and Goblets Cove
- **Combined Water Body Volume:** 144,948 acre-feet at elevation 55.0 ft NGVD
- **Combined Water Body Acreage:** 22,019 acres at elevation 55.0 ft NGVD
- **Contributing Watershed Area:** 153,040 acres
- **Drainage Area:** 14.9% of Upper Kissimmee Basin Drainage Area
- **Annual Discharge:** 26.1% of S-65 water control structure annual flow
- **Mean Water Body Depth:** 6.1 feet
- **Maximum Water Body Depth:** 13 feet
- **Fish & Wildlife Assets**: Lake Toho is designated by the FWC as a fish management area. The lake is world renowned for its largemouth bass, black crappie, bluegill, redear sunfish, and warmouth fisheries that are valued in the millions of dollars to the local economy. It is also recognized around the world as a destination for bird watching and is home to the endangered whooping crane and Everglades snail kite. In 2010, the Lake Toho LMA supported 26 bald eagle nests and an alligator population estimated to be 4,183 (Personal communication, Arnold Brunell 2011).
- **Economic Value:** Lake Toho generates almost $2.7 million in spending, nearly 25 jobs, and almost $405,000 in wages (Bell 2006).
- **Primary Recreational Uses:** Boating including airboat use, fishing and hunting (duck, frog, alligator, turkey, etc.), picnicking, and wildlife viewing.
- **Public Use and Recreational Areas:** Makinson Island, Mac Overstreet Park, Lake Toho Park, Southport Park, City of Kissimmee Lakefront Park, Brinson Park, and public boat ramps at Whaley's Landing and Granada Road
- **Key Wildlife Habitat:** Little Grassy Island is considered extremely important for Everglades snail kite nesting but is not designated as Critical Habitat. The FWC does enforce restrictions during nesting season.
- **Recreational Visitors per year:** Approximately 82,400 recreational visitors per year based on the 2004–2005 period (Bell 2006).

Management Challenges:

- **Rooted and Floating Aquatic Plants**: Water hyacinth and water lettuce are the FWC's highest aquatic plant management priorities because of their rapid growth and propensity to block flood control structures, navigation, and critical fish and wildlife habitat. A total of 191 acres of floating plants were controlled during fiscal year 2007–2008. Lakeshore residents have expressed concerns about aquatic vegetation along the shore of Lake Toho. Specific concerns include access to open water from private docks, navigation around the lake, and general conditions of aquatic weeds adjacent to lakefront property. Hydrilla, American lotus (*Nelumbo lutea*), and smartweed (*Polygonum densiflorum*) were identified by FWC as the plants of greatest concern. Cattail, pickerelweed, water primrose (*Ludwigia* spp.), and tussocks also become problematic as a result of stabilized water levels and require management to maintain desirable fish and wildlife habitat.

- **Hydrilla Management**: Hydrilla coverage has reached levels of up to 80 percent of the lake in the recent past and the majority of the lake is infested at densities not seen in other lakes in the KCOL (except Cypress Lake). With a standing crop of more than 12,000 acres reported in 2008, Lake Toho is the most heavily hydrilla-infested water in the state. Nearly 4,700 acres of hydrilla were controlled in Lake Toho during fiscal year 2007-2008 at a cost of $3.03 million (Appendix F).
- **Water Quality**: Lake Toho appeared on the verified list for nutrient impairment in 2010. The final impairment status of Lake Toho is currently under discussion between FDEP and local stakeholders. Originally the waterbody was being considered as being impaired and needing a TMDL. However, a restoration planning process is underway that may move the water body into a category known as ”impaired, but recently completed or on-going restoration activities are underway to restore the designated uses of the waterbody.” The restoration planning and potential listing modification are expected to be completed by December 2011. Further study is required to determine how lake sediment nutrient concentrations and nutrient masking by hydrilla are affecting lake ecology and contributing to aquatic plant management problems. Stakeholders are concerned that development within the watershed will increase nutrient and pollutant loads to the lake.
- **Muck Accumulation**: Littoral wetland plants in Lake Toho are highly productive. Stabilized water levels prevent both periodic flushing during high water events and consolidation and oxidation of decomposing organic materials during low water events. This has resulted in high muck accumulation rates within the littoral wetlands. The FWC has performed four extreme draw downs (1971, 1979, 1987, 2004) on Lake Toho since the C&SF Project was constructed, which is more than on any other lake. Although Lake Toho is by nature more productive than other lakes within the KCOL, it is believed that anthropogenic additions of nutrients further increase primary production.
- **Development**: Lake Toho and its contributing watershed are entirely within the Osceola County Urban Service Area. Since early 2000, the majority of the agricultural acreage around the lake has been sold to developers. Although the majority of this acreage will be within developments of regional impact (see “Management Tools” discussion in Chapter 4) and subject to stricter regulatory standards, conversion of these lands will dramatically change the landscape and increase the number of people living around the lake.
- **Water Supply**: Water supplies to meet the projected growth within the Lake Toho LMA have not yet been identified or developed.

- **Flood Control**: Because lake water levels tend to rise and fall quickly in response to large rainfall events, Osceola County becomes concerned with flood storage whenever Lake Toho water levels are within 0.5 feet of its maximum regulatory water level**.**
- **Navigation:** Aquatic and nuisance vegetation as well as low water levels can obstruct access and navigation within the lakes.
- **Recreational User Conflicts**: Development is expected to increase the number of boats and recreational users on the lake. This will increase conflicts between wildlife and habitat protection activities and recreational uses and between recreational users and lakeshore homeowners. Of particular concern is the impact increased boat traffic will have on the nesting and foraging activities of wading birds, waterfowl, and Everglades snail kites. There are existing conflicts between lakeshore residents and alligator and duck hunters over noise, safety, and rights and privileges.
- **Exotic Apple Snail**: Exotic apple snails first appeared on Lake Toho in the Goblet's Cove area in 2001. Since that time they have expanded throughout Lake Toho and the KCOL.
- **Federal and State Listed Species**: Lake Toho serves as a primary nesting and foraging habitat for resident populations of the endangered Everglades snail kite (*Rostrhamus sociabilis plumbeus*) and the primary foraging and nesting refuge for the Everglades snail kite during regional droughts like those experienced throughout South Florida in 2001, 2006 and 2007 (Appendix G). It is also home to the endangered whooping crane, limpkin, wood stork, American alligator, snowy egret, white ibis, little blue heron, tricolored heron, and bald eagle.

Second Highest Priority: East Lake Tohopekaliga, Fells Cove, and Ajay Lake LMA

The East Lake Toho LMA is the second-highest ranked management priority because of the size of the resource, the value of fish and wildlife assets, and the development pressures facing the LMA. East Lake Toho is an urban recreational lake and water quality and navigation are of utmost importance to users.

Management Goal: Enhance major system components within the LMA.

Key Characteristics:

- **C&SF Water Bodies:** East Lake Toho, Fells Cove, Ajay Lake
- **Combined Water Body Volume:** 125,538 acre-feet at elevation 58.0 ft NGVD
- **Combined Water Body Acreage:** 12.125 acres at elevation 58.0 ft NGVD
- **Contributing Watershed Area:** 91,750 acres
- **Drainage Area:** 8.9% of Upper Kissimmee Basin Drainage Area
- **Annual Discharge:** 8.4% of S-65 water control structure annual flow
- **Mean Water Body Depth:**
    - East Lake Toho: 9.9 feet

  - Fells Cove: 4.2 feet
- **Maximum Water Body Depth:**
  - East Lake Toho: 18 feet
  - Fells Cove: 10 feet
- **Fish & Wildlife Assets**: East Lake Toho is designated by the FWC as a fish management area and is well known for its largemouth bass, black crappie, bluegill, redear sunfish, and warmouth fisheries. The lake supports bald eagle nesting, a stable population of American alligator (~100) and Florida sandhill cranes. The lake has served as a commercial alligator egg collection area since 2007.
- **Economic Value:** Information not available.
- **Primary Recreational Uses:** Recreational uses include fishing, boating, water skiing, jet skiing, boat racing, sightseeing, canoeing, kayaking, and ecotourism.
- **Public Use and Recreational Areas**: City of St. Cloud Lakefront Park, Marina and Boat Ramp, Ralph V. Chisholm Park and Boat Ramp, and Austin Tindall Park.
- **Critical Wildlife Habitat:** None designated.
- **Recreational Visitors Per Year:** Information not available.

Management Challenges:

- **Rooted and Floating Aquatic Plants:** Cattail, pickerelweed, water primrose, and tussocks are problematic because of stabilized water levels and require management to maintain desirable fish and wildlife habitat. Torpedo grass is also a management concern.
- **Hydrilla Management:** Hydrilla is not a major management concern on East Lake Toho.
- **Water Quality:** Nutrient reduction goals need to be reviewed to ensure that watershed loads are consistent with maintaining the current mesotrophic state of the lake. There are concerns that *E. coli* levels in swimming areas adjacent to ranching activities will increase without appropriate agricultural best management practices.
- **Muck accumulation:** East Lake Toho was drawn down in 1990 for muck removal and habitat enhancement. Since then conditions have deteriorated to the point that another extreme draw down and habitat enhancement project is required to improve littoral fish and wildlife foraging habitat. The FWC is in the planning stages for that draw down, which is expected to occur after new water control structure operating criteria are implemented by the USACE.
- **Development**: East Lake Toho is experiencing the same types of urban growth pressures as Lake Toho. There are concerns that development will encroach on nesting and foraging habitat and reduce the total acreage of desirable habitat in the KCOL.
- **Water Supply**: Water supplies to meet the projected growth in the Orlando metropolitan area have not yet been identified or developed. Water supply utilities in the area consider East Lake Toho a potential water supply source.

- **Flooding**: East Lake Toho water levels tend to rise and fall quickly in response to rainfall events due to the volumes of runoff discharged directly to the lake. Street flooding occurred in 1994, 1997, 1998, 2003, and 2004. There are additional concerns with floating muck deposits/islands on Lake Runnymede that have the potential to break loose, float to the surface, and move into East Lake Toho creating a potential for flooding by obstructing the outlet structure. Although this has never occurred, flooding in the city of Runnymeade has been attributed to these islands breaking loose and blocking the outfall canal from Lake Runnymeade.
- **Navigation**: Aquatic and nuisance vegetation as well as low water levels can obstruct access and navigation within the lakes.
- **Recreational User Conflicts:** Development is expected to increase the number of boats and recreational users on the lake. Since East Lake Toho is an urban recreational lake, conflicts between wildlife and recreational uses are expected. Of particular concern is the impact increased boat traffic will have on the nesting and foraging activities of wading birds, waterfowl, and Everglades snail kites.
- **Exotic apple snail:** Exotic apple snails are present in East Lake Toho.
- **Federal and State Listed Species:** Everglades snail kite and whooping crane, among other species, use this lake for nesting and foraging. Although not present in the quantities seen on Lake Toho, Everglades snail kites nest and forage in East Lake Toho and have done so off and on since the mid-1980s. East Lake Toho's importance as snail kite habitat is relative to conditions in South Florida. When conditions in South Florida are not conducive for snail kite nesting, East Lake Toho is of secondary importance to Lakes Toho and Kissimmee based on past nesting numbers. Based on recent nest numbers, its importance appears to be increasing. However, if South Florida is conducive to snail kite nesting, East Lake Toho probably would fall to a tertiary position for relative importance for nesting (Alex Kropp, Janell Brush and Jim Rodgers of the FWC and FWC KCOL Standing Team). East Lake Toho also supports a stable population of threatened American alligator and bald eagle nesting.

Third Highest Priority: Alligator Chain-of-Lakes and Lake Gentry LMAs

The Alligator Chain of Lakes and Lake Gentry LMAs are ranked third because they are smaller and have less fish and wildlife value than East Lake Toho. The Alligator Chain is valued for its recreational opportunities and good water quality. Development pressure on these resources is similar to that on East Lake Toho.

Management Goal: Enhance major system components within the LMA.

Key Characteristics:

- **C&SF Water Bodies:** Lakes Alligator, Brick, Lizzie, Coon, Center, Trout, and Gentry
- **Combined Water Body Volume:**
    - Alligator Chain of Lakes: 57,287 acre-feet at elevation 64.0 ft NGVD
    - Lake Gentry: 16, 675 acre-feet at elevation 61.5 ft NGVD

- **Combined Water Body Acreage:**
  - Alligator Chain of Lakes: 7,514 acres at elevation 64.0 ft NGVD
  - Lake Gentry: 1,947 acres at elevation 61.5 ft NGVD
- **Contributing Watershed Area:**
  - Alligator Chain of Lakes: 59,460 acres
  - Lake Gentry: 29,943 acres
- **Drainage Area:**
  - Alligator Chain of Lakes: 5.8% of Upper Kissimmee Basin Drainage Area
  - Lake Gentry: 2.9% of Upper Kissimmee Basin Drainage Area
- **Annual Discharge:**
  - Alligator Chain of Lakes: 4.1% of S-65 water control structure annual flow
  - Lake Gentry: 2.9% of S-65 water control structure annual flow
- **Mean Water Body Depth** (by C&SF water body)**:**
  - Trout: 3.5 feet
  - Center: 3.4 feet
  - Alligator: 8.0 feet
  - Lizzie: 5.5 feet
  - Lost: 3.1 feet
  - Brick: 6.1 feet
  - Gentry: 7.8 feet
- **Maximum Water Body Depth** (by C&SF water body)**:**
  - Trout: 11 feet
  - Center: 9 feet
  - Alligator: 25 feet
  - Lizzie: 21 feet
  - Lost: 8 feet
  - Brick: 18 feet
  - Gentry: 18.5 feet
- **Fish and Wildlife Assets:** The Alligator Chain of Lakes supports stable populations of largemouth bass (16-35 bass/hr) and American alligator (~110) and is utilized for nesting and foraging by a variety of wading birds and cranes, including Florida sandhill crane. Two bald eagle nests were identified in 2007. Big Bend Swamp is located along the southern shore of Lake Gentry. Big Bend Swamp is a large cypress-dominated strand swamp with depressional marshes, wet prairies, and hydric hammocks. Big Bend Swamp may be particularly important for up to 30 rare animal species that require large areas of

flatwoods, prairie, and wetlands, such as red-cockaded woodpecker, Florida sandhill crane, Florida grasshopper sparrow, Sherman's fox squirrel, swallow-tailed kite, and the threatened Audubon crested caracara.

- **Economic Value:** Information not available.
- **Primary Recreational Uses:** Fishing, boating, water skiing, wake boarding, sightseeing, canoeing, kayaking, and hunting (alligator, frog, duck).
- **Public Use and Recreational Areas:** Lake Lizzie Nature Preserve and public boat ramps at Trout Lake, C-Gate on the C-31 Canal (access to Alligator Lake), and Smith's Landing (Lake Gentry).
- **Critical Wildlife Habitat:** Lake Lizzie Nature Preserve (918 acres) is part of the Lake Mary Jane–Upper Econ Mosaic designated by the Audubon Society as an Important Bird Area. It is noted for its Florida scrub-jay populations and its proximity to the undeveloped lands within the Deseret Ranches to the north. Lake Lizzie is the southern terminus of a mosaic of natural communities including long-leaf pine flatwoods; cypress and bay swamps; lacustrine, flag, and sawgrass marshes; xeric oak scrub and sand pine scrub; slash pine flatwoods; temperate hammock; and riverine communities. These habitats are considered important to the endangered wood stork, Florida sandhill crane, red-cockaded woodpecker, threatened Florida scrub-jay, and Bachman's sparrow (http://iba.audubon.org/iba/viewSiteProfile.do?siteId=77&navSite=state).
- **Recreational Visitors Per Year:** Information not available.

Management Challenges:

- **Rooted and Floating Aquatic Plants:** Residents have expressed concerns with torpedo grass along littoral areas and pickerelweed, duck potato (*Sagittaria lancifolia*), and other aquatic plants blocking access to canals between the lakes. Cattail, pickerelweed, water primrose and tussocks become problematic as a result of stabilized water levels and require management to maintain desirable fish and wildlife habitat.
- **Hydrilla Management:** While hydrilla is not a major management concern, it requires periodic small-scale management efforts.
- **Water Quality:** Water quality on these lakes is considered good.
- **Muck Accumulation:** The Alligator Chain of Lakes was drawn down in 2000 for muck removal and habitat enhancement. The FWC removed nearly 1 million cubic yards of organic material at the cost of $1.2 million.
- **Development:** The Alligator Chain of Lakes and Lake Gentry are expected to experience the same types of urban growth pressures as Lake Toho because the Osceola County Urban Service Area encompasses the majority of the watershed surrounding the lakes.
- **Water Supply:** Water supplies to meet the projected growth within the Alligator Chain of Lakes and Lake Gentry area have not yet been identified or developed.
- **Flood Control:** Septic systems are impacted by water levels equal or greater than 64.8 ft NGVD in the LMA. (Regulatory water level range is between 62.0 and 64.0 ft NGVD.)

- **Navigation**: Navigation between the lakes can be obstructed by floating plants as well as sand bars/shoaling that occurs at the outlets of canals. Maintenance of navigational beacons and markers to ensure safe navigation is another concern. Stakeholders would like to see lakes and project canals navigable at elevation 60.5 ft NGVD. (Regulatory water level range is between 62.0 and 64.0 feet NGVD.)
- **Recreational User Conflicts:** There are conflicts between wake boarders and fishermen, especially under high water conditions. The number of users on the lakes is expected to increase with development and these increases are expected to increase conflicts between the different types of uses.
- **Exotic apple snail**: Present in small numbers throughout the Alligator Chain of Lakes and Lake Gentry.
- **Federal and State Listed Species:** The Alligator Chain of Lakes supports a stable population of American alligators. Wood stork, white ibis, snowy egret, little blue heron, and bald eagle utilize these lakes for nesting and foraging. Areas within the Lake Lizzie Preserve are important to the threatened Florida scrub-jay. Areas within Big Bend swamp are considered important to the threatened Audubon crested caracara. Everglades snail kites currently are not known to use the Alligator Chain of Lakes or Lake Gentry for nesting or foraging, however, there have been sightings of the birds within the area.

Fourth Highest Priority: Lake Kissimmee, Lake Hatchineha, and Cypress Lake LMA

The Lake Kissimmee, Lake Hatchineha, and Cypress Lake LMA is ranked fourth because it is not experiencing the same development pressures and management challenges as the higher ranked LMAs. This ranking is not intended to diminish the importance of the LMA, because this LMA is considered highest ranked in terms of fish and wildlife and economic value to the region. Its ranking is reflective of the protections provided through the KRRP, the Osceola and Polk County urban growth boundaries, and the public land holdings around the lakes. These lakes are the headwater lakes for the KRRP and have the greatest potential to benefit from both theKRRP and implementation of new water control structure operating criteria in the KCOL.

Management Goal: Enhance major system components within the LMA.

Key Characteristics:

- **C&SF Water Bodies:** Lake Kissimmee, Lake Hatchineha, and Cypress Lake
- **Combined Water Body Volume:** 508,026 acre-feet at elevation 52.5 ft NGVD
- **Combined Water Body Acreage:** 36,284 acres at elevation 52.5 ft NGVD
- **Contributing Watershed Area:** 645,793 acres
- **Drainage Area:** 62.8% of Upper Kissimmee Basin Drainage Area
- **Annual Discharge:** 52.8% of S-65 water control structure annual flow

- **Mean Water Body Depth** (by C&SF water body)**:**
    - Kissimmee: 7.4 feet
    - Hatchineha: 4.5 feet
    - Cypress: 4.8 feet
- **Maximum Water Body Depth** (by C&SF water body)**:**
    - Kissimmee: 18.5 feet
    - Hatchineha: 11.5 feet
    - Cypress: 10.5 feet
- **Fish & Wildlife Assets:** Lake Kissimmee, Lake Hatchineha, and Cypress Lake are designated by the FWC as fish management areas. These lakes are well known for their largemouth bass, black crappie, bluegill, redear sunfish, and warmouth fisheries, which are valued in the millions to the local economy. Bird Island and Rabbitt Island in Lake Kissimmee support wading bird rookeries. Bald eagle (49 nests in 2007), Everglades snail kite, and whooping crane are among the species that use Lake Kissimmee and the surrounding areas for nesting and foraging. In 2010, the estimated alligator population was approximately 6,522 on Lake Kissimmee and 2,296 on Lake Hatchineha (Personal communication, Arnold Brunell 2011). In addition, the Drasdo Property consists of rare scrub habitat that supports the Florida scrub jay.
- **Economic Value:** Lakes Kissimmee, Lake Hatchineha, and Cypress Lake generate almost $4.29 million in spending, nearly 41 jobs, and almost $670,000 in wages (Bell 2006).
- **Primary Recreational Uses:** Fishing and hunting (duck, frog, alligator, turkey, etc.), picnicking, and wildlife viewing.
- **Public Use and Recreational Areas:** Gardner-Cobb Marsh, Drasdo Property, Three Lakes Wildlife Management Area, Lake Kissimmee State Park, Disney Wilderness Preserve, and Tiger Creek Preserve.
- **Critical Wildlife Habitat:** None designated.
- **Recreational Visitors Per Year:** Approximately 216,400 recreational visitors per year based on the 2004–2005 period (Bell 2006)

Management Challenges:

- **Rooted and Floating Aquatic Plants:** Management of rooted vegetation and floating plants, such as water lettuce and water hyacinth, can be a major problem. Cattail, pickerelweed, water primrose, and tussocks become problematic as a result of stabilized water levels and require management to maintain desirable fish and wildlife habitat.
- **Hydrilla Management:** Hydrilla has been a significant problem in Lakes Kissimmee, Lake Hatchineha, and Cypress Lake and has covered as much as 90 percent of the water surfaces in Cypress Lake and Lake Hatchineha and as much as half of Lake Kissimmee. Nearly $700,000 was spent controlling 3,720 acres of hydrilla in Cypress Lake during fiscal year 2007–2008. Treatment can be complicated by conflicts with Everglades snail

kite management, continuous flow requirements for the KRRP, and recreational uses of these lakes.

- **Water Quality:** Lakes Kissimmee and Hatchineha and Cypress Lake are on the verified list for nutrient impairment. These lakes are eutrophic and algal blooms occur at times during the year.
- **Muck accumulation:** The FWC has performed two extreme draw downs (1977, 1996) on Lake Kissimmee, Lake Hatchineha, and Cypress Lake since the C&SF Project was completed.
- **Development:** Development pressures are less severe in this LMA because much of the land surrounding these lakes is held in public ownership. The shorelines of these lakes are not within the Osceola County urban growth boundary but a portion of Lake Hatchineha is within the Polk County urban growth boundary.
- **Water Supply:** Water stored within this LMA is intended for use by the KRRP. The increase in high pool stage associated with the Kissimmee River Restoration Headwaters Revitalization Project will provide storage for water needed to meet the hydrologic criteria for the restored Kissimmee River and to achieve the secondary project purposes of increasing the quantity and quality of wetland habitat around these lakes.
- **Flood Control:** There are fewer flood control concerns on these lands because much of the area surrounding the lakes is held in public ownership, is rural, and/or has a flowage easement. However, floating invasive plants, tussocks, floating islands, and hydrilla must be managed to prevent these plants from jamming against the Highway 60 bridge and flood control structure at the southern end of Lake Kissimmee.
- **Navigation:** Aquatic and nuisance vegetation can obstruct access and navigation within the lakes.
- **Recreational User Conflicts:** Recreational uses (fishing, hunting, wildlife viewing, picnicking) are similar among the three lakes. Conflicts exist between recreational users and residents over use of lakeshore public lands.
- **Exotic apple snail:** Exotic apple snails are present in Lake Kissimmee and Cypress Lake and are abundant in Lake Hatchineha.
- **Federal and State Listed Species:** Bald eagle, Everglades snail kite, American alligator, and whooping crane use Lake Kissimmee and areas surrounding Lake Kissimmee for nesting and foraging.

Fifth Highest Priority: Lakes Hart and Mary Jane LMA

Lakes Hart and Mary Jane are headwater lakes, with inflows from the Preston/Myrtle/Joel LMA. There is some urban growth pressure in the watershed, however, the majority of areas around both lakes are parts of rural settlements with covenants intended to preserve the rural/agricultural nature of the areas surrounding these lakes. Lake Mary Jane, Moss Park, and Split Oak Preserve are part of the Lake Mary Jane–Upper Econ Mosaic designated by the Audubon Society as an Important Bird Area. This area is of particular importance given its proximity to the Upper Econ Mosaic CARL–Florida Forever Project and the undeveloped lands within Deseret Ranches.

Management Goal: Enhance major system components within the LMA.

Key Characteristics:

- **C&SF Water Bodies:** Lakes Hart and Mary Jane
- **Combined Water Body Volume:** 25,880 acre-feet at elevation 61.0 ft NGVD
- **Combined Water Body Acreage:** 3,919 acres at elevation 61.0 ft NGVD
- **Contributing Watershed Area:** 34,408 acres
- **Drainage Area:** 3.3% of Upper Kissimmee Basin Drainage Area
- **Annual Discharge:** 2.4% of S-65 water control structure annual flow
- **Mean Water Body Depth** (by C&SF water body)**:**
  - Hart: 6.6 feet
  - Mary Jane: 4.5 feet
- **Maximum Water Body Depth** (by C&SF water body)**:**
  - Hart: 20 feet
  - Mary Jane: 12 feet
- **Fish and Wildlife Assets:** The most notable asset is the Bird Island rookery located within Lake Mary Jane. It is part of the Lake Mary Jane–Upper Econ Mosaic designated by the Audubon Society as an Important Bird Area and supports between 125 and 150 wood stork nests, making it one of the larger colonies in central Florida. This rookery also supports many species of wading birds including great white egret, great blue heron, little blue heron, anhinga, snowy egret, white ibis, tricolored heron, black-crowned night heron, yellow-crowned night heron, glossy ibis, American coot, and cattle egret. In addition to the Bird Island rookery, American alligator and Florida sandhill crane are important assets. Lakes Hart and Mary Jane support stable American alligator populations of approximately 60 and 200 alligators, respectively. Surveys in 2008 found 75 active Florida sandhill crane nests in the littoral wetlands in Lakes Hart and Mary Jane. One bald eagle nest was recorded in the area in 2007. Residents have been working with the Orange County Green Ways program to acquire additional lands east of the Split Oak Preserve to establish a wildlife corridor from Eagle Creek Conservation Area to the Econ Mitigation Bank. Species expected to use that corridor include raccoon, Florida black bear, deer, and turkey.
- **Economic Value:** Information not available.
- **Primary Recreational Uses:** Wildlife viewing; horseback riding, hiking, camping; recreational boating, fishing, and swimming; wakeboarding; water skiing; and hunting (frog, alligator, duck, turkey).
- **Public Use and Recreational Areas:** Moss Park, Split Oak Forest/Preserve, Eagle Creek Conservation Area.
- **Critical Wildlife Habitat:** Lake Mary Jane–Upper Econ Mosaic is an area of approximately 36,000 acres that includes a mosaic of natural communities including long-leaf pine flatwoods; cypress and bay swamps; lacustrine, flag and sawgrass marshes;

xeric oak scrub and sand pine scrub; slash pine flatwoods; temperate hammock; and riverine communities. These habitats are important to endangered wood stork, Florida sandhill crane, red-cockaded woodpecker, threatened Florida scrub-jay, and Bachman's sparrow (http://iba.audubon.org/iba/viewSiteProfile.do?siteId=77&navSite=state).

- **Recreational Visitors per Year:** Moss Park is the largest Orange County park (1,600 acres) with an estimated 200,000 visitors per year (Personal communication, J. Paradise 2008).

Management Challenges:

- **Rooted and Floating Aquatic Plants:** Residents are concerned with wax myrtle (*Myrica cerifera*) encroachment in wetlands and sloughs, cattail encroachment, and torpedo grass.
- **Hydrilla Management:** Hydrilla is not a major management concern.
- **Water Quality:** Florida LAKEWATCH data indicate the current water quality is good.
- **Muck accumulation:** Evidence of muck accumulation is present but FWC has never performed an extreme draw down on Lakes Hart or Mary Jane. New water control structure operating criteria will specify periodic draw down of these lakes to reduce and remediate muck accumulations.
- **Development:** The majority of areas around both lakes are parts of rural settlements with covenants intended to preserve the rural/agricultural nature of the areas surrounding these lakes. Residents are working with the Orange County Green Ways program to acquire additional private lands east of the Split Oak Preserve to establish a wildlife corridor from Eagle Creek Conservation Area to the Econ Mitigation Bank.
- **Water Supply:** Water supplies to meet the projected growth within the Lake Hart and Mary Jane area have not yet been identified or developed.
- **Flood Control:** Docks have flooded in the past but no major issues have been identified.
- **Navigation:** Most residents access the lake from their lakeshore property and are concerned with navigation obstructions caused by aquatic plants or low water levels.
- **Recreational User Conflicts:** Moss Park has a public swimming beach and public boat ramp that experience high volume usage during the weekends. There are concerns with the number of watercraft using the lakes and the associated impacts on wildlife, water quality, lakeshore residents, and public safety. Additional concerns are with the potential for conflicts between recreational boaters, water skiers, jet skiers, and wake boarders.
- **Exotic apple snail:** Exotic apple snails have not been reported on these lakes.
- **Federal and State Listed Species:** Bird Island Rookery within Lake Mary Jane supports one of the larger wood stork colonies in central Florida along with colonies of limpkin, snowy egret, little blue heron, white ibis, and tricolored heron. Lakes Hart and Mary Jane also support populations of American alligator and Florida sandhill crane.

Sixth Highest Priority: Lakes Preston, Myrtle, and Joel LMA

Lakes Preston, Myrtle, and Joel are surrounded by private lands owned by Deseret Ranches of Florida. The watershed and shoreline remain in near natural/native condition. Lands west of

Lake Preston are within the Osceola County Urban Service Area. A conceptual master plan has been developed for a 17,150-acre parcel and the Osceola County Board of County Commissioners has adopted a comprehensive plan amendment for the area. Management challenges are undetermined at this time although there are concerns with preserving the relatively natural and unimpacted nature of these lakes. Lands north and south of this LMA are part of the Lake Mary Jane–Upper Econ Mosaic Important Bird Area.

Management Goal: Sustain major system components within the LMA.

Key Characteristics:

- **C&SF Water Bodies:** Lakes Preston, Joel, and Myrtle
- **Combined Water Body Volume:** 9,913 acre-feet at elevation 62.0 ft NGVD
- **Combined Water Body Acreage:** 1,862 acres at elevation 62.0 ft NGVD
- **Contributing Watershed Area:** 13,939 acres
- **Drainage Area:** 1.4% of Upper Kissimmee Basin Drainage Area
- **Annual Discharge:** 3.2% of S-65 water control structure annual flow
- **Mean Water Body Depth** (by C&SF water body)**:**
  - Preston: 4.3 feet
  - Myrtle: 2.5 feet
  - Joel: 4.2 feet
- **Maximum Water Body Depth** (by C&SF water body)**:**
  - Preston: 10 feet
  - Myrtle: 10 feet
  - Joel: 10 feet
- **Fish and Wildlife Assets**: While limited data are available, resource levels are assumed to be similar to the Lake Mary Jane–Upper Econ Mosaic Important Bird Area. Habitats would include long-leaf pine flatwoods; cypress and bay swamps; lacustrine flag and sawgrass marshes; xeric oak scrub and sand pine scrub; slash pine flatwoods; temperate hammock; and riverine communities that support endangered wood stork, Florida sandhill crane, red-cockaded woodpecker, threatened Florida scrub-jay, and Bachman's sparrow.
- **Economic Value:** Information not available.
- **Primary Recreational Uses:** Private recreational boating, fishing, and hunting.
- **Public Use and Recreational Areas:** None
- **Critical Wildlife Habitat:** Entire contributing watershed.
- **Recreational Visitors per Year:** Not applicable because there is no public access to the lakes.

Management Challenges:

- **Rooted and Floating Aquatic Plants:** There is no history of aquatic plant problems or aquatic plant treatments of any kind. Because there are no public boats ramps on these lakes or navigable connections to waters with public access, these waters are not eligible for FWC aquatic plant management funding.
- **Hydrilla Management:** There is no reported occurrence of hydrilla in these lakes.
- **Water Quality:** Very good as evidenced by the biological indicator of mayfly presence (http://www.epa.gov/med/grosseile_site/indicators/mayflies.html#references).
- **Muck accumulation:** Minimal near the shore line but more evident along the lakeward edge of the littoral zones.
- **Development:** This area is undeveloped. Osceola County has adopted its comprehensive plan and included a large portion of the land around these lakes within the urban growth boundary.
- **Water Supply:** Water supplies to meet the projected growth within the Lake Preston, Myrtle, and Joel area have not yet been identified or developed.
- **Flood Control:** In the past, Deseret Ranches and the SFWMD have had an informal agreement that allowed lake water levels to exceed maximum regulatory stages for extended periods of time during flood events. Deseret Ranches has since requested SFWMD to adhere to approved regulation schedules and rules.
- **Navigation:** No issues identified.
- **Recreational User Conflicts:** None.
- **Exotic apple snail:** Not present.
- **Federal and State Listed Species:** Unknown but assumed to be similar to those identified as important in the Lake Mary Jane–Upper Econ Mosaic Important Bird Area (wood stork, Florida sandhill crane, red-cockaded woodpecker, Florida scrub-jay, Bachman's sparrow, white ibis, snowy egret, little blue heron, American alligator, bald eagle).

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4

Monitoring and Assessment Program

Introduction

This chapter presents the proposed monitoring and assessment program for the LTMP. The monitoring and assessment program is a critical component of the adaptive management process described in Chapter 5 and shown in Figure 4.1. It will provide the necessary information for identifying whether a problem exists, assessing what types of management intervention may be necessary, and determining the effectiveness of deployed management tools. System assessments will be performed annually to compare ecosystem conditions with assessment targets and provide information in a form suitable for decision making, adaptive management, and determination of management success.

Proposed Monitoring and Assessment Program

The monitoring and assessment program proposed for the LTMP is comprised of three types of monitoring activities: long-term monitoring to assess current conditions, monitoring to assess the effectiveness of management actions, and monitoring to improve understanding of ecosystem functions and processes. These three types of monitoring lead to three different reporting outcomes as shown in Figure 4.1. These reporting outcomes will be used in combination to produce the system assessment.

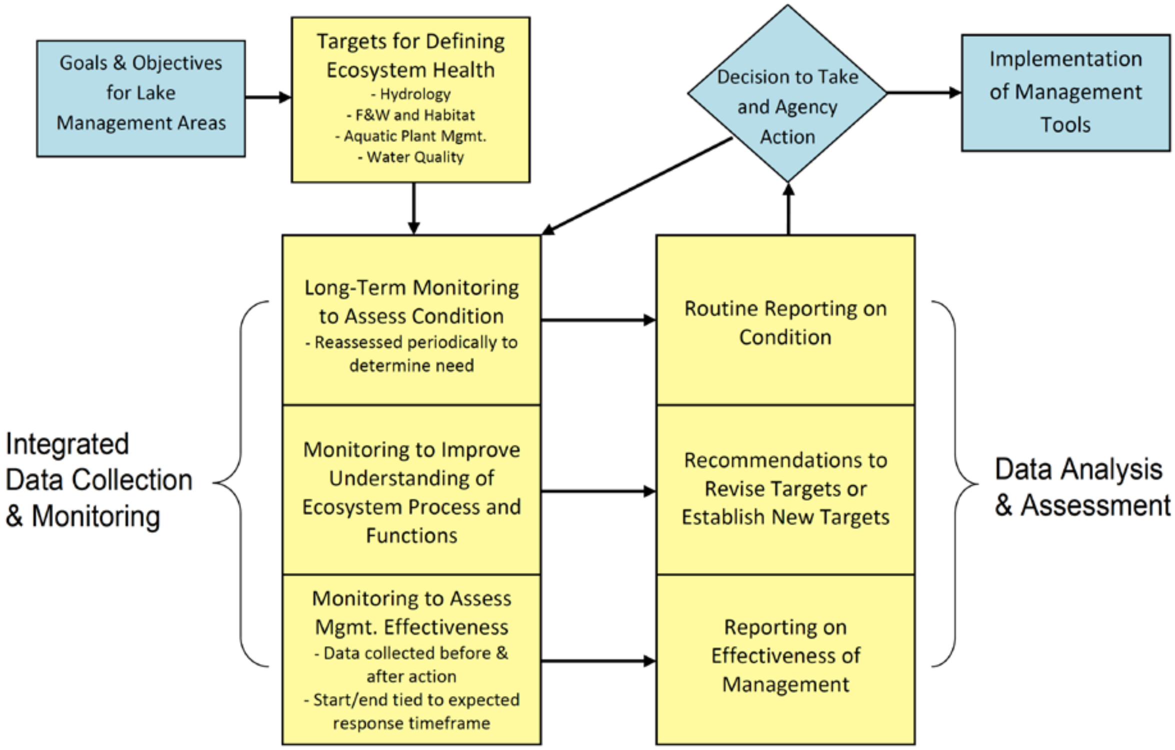

Figure 4.1 – Relationship among management objectives and targets, monitoring and assessment activities, and the interagency team management tool implementation process.

Long-term monitoring will be conducted routinely to assess the condition of the lakes and to examine trends. Examples of this type of activity includes monitoring lake stage and discharges from structures, collection of water quality data, and routine surveys of key fish and wildlife species. Long-term monitoring does not have a defined end because it is tied to agency mandates with an ongoing need for information. The design of this type of monitoring program can be quite simple if it is limited only to the data required to assess the status of metrics relative to specified target values, ranges of values, or directions of change.

Although long-term monitoring may be used to assess management effectiveness, additional monitoring may be needed. Monitoring to assess management effectiveness should begin prior to an action being implemented so a baseline condition can be established. The duration of data collection will depend on the expected system response time. Monitoring to assess management effectiveness may take the form of a quasi-experimental design if some lakes (or areas within a lake) are subjected to treatment while others are left alone.

The third type of monitoring is intended to improve understanding of ecosystem processes and functions. This monitoring is intended to fill information gaps concerning key attributes of the lakes and their watersheds. Data collected would be used to recommend improvements to existing targets or to support establishment of new targets. In this type of assessment, agencies may wish to use more elaborate designs to investigate correlations among metrics or the mechanisms that influence these relationships.

Results and assessments from these three types of monitoring activities will be assembled into an annual system assessment report intended to assist resource managers in making appropriate adjustments to management and monitoring programs. The report will be prepared annually. Key findings and concerns will highlight areas where management intervention or corrections are required..

In addition to showing the types of monitoring and assessment activities, Figure 4.1 shows how management objectives and targets drive the monitoring and assessment work and how that work provides information to guide decision making related to the deployment of management tools. Assessment activities are depicted in yellow, while management activities are shown in blue.

Figure 4.2 shows the proposed management framework for the LTMP that is presented in more detail in Chapter 5. This diagram depicts the interaction between Stakeholders, Agency Representatives and Decision Makers.

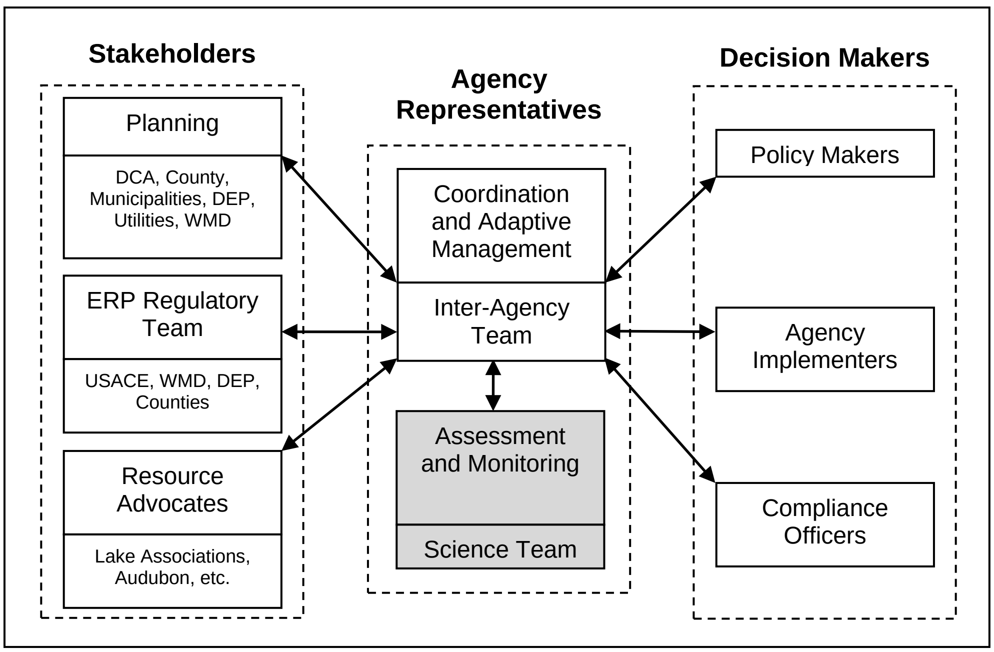

Figure 4.2 – Proposed management framework for the Kissimmee Chain of Lakes Long-Term Management Plan.

Two "teams" of Agency Representatives are identified in Figure 4.2: the Interagency Team and the Science Team. The role of the Interagency Team is to coordinate agency actions and facilitate the adaptive management process. The role of the science team is to implement and oversee the monitoring and assessment program to ensure that the needed information for adaptive management is being collected and reported. The Science Team will be lead by a coordinating scientist appointed to oversee coordination of monitoring and assessment related activities between the plan partners.

The proposed monitoring and assessment program supports the proposed adaptive management process by providing a systematic approach for collecting and assessing ecosystem information relative to management objectives, management actions, and ecosystem and management uncertainty. It will be designed to investigate ecological processes and functions for the purpose of understanding how ecosystems respond to management actions. It will provide insight into the effectiveness of management actions and provide information critical to evaluating what did and did not produce desired results.

Responsibility for implementation of the proposed program is shared by the partner agencies, but coordinated through a single scientist. For the program to work, partner agencies must be willing to allocate resources at the level necessary to support core monitoring, assessment, and reporting activities.

Phased Implementation

The monitoring and assessment program for the LTMP will be implemented using a phased approach. Figure 4.3 describes the three phases and the sequence of monitoring and assessment activities.

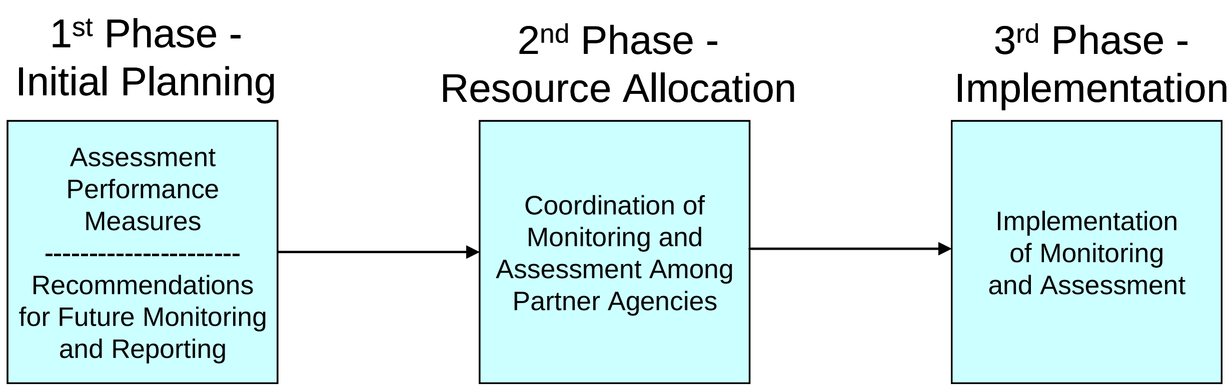

Figure 4.3 – Sequence of Kissimmee Chain of Lakes assessment activities.

Phase I – Initial Planning

The first phase of the monitoring and assessment program was initiated in May 2004 as part of the plan development for the LTMP and was completed in 2008. This work focused on assembling a base of knowledge for assessing the ecological status of the LMAs and included the development of a conceptual ecological model, a definition for lake ecosystem health, assessment performance measures, and the compilation of an extensive annotated bibliography and inventory of data collection and monitoring activities. These products were compiled into the *Draft Scientific and Technical Basis for the KCOL LTMP* (SFWMD et al. 2007a) and submitted to a panel of ecologists for peer review. This panel reported their recommendations in Karr et al. (2007).

The conceptual ecological model (Appendix H) shows how various components of the lake ecosystem relate to each other and to human-induced stressors. This model follows the example of similar models that were developed for other South Florida ecosystems (RECOVER 2004). The conceptual model was helpful in identifying key ecosystem attributes (hydrology, fish, birds, vegetation, water quality, etc.) that are important to lake users, affected by stressors, responsive to management, and cost-effective to monitor. Existing information on these attributes was gathered and documented in an annotated bibliography.

The definition for "lake ecosystem health" was developed to provide a clear explanation of what is meant relative to the plan purpose for the LTMP. Brief definitions of these terms were provided in Chapter 1. They are discussed more fully in Appendix I.

The criteria for defining ecological health for the LMA are presented as metrics and in some cases targets and are contained in the assessment measures (Appendix J). Two types of assessment measures have been developed. Assessment performance measures (APMs) include assessment targets based on metrics used to measure key lake attributes. Assessment indicator measures (AIMs) are similar, but do not include specific targets, usually because insufficient information is available to support target development. The assessment targets in the APMs represent preferred conditions as determined by LTMP partners. Future monitoring needs associated with these assessment measures are identified.

Phase I of the monitoring and assessment program assembled the information necessary to develop the assessment performance measures and targets presented in Appendix J and identified significant data gaps and the need for more focused, streamlined, and enhanced data collection efforts.

Phase II – Resource Allocation, Including Coordination of Monitoring and Assessment among Partner Agencies

The next phase of work, the Resource Allocation Phase, was initiated in 2010 and involves development of more detailed monitoring and assessment plans. This second phase will be followed by full implementation of the coordinated monitoring and assessment plan, which will be used to identify trends, signal deviations from targeted conditions, evaluate system health, and guide resource managers in the maintenance and enhancement of conditions in the KCOL.

Monitoring

Currently, plan partners do not coordinate monitoring activities in the KCOL, and assessment and reporting activities are usually limited to individual projects. The first challenge facing the science team is to align current assessment measures with management objectives and to identify additional assessment measures that need to be developed to address the full suite of KCOL management objectives. The second major challenge will be coordinating and streamlining monitoring activities. As the LTMP monitoring and assessment program moves forward, partner agencies must be willing to modify, streamline, and expand existing monitoring activities to align with the requirements of the proposed monitoring and assessment program. It is well understood that LTMP partners are working in a resource limited environment and that increasing monitoring activity levels of effort will be a challenge for all partner agencies. However, for the LTMP to be successful, partner agencies must be willing to reconsider resource allocations and priorities. Chapter 3 has defined priorities for each LMA along with overall management objectives. This information is presented to provide managers with a full picture of the challenges facing these valued resources and to emphasize the need to rethink management priorities regionally and statewide.

Karr et al. (2007) recommended adoption of a framework for developing and evaluating monitoring programs that takes into account the whole information cycle needed for effective management. The panel suggested using the general framework developed by Vos et al. 2000 (Figure 4.4).

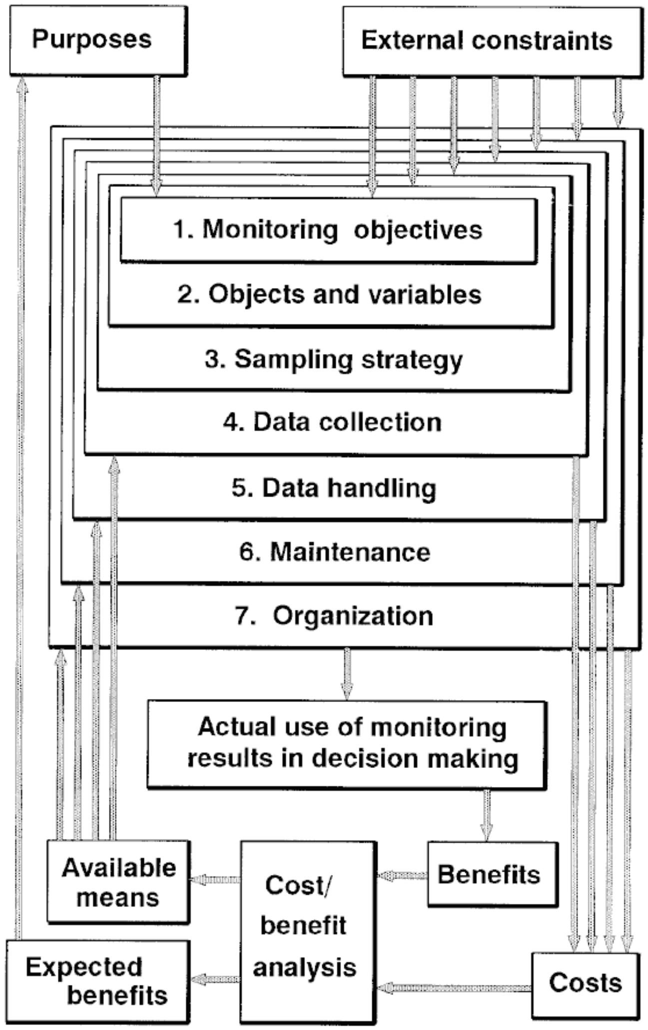

Figure 4.4 – A general framework for the design and evaluation of monitoring programs (Vos et al. 2000).

It is agreed that a framework similar to Vos et al. 2000 should be considered and that the goal of such an effort should be to eliminate redundant activities, reduce costs, and improve the applicability of the collected data. Given the current inventory of monitoring activities and proposed future monitoring activities, this will represent a significant level of effort. To assist the agencies in this endeavor, the SFWMD has contracted with Florida Atlantic University's Center for Environmental Sciences to provide a Lake Science Program Coordinator. The Lake Science Program Coordinator will develop a detailed plan for coordinating, integrating, and enhancing partner agency monitoring activities. The work will include the following:

- Examining the LTMP planning document, assessment measures, and associated information to:
  - Assess the strengths and shortcomings of current monitoring activities.
  - Identify additional information required to support the adaptive management process.
  - Determine the right attributes and variables (metrics) to sample based on the stated management objectives.

- Providing recommendations for better coordination and streamlining of existing monitoring activities. These recommendations should cover:
    - Appropriate design of monitoring networks – locations, metrics, and frequencies.
    - Modification or customization of monitoring activities to address KCOL management objectives.
- Expansion of existing programs to smaller lakes in the chain.
    - Optimization of similar monitoring by different agencies.
    - Standardization of data collection, handling, maintenance, organization, and storage, including use of standard methods, chain of custody, and quality assurance procedures.
    - Communication and sharing of data.
- Providing recommendations for new monitoring:
    - Long-term monitoring to fill information gaps.
    - Monitoring to assess management success, including event-based sampling.
    - Sampling to improve understanding of ecosystem processes and functions.
- Providing recommendations on other information needs:
    - Further development of targets and reference conditions.
    - Pilot studies.
    - Experimental projects.
    - Estimation of uncertainty in targets and results from data collection to assist in designing monitoring programs.
- Implementation of new monitoring activities.

Assessment

The system assessment report will be produced annually to provide a high-level summary of the state of the KCOL. It will provide an integrated ecosystem perspective and communicate resource status and needs to upper management, government officials, and interested stakeholders. Its purpose is to focus on the information that managers and the public most need to know to understand the status of the KCOL.

The Lake Science Program Coordinator will provide a detailed plan for establishing and coordinating the assessment and reporting activities associated with producing the annual system assessment report. This portion of the proposed work will include:

- Examining the LTMP planning document, assessment measures, and associated information to:
    - Identify assessment and reporting activities required to support the adaptive management process.
    - Determine what information is relevant to report to the public, agency managers, legislators, and the scientific community.

- Providing recommendations for coordinating and streamlining assessment and reporting activities. These recommendations should cover:
    - Agency responsibilities for analysis and interpretation.
    - Timing of data analysis and reporting.
    - Formats of data reports and summary reports.
- Providing guidance on how to best synthesize data and results from multiple monitoring activities originating from several sources.
- Coordinating production of the first series of annual system assessment reports.

The partner agencies will work together to produce this report, led by the Lake Science Program Coordinator under contract to the SFWMD. Each agency will be responsible for assembling data, analyses, reports, and other information produced over the previous year and transmitting these materials to the Lake Science Program Coordinator who will lead the agencies in synthesizing, formatting, and producing the report. Procedures for gathering, assembling, transmitting, and synthesizing the information will be developed by the Lake Science Program Coordinator. The university and partner agencies will also develop a schedule for information gathering, drafting various sections, writing and reviewing drafts, and producing the final draft. There will be ample time for agency and public review before the final report is released.

The following outline summarizes proposed content for the System Assessment Report:

1. Year in review (climate, inter- and intra-basin management challenges, etc.)
2. Description of the system and management priorities
    a. Presentation of management objectives, concerns, targets, priorities, and challenges
        i. Basin level
        ii. Lake/lake management area level
    b. New management actions
    c. Emerging management issues since the previous system report
    d. New stakeholder concerns and priorities
3. Description of changes in the monitoring and assessment program since the previous system report
    a. Description of whole system and resource-specific conceptual ecological models
    b. Description of assessment metrics and associated monitoring programs
    c. Description of management specific monitoring and assessment
        i. Agency responsibilities and collaborations
        ii. Management changes since last report
            1. New management actions and programs
            2. New cooperative efforts
            3. New assessment programs and significant enhancements/changes
            4. Significant assessment results or milestones

4. Annual system assessment
    a. Report on long-term monitoring to assess system conditions
        i. Report on all assessment measures by lake/lake management area
        ii. Show system status and whether or not objectives were met, as determined by assessment targets
            1. Green – Objective met for that lake/lake management area
            2. Yellow – Some lakes within an lake management area are meeting targets applying to the objective, or some targets are being met for all lakes in that lake management area
            3. Red – No lakes met the targets for the objective
            4. Gray – No assessment is provided at this time/more information is needed
        iii. Interpretation of status and report on trends and causes (through management or by natural events)
            1. How partner agencies are following up?
            2. Is the condition improving, showing no change, or declining?
            3. Any changes from last report?
            4. Any management or natural events that helped or hindered efforts to meet targets
    b. Report on monitoring to improve understanding of ecosystem processes and functions
        i. Proposed changes to the whole system and resource-specific conceptual ecological model
        ii. Science team priorities for coming year
    c. Report on monitoring to assess management effectiveness
        i. Report on specific management action effectiveness
        ii. Proposed changes to management actions
5. Summary of status and considerations for the management team

Phase III – Full Implementation

Full implementation of the KCOL Monitoring and Assessment Program is dependent on available funding and resources being made available by partner agencies. Given the current economic conditions it is uncertain when this will occur.

Full implementation assumes that: (1) partner agency monitoring activities have been realigned and prioritized within each agency and coordinated across agencies, (2) reporting processes and data management practices have been established to support the annual production of a system assessment report, and (3) agency staff has been allocated at the levels necessary to support the IAT, science team, and adaptive management process.

Management Tools

Long-term management of the KCOL watershed to enhance and/or sustain lake ecosystem health will require a variety of management tools to address the landscape changes and water supply demands expected under projected population growth within the region. Impacts frequently associated with landscape change are habitat loss and fragmentation and degradation of natural resources and water quality through changes in drainage patterns and increases in the volume, timing, distribution, and rate of surface water runoff. Assessment and reporting on conditions relative to management objectives and assessment targets will assist partner agencies in determining when and where management intervention is required.

Appendix K summarizes existing tools available to federal, state, and local government agencies within the KCOL to address the management challenges that were described in Chapter 3. Where no tools exist, recommendations are made to fill management gaps. Management tools for the KCOL are grouped into two categories: watershed management and in-lake management tools. The watershed management tools are used to manage the landscape surrounding the lakes and the quantity and quality of the water flowing into the lakes. In-lake management tools are used to manage the water and habitat within the C&SF Project lakes and associated fish and wildlife resources.

5
Assessment Targets, Existing Information and Application of Monitoring to Management Needs

Introduction

Assessment targets define specific values, threshold values (minimum or maximum), ranges of values, or directions of change and are associated with metrics used to evaluate change in the state of the system relative to management objectives. Assessment targets were identified during the development of assessment performance measures for the KCOL. Appendix J contains the assessment performance measures and indicators developed by the participating agencies. These performance measures and indicators were originally presented in the Draft Kissimmee Chain of Lakes Long-Term Management Plan (SFWMD 2007) and were peer reviewed in 2007 (Karr et al 2007).

An important purpose of this chapter is to present assessment targets and link those to management objectives, and existing and proposed monitoring and assessment activities. This is done through tables and brief summaries of past and present monitoring activities and other studies that can serve as a starting point for the next phase of the monitoring and assessment program. The material is organized by the major system attributes: hydrology, vegetation, birds, fish and other aquatic fauna, and water quality.

Hydrology

Surface Water Data

The hydrology of the KCOL (Figure 2.2) is regulated by C&SF Project structures operated in accordance with regulations prescribed by the Secretary of the Army (described in Chapter 2). The SFWMD maintains a network of surface water elevation (stage) recorders in the KCOL to support operation of the C&SF Project. Because these data are needed to support operations, SFWMD will continue this monitoring for the foreseeable future. Stage data are collected continuously and are available through the SFWMD hydrologic database DBHYDRO, which can be accessed through the agency's website (http://www.sfwmd.gov).

The C&SF Project structures that regulate water levels in the KCOL were built between 1962 and 1971. Prior to their construction, mean daily stage data were collected from sites established by the U.S. Geological Survey (USGS) during the 1930s and 1940s (Parker et al. 1955). The USGS sites were in the approximate locations of the present C&SF Project structures. These pre-C&SF Project data are considered reference data and are available for all of these structure locations except S-57, which regulates Lakes Myrtle, Preston, and Joel. Data collection began in 1941 for most of these lakes, in 1949 for Lake Gentry, and in 1929 for Lake Kissimmee. Although the reference data pre-dates water level regulation by the C&SF Project, lake water levels were most likely influenced by earlier canal construction, channelization, and construction of a federal navigable waterway between the town of Kissimmee on Lake Toho and the Kissimmee River (Anderson and Chamberlain 2005). Figures 5.5 through 5.10 show the average pre- and post-regulation mean daily stages for each of the LMAs.

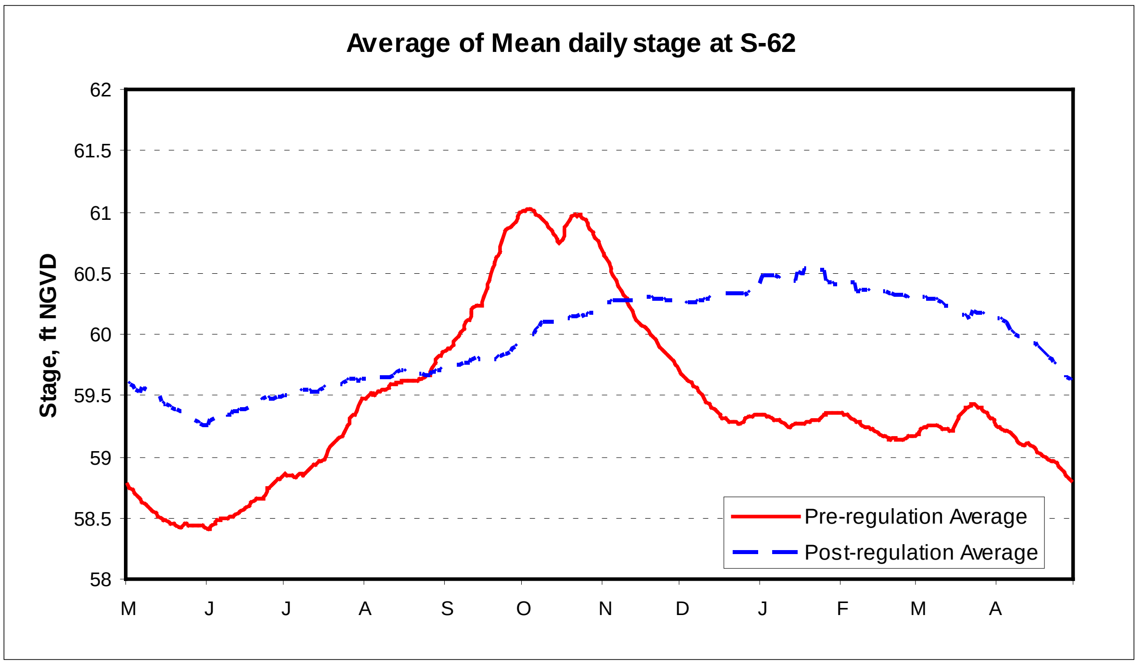

Figure 5.1 – Average of mean daily stage at S-62 water control structure, Lake Hart outlet.

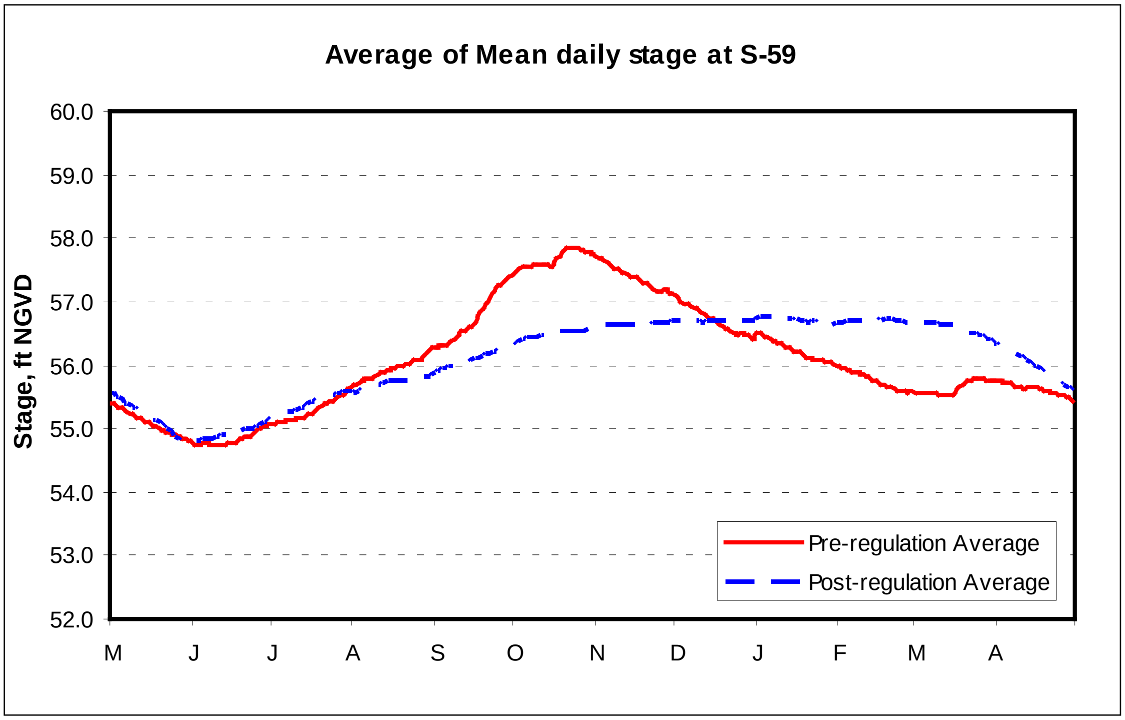

Figure 5.2 – Average of mean daily stage at S-59 water control structure, East Lake Tohopekaliga outlet.

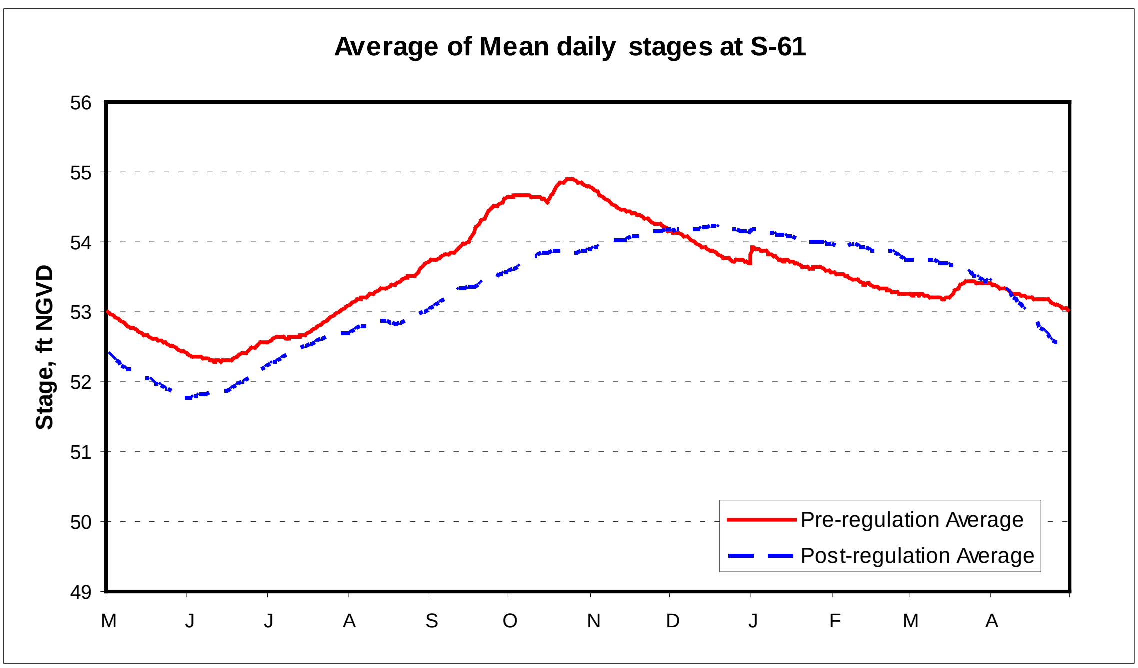

Figure 5.3 – Average of mean daily stage at S-61 water control structure, Lake Tohopekaliga outlet.

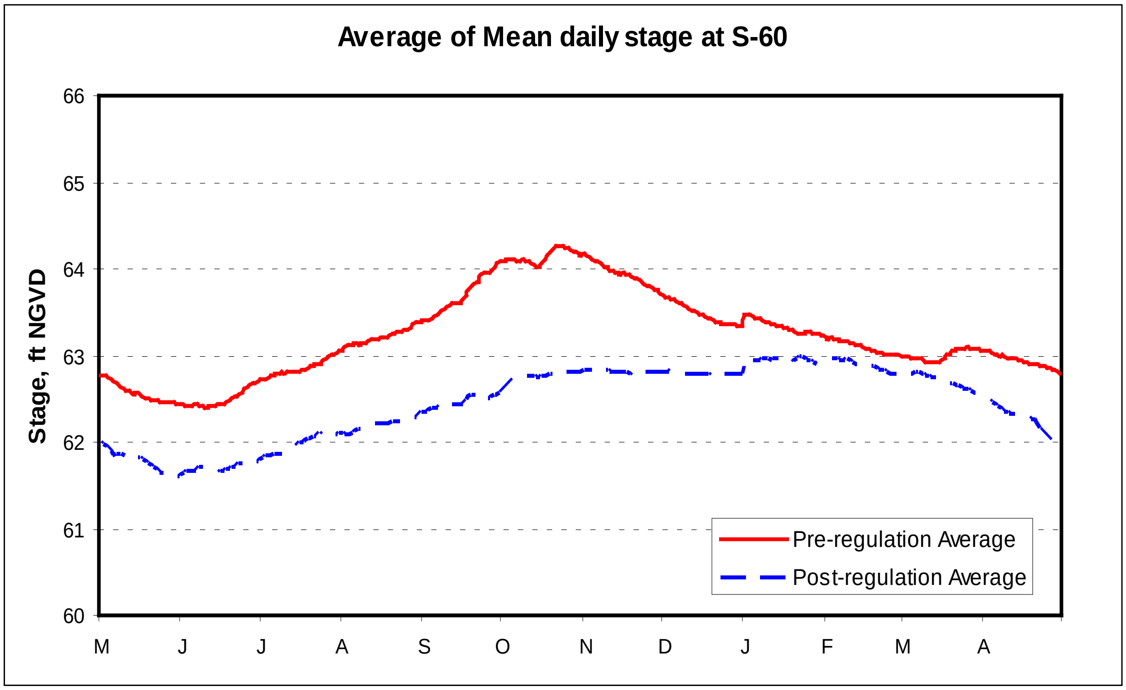

Figure 5.4 – Average of mean daily stage at S-60 water control structure, Alligator Lake outlet.

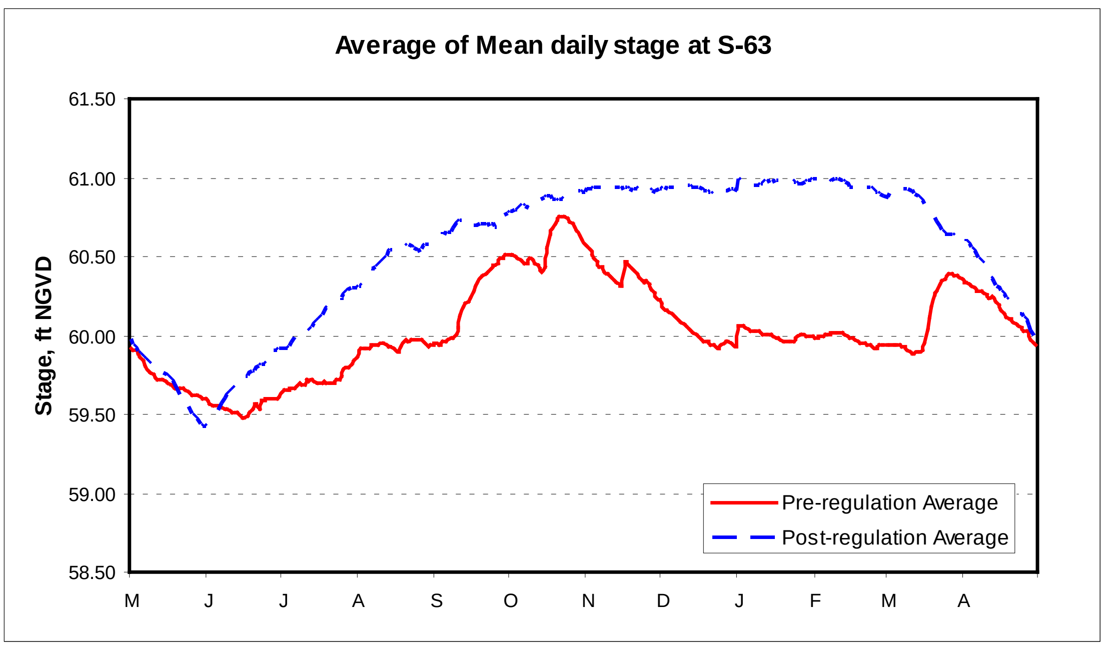

Figure 5.5 – Average of mean daily stage at S-63 water control structure, Lake Gentry outlet.

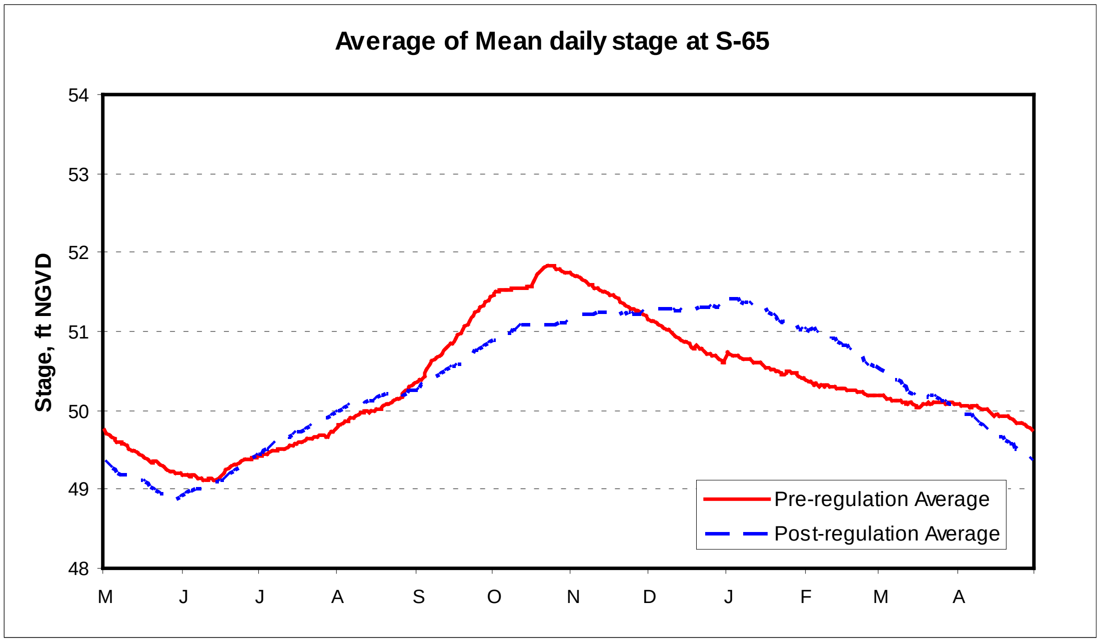

Figure 5.6 – Average of mean daily stage at S-65 water control structure, Lake Kissimmee outlet.

Current discharges at C&SF Project structures are also estimated by the SFWMD and are available daily. If water quality data are collected at or near these structures, loads of phosphorus, nitrogen, and other materials can be estimated through the load calculation program utilized at the SFWMD. Daily discharge data are also available from the USGS for the major lake tributaries. These USGS data are included in the SFWMD database.

Groundwater Data

Information on groundwater levels within the surficial and Floridan aquifer systems (SAS and FAS, respectively) in the vicinity (within two miles) of the KCOL is available from monitoring wells installed and/or maintained by the SFWMD, USGS, and Southwest Florida Water Management District (SWFWMD). The breakdown of these well sites (some of which consist of multiple wells) is shown in Table 5.1.

Table 5.1 – Approximate number of Surficial Aquifer System and Floridan Aquifer System well sites within two miles of the Kissimmee Chain of Lakes.

Status	SAS	FAS
Active (as of 2008)	32 (1969-2008)	17 (1960-2008)
Inactive	28 (1941-2007)	44 (1972-2007)

Note: Cumulative periods of record for each category are given in parentheses.

A network of SAS wells is distributed around Lake Toho and was used to support development of an integrated surface water/groundwater model to predict aquifer responses to drawdowns of the lake (Sorensen and Turner 2001). This well network was subsequently used to monitor groundwater levels associated with the 2003–2004 Lake Toho draw down. Another set of wells was installed in 2008 between Lakes Jackson and Marian to support development of an integrated groundwater/surface water model of the Three Lakes Wildlife Management Area. FAS wells are more evenly distributed throughout the KCOL region. In conjunction with data from other wells in Polk, Osceola, and Orange counties, data from groundwater monitoring wells in the KCOL area have been used to characterize regional potentiometric surface conditions and variations (e.g., Adamski and German 2004, Schiner 1993, Shaw and Trost 1984, Spechler and Kroening 2007) and provide data for regional model calibration and verification (Butler 2008).

Groundwater data, including construction information, from wells maintained by the SFWMD and USGS are stored in the SFWMD's DBHYDRO database. Groundwater level data is available either as continuous time-series data from automated recorders or discrete field-water-level measurements. Data for additional USGS and SWFWMD wells may be found within the National Water Information System (NWIS) (http://waterdata.usgs.gov/fl/nwis/gw) and Water Management Information System (WMIS) (http://www.swfwmd.state.fl.us/data/), respectively.

Hydrologic Objectives and Assessment Targets

KBMOS evaluation performance measures (AECOM 2011) and USACE flood performance evaluation metrics (USACE 2011) document the hydrology needed to achieve LTMP hydrologic management objectives. The KBMOS will identify new water control structure operating criteria intended to achieve KCOL hydrologic requirements within the constaints of the C&SF Project. Success of these modified operating criteria in achieving KCOL management objectives will be measured through KCOL habitat and fish and wildlife APMs presented in the following sections, KRRP restoration expectations, and Lake Okeechobee hydrologic performance measures.

Water Quality

Trophic State

The most significant water quality attribute from a management standpoint is trophic state, which is described in Appendix J, APM 5-01. The AIMs – phosphorus loading, phosphorus assimilation capacity of lake sediments, and frequency and duration of algal blooms – also have been prepared to support the trophic state measure. They are classified as AIMs because: 1) not enough data are available to establish assessment targets for them or 2) they do not contain criteria for establishing assessment targets. Given better data and understanding, one or more of these AIMs could be promoted to APMs in the future. In particular, phosphorus loading could become a performance measure once the FDEP establishes TMDLs for the KCOL.

In the 1960s, water quality in the KCOL became a wider regional issue when concern was raised that channelization of the Kissimmee River would facilitate the downstream transport of nutrient-enriched water from Lake Toho and exacerbate the eutrophication of Lake Okeechobee (Anthony 1972, Marshall et al. 1972). Although subsequent studies found that more concentrated nutrient sources existed in the Lower Kissimmee Basin closer to Lake Okeechobee (Federico and Brezonik 1975, Huber et al. 1976, Hutchinson et al. 1976, Joyner 1971, 1974, Lamonds 1975, MacGill et al. 1976, McCaffrey et al. 1975), nutrient control is still needed to protect the KCOL and prevent a cascading effect that would eventually make the eutrophication of Lake Okeechobee more difficult to control. Therefore, water quality management in the UKB has been approached from two perspectives: water quality protection for individual lakes and control of basin-wide nutrient export downstream.

Reference Data

Water quality reference data, defined as data collected prior to construction of the C&SF Project features and regulation of water levels, are insufficient to assess prior nutrient loading and lake trophic state. Most of the available publications (e.g., Love 1955) discussed general water quality in relation to the lakes' usefulness as potential water supplies. Except for a few reports on pollution problems related to public wastewater treatment plants, water quality studies were not focused on eutrophication issues.

Despite the lack of historical data, prior trophic state conditions still can beinferred from other information such as natural characteristics of the watershed (soils, drainage, etc.), paleolimnological studies, photographic evidence, or anecdotal information indicating vegetation coverage and composition, conditions of the water and sediment, and other information about biological productivity, including lake fisheries. An example of this type of analysis is found in the report by Griffith et al. (1997), which describes 47 lake regions in Florida as part of the FDEP Lake Bioassessment/Regionalization Initiative. These 47 regions were defined by mapping and analyzing water quality data sets in conjunction with information on soils, physiography, geology, hydrology, vegetation, climate, and land use/land cover, as well as relying on the expert judgment of local limnologists and resource managers. The resulting map delineates regions within which there is homogeneity in the types and quality of lakes and their association with landscape characteristics, or where there is a particular mosaic of lake types and quality. The product is intended to provide a framework for assessing lake characteristics, calibrating predictive models, guiding lake management, and framing expectations by lake users and lakeshore residents.

Most of the Upper Kissimmee Basin lies within the Kissimmee/Okeechobee Lowland region, which includes Lake Toho, Cypress Lake, Lake Hatchineha, and Lake Kissimmee. The Osceola Slope region includes East Lake Toho, Lake Hart, Lake Mary Jane, Alligator Lake, Lake Gentry, and other smaller lakes. These lakes have lower color, pH, alkalinity, conductivity, and nutrient values than lakes in the Kissimmee/Okeechobee Lowland region (Table 5.2).

Table 5.2 – Regional median values of water quality in the Kissimmee/Okeechobee Lowland and Osceola Slope lake regions (Griffith et al. 1997).

Parameter	Kissimmee/Okeechobee Lowland	Osceola Slope
Total Phosphorus (μg/L)	30–49	15–19
Total Nitrogen (μg/L)	1000–1400	800–999
Chlorophyll *a* (μg/L)	12–15	4–7
Total Alkalinity (mg/L)	20–40	2.0–3.9
Color (pcu)	50–99	100–200
Secchi Depth (m)	< 1.0	1.0–1.4
pH	7.0–7.5	5.5–5.9

Note that the values in Table 5.2 are intended only to illustrate general differences between lakes in the two regions. They should not be interpreted to be representative of the average water quality of any particular lake in the KCOL. Actual averages for individual lakes may differ substantially. For example, more than 20 percent of lakes in the Kissimmee/Okeechobee Lowland region have average total phosphorus concentrations greater than 80 micrograms per liter (μg/L), and more than 10 percent of lakes in the Osceola Slope region have average total phosphorus concentrations more than 50 μg/L (Griffith et al. 1997).

In addition, the Table 5.2 values are not intended to represent true reference conditions. Most of the data used by Griffith et al. was collected between 1990 and 1996, which was during or immediately prior to data used by the FDEP for its baseline assessments (see the following section). The main source of data was the University of Florida and its Florida LAKEWATCH program. Data collected by the SFWMD, FDEP, and FWC were not incorporated in the Table 5.2 statistics, although they were examined for the delineation of lake region boundaries.

Finally, in comparison to the water quality of other Florida lake regions, the values in Table 5.2 fall somewhere in the middle of the range. In other words, these lakes have higher nutrient levels than the clear, oligotrophic lakes on the sandy ridges of north and central Florida, but they are not as eutrophic as some lakes in phosphate-rich regions. Instead, they represent the water quality typical of eutrophic or mesotrophic lakes that have been more or less impacted by human activities. Their water quality has been influenced by their historical evolution, morphometry, hydrology, and various characteristics of their watersheds including drainage patterns, soils, geology and vegetation.

While the analysis by Griffith et al. is not intended to estimate the water quality of formerly natural, pristine lakes, it does show that lake water quality may vary significantly by region, and these differences are affected by natural variations among the lakes and their watersheds. Consequently, as pointed out by Canfield (1981), the environment in which lakes have developed should be taken into account when developing water quality goals. For example, lakes in the Kissimmee/Okeechobee Lowland region seem to be generally more productive than lakes in the Osceola Slope region. Nutrient reductions intended to shift a lake in the Kissimmee/Okeechobee Lowland region to a mesotrophic condition may not be feasible, effective, or even desirable given current recreational uses. On the other hand, stricter nutrient controls may be desired for a lake in the Osceola Slope region to maintain that lake's mesotrophic state.

Additional development of reference conditions for KCOL watersheds is expectedif the FDEP's draft Statewide Stormwater Rule is implemented This rule would provide a standard process to ensure that appropriate Environmental Resource Permitting criteria are used for stormwater runoff from new developmentsand would address water detention and nutrient runoff. The proposed treatment standard is that post-development runoff of total phosphorus and total nitrogen will be no more than pre-development runoff based on natural land characteristics. As part of this initiative, the FDEP would need to estimate pre-development hydrology and stormwater loadings of natural lands.

Currently, development and implementation of the Statewide Stormwater Rule is on hold. In the meantime, under current rules, the SFWMD requires development projects that discharge to an impaired water body to show that the project will not cause or contribute to the impairment by comparing a pre and post estimate of average annual discharge load. They must show that the post load is a net improvement over the pre load. Under the current rules the pre load is based on existing conditions at the time of permit application.

Baseline Data

The lakes in the KCOL vary considerably in their water chemistry, with a wide range in pH, dissolved color, total and soluble nitrogen and phosphorus, chlorophyll *a* (an indicator of phytoplankton biomass), and Secchi disk transparency (Havens 2003). Chlorophyll *a* concentrations correlate significantly with both nitrogen and phosphorus, in a manner that is not distinguishable from the general pattern observed for North American lakes (Havens and Nurnberg 2004). These correlations exist in most lakes worldwide, and reflect that one is measuring three components of algae that correlate with their biomass. The correlations are not sufficient evidence, when taken alone, that nitrogen or phosphorus are limiting the growth of algae and certainly not sufficient evidence that nutrients are ecological stressors.

Table 5.3 presents average total phosphorus, total nitrogen, and chlorophyll *a* concentrations for C&SF Project water bodies in the KCOL from 1997 to 2007. Lakes Mary Jane, Lizzie, Alligator, Trout, and Brick have total phosphorus concentrations less than 20 μg/L, which is indicative of low nutrient conditions (oligotrophic-mesotrophic). Lakes Center, Toho, and Kissimmee, and Cypress Lake have concentrations above 50 μg/L, which is indicative of high nutrient conditions (eutrophic). Lakes Toho, Kissimmee, and Cypress have moderate chlorophyll *a* concentrations, less than 40 μg/L, and support dense populations of hydrilla. When hydrilla occupies substantial portions of the water column, especially when it forms dense surface mats, it can mask water quality problems when using the trophic state index as a measure of water quality. Soluble nutrients are immoblized in hydrilla and associated periphyton biomass and are not available for planktonic algal uptake, thereby lowering in-lake nutrient and chlorophyll *a* concentrations. Vast expanses of hydrilla surface mats also prevent wave action from agitating sediments and resuspending nutrients. Currently this appears to be the case for Cypress Lake and Lake Toho and for Lake Kissimmee between 2000 and 2006 (SFWMD et al. 2007a).

Table 5.3 – Measured water quality data for the various lakes in the Kissimmee Chain of Lakes.

Lake Name	**Area** (acre)	**Total Phosphorus** (µg/L)	**Total Nitrogen** (µg/L)	**Chlorophyll *a*** (µg/L)	**Secchi Disk** (ft)	**Color** (Pt-Co)
Ajay Lake	137	22	1173	5.2	2	N/A
Alligator Lake	3,399	14	630	4	5.4	66
Brick Lake	615	19	1012	6	1.8	277
Coon Lake	126	37	1140	11	1.8	225
Cypress Lake	4,041	79	1333	39	2.1	118
East Lake Tohopekaliga	11,048	**22**	**730**	**4.3**	**5.2**	**57**
Fells Cove	837	28	1202	6	2.4	229
Lake Center	406	61	1389	10	1.1	360
Lake Gentry	1,803	17	706	3.6	5.2	N/A
Lake Hart	1,843	**30**	**1420**	**7.3**	N/A	N/A
Lake Hatchineha	6,629	**58**	**1387**	**18.9**	**1.8**	**146**
Lake Joel	218	N/A	N/A	N/A	N/A	N/A
Lake Kissimmee	31,911	**56**	**1273**	**28**	**2.1**	**87**
Lake Lizzie	789	18	811	5	3.8	134
Lake Mary Jane	1,142	16	1241	7	1.7	288
Lake Myrtle	551	**16**	N/A	N/A	N/A	N/A
Lake Preston	N/A	N/A	N/A	N/A	N/A	N/A
Lake Tohopekaliga	18,819	**53**	**985**	**14**	**3.0**	**93**
Trout Lake	267	17	888	6	2.5	101

Note: Values in bold text are from SFWMD. Lake Hart and Myrtle data are from the DBHYDRO database. East Lake Tohopekaliga, Lake Tohopekaliga, Lake Hatchineha, and Lake Kissimmee data provided by James et. al. (2011) for the 1998-2007 period. Remaining data were from Florida LAKEWATCH.

There is strong evidence of a causal relationship between point-source nutrient discharges and eutrophication of certain lakes in the KCOL. Municipal wastewater inputs to Lake Toho and its tributaries began in the 1950s. Rapid population growth resulted in treatment plant expansions, and by the early 1960s, wastewater treatment facilities operated by Orange County and the cities of Orlando, Kissimmee, and St. Cloud were discharging secondary effluent to the lake that contained high concentrations of phosphorus and nitrogen. By the late 1960s, Lake Toho water quality, aquatic habitat, and biological communities were on the decline and in 1979 annual phosphorus loading to the lake was 11 times higher and nitrogen loads had nearly doubled compared to natural conditions (Williams 2001). In addition, Jones et al. (1983) documented frequent algal blooms in Lake Toho and downstream lakes in the early 1980s and elevated phosphorus concentrations were observed as far south as the northern end of Lake Kissimmee (Jones 2005). Efforts to reduce phosphorus concentrations in effluent from the two largest point sources began in 1982, followed by complete removal of all wastewater treatment plant discharges by 1988. Annual nutrient inputs declined significantly and 10 years later measurable improvements in water quality were documented for Lakes Toho, Hatchineha, and Kissimmee and Cypress Lake (James et al. 1993, 1994, Williams 2001). These improvements were facilitated by the relatively short hydraulic residence time for these lakes (Fan and Lin 1984, Jones et al. 1983).

Despite past improvements in water quality, lakes from Toho to Kissimmee, remain in a eutrophic condition. Some residual effect from the earlier nutrient inputs may remain in the form of elevated nutrient levels in the lake sediments and perhaps enhanced internal recycling (loading). In addition, long-term lake health continues to be threatened by imports of phosphorus that exceed natural loading rates (Personal communication, Paul Gray). Some agricultural inputs, although rarely discharging to the lakes, are high in phosphorus (unpublished FWC and SFWMD data). Residential and commercial development along with associated infrastructure increases the amount of impervious surfaces and intensifies runoff rates (Mock, Roos & Associates 2003). Subsurface runoff from developed areas that were formerly poorly drained is also an important factor (Mock, Roos & Associates 2003). In addition, septic fields around lakeshores have potential for seeping into lakes (Mock, Roos & Associates 2003).

Currently, nutrient inputs to KCOL waterbodies are partially assimilated into lake sediments, decreasing the quantity of nutrients transported downstream to the Kissimmee River and Lake Okeechobee. Although work by the University of Florida concluded that the phosphorus assimilation capacity of KCOL lake sediments may be exceeded in approximately 9 to 15 years (White et al. 2004, Belmont et al. 2009), a reevaluation of those results indicated that the time to exceedance may be significantly longer for KCOL lakes (Personal communication, T. James and B. Jones, SFWMD). Research on Lake Okeechobee indicated that surficial sediments are losing their ability to absorb soluble phosphorus (Fisher et al. 2001). This loss of assimilation capacity has necessitated more stringent criteria and costly controls in the Lake Okeechobee basin. Such an outcome for the KCOL would complicate eutrophication management for these lakes and Lake Okeechobee.

Table 5.4 presents the Hydrologic Simulation Program-Fortran (HSPF) hydraulic and nutrient budgets for the KCOL simulated as part of FDEP's TMDL Study (CDM 2008). Some lakes were not modeled individually, but were grouped as one LMA, such as East Lake Toho, Fells Cove, and Ajay Lake. Total phosphorus loading rates are highest for Lake Hatchineha, Cypress Lake, Lake Gentry, and Lake Kissimmee, in decreasing order. Lakes Kissimmee, Hatchineha, and Toho and Cypress Lake have higher measured in-lake total phosphorus concentrations. These lakes also have significant aquatic plant management challenges. More research is required to determine causal effects in the relationship between in-lake total phosphorus concentrations and aquatic plant management challenges.

Table 5.4 – Hydrologic and nutrient budgets for the various lakes in the Kissimmee Chain of Lales from the Hydrologic Simulation Program-Fortran.

Lake Group	**Inflow Total Phosphorus Load** (lb/yr)	**Outflow** (ac-ft/yr)	**Total Phosphorus Loading Rate** (g/m-yr)	**Predicted/ Measured In-lake Total Phosphorus** (μg/L)
Myrtle, Preston, Joel	3,761	22,281	0.27	20/16
Hart and Mary Jane	13,540	47,388	0.51	40/16-30
E. Lake Toho, Fells, Ajay	49,765	139,164	0.46	60/22
Alligator COL	16,903	38,721	0.33	33/14-18-19-37-61
Lake Gentry	15,955	64,722	0.99	130/17
Lake Toho	128,494	345,906	0.77	60/53
Cypress Lake	96,400	453,765	2.67	60/79
Lake Hatchineha	161,014	762,909	2.72	60/58
Kissimmee Lake	227,091	1,084,838	0.80	60/56

Note: Values were extracted from the CDM HSPF Model result files, as run by A.D.A. Engineering, Inc. to specify output tables for the above listed lake groups. The CDM model provided to FDEP only provided output tables for Cypress Lake and Lake Kissimmee. Measured concentration data were taken from Table 2.2 of this document.

Other Water Quality Data

The APM (Appendix J) for this attribute concerns Class III water quality parameters other than nutrients. This performance measure gathers various water quality measures (dissolved oxygen, bacteriological indicators, trace metals, etc.) the FDEP has identified as potential or verified impairments to water quality in the KCOL (FDEP 2004, 2006). For these parameters, the State of Florida has established specific criteria required for protecting ecological resources and human health. The 19 lakes within the geographic scope of the LTMP are not used currently for potable water supplies; therefore, the Class I criteria specific to drinking water requirements do not apply.

Water Quality Monitoring

Several agencies and organizations have established monitoring programs in the KCOL region. The primary long-term programs are run by the SFWMD, FDEP, and the Institute of Food and Agricultural Sciences (IFAS) Florida LAKEWATCH Program at the University of Florida. The SFWMD has monitored the five major lakes in the chain (East Lake Toho, Lake Toho, Cypress Lake, Lake Hatchineha, and Lake Kissimmee) on a monthly basis since 1981. Lake tributaries also have been sampled. The three main tributaries (Boggy Creek, Shingle Creek, and Reedy Creek) have been monitored throughout the period of record. The FWC ran a somewhat similar program until 2009, although lakes and sampling stations differed and samples were collected on a quarterly basis. The FDEP samples periodically as part of a more synoptic sampling design. Florida LAKEWATCH samples 12 of the 19 lakes: Alligator Lake, Brick Lake, Lake Lizzie, Coon Lake, Lake Center, Ajay Lake, Fells Cove, Lake Gentry, East Lake Toho, Lake Toho, Cypress Lake, and Lake Kissimmee.

Much of the SFWMD data have been discussed by Havens (2003), James et al. (1993, 1994, 2011), Jones (2005), Jones et al. (1983), Milleson (1975), O'Dell (1994), and SFWMD (1982). The FWC data are summarized in various reports, some of which are Duchrow (1970, 1971), Duchrow and Starling (1972) Egbert (1995, 1996), Florida Game and Fresh Water Fish Commission (1979), Holcomb (1967, 1968, 1969), Holcomb and Starling (1973), and Holcomb and Wegener (1972, 1973, 1974). Florida LAKEWATCH data are available online (Florida LAKEWATCH 2009). Additional data have been reported by the USGS (Gaggiani and McPherson 1978, Hughes and Frazee 1979, Joyner 1971, 1974, Kaufman and Dysart 1987, Lamonds 1975, Pfischner 1982, Slack and Goolsby 1976, Slack and Kaufman 1973), Reedy Creek Improvement District (RCID), city of Orlando, Polk and Orange counties, and the USACE. In addition to the more common water chemistry data, some data also exist for phytoplankton composition (Duchrow and Starling 1972, Swift 1985, SFWMD unpublished data). For some of these water quality databases, a more comprehensive summarization is needed, especially for more recent data. However, the FDEP's *Water Quality Status Report* (FDEP 2004) and *Water Quality Assessment Report* (FDEP 2006), bi-annual statewide water quality assessments (e.g., FDEP 2010), and TMDL Study (CDM 2008) provide good starting points for summarizing available data and identifying water quality concerns.

Another especially useful reference is the *Lake Istokpoga/Upper Chain of Lakes Basin Phosphorus Control Report* (Mock, Roos & Associates 2003) sponsored by the SFWMD. This report assesses sources of phosphorus in these basins and their relative contribution to the water quality of Lake Okeechobee. It presents a detailed land use survey and phosphorus assessment (mass-balance budget analysis) to determine sources of phosphorus import and export in these basins. Included in this study is an extensive literature review.

In general, data exist to evaluate phosphorus, nitrogen and chlorophyll concentrations, algal bloom frequencies, water transparency (Secchi disk depth), trophic state indices, turbidity, and color. Less data are available for littoral zone dissolved oxygen (DO), phytoplankton species composition, organic content of profundal sediments, phosphorus assimilation capacity, *E. coli*, pesticides, and trace metals. The SFWMD is directing an effort to build a regional hydrologic and hydraulic model for the Kissimmee Basin. Eventually, this model may be applied to nutrient load and water quality modeling. The SFWMD has also contracted for the development of the Watershed Assessment Model (WAM). This model will be used to estimate nutrient runoff from UKB watersheds.

Water Quality Objectives and Assessment Targets

Table 5.5 lists LTMP management objectives and assessment targets related to water quality monitoring programs. The targets are taken from the assessment performance measures in Appendix J.

Table 5.5 – Water quality management objectives, assessment targets, and associated monitoring programs.

Management Objective	Assessment Target	Measure	Lake	Resource Maintenance or Enhancement	Monitoring Program	Monitoring Status	Agency
Meet or maintain state water quality standards and trophic state criteria including TMDLs.	FDEP is developing nutrient and TSI targets for lakes identified as impaired. Protective targets should be developed for other lakes.	5-01. Trophic State Index (APM)	All lakes	Maintenance (most lakes) or Enhancement (Cypress Lake and Lake Kissimmee)	Water quality monitoring of lakes, structures, and major tributaries	Long-term programs exist, but a few lakes are not sampled; better coordination and expanded monitoring is proposed.	FDEP, SFWMD, FWC, Florida LAKEWATCH
Meet or maintain state water quality standards and trophic state criteria including TMDL s.	FDEP is developing target nutrient loading rates for lakes identified as impaired. Protective targets should be developed for other lakes.	5-02. Nutrient Loads (AIM)	All lakes	Maintenance or Enhancement depending on lake	Water quality and discharge monitoring of lake structures and major tributaries	Long-term programs exist, but estimates of nutrient loads could be improved for some lake watersheds. Land use and watershed models need further investigation.	FDEP, SFWMD, FWC, Florida LAKEWATCH
Meet or maintain state water quality standards and trophic state criteria including TMDLs.	No target exists at this time. Further investigation is needed.	5-03. Frequency and Duration of Algal Blooms (AIM)	Initial focus on Lakes Toho, Cypress, Hatchineha, Kissimmee	Maintenance or Enhancement depending on lake	Phytoplankton monitoring	Program exists; dedicated funding needed.	SFWMD

Management Objective	Assessment Target	Measure	Lake	Resource Maintenance or Enhancement	Monitoring Program	Monitoring Status	Agency
Meet or maintain state water quality standards and trophic state criteria including TMDLs.	No target exists at this time. Further investigation is needed.	5-04. Phosphorus Assimilation Capacity of Lake Sediments (AIM)	Initial focus on Lakes Toho, Cypress, Hatchineha, Kissimmee	Maintenance	Initial study done	Follow-up study recommended with expansion to other lakes.	SFWMD
Meet or maintain state water quality standards and trophic state criteria including TMDLs	Dissolved oxygen (littoral and limnetic), fecal coliforms, and certain trace metals, pesticides, and polyaromatic hydrocarbons and phenols shall meet standards established in the FDEP Impaired Water Rule.	5-05. Class III Water Quality Parameters (APM)	All lakes identified by FDEP	Maintenance or Enhancement	Ambient water quality monitoring programs	Some parameters may not be monitored currently; FDEP and other agencies will determine monitoring needs.	FDEP

Aquatic and Wetland Vegetation

Reference Data

Although a comprehensive picture of pre-regulation conditions of the KCOL's plant communities is not available, plant species frequency data collected in 1957 (Sincock and Powell 1957, Sincock et al. 1957) were used to estimate species composition of littoral plant communities. The Sincock data and a study by Holcomb and Wegener (1971) support the view that changes in littoral plant communities have occurred since regulation began and are attributable at least in part to the reduced range of stage fluctuation. These results are consistent with a substantial body of literature indicating the importance of stage fluctuations to submerged and emergent littoral vegetation (e.g., Havens et al. 2005b, Herdendorf 1992, Keddy and Fraser 2000, Keddy and Reznicek 1986, Van der Valk 2005). There is evidence from Lake Toho that: lakeward limits of emergent vegetation may be established primarily by extreme low events, that current limits are at approximately the same elevation as prior to regulation, and that the primary changes in littoral zones have been in species composition and overall plant density (Holcomb and Wegener 1971).

Remote Sensing and Vegetation Mapping

Remotely sensed imagery (aerial photography and/or satellite imagery) will be useful or essential as a data source for assessing several measures concerning lake vegetation and wetlands. Littoral wetlands in the KCOL have been mapped most recently by the FWC Aquatic Plant Research group in cooperation with the SFWMD Lake and River Sciences (LARS) Division and these maps (to be complete for all 19 water bodies in the KCOL in 2011) can serve as the major source of data regarding lake littoral vegetation in the region. Wetlands in the area have also been mapped by the SFWMD under its Land Cover/Land Use (LC/LU) Update Program, and by the USFWS under the National Wetlands Inventory (NWI). However, neither of these mapping programs provide up-to-date data detailed enough for the current application.

FWC/LARS littoral maps of lakes in the basin are based on 2009 aerial imagery and are expected to be updated periodically based on need and funding availability at the two agencies. Larger lakes (e.g., Lakes Tohpekaliga, East Tohopekaliga, Kissimmee, Hatchineha, and Cypress) will likely be updated as often as every three years because of wider interest in their status, while smaller lakes may have much longer update cycles.

Vegetation was delineated based on a classification system originally developed by FWC in 2005, and enhanced and extended in cooperation with SFWMD in 2010. This classification system is based on an FWC-modified version of the Florida Land Use/Land Cover Classification System (FLUCCS) specifically adapted for freshwater littoral vegetation. This modified classification system is referred to here as FWC Littoral FLUCCS (see Table 5.6). The FWC Littoral FLUCCS classification system is suitable for most of the metrics described in the habitat and vegetation measures (Appendix J).

As a potential source of pre-development reference conditions, black-and-white aerial photography exists for portions of South Florida prior to KCOL regulation (e.g., from the 1940s and 1950s). This imagery largely covers the KCOL region and is in digital form in the SFWMD LARS imagery library. However, it is not geo-referenced, so it cannot be overlain on other imagery or maps of the region for direct comparison. A project to geo-reference these data has been discussed internally and with the USGS, but funding is not currently available to do this work.

Table 5.6 – Categories applicable to Kissimmee Chain of Lakes vegetation from the FWC Littoral FLUCCS Classification System

1000 UPLAND
5000 WATER
5200 Lakes (Open Water)
6000 WETLANDS
6100 Wetland Hardwood Forests 6181 Willow **6300 Wetland Forested Mixed** 6301 Other Wetland Forest
6400 Vegetated Non-Forested Wetlands When the community is 66 percent or more dominated by a single species or community, one of the following Level IV classifications is used. 6412 Cattail (*Typha*) 6413 Spikerush (*Eleocharis*) 6414 Maidencane / Egyptian Paspalidium (*Panicum hemitomon* and/or *Paspalidium geminatum*) 6417 Freshwater Marsh with shrubs, brush, and vines (shrubs/brush (e.g., buttonbush (*Cephalanthus*), primrose willow (*Ludwigia*), wax myrtle (*Myrica*), willow (*Salix*)), often combined with a mixture of other non-forested wetland classes) 6419 Smartweed (*Polygonum hydropiperoides*) 6420 Pickerelweed / Arrowhead (*Pontederia*, *Peltandra*, and/or *Sagittaria*) 6421 Bulrush (*Schoenoplectus* (syn. *Scirpus*)) 6423 Torpedograss (*Panicum repens*) 6424 Water primrose / Knotweed (*Ludwigia* and/or *Polyonum densiflorum*) 6425 American cupscale grass (*Sacciolepis*)

6426 Other Freshwater Marshes (Dominant plants that are either not recognizable or not defined in this classification system)

6440 Emergent Aquatic Vegetation

This category of wetland plant species includes both floating vegetation and vegetation which was found either partially or completely above the water surface.

When the community was 66 percent or more dominated by a single species by cover, one of the following Level IV classifications was employed.

6442 Spatterdock (*Nuphar*)

6445 Water Lily, Banana lily (*Nymphaea* and/or *Nymphoides*)

6446 Lotus (*Nelumbo*)

6450 Submerged Aquatic Vegetation

This category includes vegetation which is completely submerged below the water surface during imagery acquisition. Due to imagery constraints, not all submerged aquatic vegetation can be mapped. Where visible on the imagery it is classified as 6450.

Mixed Community Classes

This category depicts certain classes that are commonly found grouped together in a mixed community. When two species combined were greater than 66% dominant but neither species alone was greater than 66 percent dominant, then a mixed classification was applied. The following level IV classification was applied.

6412-6420 Cattail, Pickerelweed / Arrowhead

6412-6421 Cattail, Bulrush

6412-6414 Cattail, Maidencane / Egyptian Paspalidium

6412-6442 Cattail, Spatterdock

6413-6420 Spikerush, Pickerelweed / Arrowhead

6414-6420 Maidencane / Egyptian Paspalidium, Pickerelweed / Arrowhead

6414-6421 Maidencane / Egyptian Paspalidium, Bulrush

6414-6442 Maidencane / Egyptian Paspalidium, Spatterdock

6414 -6446 Maidencane / Egyptian Paspalidium, Lotus

6419-6423 Smartweed, Torpedograss

6420-6421 Pickerelweed / Arrowhead, Bulrush

6420-6423 Pickerelweed / Arrowhead, Torpedograss

6420-6424 Pickerelweed / Arrowhead, Water primrose / Knotweed

6420-6442 Pickerelweed / Arrowhead, Spatterdock

6421-6424 Bulrush, Water primrose / Knotweed

6421-6442 Bulrush, Spatterdock

6424-6425 Water primrose / Knotweed, American cupscale grass

6424-6442 Water primrose / Knotweed, Spatterdock

6440-6410 Mixed Community (mixture of defined classes, but not dominated by a defined mixed class community)

Vegetation Community Field Data

Post-regulation littoral vegetation data were collected for a number of KCOL lake studies in the 1990s (Egbert 1995, 1996, 1998, Moyer et al. 1995) as pre-project data to assess the effects of various KCOL restoration or enhancement projects. Pre-enhancement vegetation data exist for Lake Kissimmee (Allen and Tugend 2002, Florida Game and Fresh Water Fish Commission 1995, Tugend and Allen 2004), Lake Toho (Butler et al. 1992), Cypress Lake and Lake Hatchineha (Hulon et al. 2000), and other Florida lakes (Canfield and Hoyer 1992, Canfield et al. 1984, Champeau and Furse 2003, Clugston 1963, Conrow and Stenberg 1994, Gregory et al. 1990, Kitchens et al. 2002, Williams 1988). None of these sources represents a long-term view of post-regulation conditions, but many indicate overgrown littoral zones with layers of accumulated organic material prior to enhancement.

Florida LAKEWATCH has collected vegetation data at a number of KCOL lakes at varied intervals since 1993. These lakes are East Toho, Toho, Hatchineha, Kissimmee, Alligator, Brick, Center, Coon, Lizzie, and Trout. Data collection has been at an approximately two to four year intervals. The LAKEWATCH vegetation data include absolute frequency by species, percent area covered (PAC) by aquatic vegetation, percent of lake volume infested (PVI) with submergent vegetation, average emergent plant biomass, average floating-leaved plant biomass, average submerged plant biomass, average width of the emergent and floating-leaved zone, and average lake depth (Florida LAKEWATCH 2009).

LAKEWATCH data may provide a picture of changing lake vegetation conditions in the KCOL since 1993. However, uncertainties surrounding the availability and sampling interval of this program limits its use as a long-term data source. The KCOL LTMP Conceptual Ecological Model (CEM) peer review panel (Havens et al. 2005a) recommended against reliance on this data stream for LTMP vegetation monitoring, specifically because of the unknown status and frequency of future LAKEWATCH data collection. A contractual arrangement with LAKEWATCH could ensure that data are collected in a systematic fashion at a determined sampling interval. If needed, metrics might be added to meet the requirements of performance measures that will require detailed ground vegetation data, such as the Fish and Wildlife Littoral Habitat performance measure.

The FDEP has inventoried aquatic vegetation in most of the KCOL annually since 1982. The FDEP data provide coarse estimates of whole-lake areal coverage of many common aquatic species, but are not well-suited to estimating plant community changes, the suitability of specific littoral areas as animal habitat, or conditions in these littoral zones.

Lake Littoral Zone Organic Sediment Data

Information on the extent and depths of muck sediment in lake littoral zones is necessary for determining the quality of habitat within lake littoral zones. It is also critical for establishing baseline conditions and subsequent accumulation rates of organic sediments.

The most thorough evaluation of organic sediments in the KCOL has been presented by Hoyer et al. (2006, 2008). Their study focused on investigating the possibility of nutrient leaching from muck islands created during a lake enhancement project conducted in Lake Toho in 2004. The muck removal project involved drawing down the lake far enough to dry out the vegetated areas and then scraping off the plants and dead organic material with heavy equipment. Most of this material was heaped in large piles in shallow parts of the lake to form 29 artificial islands. The study found that nutrient leaching from these islands, if it occurred, had no statistically significant impact on the chemistry of water in the vicinity. Although total phosphorus, phytoplankton chlorophyll, and color increased, and dissolved oxygen decreased, at open water stations in the two years following muck removal, these changes were attributed, at least in part, to three hurricanes with heavy rainfalls that passed over the area immediately following the muck removal project's completion. Regardless of whether these water quality changes were caused by muck scraping, hurricanes, or both, the impacts were relatively short-lived (approximately 2 years). Hoyer et al. also collected 145 sediment cores from scraped areas around the islands to determine the thickness of organic sediment. They found that scraping reduced the average thickness of organic materials from 46 cm to 1.6 cm. This result indicates that the scraping project was effective. The sediment core data also provide essential baseline information for future determination of the rate of organic sediment accumulation in Lake Toho. Similar surveys of sediments should be conducted as future KCOL enhancement projects are considered.

Invasive Plant Distribution and Abundance Data

The FWC's Aquatic Habitat Restoration/Enhancement Section (AHRES) manages floating plants, water hyacinth, water lettuce, hydrilla, Wright's nut-rush (*Scleria lacustris*), wild taro (*Colocasia esculenta*), and torpedo grass (*Panicum repens*) on all C&SF Project water bodies with the exception of Lakes Preston, Joel, and Myrtle. Table 5.7 provides 2007 estimates of invasive plant coverage in the KCOL, annual treatment cost allocations, and the historical maximum extent of hydrilla coverage (High Acres). Appendix F presents maps of hydrilla infestation for Lake Toho (2001–2007); Cypress Lake (2005, 2007); Lake Hatchineha (2005, 2007), and Lake Kissimmee (2006, 2007).

Water hyacinth, water lettuce, and other floating plants are the AHRES's highest priority and are managed to prevent them from blocking navigation and access, clogging flood control structures, covering or displacing valuable fish and wildlife habitat, accelerating sedimentation, and harboring mosquitoes. Hydrilla is AHRES's second management priority and is managed to control plant coverage and expansion into new water bodies. Hydrilla is the most abundant invasive aquatic plant in the KCOL waters, with tubers (underground plant structures that serve as reproductive and food reserves) infesting about 45,000 acres (approximately 70%) in the four lakes from Lake Toho through Lake Kissimmee. Shoreline invasive emergent plants (Wright's nut sedge, wild taro, and torpedo grass) are technically and logistically challenging to control and eradication is impossible in most cases. These species are managed to maintain the heterogeneity of littoral wetlands and to provide habitat for a broad range of bird species. Treatment is complicated by irrigation restrictions for some of the more effective herbicides and the plants' ability to survive in shallow waters or in moist to dry soils. In addition, plants, such as torpedo grass, grow on state-owned lands as well as adjacent private properties. This situation can reduce the effectiveness of management efforts because uncontrolled weeds on private properties can quickly reinfest managed lake habitats.

Table 5.7 – Invasive plant coverage management cost, and management goal.

Water Body	Invasive Plant	2007 Coverage (Acres)	Management	2007 Allocation ($)	High Acres
Alligator Lake	Para Grass	7.0			
	Wild taro	1.0			
	Water hyacinth	0.6	maintenance	2,800	
	Hydrilla	0.4	eradicate	7,000	2
	Torpedo grass	625	maintenance	17,000	
	Tussocks	5.0	maintenance	750	
Brick Lake	Para Grass	7.0			
	Water hyacinth	1.5	maintenance	700	
	Torpedo grass	6.0			
Lake Center	Para Grass	0.3			
	Water hyacinth	0.1	maintenance	2,800	
	Wild taro	0.1			
	Hydrilla	0.0			0.2
	Torpedo grass	2.0			
	Tussocks	5.0	maintenance	750	
Coon Lake	Para Grass	0.1			
	Wild taro	0.7			
	Water hyacinth	0.1	maintenance	2,100	
	Hydrilla	0.1	eradicate	2,200	3
	Torpedo grass	1.2			
	Tussocks		maintenance	1,500	
Cypress Lake	Water hyacinth	6.0	maintenance	21,000	
	Hydrilla	2,100	large-scale	1,197,200	3,200
	West Indian marsh grass	6.0	maintenance	7,500	
	Water lettuce	2.0	maintenance	21,000	
East Lake Tohopekaliga	Para Grass	200			
	Wild taro	22			
	Water hyacinth	7.0	maintenance	28,000	
	Hydrilla	5.0	eradicate	13,500	25
	Hygrophila	85	maintenance	10,500	
	Torpedo grass	900			
	Water lettuce	3.0	maintenance	28,000	
Lake Gentry	Para Grass	2.0			
	Water hyacinth	0.3	maintenance	1,400	
	Hydrilla	80	maintenance	21,000	90
	Hygrophila	1.0			
	Torpedo grass	17	access	1,700	
	Water lettuce	0.1	maintenance	1,400	
	Tussocks		maintenance	3,000	
Lake Hart	Para Grass	20			
	Wild taro	0.1			
	Water hyacinth	0.1	maintenance	2,800	
	Hydrilla	0.1	eradicate	700	0.1

Water Body	Invasive Plant	2007 Coverage (Acres)	Management	2007 Allocation ($)	High Acres
	Torpedo grass	60			
	Tussocks		maintenance	750	
Lake Hatchineha	Para Grass	5.0			
	Wild taro	2.0			
	Water hyacinth	0.5	maintenance	35,000	
	Hydrilla	625	maintenance	429,200	4,300
	West Indian marsh grass	1.0	maintenance	2,000	
	Torpedo grass	15			
	Water lettuce	0.2	maintenance	35,000	
	Wright's nut sedge	25	maintenance	3,750	
	Tussocks		maintenance	33,000	
Lake Kissimmee	Para Grass	80			
	Wild taro	3.8			
	Water hyacinth	75	maintenance	168,750	
	Hydrilla	1,100	maintenance	709,035	7,900
	West Indian marsh grass	25	spot	300	
	Torpedo grass	325			
	Water lettuce	25	maintenance	168,750	
	Wright's nut sedge	10	maintenance	1,500	
	floating islands		maintenance	100,000	
Lake Lizzie	Para Grass	0.4	eradicate	1,400	
	Wild taro	0.6	maintenance	650	
	Torpedo grass	36	maintenance	1,750	
	Tussocks		maintenance	750	
Lake Mary Jane	Water hyacinth	0.1	maintenance	11,100	
	Torpedo grass	10			
	Tussocks		maintenance	10,000	
Trout Lake	Para Grass	0.2			
	Wild taro	1.7			
	Water hyacinth	0.1	maintenance	5,600	
	Hydrilla	0.3	eradicate	700	0.3
	Torpedo grass	0.5			
	Water lettuce	2.0			
Lake Tohopekaliga	Para Grass	150			
	Wild taro	32			
	Water hyacinth	42	maintenance	70,000	
	Hydrilla	13,500	maintenance	1,750,000	15,580
	Hygrophila	40			
	Torpedo grass	1,100	maintenance	30,000	
	Water lettuce	14	maintenance	70,000	
	Tussocks		maintenance	12,599	

FWC management is based on field evaluation methods used to define a strategy for annual management responses. To support its control programs, the FDEP funds annual monitoring of hydrilla. Because of hydrilla's aggressive growth habits, a population can expand from moderate subsurface abundance to extreme and harmful coverage at the water surface within a single season. Traditional measures of abundance (e.g., surface cover), if used inappropriately, may give little indication of the actual scope of a hydrilla infestation or its potential for expansion. Assessment of hydrilla requires an adaptive approach subject to frequent expert assessment and rapid responses based on timely information.

Metrics currently used for estimating hydrilla abundance in the IPMS's monitoring program are biocover (lake area covered by hydrilla) and biovolume (volume of the lake's water column filled with hydrilla). The IPMS's preemptive, adaptive approach involves evaluation of subsurface cover and volume to estimate surface canopy extents before plants reach the surface. Especially at high levels, hydrilla can negatively impact native populations of plants and animals; can cause wide fluctuations in dissolved oxygen levels, pH and surface water temperatures; and can impair navigation, flood control, water storage and recreational activities.

The IPMS's data will be used by the LTMP as the primary indicators of hydrilla abundance and potential for expansion. Additional metrics may be monitored by the IPMS, such as estimates of turion abundance in the lake bed, estimates of areal distribution, or comparisons of areal change over time. Although historical hydrilla data may provide a view of the increasing abundance of hydrilla in some KCOL lakes and may be useful in interpreting data collected on other ecosystem components, past data are not needed for ongoing control efforts. These efforts must be guided by timely data, usually collected within the same growing season as the planned treatment. A working group composed of biologists and water managers, led by the IPMS and composed of representatives from the SFWMD, FWC, and USACE, will annually determine monitoring needed to estimate hydrilla abundance, review control methodology, and determine appropriate management responses.

Watershed Wetlands Data

Wetlands within the KCOL watershed represent an under-studied and poorly-monitored water resource. These wetlands provide important services and functions including stormwater attenuation, water quality improvement, groundwater recharge, green space, and wildlife habitat. On-going SFWMD research in the basin is monitoring vegetative and hydrologic changes in these wetlands using both stress indicators (soil subsidence, excessive leaf litter accumulation, etc) and aerial photography time series analysis. The collected/complied data is then used to perform multiple analyses/charaterizations for each wetland, including: 1) determination of the relationship between relative stage and vegetation community types, 2) recording vegetation community composition and change along the hydrologic gradient, 3) documenting the occurrence of speices of interest such as invasive, protected, or indicator species, and 4) recording hydrologic or vegetation changes through time. The developed database of wetland site assessments will record the state of and change in watershed resources throughout the KCOL.

Vegetation and Habitat Objectives and Assessment Targets

Table 5.8 lists LTMP management objectives and assessment targets related to vegetation monitoring programs. The targets are taken from the assessment performance measures in Appendix J. For the Fish and Wildlife Habitat measure (2-02), metrics are listed in place of assessment targets. The list of assessment targets for this measure is too lengthy to present in this table. Refer to Measure 2-02 in Appendix J for a complete listing of these habitat targets.

Table 5.8 – Vegetation and habitat management objectives, assessment targets, and associated monitoring programs.

Management Objective	Assessment Target	Measure	Lake	Resource Maintenance or Enhancement	Monitoring Program	Monitoring Status	Agency
Sustain and/or enhance the quantity and quality of watershed wetlands throughout the UKB	No net loss in area and quality of palustrine wetlands in watersheds of each Lake Management Area.	2-01. Palustrine Wetlands (APM)	All lakes	Maintenance	Wetland monitoring using aerial imagery and ground-based data	Proposed	SFWMD
Conserve and/or enhance aquatic and littoral habitats.	Area of littoral habitat types (for waterfowl, snail kites, fish, amphibians, and reptiles)	2-02. Fish and Wildlife Habitat in Lake Littoral Zones (APM)	All lakes	Maintenance	Littoral monitoring using aerial imagery and ground-based data	Proposed; mapping and ground monitoring already planned for Kissimmee, Hatchineha and Cypress under SFWMD's Headwaters Revitalization Project	FWC, SFWMD
Promote plant diversity, quality of lake littoral substrate, and fish and wildlife productivity within lake littoral zones.	Percent cover of emergent and submersed plants (for snail kites, wading birds, waterfowl, fish, amphibians, reptiles, and apple snails)						
	Littoral plant species composition (for wading birds, waterfowl, snail kites, fish, amphibians, and reptiles)			Maintenance or Enhancement	Ground surveys of littoral vegetation and sediment		
	Depth of organic detritus and muck overlying sand substrate (for alligators and wading birds)						
Contain established invasive aquatic plnat populations at minimal levels that current technology, funding, and environmental and biological conditions will allow.	Management is based on monitoring of hydrilla abundance (cover and volume), but no assessment targets are specified. Hydrilla control depends on annual assessments by hydrilla working group led by FDEP.	2-03. Hydrilla Abundance and Management (AIM)	Lakes Toho, Kissimmee, Cypress, and Hatchineha	Enhancement	FDEP hydrilla monitoring program	Adequate program exists	FDEP

Birds

Bald Eagle Monitoring Data

No pre-regulation reference data are available for bald eagle reproduction within the KCOL. The earliest available data come from summaries of the field notes of G. Heinz, who monitored bald eagle nesting in the Kissimmee Basin from 1962–1971 (Shapiro et al. 1982). During 1962–1971, an average of 33.3 nesting territories/year was found within the UKB, but locations of individual nests were not reported. These years represent the time period when C&SF Project canals and water control structures were being constructed in the KCOL. It is also important to note that bald eagle populations were low in most areas throughout their range during this time due to eggshell thinning that resulted from exposure to DDT and other organochlorine pesticides (Buehler 2000).

In 1972, the FWC began annual, statewide monitoring of bald eagle nesting territories and nesting success. The number of bald eagle territories in Florida increased from the late 1970s through the 1990s before leveling off near 1,340 nesting territories during the 2008-2009 nesting season (FWC 2010). During 2000, 2001, 2002, 2003 and 2004, there were 90, 84, 95, 92 and 84 active nests, respectively, within 2 kilometers (km) of LTMP water bodies (Figure 5.11). In the KCOL, Lakes Kissimmee, Toho, and Hatchineha support the largest number of nests. Currently, Florida has the third-largest nesting population in the lower 48 states, and the KCOL supports an area of concentrated nesting within the state (FWC 2005a, FWC Eagle Nest Locator http://myfwc.com/eagle/eaglenests/Default.asp).

The existing FWC bald eagle monitoring program, which includes coverage of the KCOL region, is sufficient for tracking the number of eagle nests. No additional monitoring is needed. Status will be tracked using an annually updated, five-year moving average of active nests with 2 km of LTMP water bodies.

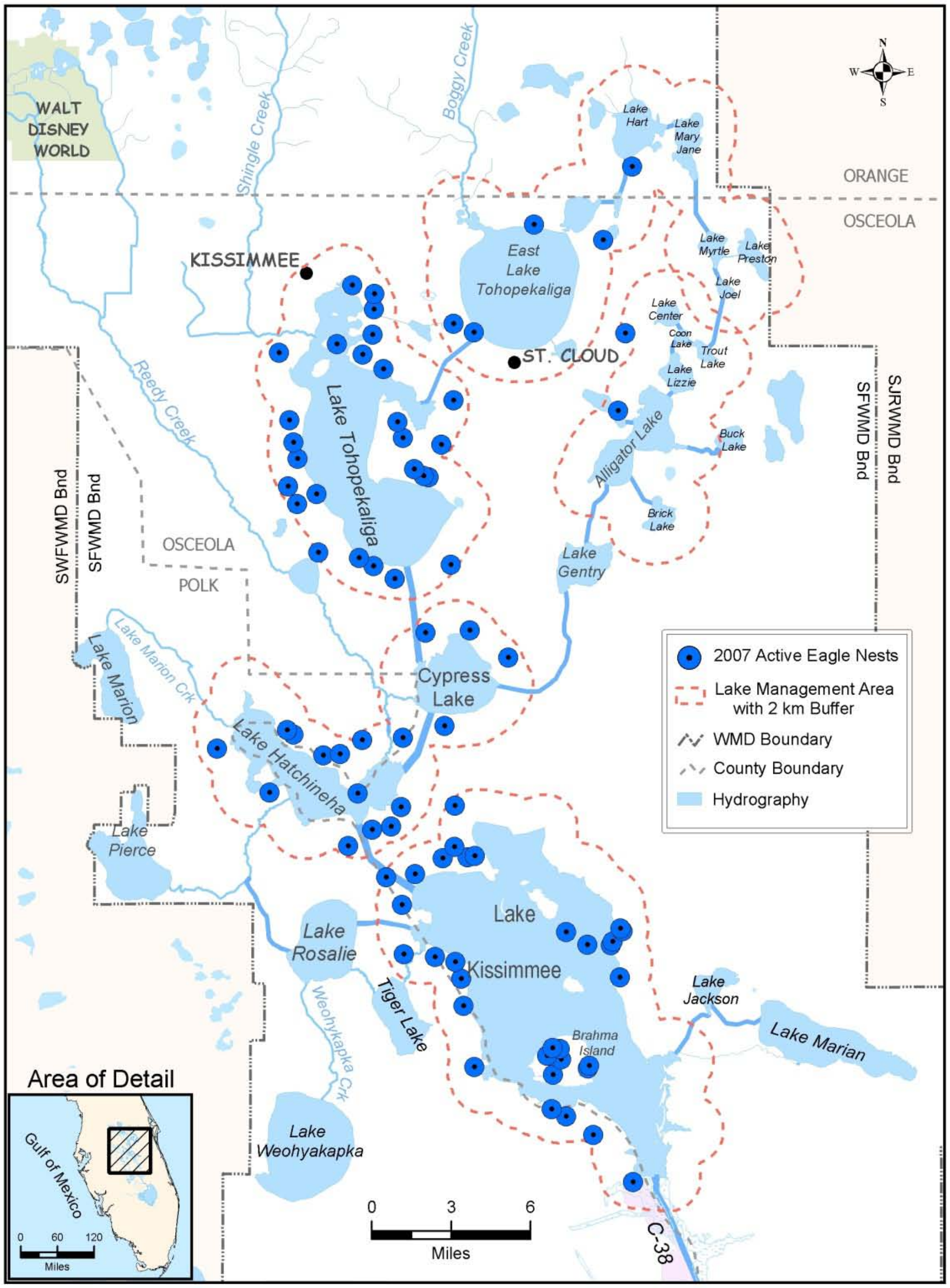

Figure 5.7 – Active bald eagle nests within 2 km of Kissimmee Chain of Lakes Long-Term Management Plan water bodies during 2007.

Snail Kites Monitoring Data

Snail kite nesting data are available from the FWC (1987–2001, James Rodgers) and the USGS/University of Florida (1996–2006, Wiley Kitchens). Both the FWC and USGS/UF data sets contain data on nest occurrence, location, fate, and productivity for the KCOL and other areas within the snail kite's range in Florida. Methods for nest surveying, detection, monitoring, and recording are described in more detail by Rodgers (2007) for the FWC data set. Snail kites require flooded conditions under nests for reproductive success. Therefore, active nests may be negatively impacted by receding water regulation schedules.

Both data sets are comparable, and include coordinates of each nest, the vegetation type that the nest was located in (substrate), a reference date (nest initiation date or nest check date), whether each nest was successful, and the number of young fledged from each nest. Minor differences in data collection and recording, such as differences in the frequency of nest checks, may result in slight differences or bias in nest success estimates, but the data used in developing the snail kite performance measure (Appendix J) were reduced to data that were comparable between the studies.

No nest data are available from some years for some lakes, and it is unclear whether this reflects a true absence of nests or a reduced nest searching effort that affected detection of nests in those years. To address this potential limitation, the performance measure focuses on the rate of nesting success, and success rates were calculated only for lakes and years in which at least four nests were reported with a known outcome.

The FWC and USGS/UF nest data were reduced to common and comparable data, which included nest location, year, and number of young fledged (Appendix G). Nest success was summarized within each lake of the KCOL within each year, and was calculated as the proportion of all active nests (nests with eggs) within each lake that fledged at least one young. The average nest success during years when there were at least four known-fate nests was 42, 45, and 34 percent for Lake Kissimmee, East Lake Toho, and Lake Toho, respectively. The snail kite performance measure presents a more detailed discussion of methodology and results from these studies.

The existing FWC snail kite monitoring program, which includes coverage of the KCOL region, is sufficient for tracking the number of kite individuals and nests. No additional monitoring is needed.

Wading Bird Monitoring Data

The presence or abundance of wading birds in the KCOL depends mainly on the amount and quality of foraging habitat. The abundance and species of wading birds present in a particular foraging patch can be influenced by regional factors, such as recruitment and post-juvenile dispersal from distant breeding colonies, an influx of seasonal migrants from more northern latitudes, large-scale weather patterns, and degradation or loss of adjacent foraging habitat (Coffey 1943, 1948, Melvin et al. 1999, Frederick and Ogden 2001, Fasola et al. 1996). Local factors affecting wading bird foraging are more readily measured and include area of wetlands and lake littoral zones, water depths, aquatic plant species diversity and percent cover, patch size of vegetated and open water areas, presence of tussocks, organic content of foraging substrate, and prey biomass (Kushlan 1978, Gawlik 2002). These factors may be affected by proposed lake management activities (Johnson et al. 2007).

Although information on habitat and resource use patterns for wading birds is available from many studies (Brush 2006, Gawlik 2002, Kushlan 1981, Strong et al. 1997, Weller 1995), little information exists on the long-term use of the KCOL system by foraging wading birds. Some data on the use of the Lake Toho littoral habitat by foraging wading birds are available in Brush (2006). The targeted values in the Fish and Wildlife Littoral Habitat performance measure are based on information from that study, which is being funded by the FWC (Appendix L). Florida's resident population of wading birds is augmented by migratory birds from more northern latitudes (especially the Atlantic coastal populations) during the months of October–March (Hancock and Kushlan 1984, Palmer 1962). Central Florida lakes and wetlands, including Lake Toho, are important to both resident and migrant wading birds that disperse into the state during the winter. Table 5.9 presents wading bird densities for Lake Toho. Tricolored herons were present in higher numbers than other birds measured in Lake Toho. Data for other lakes within the KCOL does not exist.

Table 5.9 – Mean wading bird densities in 26 transect across 2,228 hectares of littoral habitat on Lake Tohopekaliga based on Brush 2006.

Species	**Mean Density** (birds/km^2)
Great egret	1.8
Little blue heron	1.5
Tricolored heron	4.0
Glossy ibis	2.6

Note: Target population levels are greater than or equal to the mean, while unacceptable population levels are below the mean (Source: FWC).

The LTMP proposes that nesting success of wading bird colonies on individual lakes depends on quality and quantity of foraging habitat. Good quality foraging habitat should improve foraging success rates, which ultimately would result in higher nestling survivorship and fledging rates. Without suitable foraging habitat, wading birds cannot access the food resources of a wetland and provide nourishment for their nestlings. Changes in density and species richness may reflect changes in quality of littoral zone habitats and the ecotone between them and the surrounding upland habitats. These changes also may be an effect of accessibility to prey due to water depth and fluctuation. One controlled study conducted by Gawlik (2002) showed that bird density and prey density can be positively related, however, the relationship was also affected by water depth. In addition to assessment targets for wading bird foraging habitat, the LTMP proposes target population values for select species of wading birds that may serve as a substitute for area of foraging habitat.

Existing wading bird monitoring programs are not sufficient for tracking populations of interest. Additional monitoring programs are needed to assess the current and future status of these speices. In addition, nesting/roosting colonies such as the colony at Lake Mary Jane should be consistently monitored. Measurements should include number of colonies and number of nests by species.

Waterfowl Monitoring Data

The species and numbers of waterfowl within a given area can be strongly influenced by external factors, such as reproductive output on northern breeding grounds, weather, and the availability of quality habitat elsewhere (Bellrose 1980). Thus, current local waterfowl populations are not necessarily indicative of the current quality of local habitat. Characteristics of high-quality waterfowl habitat are well known, however (Chamberlain 1960, Gray 1993, Weller 1999). Water depths, plant species, and the arrangement and percent coverage of plants relative to open water are all key determinants of the suitability of habitat for waterfowl (Chamberlain 1960, Bellrose 1980, Weller 1999). While the characteristics of high-quality waterfowl habitat are known, the amount of habitat needed to consistently attract and support a population of waterfowl is less well understood.

The Midwinter Waterfowl Inventory (MWI) is an aerial survey designed to determine numbers and distribution of waterfowl (ducks, geese, and coots) over traditional areas of concentration. Biologists throughout the United States fly in fixed-wing aircraft to conduct the survey each year during early January. The MWI in Florida is a statewide survey of only traditional waterfowl concentration areas and does not provide estimates of the entire wintering duck population. Birds using smaller or less conspicuous and discrete wetlands are not counted. For a number of reasons, changes in the MWI counts may not reflect real year-to-year changes in actual population size. Changes in habitat conditions within and outside of Florida, bird distribution within and outside of Florida, personnel involved in the survey, and survey effort are among the sources contributing to temporal variation in these data (Eggeman and Johnson 1989). Because of the lack of representative sampling and within-year replication, no statistical measures of reliability are available for data from the MWI. Within the KCOL, MWI data are available for Lake Kissimmee, Lake Toho and East Lake Toho from 1973–2003, and for Lake Hatchineha and Cypress Lake from 1994–2003. The FWC, which was primarily responsible for Florida's MWI, stopped participating in this survey after 2003 because of budget reductions. Therefore, no MWI data exist for the KCOL after that time.

Existing waterfowl monitoring programs are not sufficient for tracking populations of interest. Additional monitoring programs are needed to assess the current and future status of these speices.

Crane Monitoring Data

Long-term recruitment surveys in north and central Florida show a decline in numbers of Florida sandhill cranes, likely associated with habitat loss and recurring droughts (FWC, unpublished data). From 1974 and 2003, suitable habitat in Florida declined an average of 16.6 percent during each of the 10-year increments (Nesbitt and Hatchitt 2008). In Osceola County, this problem is most prevalent at the north end near Kissimmee and St. Cloud. Cranes will inhabit developed land and are highly visible in urban areas. It is suspected that these habitats are not conducive to a self-sustaining population due to the increased mortality associated with a higher density of roads, power lines, fences, and human debris, all of which have been identified as sources of mortality for urban cranes (Folk et al. 2001). There have been comprehensive studies of Florida sandhill cranes, but only in rural settings. A dedicated study is needed to determine the effects of human development and habitat conversion on cranes to better anticipate and manage for the long term existence of the birds.

Cranes will nest in littoral zones of lakes, especially during drought when isolated marshes are not available for nesting. The FWC has not conducted surveys to determine the importance of lake edges as crane nesting habitat, but several opportunistic observations indicate that lakes may be more important than previously known. In 2002, more than 200 sandhill crane nests were observed on Lake Tohopekaliga (Personal communication, Janell Brush). These nests were mainly in beds of pickerelweed; this plant and maidencane are the primary plants in which Florida sandhill cranes build their nests. During drawdown and demucking of central Florida lakes, these mats of pickerelweed are largely removed, effectively reducing the crane nesting habitat proportional to the amount of pickerelweed removed. In future management of central Florida lakes, consideration should be given to leaving some pickerelweed to serve as sandhill crane nesting habitat. In drought years, this may be the only nesting habitat available to the birds.

Avian Management Objectives and Assessment Targets

Table 5.10 lists LTMP management objectives and assessment targets related to avian monitoring programs. The targets are taken from the assessment performance measures in Appendix J.

Table 5.10 – Avian management objectives, assessment targets, and associated monitoring programs.

Management Objective	Assessment Target	Measure	Lake	Resource Maintenance or Enhancement	Monitoring Program	Monitoring Status	Agency
Protect lake-associated listed species.	3-year running average of active bald eagle nests within 2 km of all LTMP water bodies will be ≥ 81. Lakes Kissimmee, Hatchineha, and Cypress: >50 nests; Lake Toho: > 26.4 nests, East Lake Toho, Fells Cove, Lakes Ajay, Hart, Mary Jane, Joel, Myrtle, and Preston:: >2.7 nests; Alligator Chain of Lakes: >= 2 nests	3-01. Number of Bald Eagle Nests (APM)	All lakes	Maintenance	Bald eagle nesting surveys	Adequate program exists	FWC
Protect lake-associated listed species.	Nesting (containing eggs) within at least 2 of the 3 primary lakes, in at least 3 of every 5 years. 3-year moving average of total number of nests within the three primary lakes ≥37.8 (±27.4 SD), with lake-specific moving averages of ≥18.2 (±13.6 SD) (Lake Kissimmee), ≥19.3 (±16.6 SD) (Lake Tohopekaliga), and ≥2.2 (±2.6 SD) (East Lake Tohopekaliga). 5-year moving average nest success rate ≥ 0.88 (± 1.01 SD) fledglings/nest within at least 2 of the 3 primary lakes.	3-02. Snail Kite Nesting Success (APM)	TBD	Maintenance	Snail kite surveys	Snail kites surveyed on Lakes Kissimmee, Toho, and East Toho. Propose expanding monitoring to other lakes.	Multi-agency
Support life cycle requirements of KCOL-dependent fish and wildlife resources.	Indicator measure; no target has been set	3-03. Wading Bird Nesting Effort (APM)	All lakes	Maintenance	Wading bird nesting effort	Proposed	SFWMD
	Great egret = 1.8 ± 0.0011 birds/km² Little blue heron = 1.5 ± 0.0012 birds/km² Tricolored heron = 4.0 ± 0.0010 birds/km² Glossy ibis = 2.6 ± 0.0020 birds/km²	3-04. Wading Bird Abundance (APM)	Lake Toho	Maintenance	Wading bird population surveys	Proposed	FWC
	Indicator measure; no target has been set	3-05. Waterfowl Populations (AIM)	Lake Toho and Lake Kissimmee	NA	Waterfowl population surveys	Proposed	FWC

Fish and Aquatic Fauna

Largemouth Bass Monitoring Data

The FWC has long-term data sets (~20 years) on angler total catch (creel) for largemouth bass for Lake Kissimmee and Lake Toho. Data collection began in the late 1970s, and continues as part of the FWC's management strategy for game fish in the KCOL. Because the largemouth bass fisheries of both lakes are excellent and considered to be world class, the existing monitoring program is believed to be reliable for the purposes of the LTMP. These data will be used as the baseline and reference conditions for generating target values for angler total catch of largemouth bass, a recruitment model for largemouth bass, and size and age-0 distribution for largemouth bass APMs.

Tables 5.11 presents largemouth bass angler catch data for Lake Toho and Lake Kissimmee (FWC 2006a), which have similar catch rates. In recent years, Lake Toho catch rates have ranged from 16,000 to 50,000 fish over a 12-week period (Anderson and Neumann 1996). Catch rates were high in 2001–2002 and dropped in 2003–2005. The low numbers in 2003–2004 may have been due to the lake drawdown that limited fishing. The low numbers in 2004–2005 were likely due to habitat disruptions resulting from the 2004 hurricanes that resuspended bottom sediments, altered aquatic plant vegetation community structure, and likely led to reduced fishing effort. Lake Kissimmee largemouth bass catch rates have generally been good since 2003.

Table 5.11 – Angler total catch rate for largemouth bass on Lakes Tohopekaliga and Kissimmee (rate determined for a 12 week period).

Year	Lake Tohopekaliga	Lake Kissimmee	Year	Lake Tohopekaliga	Lake Kissimmee
1976		6,220	1992	15,946	31,297
1977	8,258	7,348	1993	12,173	
1978	10,309	3,808	1994	15,675	
1979	6,326	12,414	1995	24,665	
1980	7,583	15,771	1996	15,199	
1981	19,702	13,157	1997	16,339	
1982	19,364	22,793	1998	19,866	
1983	13,940	11,561	1999	26,951	
1984	9,009	17,107	2000	35,011	40,416
1985	6,917	24,609	2001	48,111	2,380
1986	5,988	12,581	2002	49,995	10,184
1987	4,533	13,568	2003	26,400	16,074
1988	11,390	29,096	2004	17,414	20,403
1989	23,188	24,176	2005	16,171	23,081
1990	10,110	22,791	2006		19,385
1991	14,607	19,707			
			Average 1976-2006	**17,626**	**17,497**

Littoral Fish Monitoring Data

Fish communities may be influenced by the variation in abundance and composition of aquatic plant species in the littoral zone (Hoyer and Canfield 1996). Littoral vegetation provides refuge from predation, substrate for reproduction and increased invertebrate forage (Savino and Stein 1982, Shaeffer and Nickum 1986, Gladden and Smock 1990, Chick and McIvor 1994). In Florida lakes, fish species richness has been found to be positively related to littoral plant abundance (Bachmann et al. 1996). Furthermore, the relative complexity of vegetation types comprising the littoral aquatic plant community has been found to influence fish species richness based on its use by the varied life history stages of fishes. Gregory et al. (1990) found that maidencane (an emergent species) was important to larvae, while the highest numbers of juveniles were collected in emergent/floating leaved plant communities and lower numbers were collected in hydrilla and maidencane habitats. Many fish species typically inhabiting the littoral zone serve as prey for largemouth bass and other important game fish. Therefore, changes to fish assemblages associated with water management could potentially affect performance measures for largemouth bass.

The FWC has long-term, regulated-period data sets (~10 years) on fishes collected in the shallow, vegetated littoral zone for Lake Kissimmee and Lake Toho. Data collection began in the late 1970s and continued as part of the FWC's management strategy for game fish in the KCOL. Table 5.12 provides the average, minimum, and maximum biomass values for littoral fish caught in Lake Kissimmee and Lake Toho for 1974 through 1982 (FWC 2006b). The productivity of Lake Toho is approximately three times larger than Lake Kissimmee. No measurements are available for other lakes of the KCOL.

Table 5.12 – Lake Kissimmee and Lake Tohopekaliga littoral fish assemblage biomass (pounds/acre).

	Average Biomass	Maximum	Minimum
Lake Kissimmee	193	353	59
Lake Tohopekaliga	562	741	350

Table 5.13 presents species richness and diversity data for Lake Kissimmee and Lake Toho for 1981–1991 (FWC 2006b). Species richness is a measure of the number of species caught in the littoral zone during the surveys. Diversity is calculated using Shannon's Diversity Index, which measures the relative distribution of species in a population. For example, consider two hypothetical lakes. In lake one, 100 fish were caught during a sampling event, and there were 10 individuals from 10 species in that lake. In lake two, there were also 10 species, but in this lake, 91 were individuals of one species, and one individual of the remaining nine species. Lake one would have a higher diversity index than lake two. Lake Kissimmee and Lake Toho have similar values for species richness and diversity. As with littoral fish biomass, there are no data available for other KCOL lakes.

Table 5.13 – Lake Kissimmee and Lake Tohopekaliga littoral fish assemblage species richness and diversity.

	Lake	Average	Maximum	Minimum
Species Richness	Kissimmee	24	28	20
	Tohopekaliga	27	30	23
Diversity	Kissimmee	2.9	3.5	2.1
	Tohopekaliga	3.0	3.9	2.3

Since the early 1990s, data collection for the FWC monitoring program has not occurred on an annual basis. Monitoring is needed to assess characteristics of KCOL littoral fish species, including: fish density, biomass, diversity, and species richness. In addition, habitat data should be collected in conjunction with the fish data to accurately assess habitat needs of the littoral fish assemblages.

Amphibians and Reptiles Monitoring Data

No existing or previous long-term monitoring projects exist for amphibians or reptiles on the KCOL. Some data on the occurrence of various amphibian and reptile species on Lake Toho are available from Muench (2004). Other records documenting the occurrence of amphibians and reptiles within the KCOL can be found in the Florida Museum of Natural History, University of Florida, inventory compiled by Dr. Kenney Krysko, who is the collection manager for the museum's Division of Herpetology. Information on the distribution and habitat preferences of amphibians and reptiles within the KCOL can be found in Tennant (1997) and Bartlett and Bartlett (1999).

Post-regulation schedule data on alligator populations are available for several lakes in the KCOL. Alligator population surveys are conducted on public waterways annually throughout Florida by FWC staff. Survey data are available for Lakes Kissimmee (1991–present), Toho (1995–present), Hatchineha (1988–present), and East Lake Toho (2003–present) and Cypress Lake (2000 and 2005). Alligator counts for the Lake Kissimmee, Lake Toho, and Lake Hatchineha are presented in Table 5.14 (Personal communication, Arnold Brunell, FWC). Data will be provided at a later date for Cypress Lake and East Lake Toho.

Table 5.14 – Alligator counts for selected Upper Kissimmee Basin lakes.

Lake	Years Measured	Age Class	Initial	Current
Kissimmee	1991 – 2006	Total	4,497	10,344
		> 6 foot	2,549	1,780
Hatchineha	1988 – 2006	Total	1,214	4,485
		> 6 foot	394	928
Tohopekaliga	1995 – 2006	Total	2,754	5,414
		> 6 foot	724	1,558

The FWC has a number of population models that are used to determine the alligator population each year. When numbers increase the FWC allows individual alligators to be "harvested" from the system to maintain a population in any given year that is no more than 25 percent less than the initial population. If the measured population is 25 percent greater than the initial population, then the allowable harvest amount is increased to keep the population from getting too high.

Invertebrates Monitoring Data

Pre-regulation data on benthic macroinvertebrate community structure in the KCOL is limited, and it is currently unclear whether suitable reference sites exist for developing realistic performance measures for assessing responses to future changes in lake operational schedules. Other than apple snail investigations carried out by Phillip Darby (University of West Florida), much of the aquatic macroinvertebrate monitoring in the KCOL has been conducted by the FWC. Most studies (Butler et al. 1992, Moyer and Williams 1982, Williams et al. 1979) were conducted in conjunction with habitat restoration (lake drawdown) projects on Lakes Toho and Kissimmee and quantified aquatic invertebrates in littoral and/or limnetic habitats prior to and following habitat restoration.

No pre-regulation schedule data are available for density and distribution of native or nonnative apple snails within the KCOL. Post-regulation ecological studies of apple snails within the KCOL are limited to Lakes Kissimmee and Toho and will be used as a baseline measure for assessing responses resulting from changes in lake regulation schedules. These studies have focused on snail movement and survivorship during the extreme drawdown of Lake Kissimmee in 1996 (Darby et al. 2002, 2004) and long-term trends in snail density following the drawdown (Darby 2005).

Florida apple snails are sensitive to both habitat and hydrologic conditions and may be negatively impacted by water management actions resulting in inappropriate/undesirable water levels, timing, or transitions. Peak snail reproduction occurs during the dry season and receding water levels appears to promote egg production (Hanning 1979, Turner 1996). However, appropriate water levels (<2 feet but >4 inches) and slow recession rates (≤6 inches per 30 days) are important to maximize snail reproduction and prevent stranding. Timing, duration, and frequency of drydowns (May/June, <6-8 weeks, no more than every 2 to 3 years) are also important to maximize snail survival and recruitment (Darby et al. 2008). Additionally, rapid increases in lake levels can inundate egg masses and cause egg mortality, thereby influencing the density and distribution of apple snails. Such rapid increases in water depths during the snail's reproductive season should be avoided or kept to less than 3 inches whenever possible.

The habitat quality for apple snails is approaching ideal on Lake Kissimmee and there is significant egg production in areas where bulrush was recently planted by the FWC at the southern end of Lake Toho. In 1995, sampling performed at Brahma Island on Lake Kissimmee found apple snail densities of 1.0 snails/m on the north side and 3.0 snails/m^2 on the south side of the lake. At that time there was a high density of tape grass. In places where the drawdown in the mid-1990s consolidated organic matter, there is now abundant submerged aquatic vegetation and snails. In locations where torpedo grass or alligator weed is the predominant vegetation, there are no snails (Personal communication, Darby 2008). Conditions can change due to a wide variety of factors. Snail densities in many areas have been negatively impacted by extended drought and/or unseasonably high water. For example, in past years, record high stages in WCA-3A were sustained from the summer through early spring, negatively impacting apple snail egg production and contributing to the snail population plummeting in this area.

Exotic apple snails were first observed in Lake Toho in 2000–2001 in the Goblet's Cove area and are now present throughout the entire KCOL system. The distinctive pink egg mats were first spotted around the mouth of C-31 as it enters Lake Toho. There are more exotic snails in locations where the organic matter was scraped during the 2004 drawdowns than in locations where no scraping was performed. Based on exotic snail density monitoring conducted in 2008, the population has currently leveled off at 0.3 to 0.7 snails/m^2 in the Goblet's Cove area. Although concerns exist that exotic snails may outcompete native snails for food resources and habitat, there are no available data to support these claims. Currently, exotic and native snails reside within the same habitats in the KCOL (Darby personal communication).

Management Objectives and Assessment Targets for Fish and Other Aquatic Fauna

Table 5.15 lists LTMP management objectives and assessment targets related to monitoring of fish and other aquatic fauna. The targets are taken from the assessment performance measures in Appendix J.

Table 5.15 – Management objectives, assessment targets, and associated monitoring programs for fish and other aquatic fauna.

Management Objective	Assessment Target	Measure	Lake	Resource Maintenance or Enhancement	Monitoring Program	Monitoring Status	Agency
Support life cycle requirements of KCOL-dependent fish and wildlife resources.	Angler total catch for largemouth bass should not be < 17,500 bass caught during a 12-week period when averaged across 10 years.	4-01. Angler Total Catch for Largemouth Bass (APM)	Lakes Toho and Kissimmee	Maintenance	Creel surveys	Adequate program exists	FWC
Support life cycle requirements of KCOL-dependent fish and wildlife resources.	No target established; indicator measure	4-02. Recruitment Model for Largemouth Bass (AIM)	Lakes Toho and Kissimmee	Enhance	Electrofishing surveys	Adequate program exists	FWC
Support life cycle requirements of KCOL-dependent fish and wildlife resources.	In at least one of four years, at least 30% (± 8%) of largemouth bass will be in the 0-20 cm size class.	4-03. Size and Age-0 Distribution for Largemouth Bass (APM)	Lakes Toho and Kissimmee	Maintenance	Electrofishing surveys	Adequate program exists	FWC
Promote plant diversity, quality of lake littoral substrate, and fish and wildlife productivity within lake littoral zones.	Species richness and diversity of littoral fishes will be at least 27 (± 0.6) and 3.25 (± 0.12), respectively, when averaged over 10 years (Lake Toho). Species richness and diversity of littoral fishes will be at least 24 (± 0.9) and 2.89 (± 0.16), respectively, when averaged over 10 years (Lake Kissimmee). Biomass targets are yet to be determined.	4-04. Littoral Fish Assemblage Structure – Species Richness, Diversity and Biomass (AIM)	Lakes Toho and Kissimmee	Maintenance	Littoral fish surveys	Proposed	FWC
Support life cycle requirements of KCOL-dependent fish and wildlife resources.	No quantitative target established; abundance of selected amphibian and small reptile species should remain stable or increase on each lake selected for sampling.	4-05. Amphibian Abundance (AIM) 4-06. Small Reptile Abundance (AIM)	Lakes Kissimmee, Toho, Hatchineha, Cypress	Maintenance	Amphibian and reptile surveys	Proposed	FWC

Management Objective	Assessment Target	Measure	Lake	Resource Maintenance or Enhancement	Monitoring Program	Monitoring Status	Agency
Support life cycle requirements of KCOL-dependent fish and wildlife resources.	-Adult-size alligators ≥1,900 and recruitment-size alligators ≥3,500 (Lake Kissimmee) -Adult-size alligators ≥500 and recruitment-size alligators ≥900 (Lake Toho) -Adult-size alligators ≥250 and recruitment-size alligators ≥500 (Lake Hatchineha) -Targets for Cypress Lake and East Lake Tohopekaliga will be established after more survey data are collected	4-07. Alligator Abundance and Size Distribution (APM)	Lakes Kissimmee, Hatchineha, Cypress, Toho, and East Lake Toho	Maintain	Alligator surveys	Adequate program exists for Lakes Kissimmee, Hatchineha, and Toho; more data needed for Lake Cypress and East Lake Toho	FWC
Promote plant diversity, quality of lake littoral substrate, and fish and wildlife productivity within lake littoral zones.	>0.28 (+0.11) native snails/m² and 0 nonnative snails/m² (Lake Kissimmee) <0.18 (+0.16) nonnative snails/m² (Lake Toho)	4-08. Density of Native and Nonnative Apple Snails (APM)	Lakes Kissimmee and Toho	Enhance	Apple snail surveys	Proposed; expand monitoring to other lakes	FWC
Promote plant diversity, quality of lake littoral substrate, and fish and wildlife productivity within lake littoral zones.	No target established; indicator measure	4-09. Benthic Macroinvertebrates (AIM)	Lakes Kissimmee and Toho	N/A	Invertebrate surveys	Proposed	FWC

6
Proposed Adaptive Management Process and Management Framework

Introduction

This chapter presents the proposed adaptive management process and management framework for the LTMP. The adaptive management process defines a structured approach to decision making. The management framework defines the players, roles, responsibilities, and relationships required for successful implementation of the adaptive management process.

Adaptive Management

Adaptive management is a systematic approach for improving resource management by learning from management outcomes. It requires a set of clearly defined management objectives (Chapter 3) and associated targets (Chapter 5) that can be evaluated to determine whether the system is responding as expected. It also requires stakeholder participation to ensure support for management strategies, objectives, and targets. (Williams et al. 2007).

Figure 6.1 illustrates a general approach to adaptive management. A problem is identified and assessed and a management action is designed and implemented. Ecosystem response is monitored and evaluated to determine whether a given management action is producing the desired response and/or outcome. If the desired response and/or outcome are not achieved, the management action is adjusted. If that still does not produce the desired response and/or outcome, the process begins again with the assessment of why the desired response, outcome, or objective is not being achieved.

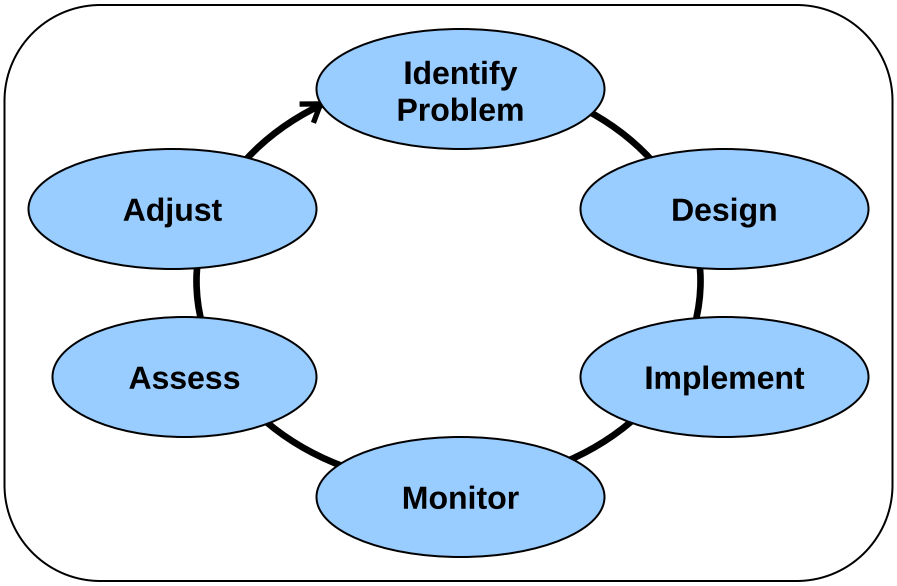

Figure 6.1 – Adaptive management process (Williams et al. 2007).

An adaptive management approach is being proposed for the LTMP because knowledge and understanding of the system is incomplete and data on the linkages between management actions and ecosystem responses are limited. It is also an appropriate approach because the stakeholders invested in the long-term health of these lake ecosystems represent a large and diverse group of interests.

Adaptive management, as proposed for the KCOL, is a mechanism for increasing the understanding of the lake ecosystems and reducing management uncertainty. The monitoring associated with both system assessment and ecosystem response to management practices described in the LTMP monitoring and assessment program (See discussion in Chapter 5) will be conducted annually to determine the state of each LMA ecosystem and the effectiveness of deployed management tools.

Adaptive management will be applied when ecosystem status indicates a need for management intervention or when management strategies are not working as intended. Once it is decided that the ecosystem response is different from the expectation, a new or modified management approach will be defined and presented to appropriate decision-making entities (See Table 6.1) for resource allocation and/or implementation. Details of how the adaptive management process will be applied are provided in the sections below.

Proposed management Framework

The management framework proposed for the LTMP intends to provide a coordinated, multi-disciplinary framework for achieving management objectives in the KCOL. The success of the framework will depend on the participants' ability to: 1) build partnerships between stakeholders, managers, and scientists; 2) obtain resource commitments and policy guidance from federal, state, and local partners; and 3) make science-based decisions on how to apply and/or modify management actions to meet stated management objectives.

To formally initiate the management framework and adaptive management process for the LTMP, plan partners will be requested to enter into memorandum of understanding with the SFWMD that explicitly defines how their partner agency intends to align their management policies, actions, and resources with the goals and management objectives of the LTMP. Through the memorandum of understanding plan partners will commit to the adaptive management process, acknowledge that uncertainty exists, and be willing to accept the risks associated with our limited knowledge and understanding of the system and the system's responses to management actions. The shared goal of plan partners is to sustain the KCOL ecosystems and dependent fish and wildlife resources through applied learning aimed at reducing risk and uncertainty through monitoring and assessment. Table 6.1 describes the players, roles, and responsibilities for the proposed management framework.

Figure 6.2 further categorizes the players into stakeholders, agency representatives, and decision makers. The stakeholders include the planners, regulators, and resource advocates. These players are in the field and are generally the first to see emerging issues and concerns or where current management tools are not well aligned with management objectives. For the management framework to work, the stakeholders must bring issues and concerns to the agency representatives.
The agency representatives are organized into two groups: the Interagency Team (IAT) and the Science Team. Agency representatives have primary responsibility for implementing the adaptive management process and management framework proposed in the LTMP. Agency representatives to the IAT and science team have formal roles and responsibilities for implementing the LTMP and aligning their agency's mandates and resources with the stated management objectives. This group includes at least one manager and scientist from each partner organization. The primary responsibility of the agency representatives is to ensure that management objectives are being met and/or adaptive management approaches are being applied to move in a positive direction towards meeting management objectives.

The IAT will be led by a coordinator/facilitator with primary responsibility for coordinating the interactions between the stakeholders, agency representatives, and decision makers and ensuring that the plan proposal is implemented as adopted by the plan partners. The science team will be led by a coordinating scientist appointed to oversee monitoring and assessment-related activities between the plan partners. The IAT is expected to meet quarterly and will consist of one or more representatives from each partner agency. The make-up of the IAT will change when new partner agencies join the management team. The science team will also meet quarterly and will consist of one or more representatives from each partner agency; however, the specific individuals representing those organizations will have a scientific focus rather than a management focus.

The decision makers include policy makers, agency implementers, and agency regulators. Decision makers have long-term responsibility for the management tool set. They have the authority to add and modify tools, allocate resources, initiate new projects and programs, and ensure compliance with laws and regulations.

Table 6.1 – Kissimmee Chain of Lakes, Long-Term Management Plan players, roles, and responsibilities.

Player	Role	Responsibility
Resource Advocate	Resource advocate	Promote issues and concerns to IAT.
Planners	Resource planner	Propose new or modify existing land development codes and ordinances to ensure consistency/compatibility with management objectives.
Environmental Resource Permit Regulators	Resource regulator	Ensure rules and regulations are implemented consistent with management objectives.
Interagency Team(IAT)	Resource manager	Identify management strategies to achieve assessment targets. Propose and/or modify management actions to address management concerns. Revise and/or identify new management objectives and assessment targets.
Science Team	Resource assessor/ evaluator	Collect and analyze data. Assess and report on ecosystem state. Assess and report on the effectiveness of management actions. Establish and/or modify assessment targets.
Policy Makers	Resource administrator	Establish/adopt policies that align with management objectives. Modify policies, rules, and regulations to improve management tool set Allocate resources.
Agency Implementers	Implementer	Initiate new projects, programs, rules, regulations, and policies and/or modify existing ones to fill management gaps. Allocate resources.
Regulators	Compliance officers	Ensure compliance with laws and regulations

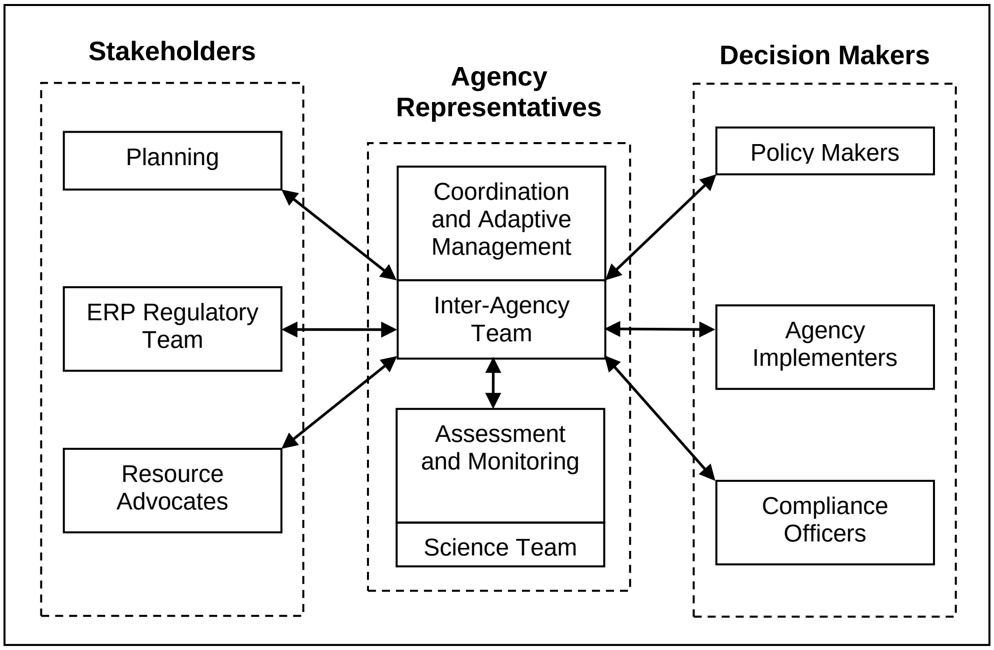

Figure 6.2 – Proposed management framework for the Kissimmee Chain of Lakes, Long-Term Management Plan.

Interactions between the stakeholders, agency representatives, and decision makers are shown in Figure 6.2. The IAT is shown as the focal point for interactions between the stakeholders, decision makers, and science team. The two-way arrows indicate that interactions should go both ways. The IAT should engage stakeholders, decision makers, and the science team, and the stakeholders, decision makers, and science team should engage the IAT.

For the proposed management framework to work, plan partners must be fully committed to the overall management strategy and there must be assurances between plan partners that appropriate resource allocations will be made to support implementation of the LTMP. This is especially important in regard to the IAT and science teams. If agency personnel are not formally assigned responsibilities associated with these roles, the adaptive management process cannot be implemented.

Proposed Adaptive Management Process

The proposed adaptive management process for the KCOL, shown in Figure 6.3, will follow the general principles of adaptive management illustrated in Figure 6.1. Once problems, issues, or concerns are identified by stakeholders or through the monitoring and assessment program, the IAT will be called to a "special session" to assess the problem (with input from the science team) and determine whether management actions are required. If management action is required, the IAT will promote their concerns and the technical basis for the proposed management action to the appropriate decision makers to gain authorization to allocate resources towards implementation of the proposed management action. The science team will then evaluate the uncertainties associated with both the problem and the management action and develop an appropriate set of monitoring criteria to support the assessment of the effectiveness of the management action. Ecosystem response will be monitored and evaluated to determine whether a given management action is producing the desired response and/or outcome.

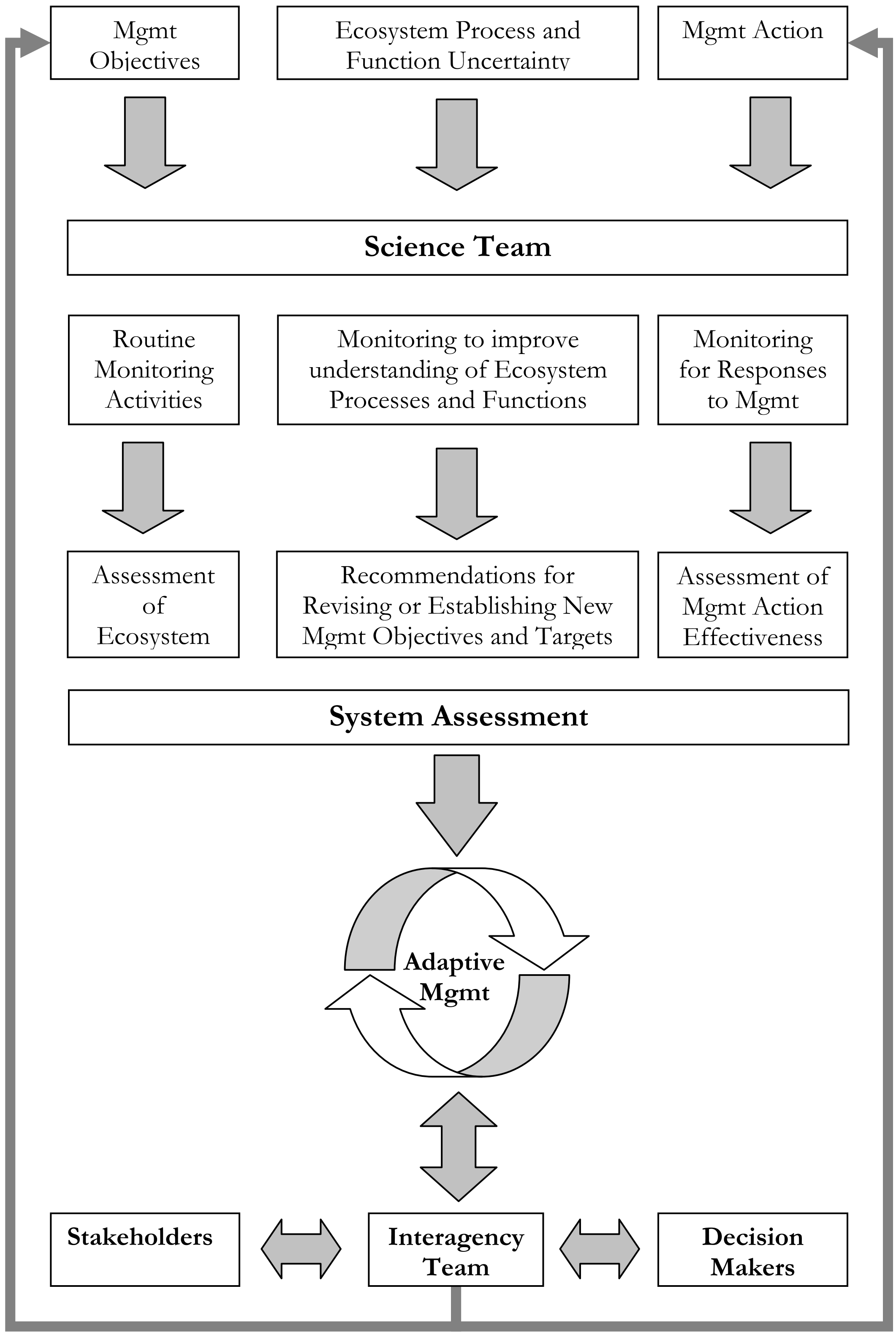

Figure 6.3 – Interaction between Proposed Monitoring and Assessment Program, Adaptive Management Process, and the Management Framework.

Implementation

A structured approach to decision making is critical to successful implementation of the LTMP because the resource management issues are complex and knowledge and understanding of both the system and the system's likely response to management actions is limited. The management objectives (Chapter 3) and assessment targets (Chapter 5) provide a shared vision of the desired outcomes stakeholders expect from management actions. The monitoring and assessment program described in Chapter 4 defines the three types of monitoring and assessment required to support adaptive management. The management framework defined in this chapter identifies the resources needed for successful implementation of the LTMP as well as the required interactions between agencies and players..

As implementation of the LTMP moves forward, it is critical for plan partners to understand, support, and be willing to allocate resources towards implementation of each of these components. Plan development that has been in progress since August 2003 has built the foundation for the coordinated, multi-disciplinary, multi-agency management framework described in this document. Continued support from these partner agencies is critical to plan success and for moving towards the goal of the enhancing and/or sustaining lake ecosystem health in the KCOL.

In addition to resource allocation, partner agencies need to commit to learning from management outcomes because they are not all likely to be desirable. To improve understanding of how the ecosystem responds to management actions and lay the foundation for improved management in the future, partner agencies must commit to learning from both desirable and undesirable management outcomes.

Maintaining Positive Relations between Partner Agencies

Coordinated, multidisciplinary, multi-agency management frameworks require positive relationships between agencies and agency personnel. Such relationships are established and maintained through open, honest, and respectful communication and shared values and goals. The plan development process established the foundation for positive partner relationships by developing shared management goals, objectives, and priorities. IAT meetings will be the mechanism for maintaining the open, honest, and respectful communication that built that foundation.

To maintain this positive work environment, quarterly IAT and science team meetings will be held. These meetings will provide a forum for the partner agencies to discuss issues related to implementation, to provide updates on projects and programs, and to discuss system assessment results and emerging issues and concerns. Additional meetings will be scheduled as needed to discuss specific implementation issues or concerns.

Special sessions will be called to discuss management actions or modifications to management actions. These IAT meetings will provide the forum for partner agencies to discuss and express concerns with proposed management actions. The IAT will be obligated in these special sessions to provide a means to move forward with addressing the management concerns. The science team will then meet to determine what additional monitoring and assessment is required to evaluate the effectiveness of the management action. This information will be brought back to the IAT if there are resource allocation issues that need to be discussed or resolved.

Partner agencies and the science team must recognize the time sensitivities associated with the proposed management actions and be willing to accommodate project schedules and deadlines. Partner agencies proposing management actions should also be sensitive to science team and IAT workloads associated with the proposed adaptive management process. Committing to the process means anticipating the increased work load and "bureaucracy" associated with the management framework and adaptive management process as a trade-off for the benefits provided by both.

Long-Term Manangement Plan Decision Making

The IAT has primary responsibility for managing the KCOL relative to the management objectives described in Chapter 3 and for applying the proposed adaptive management approach to move in a positive direction towards meeting those objectives. Decision makers have long-term responsibility for the management tool set. They have the authority to add and modify tools, allocate resources, initiate new projects and programs, and ensure compliance with laws and regulations. The IAT and decision makers will share responsibility for LTMP decision making. IAT decision making is limited to the authorities provided to the members of the team. Decisions requiring authorities greater than those of IAT members will be promoted to the appropriate decision makers. When a decision is promoted and involves multiple agencies, the IAT will facilitate the coordination of that decision between the agency decision makers.

Kissimmee Chain of Lakes Long-Term Management Plan Updates

LTMP updates will occur as part of a detailed 5-year review that will include updates to management objectives, assessment targets, the monitoring and assessment program, the management framework, and the adaptive management process. If more frequent changes are required, the IAT will collectively decide if the update is necessary. The 5-year review will include an independent peer review to augment the deliberations of the IAT.

7
Proposed Agency Action Plan

Introduction

This chapter presents the proposed agency action plan needed to move forward with the LTMP. Chapters 2 provided background on the basin. Chapter 3 identified the management objectives, concerns, targets, priorities, and challenges. Chapter 4 described the proposed monitoring and assessment program. Chapter 5 identified assessment targets and linked them to management objectives and existing and proposed monitoring and assessment activities. Chapter 6 proposed an adaptive management process for the KCOL and a management framework to support implementation of this process. This chapter describes a proposed four-part plan to align management policies, actions, and resources with management objectives.

Plan Proposal (a.k.a Proposed Path Forward)

The LTMP is a plan to enhance and/or sustain lake ecosystem health through interagency cooperation and coordination. Moving forward with the plan proposal means changing and adapting current management strategies to align them with the management objectives defined in Chapter 3. Because existing agency resources are already strained by current management responsibilities, a strategy must be deployed that maximizes the utility of existing resources and encourages the development of new partnerships and new approaches for addressing existing management concerns. The proposed agency action plan for the LTMP has four parts. The first formalizes the partnership between the participating agencies and stakeholders and allocates resources to core functions described for the proposed management framework and monitoring and assessment program. The second involves a commitment to work within and across agencies to fill management gaps. The third involves coordination within and across agencies in the development of the basin rule, statewide stormwater rule, and the Kissimmee Basin Water Reservation rule. The fourth involves commitment to seek funding for development of an integrated watershed management plan.

Part 1: Become a Plan Partner

The first step in implementing the LTMP is identification of plan partners and formalizing plan partner commitments in partnership agreements. Appendix B presents agency mission statements specific to the KCOL that have been approved by the various decision-making authorities. Each of these agencies participated directly in the development of the LTMP. To become a plan partner, each agency will need to enter into a memorandum of understanding with the South Florida Water Management District that explicitly defines how their agency intends to align their management policies, actions, and resources with the management objectives of the LTMP.

Partnership Requirements

Plan partners must be committed to the adaptive management process, acknowledge that uncertainty exists, and be willing to accept the risks associated with our limited knowledge and understanding of the system and the system's responses to management actions. The shared purpose of the partners must be sustainable ecosystems and achieving that purpose through applied learning aimed at reducing risk and uncertainty through monitoring and assessment. Plan partners are expected to:

> ***Adopt LTMP management objectives.*** Chapter 3 presented a set of shared management objectives identified by participating agencies during plan development. Plan partners are to formally adopt these management objectives and to agree to align agency management actions, policies, and resources with these management objectives.

> ***Allocate agency staff to serve on the IAT and science team.*** Agency representatives to the IAT and science team have formal roles and responsibilities for implementing the LTMP and aligning their agency's policies, actions, and resources with the management objectives. Each partner agency must be willing to identify at least one staff member and a backup to participate on the interagency team and at least one more staff member and backup to participate on the science team. These agency representatives will make up the management team and technical support for implementing the plan. They will need to rely on others within their agencies to assist on an as needed basis. The primary responsibility of the agency representatives is to ensure that management actions are aligned with management objectives and adaptive management approaches are being correctly applied.

> ***Allocate resources and/or realign current resources to support implementation of the LTMP monitoring and assessment program.*** Responsibility for implementation of the proposed program is shared by the partner agencies but coordinated through a single scientist. For the program to work, partner agencies must be willing to allocate resources at the level necessary to support monitoring and assessment activities associated with routine monitoring, monitoring to improve our understanding of the ecosystem, and monitoring to evaluate the effectiveness of management actions.

Part 2: Fill Management Gaps

To achieve all the management objectives defined in Chapter 3, gaps in the management tool set need to be addressed through policy revisions.

- Regulatory Gap #1: Existing regulations do not cover development of existing platted properties less than 10 acres. There are no current flood control or water quality requirements for these types of future developments.
- Regulatory Gap #2: Standards need to be developed for MS4-exempt developments, municipalities, and individually owned properties to align stormwater management facilities with basin restoration/enhancement goals.
- Urban BMP Program Gap: Septic system retrofit projects should be considered as part of the nutrient reduction goals associated with basin TMDLs and the NEEPP to address septic

systems in urban/residential areas developed prior to implementation of the Water Quality Assurance Act of 1983 that mandated increased distances to groundwater, lower densities of septic systems, and greater setbacks from surface waters.

Part 3: Near-Term Coordination

The Basin Rule, Statewide Stormwater Rule, and the Kissimmee Basin Water Reservation Rule are currently under development. The partner agencies consider these important initiatives that need to be vetted within the IAT to ensure that new regulatory criteria are appropriately aligned with the KCOL management objectives.

Part 4: Develop an Integrated Watershed Management Plan Specific to the KCOL

Because conditions within the KCOL are dependent upon and influenced by conditions within the watershed, integrated watershed management solutions are needed to address the combined set of management objectives outlined in Chapter 3. Current programs are designed either to address a single and/or narrow objective or are focused on meeting the requirements of a downstream resource (e.g., nutrient loads to Lake Okeechobee, flows to the Kissimmee River).

Chapter 3 presented concerns and management challenges related to current conditions. The best way to address these concerns is through a combination of land acquisition, infrastructure improvements, regulatory modifications, C&SF water control structure operating criteria modifications, storm water treatment and storage projects, watershed wetland enhancement projects, agricultural and urban BMPs, and regional and local planning. Although the majority of these tools already exist, an integrated strategy for deploying these tools has not been defined. This strategy should:

- Minimize the cumulative impact of development on lake water quality, fish and wildlife habitat, flood protection levels, and recreational uses through application of smart growth and storm water best management practices;
- Manage lake inflows to maintain desired lake trophic states and fish and wildlife habitats;
- Preserve/protect lakeshore marshes from development-related filling;
- Increase the acreage of conservation lands within the watershed;
- Maintain and/or restore base flow to tributary streams and wetlands;
- Reduce discharge and/or runoff volumes from existing and future land development by providing additional storage within the KCOL watershed;
- Meet irrigation demands through stormwater reuse;
- Consider increases in C&SF structure conveyance capacities as a means of providing more operational flexibility;
- Consider coupling water supply withdrawals with structure operations to provide more operational flexibility;
- Improve flood control;
- Reduce the rate of change in lake water levels and discharges;
- Reduce demand for surface water withdrawals;
- Reduce total phosphorus loads to impaired water bodies; and
- Enhance and sustain lake and wetland watershed ecosystem health.

Development of the Integrated Watershed Management Strategy for the KCOL will require coordination between the central Florida water supply utilities, developers, and federal, state and local governments. Specific management measures that should be considered include:

Construction of the S-64 Water Control Structure: The S-64 water control structure, originally designed to be constructed at the outlet of Lake Hatchineha, was authorized as part of the Kissimmee Basin C&SF Project. This structure was intended to allow Cypress Lake and Lake Hatchineha water levels to be managed within their historic range and at higher water levels than Lake Kissimmee. The structure was not constructed as a cost-savings measure. The proposal to reconsider construction of the S-64 is based on modeling results from KBMOS, which indicate that Lake Kissimmee, Lake Hatchineha, and Cypress Lake are acting as a “surge tank” between the upper lakes in the KCOL and the Kissimmee River and are constraining operational flexibility north of the S-65 structure. Construction of the S-64 Water control structure would: improve S-61 tailwater conditions, increase transient storage and improve the timing and distribution of water deliveries to downstream systems, improve lake littoral habitat on Lake Hatchineha and Cypress Lake, reduce downstream impacts associated with Lake Toho managed draw downs, improve conditions for aquatic plant management treatments on Lake Hatchineha, Cypress Lake, and Lake Toho, and reduce operational conflicts/tradeoffs between the Headwater Lakes and Kissimmee River.

Construction of Regional Stormwater Retention Facilities: Stormwater runoff flows untreated into many lakes in the KCOL and is believed to be the source for much of the the nutrient enrichment of KCOL waterbodies. These discharges also result in rapid increases in lake water levels. These conditions are considered undesirable from both a flood protection and a fish and wildlife perspective. Regional stormwater facilities should be considered to meet the needs of future development, collect basin stormwater from existing and new developments, improve flood control, reduce the occurrence of rapid increases in lake water levels and discharges, and provide treatment of nutrient impacted stormwater.

Add Off-line Storage to the C&SF System: Local governments, in recent years, have expressed concerns with rapid lake level rises associated with stormwater runoff. Increases in structure conveyance capacities have been considered, but seem contrary to the NEEPP that is seeking to reduce downstream discharges during the wet season. Increased downstream discharge capacities also are contrary to water supply utility initiatives to capture excess surface water for use in meeting public water supply demands. Providing additional off-line storage in the KCOL would provide relief for times when basin runoff would otherwise result in rapid lake level increases, flows to the lakes when needed to maintain adequate water levels, decreased nutrient loads, and additional public water supply reserves for the region.

Land Acquisition: Development within the watershed is rapidly urbanizing the basin. Lakeshore lands, lands that fill gaps associated with wildlife corridors, and lands for stormwater treatment and storage should be identified and prioritized for acquisition.

Summary

The purpose of the LTMP is to enhance and/or sustain lake ecosystem health through interagency cooperation and coordination. The management objectives (Chapter 3) and assessment targets (Chapter 5) provide a shared vision of the desired outcomes stakeholders expect from management actions. The monitoring and assessment program described in Chapter 4 defines the three types of monitoring and assessment required to support adaptive management. The management framework identifies the resources needed for successful implementation of the LTMP as well as the required interactions between agencies and players. The proposed plan is to establish partnerships between organizations, allocate resources for implementation of the proposed management framework and monitoring and assessment program, commit to filling management gaps and coordinating on-going management activities, and pursue an integrated strategy or plan to achieve management objectives The success of the plan will depend on the willingness of agencies to participate and allocate resources.

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References

AECOM. 2011. Interim Alternative Plan Selection Document, Kissimmee Basin Modeling and Operations Study. SFWMD Contract Number 4600000933-WO04. Interim Report prepared for South Florida Water Management District, West Palm Beach.

Adamski, J.C. and E.R. German. 2004. Hydrogeology and Quality of Ground Water in Orange County, Florida. U.S. Geological Survey Water-Resources Investigations Report 03-4257, Tallahassee, FL.

Allen, M. S. and K. Tugend. 2002. Effects of a large-scale habitat enhancement project on habitat quality for age-0 largemouth bass at Lake Kissimmee, Florida. Pages 265-276. In D. Phillipp and M. Ridgeway (eds.) Black Bass: Ecology, Conservation and Management. American Fisheries Society, Bethesda, Maryland.

Anderson, D.H. and J.R. Chamberlain. 2005. Impacts of channelization on the hydrology of the Kissimmee River, Florida. *In* S.G. Bousquin, D.H. Anderson, G.W. Williams, and D.J. Colangelo (eds). Establishing a Baseline: Studies of the Channelized Kissimmee River. Volume I Kissimmee River Restoration Studies. South Florida Water Management District, West Palm Beach, FL. Technical Publication ERA 432.

Anderson, R.O. and R.M. Neumann. 1996. Length, weight, and associated structural indices, In: B.R. Murphy and D.W. Willis (eds), Fisheries Techniques, Second Edition. American Fisheries Press, Bethesda, Maryland.

Anthony, D.S. 1972. Lake Okeechobee—polishing pond for East Central Florida. University of Miami, Division of Applied Ecology, Center for Urban and Regional Studies, Miami, FL.

Arnold, Suzanne. 2007. Email correspondence dated 10/13/2007. Lake Mary Jane Alliance.

Aucott, W.R. 1988. Areal Variation in Recharge to and Discharge from the Floridan Aquifer System in Florida. U.S. Geological Survey, Water-Resources Investigations Report 88-4057, map with text.

Bachmann, R.W., B.L. Jones, D.D. Fox, M. Hoyer, L.A. Bull, and D.E. Canfield, Jr. 1996. Relations between trophic state indicators and fish in Florida (U.S.A.) lakes. J. Can. Fish. Aquat. Sci. 53:842-855.

Bartlett, R.D. and P.P. Bartlett. 1999. A Field Guide to Florida Reptiles and Amphibians. Gulf Publishing Co., Houston, TX.

Bell, F.W. 2006. Economic Sectors at Risk from Invasive Aquatic Weeds for the Kissimmee Chain of Lakes in Osceola County, FL, 2004-2005. Prepared for FDEP Bureau of Invasive Plant Management.

Bellrose, F.C. 1980. Ducks, geese and swans of North America. Stackpole Books, Harrisburg, PA.

Belmont, M.A., J.R. White, and K.R. Reddy. 2009. Phosphorus Sorption and Potential Storage in Sediments of Lake Istokpoga and the Upper Chain of Lakes, Florida, USA. Journal of Environmental Quality 38: 987-996.

Bogart, D.B. and G.E. Ferguson. 1955. Surface water. Pages 291-510 *in* G.G. Parker, G.E. Ferguson and S.K. Love (eds). Water Resources of Southeastern Florida. Supply Paper 1255. U.S. Geological Survey, Tallahassee, FL.

Brush, J.M. 2006. Wetland Avifauna Usage of Littoral Habitat Prior to Extreme Habitat Modification in Lake Tohopekaliga, Florida. M.S. Thesis. University of Florida, Gainesville, FL.

Buehler, D.A. 2000. Bald Eagle (*Haliaeetus leucocephalus*). *In* A. Poole and F. Gill (eds). The Birds of North America, No. 506. The Birds of North America, Inc., Philadelphia, PA.

Butler, R.S., E.J. Moyer, M.W. Hulon and V.P. Williams. 1992. Littoral zone invertebrate communities as affected by a habitat restoration project on Lake Tohopekaliga. Journal of Freshwater Ecology 7:317-327.

Butler, D. 2008. East Central Florida Transient Model—Draft Report. South Florida Water Management District, West Palm Beach, Florida.

Canfield, D.E., Jr. 1981. Chemical and trophic state characteristics of Florida lakes in relation to regional geology. Final Report, Florida Cooperative Fish and Wildlife Unit. U.S. Fish and Wildlife Service. Gainesville, FL. 444 p.

Canfield, D.E. and M.V. Hoyer. 1992. Aquatic Macrophytes and their Relation to the Limnology of Florida Lakes. University of Florida, Gainesville, FL.

Canfield, D.E., J.V. Shireman, D.E. Colle, W.T. Haller, C.E. Watkins II and M.J. Maceina. 1984. Prediction of chlorophyll *a* concentrations in Florida lakes: Importance of aquatic macrophytes. Canadian Journal of Fisheries and Aquatic Sciences 41:497-501.

CDM. 2008. Kissimmee River Watershed TMDL Model Development Report. Prepared for Florida Department of Environmental Protection Division of Water Resource Management Watershed Assessment Division.

Chamberlain, E.B., 1960. Florida waterfowl populations, habitats and management. Florida Game and Fresh Water Fish Commission, Technical Bulletin 7.

Champeau, T.R. and J.B. Furse. 2003. Littoral zone restoration of Lake Istokpoga: Enhancing aquatic habitat, flood control and water quality. Proceedings of the 11th Annual Spring Meeting of the Southern Division of the American Fisheries Society.

Chick, J.C. and C.C. McIvor. 1994. Patterns in the abundance and composition of fishes among beds of different macrophytes: viewing the littoral as a landscape. Canadian Journal of Fisheries and Aquatic Sciences 51:2873-2882.

Clugston, J.P. 1963. Lake Apopka, Florida, A changing lake and its vegetation. Quarterly Journal of the Florida Academy of Sciences 26:168-174.

Coffey, B.B., Jr. 1943. Post-juvenile migration of herons. Bird-banding 14:34-39.

Coffey, B.B., Jr. 1948. Southward migration of herons. Bird-banding 19:1-5.

Conrow, R. and J. Stenberg. 1994. Survival and competitive abilities of wetland species in the Lake Apopka demonstration marsh project. Lake and Reservoir Management 9:65-66.

Cowardin, L.M., V. Carter, F.C. Golet and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC. 131 p.

Darby, P.C., P.L. Valentine-Darby, H.F. Percival and W.M. Kitchens. 2002. Florida apple snail (*Pomacea paludosa* SAY) responses to lake habitat restoration activity. Archiv Fur Hydrobiologie 161:561-575.

Darby, P.C., R.E. Bennetts, S.J. Miller and H.F. Percival. 2004. Movements of Florida apple snails in relation to water levels and drying events. Wetlands 22:489-498.

Darby, P.C. 2005. Apple snail habitat relationships on central Florida lakes. Annual report prepared for Florida Fish and Wildlife Conservation Commission, Tallahassee, FL.

Darby, Phillip. C., Robert E. Bennetts, and H Franklin Percival. 2008. Dry Down Impacts on Apple Snail (*Pomacea Paludosa*) Demography: Implications for Wetland Water Management. Wetlands, Vol. 28, No. 1 March 2008, pp. 204-214.

Duchrow, R.M. 1970. Annual progress report for investigations project-water quality study. Florida Game and Freshwater Fish Commission, Tallahassee, FL.

Duchrow, R.M. 1971. Annual progress report for investigations project-water quality study. Florida Game and Freshwater Fish Commission, Tallahassee, FL.

Duchrow, R.M. and C.C. Starling. 1972. Annual progress report-water quality investigations. Florida Game and Freshwater Fish Commission, Tallahassee, FL.

Egbert, A.L. 1995. Kissimmee Chain of Lakes studies. Completion report for study IV: Lakes Cypress and Hatchineha Investigations. Florida Game and Fresh Water Fish Commission, Tallahassee, FL.

Egbert, A.L. 1996. Kissimmee Chain of Lakes studies. Completion report for study III: East Lake Tohopekaliga, Alligator Lake Chain investigations. Florida Game and Fresh Water Fish Commission, Tallahassee, FL.

Egbert, A.L. 1998. Kissimmee Chain of Lakes studies. Completion report for study I: Lake Kissimmee investigations. Florida Game and Fresh Water Fish Commission, Tallahassee, FL.

Eggeman, D.R. and F.A. Johnson. 1989. Variation in effort and methodology for the midwinter waterfowl inventory in the Atlantic flyway. Wildlife Society Bulletin 17(3): 227-233.

Fan, A. and S. Lin. 1984. Water budget for Upper Kissimmee Chain of Lakes. Progress Report, DRE-186, South Florida Water Management District, West Palm Beach, FL.

Fasola, M., L. Canova, and N. Saino.1996. Rice fields support a large portion of herons breeding in the Mediterranean region. Colonial Waterbirds 19 (Special Publication 1):129-134.

Federico, A.C. and P.L. Brezonik. 1975. A Survey of Water Quality in the Kissimmee-Okeechobee Watershed. Technical Series 1(8). Florida Department of Environmental Regulation, Tallahassee, FL.

Fisher, M.M., K.R. Reddy and R.T. James. 2001. Long-term changes in the sediment chemistry of a large shallow subtropical lake. Lake and Reservoir Management 17:217-232.

Florida Department of Environmental Protection (FDEP). 2004. Water Quality Status Report: Kissimmee River and Fisheating Creek. FDEP Division of Water Resource Management, Tallahassee, FL.

Florida Department of Environmental Protection (FDEP). 2006. Water Quality Assessment Report: Kissimmee River and Fisheating Creek. Bureau of Watershed Management, Division of Water Resource Management, Florida Department of Environmental Protection, Tallahassee, FL.

Florida Department of Environmental Protection (FDEP). 2010. Florida Forever Five Year Plan. Office of Environmental Services, Division of State Lands, Florida Department of Environmental Protection, Tallahassee, FL.

Florida Game and Fresh Water Fish Commission. 1979. Phosphorous Loadings within the Lake Tohopekaliga System, Kissimmee, Florida, USA. Florida Game and Fresh Water Fish Commission, Tallahassee, FL.

Florida Game and Fresh Water Fish Commission. 1995. Lake Kissimmee 1996 Lake Restoration Project. Florida Game and Fresh Water Fish Commission, Kissimmee, FL.

Florida Fish and Wildlife Conservation Commission (FWC). 2005a. Eagle Nest Locator, http://myfwc.com/eagle/eaglenests/Default.asp. Accessed May 10, 2007.

Florida Fish and Wildlife Conservation Commission (FWC). 2005b. Unpublished Creel Data for Lakes Kissimmee and Lake Tohopekaliga provided by Tim Coughlin in 2005.

Florida Fish and Wildlife Conservation Commission (FWC). 2006a. Unpublished Catch Data for Lakes Kissimmee and Lake Tohopekaliga provided by Tim Coughlin in 2006.

Florida Fish and Wildlife Conservation Commission (FWC). 2006b. Unpublished Fish Assemblage Data for Lakes Kissimmee and Lake Tohopekaliga provided by Tim Coughlin in 2005.

Florida Fish and Wildlife Conservation Commission (FWC). 2010. Bald Eagles in Florida. http://www.myfwc.com/WILDLIFEHABITATS/Eagle_FAQ.htm. Accessed Aug 18, 2010.

Florida Fish and Wildlife Conservation Commission (FWC). 2008. FWC Midwinter Data 1973-2003 and personal communications, Jamie Feddersen, FWC, 4/4/08.

Florida LAKEWATCH. 2009. Long-Term Fish, Plants, and Water Quality Monitoring Program: 2009. University of Florida, Institute of Food and Agricultural Sciences, School of Forest Resources and Conservation. Available at:

http://lakewatch.ifas.ufl.edu/Long-term_Fish_monitor/Long-Term_Report_2009.pdfFolk, M. 2008. Personal correspondence on sandhill and whooping crane nest success in 2007–2008.

Folk, M.J., S.A. Nesbitt and M.G. Spalding. 2001. Interactions of sandhill cranes and whooping cranes with foreign objects in Florida. Proceedings of the North American Crane Workshop 8:195-197.

Frederick, P.C. and J.C. Ogden. 2001. Pulsed breeding of long-legged wading birds and the importance of infrequent severe drought conditions in the Florida Everglades. Wetlands 21(4): 484-491.

Gaggiani, N. and B.F. McPherson. 1978. Limnological characteristics of Cypress Lake, Upper Kissimmee River Basin, Florida, USA. U.S. Department of the Interior, Geological Survey, Tallahassee, FL.

Gawlik, D.E. 2002. The effects of prey availability on the numerical response of wading birds. Ecological Monographs. 72(3):329-346.

Gladden, J. E. and L. A. Smock. 1990. Macroinvertebrate distribution and production on the floodplains of two lowland headwater streams. Freshwater Biology 24:533–545.

Gray, P.N. 1993. Biology of a southern mallard: Florida's mottled duck. Dissertation, University of Florida, Gainesville, FL.

Gregory, R.W., A.V. Zale and R. Conrow. 1990. Distributions and abundances of early life stages of fishes in a Florida lake dominated by aquatic macrophytes. Transactions of the American Fisheries Society 119:521-528.

Griffith, G.E., D.E. Canfield, Jr., C.A. Horsburgh and J.M. Omernik. 1997. Lake Regions of Florida. EPA/R-97/127 U.S. Environmental Protection Agency, Corvallis, OR.

Hancock, J. and J.A. Kushlan. 1984. The Herons of the World. Harper and Row, New York, NY.

Hanning, G. W. 1979. Aspects of reproduction in Pomacea paludosa (Mesogastropoda: Pilidae). M.S. Thesis. Florida State University, Tallahassee, FL, USA.

Haskell, B.D., B.G. Norton and R. Costanza. 1992. What is ecosystem health and why should we worry about it? Pages 3-20 *in* R. Costanza, B.G. Norton and B.D. Haskell (eds). Ecosystem Health: New Goals for Environmental Management. Island Press, Washington, DC.

Havens, K., M. Allen, M. Clark, D. Gawlik, J. Gore, S. Johnson and K. Wiley. 2005a. Peer Review for the Kissimmee Chain of Lakes Long-term Management Plan Conceptual Ecosystem Model. Final report submitted to the South Florida Water Management District, West Palm Beach, FL.

Havens, K.E. 2003. Phosphorus-algal bloom relationships in large lakes of South Florida: Implications for establishing nutrient criteria. Lake and Reservoir Management 19:222-228.

Havens, K.E. and G. Nurnberg. 2004. The phosphorus-chlorophyll relationship in lakes: potential influences of color and mixing regime. Lake and Reservoir Management 20:188-196.

Havens, K.E., D. Fox, S. Gornak and C. Hanlon. 2005b. Aquatic vegetation and largemouth bass population responses to water-level variations in Lake Okeechobee, Florida (USA). Hydrobiologia 539:225-237.

Herdendorf, C.E. 1992. Lake Erie coastal wetlands: an overview. Journal of Great Lakes Research 18:533-551.

Holcomb, D.E. 1967. Annual Progress Report for Research Project-Water Quality Study. Florida Game and Freshwater Fish Commission, Tallahassee, FL.

Holcomb, D.E. 1968. Annual Progress Report for Research Project-Water Quality Study. Florida Game and Freshwater Fish Commission, Tallahassee, FL.

Holcomb, D.E. 1969. Annual Progress Report for Investigation Project-Water Quality Study. Florida Game and Freshwater Fish Commission, Tallahassee, FL.

Holcomb, D.E. and C. Starling. 1973. Final Completion Report-Water Quality Investigations. Florida Game and Freshwater Fish Commission, Tallahassee, FL.

Holcomb, D.E. and W.L. Wegener. 1971. Hydrophytic changes related to lake fluctuation as measured by point transects. Pp. 570-583 *in* J. W. Webb (ed). Proceedings of the Twenty-fifth Annual Conference, Southeastern Association of Game and Fish Commissioners. Southeastern Association of Game and Fish Commissioners, Charleston, SC.

Holcomb, D. E. and W. Wegener. 1972. Annual Progress Report-Water Level Manipulation, Lake Tohopekaliga drawdown. Florida Game and Freshwater Fish Commission, Tallahassee, Florida, USA.

Holcomb, D.E. and W. Wegener. 1973. Annual Progress Report-Water Level Manipulation, Lake Tohopekaliga drawdown. Florida Game and Freshwater Fish Commission, Tallahassee, FL.

Holcomb, D.E. and W. Wegener. 1974. Completion Report-Lake Tohopekaliga Drawdown Study. Florida Game and Freshwater Fish Commission, Tallahassee, FL.

Hoyer, M. V., and D. E. Canfield, Jr. 1996. Largemouth bass abundance and aquatic vegetation in Florida lakes: An empirical analysis. Journal of Aquatic Plant Management 34: 23-32.

Hoyer, M.V., D.E. Canfield, Jr. and R.W. Bachmann. 2006. Evaluation of Lake Tohopekaliga habitat enhancement project. Final Report. Florida Fish and Wildlife Conservation Commission, Fresh Water Fisheries Division, Tallahassee, FL.

Hoyer, M.V., R.W. Bachmann and D.E. Canfield, Jr. 2008. Lake management (muck removal) and hurricane impacts to the trophic state of Lake Tohopekaliga, Florida. Lake and Reservoir Management 24:57-68

Huber, H.C., J.P. Heaney, P.B. Bedient and J.P. Bowden. 1976. Environmental Resources Management Studies in the Kissimmee River Basin. Final Report. Dept. Environ. Eng. Sci., University of Florida, Gainesville, FL. ENV-05-76-2. 279 pp.

Hughes, G.H. and J.M. Frazee, Jr. 1979. Surface-water Features in Osceola County and Adjacent Areas. U.S. Department of the Interior, Geological Survey, Tallahassee, FL.

Hulon, M.W., J. Buntz, A.F. Landrum, C.K. McDaniel, C. Michael, D.C. Arwood, T. Penfield, A.C. Jasent, A.L. Egbert and E.J. Moyer. 2000. Completion Report for Kissimmee Chain of Lakes. Study 6301: Lakes Cypress and Hatchineha. State of Florida Fish and Wildlife Conservation, Tallahassee, FL.

Hutchinson, C., D.D. Walder, S.E. Gatewood and R. MacGill. 1976. Final report on the management plan for upland retention in the Kissimmee River Basin (Draft). Florida Department of Administration, Division of State Planning, Bureau of Comprehensive Planning, Tallahassee, FL.

James, R.T., K.M. O'Dell and B.L. Jones. 1993. Water quality improvements of Lake Tohopekaliga in response to lake management. *In* C.E. Watkins et al. (ed). Proceedings of the Southeastern Lakes Management Conference, Marietta, GA, March 18-20, 1992. North Am. Lake Manage. Soc., Alachua, FL.

James, R.T., K.M. O'Dell and V.H. Smith. 1994. Water quality trends in Lake Tohopekaliga, Florida, USA: responses to watershed management. Water Resources Bulletin 30:531-546.

James, R.T., K.E. Havens, P. McCormick, B. Jones, and C. Ford. 2011. Water quality trends in shallow south Florida lakes and assessment of regional versus local forcing functions. Critical Reviews in Environmental Science and Technology, 4(1):576-607.

Johnson, K.G., M.S. Allen, and K.E. Havens. 2007. A review of littoral vegetation, fisheries, and wildlife responses to hydrologic variation at Lake Okeechobee. Wetlands 27(1):110-126.

Jones, B.L. 2005. Water quality in the channelized Kissimmee River. Chapter 5 *in* S.G. Bousquin, D.H. Anderson, G.W. Williams and D.J. Colangelo (eds). Kissimmee River restoration studies Volume I – establishing a baseline: pre-restoration studies of the channelized Kissimmee River.

Technical Publication ERA #432. South Florida Water Management District, West Palm Beach, FL.

Jones, B.L., P.S. Millar, T.H. Miller, D.R. Swift and A.C. Federico. 1983. Preliminary Water Quality and Trophic State Assessment of the Upper Kissimmee Chain of Lakes. Technical Memorandum, DRE-167, South Florida Water Management District, West Palm Beach, FL

Joyner, B.F. 1971. Appraisal of Chemical and Biological Conditions of Lake Okeechobee, Florida, 1969-1970. U.S. Department of the Interior, Geological Survey, Tallahassee, FL.

Joyner, B.F. 1974. Chemical and Biological Conditions of Lake Okeechobee, Florida, 1969-1972. Report of Investigations No. 71. U.S. Department of the Interior, Geological Survey, Tallahassee, FL.

Karr, J., M.S. Allen and A.G. van der Valk. 2007. Environmental Peer Review of the Scientific and Technical Basis for Management Decision-Making as Described in the Draft Kissimmee Chain of Lakes Long-Term Management Plan. Final Peer Review Report. Prepared for the South Florida Water Management District, West Palm Beach, FL.

Kaufman, M.I. and J.E. Dysart. 1987. Nitrogen, Phosphorous, Organic Carbon, and Biochemical Oxygen Demand in Florida Surface Waters, 1972. U.S. Department of the Interior, Geological Survey, Tallahassee, FL.

Keddy, P.A. and L.H. Fraser. 2000. Four general principles for the management and conservation of wetlands in large lakes: the role of water levels, nutrients, competitive hierarchies and centrifugal organization. Lakes and Reservoirs: Research and Management 5:177-185.

Keddy, P.A. and A.A. Rezniceck. 1986. Great Lakes vegetation dynamics: the role of water levels and buried seeds. Journal of Great Lakes Research 12:25-36.

Kitchens, W.M., Z.C. Welch, A.M. Muench and J.M. Brush. 2002. Monitoring Floral and Faunal Succession Following Alternative Habitat Restoration Techniques in a Large Central Florida Lake, 2002 Annual Progress Report. Florida Fish and Wildlife Concervation Commission, Tallahassee, FL.

Kushlan, J.A. 1978. Feeding ecology of wading birds. pp. 249-296 in Wading birds, A. Sprunt, IV, J. C. Ogden and S. Winckler, eds. Natl. Audubon Soc., New York, New York.

Kushlan, J.A. 1981. Resource use strategies of wading birds. Wilson Bulletin 93(2):145-163.

Lamonds, A.G. 1975. Chemical Characteristics of the Lower Kissimmee River, Florida - with Emphasis on Nitrogen and Phosphorus. U.S. Geological Survey, WRI-45-75, Tallahassee, FL.

Love, S. K. 1955. Quality of ground and surface water. Pages 727-833 in G. G. Parker, G. E. Ferguson, and S. K. Love, editors. Water resources of southeastern Florida. Supply Paper 1255. U. S. Geological Survey, Tallahassee, FL

Marshall, A.R., J.H. Hartwell, D.S. Anthony, J.V. Betz, A.E. Lugo, A.R. Veri and S.U. Wilson. 1972. The Kissimmee-Okeechobee Basin - A Report to the Cabinet of Florida. Division of Applied Ecology, Center for Urban and Regional Studies, University of Miami, FL. 32 pp.

MacGill, R.A., S.E. Gatewood, C. Hutchinson and D.D. Walker. 1976. Final Report of the Special Project to Prevent Eutrophication of Lake Okeechobee. Florida Department of State Planning, Tallahassee, FL.

McCaffrey, P.M., W.W. Hinkley, R. MacGill and G.D. Cherr. 1975. Report of Investigations in the Kissimmee River-Lake Okeechobee watershed. Technical Series 2(2). Florida Department of Environmental Regulation, Tallahassee, FL.

Melvin, S.L., D. Gawlik, and T. Scharff. 1999. Long-term movement patterns for seven species of wading birds. Waterbirds 22(3):411-416.

Milleson, J.F. 1975. Progress Rreport Upper Kissimmee Chain of Lakes Water Quality and Benthic Invertebrate Sampling. Technical Publication 75-2. Central and Southern Florida Flood Control District. West Palm Beach, FL.

Mock, Roos & Associates, Inc. 2003. Lake Istokpoga/Upper Chain of Lakes Basin Phosphorus Control Report (4 volumes). Contract C-13413 report submitted to the South Florida Water Management District, West Palm Beach, FL.

Moyer, E.J. and V.P. Williams. 1982. Effects of lake bottom channelization on invertebrate fish food organisms on Lake Tohopekaliga, Florida. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 36:294-304.

Moyer, E.J., M.W. Hulon, J.J. Sweatman, R.S. Butler and V.P. Williams. 1995. Fishery response to habitat restoration in Lake Tohopekaliga, Florida. North American Journal of Fisheries Management 15:591-595.

Muench, A.M. 2004. Aquatic Vertebrate Usage of Littoral Habitats Prior to Extreme Habitat Modification in Lake Tohopekaliga, Florida. Master's thesis, University of Florida, Gainesville, FL.

Nesbitt, S.A. and J.L. Hatchitt. 2008. Trends in habitat and population of Florida sandhill cranes. Proceedings of the North American Crane Workshop 10:40-42.

Obeysekera, J.T.B. and M.K. Loftin. 1990. Hydrology of the Kissimmee River Basin – Influence of man-made and natural changes. Pp. 211-222 *in* M.K. Loftin, L.A. Toth and J.T.B. Obeysekera (eds). Proceedings of the Kissimmee River Restoration Symposium. South Florida Water Management District, West Palm Beach, FL.

O'Dell, K.M. 1994. Water quality in the Shingle Creek Basin, Florida, before and after wastewater diversion. Journal of Environmental Quality 23(3):563-571.

Orange County. 2008. Orange County, Florida # 2009-1-B-CPP-EAR Evaluation and Appraisal Report, Prepared by Orange County Growth Management Department - Planning Division, draft report dated October 28, 2008, pgs 5-7.

Osceola County. 2007. Osceola County Comprehensive Plan 2025, Prepared by Osceola County Planning & Zoning Division, adopted December 2007, updated September 2009, pg., 59.

Osceola County. 2008. Osceola County Ten-Year Water Supply Facilities Work Plan, Prepared by Osceola County Planning & Zoning Division, November 6, 2008, pgs 6-9.

Palmer, R.S. 1962. Handbook of North American Birds. Volume 1. Yale University Press, New Haven, CT.

Parker, G.G., G.E. Ferguson and S.K. Love. 1955. Water Resources of Southeastern Florida. U.S. Geological Survey Water Supply Paper 1255. U.S. Government Printing Office, Washington, DC.

Perrin, L.S., M.J. Allen, L.A. Rowse, F. Montalbano III, K.J Foote and M.W. Olinde. 1982. A Report on Fish and Wildlife Studies in the Kissimmee River Basin and Recommendations for Restoration. Florida Game and Freshwater Fish Commission, Okeechobee, FL.

Pfischner, F.L. Jr. 1982. Hydrology of Lake Tohopekaliga, Osceola County, Florida. U.S. Department of the Interior, Tallahassee, FL.

Purcell, Karen. 2008. Data provided in a 4/29/08 e-mail. Polk County Board of County Commissioners. Bartow, FL.

RECOVER. 2004. CERP Monitoring and Assessment Plan: Part 1 Monitoring and Supporting Research. Restoration Coordination and Verification Program. United States Army Corps of Engineers, Jacksonville District, Jacksonville, FL, and South Florida Water Management District, West Palm Beach, FL.

Rodgers, J. A., Jr. 2007. Breeding success of Rostrhamus sociabilis (Snail Kites) at two Florida lakes. Southeastern Naturalist 6:35-46.

Savino, J.F. and R.A. Stein. 1982. Predator-prey interactions between largemouth bass and bluegills as influenced by simulated, submersed vegetation. Transactions of the American Fisheries Society 111:255-347.

Schiner, G.R. 1993. Geohydrology of Osceola County, Florida. U.S. Geological Survey, Water Resources Investigations Report 92-4076, Tallahassee, Florida.

Sheaffer, W. A. and J. G. Nickum. 1986. Relative abundance of macroinvertebrates found in habitats associated with backwater area confluences in Pond 13 of the Upper Mississippi River. Hydrobiologia 136: 113-120.

Shapiro, A.E., F. Montalbano III and D. Mager. 1982. Implications of construction of a flood control project upon bald eagle nesting activity. Wilson Bulletin 94(l):55-63.

Shaw, J.E. and S.M. Trost. 1984. Hydrogeology of the Kissimmee Planning Area, South Florida Water Management District. Technical Publication 84-1 (DRE-188), Parts 1 and 2. South Florida Water Management District, West Palm Beach, FL.

Sincock, J.L. and J.A. Powell. 1957. An Ecological Study of Waterfowl Areas in Central Florida. Proceedings of the Southeast Association of Game and Fish Commissions 25:570-583.

Sincock, J.L., J.A. Powell, R.K. Hyde and H.E. Wallace. 1957. The Relationship of the Wintering Waterfowl Populations of the Kissimmee River Valley to the Hydrology, Topography, Distribution of the Vegetation and the Proposed Hydrological Regulations. Florida Game and Fresh Water Fish Commission, Tallahassee, FL.

Slack, L.J. and D.A. Goolsby. 1976. Nitrogen Loads and Concentrations in Florida Streams (map). U.S. Department of the Interior, Gelogical Survey.

Slack, L.J. and M.I. Kaufman. 1973. Specific Conductance of Water in Florida Streams and Canal. (map). U.S. Department of the Interior, Gelogical Survey.

Sorensen, H. R. and P. Turner. 2001. Integrated Surface and Groundwater Model for Lake Tohopekaliga Drawdown Project—Final report. DHI Inc., Trevose, Pennsylvania.

South Florida Water Management District (SFWMD). 1982. Kissimmee Chain of Lakes Limnetic and Material Budget Study Program. South Florida Water Management District, West Palm Beach, FL.

South Florida Water Management District (SFWMD). 1999. Documentation of the Lower East Coast Floridan Aquifer Model. West Palm Beach, FL.

South Florida Water Management District (SFWMD). 2000a. Kissimmee Basin Water Supply Plan.

South Florida Water Management District (SFWMD). 2005. Land Stewardship Annual Report. 28 p. South Florida Water Management District, West Palm Beach, FL.

South Florida Water Management District (SFWMD). 2006a. South Florida Environmental Report, Chapter 4. South Florida Water Management District, West Palm Beach, FL.

South Florida Water Management District (SFWMD). 2006b. Kissimmee Basin Water Supply Plan 2005-2006 Update. Water Supply Department, South Florida Water Management District, West Palm Beach, FL.

South Florida Water Management District (SFWMD). 2007. Draft Kissimmee Chain of Lakes Long Term Management Plan. South Florida Water Management District, West Palm Beach, FL.

South Florida Water Management District (SFWMD). 2009. Kissimmee Basin Modeling and Operations Study – DRAFT Alternative Plan Selection Process Document. South Florida Water Management District, West Palm Beach, FL.

South Florida Water Management District (SFWMD), Florida Fish and Wildlife Conservation Commission, Florida Department of Environmental Protection, Florida Department of Agriculture and Consumer Services, United States Amy Corps of Engineers, United States Fish and Wildlife Service and United States Environmental Protection Agency. 2004. Proposed Scope for the Kissimmee Chain of Lakes Long-Term Management Plan, Project Charter and Management Goals (Draft) (http://www.sfwmd.gov/misce/kcol_ltmp_scope_draft.pdf).

South Florida Water Management District (SFWMD), Florida Fish and Wildlife Conservation Commission, Florida Department of Environmental Protection, Florida Department of Agriculture and Consumer Services, United States Army Corps of Engineers, United States Fish and Wildlife Service and United States Environmental Protection Agency. 2007a. Draft Kissimmee Chain of Lakes Long-Term Management Plan. June 18, 2007. South Florida Water Management District, West Palm Beach, FL.

South Florida Water Management District (SFWMD), Florida Department of Environmental Protection and Florida Department of Agriculture and Consumer Services. 2007b. Lake Okeechobee Protection Plan Evaluation Report. South Florida Water Management District, West Palm Beach, FL.

South Florida Water Management District (SFWMD), Florida Department of Environmental Protection (FDEP) and Florida Department of Agriculture and Consumer Services (FDACS). 2011. Lake Okeechobee Protection Plan Update March 2011. South Florida Water Management District, West Palm Beach, FL.

Spechler, R. M. and S. E. Kroening. 2007. Hydrology of Polk County, Florida. U.S. Geological Survey Scientific Investigations Report 2006-5320, Reston, Virginia.

Strong, A.M., G.T. Bancroft and S.D. Jewell. 1997. Hydrological constraints on tricolored heron and snowy egret resource use. The Condor 99:894-905.

Swift, D.R. 1985. Phytoplankton dynamics in Upper Kissimmee Chain of Lakes. Quarterly Journal of the Florida Academy of Sciences 48:37.

Tennant, A. 1997. A Field Guide to Snakes of Florida. Gulf Publishing Co., Houston, TX.

Tugend, K.I. and M.S. Allen. 2004. Changes in the plant and fish communities in enhanced littoral areas of Lake Kissimmee, Florida, following a habitat enhancement. Lake and Reservoir Management 20:54-64.

Turner, Richard L. 1996. Use of Stems of Emergent Plants for Oviposition by the Florida Applesnail, *Pomacea Paludosa,* and Implications for Marsh Management. Florida Scientist, Vol. 59, No. 1, Winter 1996.

U.S.Army Corps of Engineers(USACE). 1994. Central and Southern Florida Projoect for Flood Control and Other Purposes Water Control Manual for Kissimmee River-Lake Istokpoga Basin. Jacksonville District, U.S. Army Corps of Engineers. August 1994.

U.S.Army Corps of Engineers(USACE). 1996. Central and Southern Florida Project for Flood Contol and Other Purposes, Kissimmee River, Florida, Headwaters Revitalization Project: Integrated Project Modification Report and Supplement to the Final Environmental Impact Statement. U.S. Army Corps of Engineers, Jacksonville District, Southern Atlantic Division.

U.S.Army Corps of Engineers(USACE). 2011. Kissimmee Basin Flood Analysis: Flood Performance Evaluation Metrics. Jacksonville District, U.S. Army Corps of Engineers. March 2011.

U.S. Fish and Wildlife Service (USFWS). 1959. A detailed report of the fish and wildlife resources in relation to the Corps of Engineers' plan of development, Kissimmee River basin, Florida. Appendix A. *In* Central and Southern Florida Project for Flood Control and Other Purposes: Part II - General Design Memorandum, Kissimmee River Basin. U. S. Army Engineers, Office of the District Engineer, Jacksonville, FL, Supplement

Van der Valk, A. 2005. Water-level fluctuations in North American prairie wetlands. Hydrobiologia 539:171-188.

Vos, P. E. Meelis, and W. J. Ter Keurs. 2000. A framework for the design of ecological monitoring programs as a tool for environmental and nature management. Environmental Monitoring and Assessment 61: 317–344.

Weller, M.W. 1995. Use of two waterbird guilds as evaluation tools for the Kissimmee River restoration. Restoration Ecology 3(3):211-224.

Weller, M.W. 1999. Wetland Birds: Habitat Resources and Conservation Implications. Cambridge University Press, Cambridge, UK.

White, J., M. Belmont, K.R. Reddy and C. Martin. 2004. Phosphorus sediment water interactions in Lakes Istokpoga, Kissimmee, Tohopekaliga, Cypress and Hatchineha. University of Florida-IFAS. Contract report to the South Florida Water Management District, West Palm Beach, FL.

Williams, B.K., R.C. Szaro and C.D. Shapiro. 2007. Adaptive Management: The U.S. Department of the Interior Technical Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC.

Williams, V.P. 1988. Impact of littoral plant communities on lake water quality. Page 10 *in* Proceedings of the 8th Annual International Symposium on Lake and Watershed Management.

Williams, V.P. 2001. Effects of point-source removal on lake water quality: A case history of Lake Tohopekaliga, Florida. Lake and Reservoir Management. 17: 315-329.

Williams, V.P., E.J. Moyer and M.W. Hulon. 1979. State of Florida Game and Fresh Water Fish Commission 1974-1979 Water Level Manipulation Project F-29-8 completion report for study III Lower Kissimmee Basin Study. Florida Game and Fresh Water Fish Commission, Kissimmee, FL.

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9
Glossary

Adaptive Management A systematic approach for improving resource management by learning from management outcomes. Adaptive management applies scientific principles and methods to improve resource management incrementally as managers learn from experience and as new scientific findings and social changes demand. In the context of the LTMP, adapative management is the development or adjustment of a management strategy based on data from an ongoing monitoring program. The data are used to learn about system responses to current management and to suggest changes that may be needed to meet project goals and assessment targets.

Affected Environment Existing biological, physical, social, and economic conditions of an area subject to change, both directly and indirectly, as the result of a proposed human action. Also, the chapter in an Environmental Impact Statement (EIS) describing current environmental conditions.

Algae Simple single-celled, colonial or multicelled, mostly aquatic plants, containing chlorophyll and lacking roots, stems and leaves.

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

Alkalinity Refers to the extent to which water or soils contain soluble mineral salts. Waters with a pH greater than 7.4 are considered alkaline.

Anaerobic Characterizing organisms able to live and grow in oxygen-free and conditions.

Anthropogenic Resulting from human influence.

Anthropogenic Driver A major human-caused forcing variable, such as intensive land use, introduction of exotic plant species, management of aquatic plants or regulation of water.

Approach Means by which to achieve a goal.

Aquatic Consisting of, relating to, or being in water; living or growing in, on or near the water.

Aquatic Algae Microscopic plants that grow in sunlit water containing phosphates, nitrates and other nutrients. Algae, like all aquatic plants, add oxygen to the water and are important in the fish food chain.

Aquatic Life All forms of living things found in water, ranging from bacteria to fish and rooted plants. Insect larva and zooplankton are also included.

Aquifer A geologic formation, a group of formations, or a part of a formation that is water bearing.

Assessment Indicator Measure (AIM) An assessment indicator measure is developed similarly to an APM, but does not have an assigned target or confidence level. If sufficient information becomes available to define a target, an AIM may be further developed into an APM.

Assessment Performance Measure (APM) An assessment performance measure describes a metric that can be obtained through field observation or measurement. Assessment targets associated with these metrics define specific values, threshold values (minimum or maximum), ranges of values, or directions of change. An APM also explains the selected metric's significance as an indicator of system health, describes the source of the target values, and assigns a level of confidence to the target values based on the information source.

Assumption Factors that, for planning purposes, are considered to be true, real or certain. Assumptions affect all aspects of project planning, and are part of the progressive elaboration of the project. Project teams frequently identify, document and validate assumptions as part of their planning process. Assumptions generally involve a degree of uncertainty and risk.

Attribute A living or nonliving environmental feature or process that can be measured, estimated or extrapolated from another ecosystem to provide insight into, or serve as an indicator of, the state of the ecosystem. In this document, attributes are organized into broad groups called attribute categories.

Baseline Condition A specified period of time during which collected data are used for comparisons with subsequent data.

Basin (Groundwater) A hydrologic unit containing one large aquifer, or several connecting and interconnecting aquifers.

Basin (Surface Water) A tract of land drained by a surface water body or its tributaries.

Basin Management Action Plan – Planning process under the FDEP TMDL program to reduce nutrient loads to lakes with established TMDLs.

Biomass The amount of living material in a particular sample, population, area or volume of habitat, usually measured as dry mass.

Biota The plant and animal life of a region or ecosystem, as in a stream or other body of water.

Central and Southern Florida Project Comprehensive Review Study (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 being presented to the Congress on July 1, 1999. The recommendations made within the Restudy, that is, structural and operational modifications to the C&SF Project, are being further refined and will be implemented in the Comprehensive Everglades Restoration Plan (CERP).

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 Lake Okeechobee to the east and west coasts and from Orlando south to the Everglades. It was designed and constructed during the 1950s by the USACE to provide flood control and improve navigation and recreation.

Chlorophyll The green pigments of plants. There are seven known types of chlorophyll; Chlorophyll *a* and Chlorophyll *b* are the two most common forms. This material allows plants to obtain energy from light.

Color The color of water, with water considered a translucent (i.e., not transparent) material, commonly associated with transmitted light, such as what a diver sees beneath the water's surface. However, the color of natural waters observed from above is associated with the upwelling light field that results from back scattering of sunlight illuminating the water volume. In this manner, the color of natural waters can be objectively specified using their spectral reflectance. Reflectance is defined as the ratio of the upwelling light to incident (downwelling) light. Remote sensing of water color is increasingly being used to infer water quality, particularly suspended solids and phytoplankton concentrations.

Comprehensive Everglades Restoration Plan (CERP) The framework and guide for the restoration, protection and preservation of the south Florida ecosystem. The CERP also provides for water-related needs of the region, such as water supply and flood protection.

Conductivity A measure of the ability of a solution to carry an electrical current.

Constraint An applicable restriction affecting the performance of the project. Any factor affecting the scheduling of an activity.

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

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.

Ecosystem Biological communities together with their environment, functioning as a unit.

Ecological Approach A method of natural resource planning and management that provides due consideration for the inter-relationships between all species, including humans, and their environment.

Ecological Assessment A process for describing the status of ecosystems, their components, related processes and effects, and associated interactions. An ecological assessment should address social, cultural and political issues relevant to resource management and use scientifically supportable data.

Ecological Effects The physical, chemical, biological, and functional responses of ecosystem attributes to drivers and stressors.

Ecological Impact The effect that a man-made or natural activity has on living organisms and their nonliving (abiotic) environment.

Ecological Indicator An individual species, assemblage of organisms, or ecosystem component that serves as a gauge of the condition of the environment. The term is a collective term for response, exposure, habitat, and stressor indicators.

Ecology The study of the inter-relationships of living things to one another and to the environment.

Ecotone A habitat created by the juxtaposition of distinctly different habitats; an edge habitat; or an ecological zone or boundary where two or more ecosystems meet. A transition line or strip of vegetation between two communities having characteristics of both kinds of neighboring vegetation, as well as characteristics of its own.

Emergent Macrophytes Wetland plants that extend above the water surface. Cattail and rushes are two examples.

Endangered Species Any plant or animal species threatened with extinction by man-made or natural changes throughout all or a significant area of its range; identified by the Secretary of the Interior as "endangered," in accordance with the 1973 Endangered Species Act (ESA).

Estuary The part of the wide lower course of a river where its current is met by ocean tides or an arm of the sea at the lower end of a river where fresh and salt water meet.

Eutrophic An aquatic environment enriched with nutrients, usually associated with high plant productivity. Such waters are often shallow, with algal blooms and periods of oxygen deficiency. Slightly or moderately eutrophic water can be healthful and support a complex web of plant and animal life. However, such waters are generally undesirable for drinking water and other needs.

Eutrophication The gradual 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 total loss of water to the atmosphere by evaporation from land and water surfaces and by transpiration from plants.

Exceedance The violation of the pollutant levels permitted by environmental protection standards.

Exotic Plant Species A nonnative species that is not recognized as being naturalized within an ecosystem.

Fauna All animal life associated with a given habitat.

Fish Recruitment The number of new juvenile fish reaching a size/age where they represent a viable target for the commercial, subsistence or sport fishery for a given species.

Floating Aquatic Vegetation (FAV) Aquatic plants that have portions floating at or near the water surface. Plants may or may not be rooted in substrate (e.g., water lily).

Floodplain Wetland Palustrine wetland area adjacent to a lake and separated by a natural berm in which flooding occurs during high water events. May or may not have been a littoral wetland historically.

Flora All plant life associated with a given habitat.

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 Agricultural and Consumer Services (FDACS) The FDACS communicates the needs of the agricultural industry to the Florida Legislature, the FDEP and the water management districts, and ensures participation of agriculture in the development and implementation of water policy decisions. The FDACS also oversees Florida's soil and water conservation districts, which coordinate closely with the federal Natural Resources Conservation Service (NRCS).

Florida Department of Environmental Protection (FDEP) The FDEP is the lead state agency for environmental management and stewardship. The SFWMD operates under the general supervisory authority of the FDEP, which includes budgetary oversight.

Florida Fish and Wildlife Conservation Commission (FWC) State agency charged with managing fish and wildlife resources for their long-term well-being and benefit of the people.

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.

Food Web The totality of interacting food chains in an ecological community.

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

Groundwater Water beneath the surface of the ground, whether or not flowing through known and definite channels. Specifically, that part of the subsurface water in the saturated zone, where the water is under pressure greater than the atmosphere.

Groundwater Heads Elevation of water table.

Harm As defined in Chapter 40E-8, F.A.C., the temporary loss of water resource functions that results from a change in surface or groundwater hydrology and takes a period of one to two years of average rainfall conditions to recover.

Hydrilla (*Hydrilla verticillata*) A submerged plant with slender stems that can grow to the surface and form dense mats. It may be found in all types of water bodies.

Hydrology The scientific study of the properties, distribution and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

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

Illinois pondweed (*Potamogeton illinoensis*) A perennial plant that has mostly submerged leaves, sometimes with a few floating leaves in an alternate pattern. The submerged leaves are blade-like and are 1 to over 7 inches long and ½ to 2½ inches wide.

Invasive Exotic Species A species of plant or animal not naturally found in a region (nonindigenous), which aggressively invades habitats. Ecosystem invasive by an exotic plants and animals can cause multiple ecological changes, including the displacement of native species.

Lacustrine Pertaining to, produced by, or inhabiting a lake.

Lacustrine Deposits Stratified materials deposited in lake waters and later become exposed either by the lowering of the water level or by the elevation of the land.

Lacustrine Wetland Wetlands that are situated within lakes, typically lack trees and shrubs, and are dominated by emergent vegetation with occasional floating and submerged species. The outer limit of a lacustrine wetland is the boundary where an upland or wetland dominated by trees, shrubs, and persistent emergent vegetation occurs. Sub-divided into Littoral Wetlands and Remnant Littoral Wetlands. Also see Wetlands.

Lake Ecosystem Health As defined for this draft LTMP, is a sustainable system capable of maintaining its structure and function over time. For the KCOL, "sustainable" refers to a sustainably managed system, since the plan partners recognize that these lakes cannot be returned to their pre-regulation condition. See additional information in Appendix I.

Lake Okeechobee At 730 square miles, the lake is the second-largest freshwater lake wholly within the United States and the largest freshwater lake in Florida.

Lake Okeechobee Water Shortage Management Plan This effort includes provisions in Chapters 40E-21 and 40E-22, Florida Administrative Code (F.A.C.), and identifies how water supplies are allocated to users within the Lake Okeechobee Service Area during declared water shortages. The plan allows for supply allotments and cutbacks to be identified on a weekly basis based on the water level within the lake, demands, time of year and rainfall forecasts.

Lake Okeechobee SWIM Planning Area The major basins that are direct tributaries to Lake Okeechobee, including those basins that are hydrologically upstream and/or from which water is presently released or pumped into the lake on a regular basis.

Lake Recharge The replacement of a volume of water removed from a lake system and used as a source of water supply or indirectly as a source of wellfield recharge. Lake recharge does not include artificial maintenance of the water level of a surface water body at a desired elevation for aesthetic purposes, but may include augmentation of the volume of water stored within a surface water body that is affecting recharge to an adjacent wellfield.

Levee An embankment to prevent flooding or a continuous dike or ridge for confining the irrigation areas of land to be flooded.

Limnetic Zone The open water zone in lakes, which may be colonized by submergent and floating plant species.

Limnology The scientific study of bodies of fresh water for their biological, physical and geological properties.

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

Littoral Wetland Lacustrine wetland generally occurring below the lake's maximum regulatory stage and inundated at least part of the year due to fluctuations in lake stage. They occur primarily as emergent marshes.

Littoral Zone The area between the perimeter of lake or in shallow areas within a lake that is inundated year-round and contains emergent, floating-leaved and submerged rooted plants.

Load The amount of a material added to a waterbody; quantified by multiplying the concentration of a material within water column by the flow of water into the system.

Macrophytes Visible (non-microscopic) plants found in aquatic environments. Examples in south Florida wetlands include sawgrass, cattail, sedges and lilies.

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

Mandate A Florida statute, administrative code, rule, policy or directive from a governing authority that justifies and/or determines resource allocation, responsibility, and/or authority within an agency or organization.

Mesotrophic Pertaining to a lake or other body of water characterized by moderate concentrations of nutrients, such as nitrogen and phosphorus, resulting in high productivity.

Metric A specific variable used to quantify and serve as an indicator of the condition or state of an attribute.

Model A computer model is a representation of a system and its operations, and provides a cost-effective way to evaluate future system changes, summarize data and help understand interactions in complex systems. Hydrologic models are used for evaluating, planning and simulating the implementation of operations within the SFWMD's water management system under different climatic and hydrologic conditions. Water quality and ecological models are also used to evaluate other processes vital to the health of ecosystems.

Morphometry The science of the structure of organisms or objects. River morphology deals with the science of analyzing the structural make-up of rivers and streams.

Muck Dark, organic soil derived from well-decomposed plant biomass.

National Geodetic Vertical Datum (NGVD) 1929 A geodetic datum derived from a network of information collected in the United States and Canada. It was formerly called the "Sea Level Datum of 1929" or "mean sea level (msl)." Although the datum was derived from the average sea level over a period of many years at 26 tide stations along the Atlantic, Gulf of Mexico and Pacific coasts, it does not necessarily represent local mean sea level at any particular place.

Native Nuisance Species Native plant species that spread rapidly under disturbed conditions and displace more desirable plant communities.

Native Species A species that is a part of an area's naturalized fauna or flora.

Nitrogen An essential element for plant growth, comprising 78 percent of the atmosphere.

Nonpoint Source Water pollution caused by diffuse sources with no discernible distinct source, often referred to as runoff or polluted runoff from agriculture, urban areas, mining, construction sites and other sites. These forms of diffuse pollution originate from land use activities and are carried to lakes and streams by surface runoff.

Nutrient Cycle The cyclic conversions of nutrients from one form to another. A simple example of such a cycle would be the production and release of molecular oxygen (O_2) from water (H_2O) during photosynthesis by plants and the subsequent reduction of atmospheric oxygen to water by the respiratory metabolism of other biota. The cycle of nitrogen is much more complex, with the nitrogen atom undergoing several changes in oxidation state (N_2, NO_3^-, $R\text{-}NH_2$ and NH_4, among others) during the cycling of this element through the biological community, and into the air, water or soil.

Nutrients Organic or inorganic compounds essential for the survival and growth of organisms.

Oligotrophic An aquatic environment with low concentrations of nutrients, resulting in low plant productivity.

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

Other Surface Waters Surface waters other than wetlands, as described and delineated pursuant to Rule 62-340.600, F.A.C., as ratified by Section 373.4211, F.S.

Palustrine Pertaining to a marsh or wetlands; wet or marsh habitats.

Palustrine Wetland Palustrine wetlands are situated further away from lakes than lacustrine wetlands, and include those wetlands separated from lakes that occur as depressional areas surrounded entirely by uplands. The outer limit of a palustrine wetland is the boundary where either uplands or other wetland systems occur. Palustrine wetlands are typically dominated by trees, shrubs, or persistent emergents. Sub-types include Floodplain Wetland, Riparian Wetland, Perched Depressional Wetland, Non-perched Depressional Wetland, and Slough.

Perched Depressional Wetland Palustrine wetland occurring in a depressional area that holds water due to nonporous soil properties and is hydrologically independent of lake stage.

Periphyton The biological community of microscopic plants and animals attached to surfaces in aquatic environments. Algae are the primary component in these assemblages, which naturally reduce phosphorus levels in water and serve a key function in stormwater treatment areas.

Performance Measure Scientifically measurable indicator or condition that can be used as a target for meeting water resource management goals. Performance measures quantify how well or how poorly an alternative meets a specific objective. Performance measures should be quantifiable, have a specific target, indicate when a target has been reached, and measure the degree to which the goal has been met.

pH (Hydrogen Ion Concentration or Potential of Hydrogen) A method of expressing the acidity or basicity of a solution in terms of the logarithm of the reciprocal (or negative logarithm) of the hydrogen ion concentration. The pH scale runs from 0 to 14; a pH value of 7.0 indicates a neutral solution. Values above a pH of 7.0 indicate basicity (basic or alkaline solutions) and values below pH 7.0 indicate acidity (acidic solutions). Natural waters usually have a pH between 6.5 and 8.5.

Phosphorus An element that is essential for life. In freshwater aquatic environments, phosphorus is often in short supply and increased levels can promote the growth of algae and other plants.

Photosynthesis The process in green plants and certain other organisms by which carbohydrates are synthesized from carbon dioxide and water using light as an energy source.

Phytoplankton The floating, usually minute, plant life of a body of water.

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

Point Source A stationary or clearly identifiable source of a large individual water or air pollution emission, generally of an industrial nature. Any discernible, confined or discrete conveyance from which pollutants are or may be discharged, including (but not limited to) pipes, ditches, channels, tunnels, conduits, wells, containers, rolling stock, concentrated animal feeding operations or vessels. Point source is also legally and more precisely defined in federal regulations. Contrast with Non-Point Source (NPS) Pollution.

Pollutant Loading Influx of a chemical or nutrient that contaminates air, soil or water.

Pollutant Load Reduction Goal (PLRG) Targeted reduction in pollutant loading to a water body needed to achieve watershed management goals.

Preferred State The desired condition of ecosystem attributes as determined by the KCOL LTMP partner agencies and stakeholders.

Recommendation A suggested action to be taken to achieve a performance measure or to collect additional information to allow for an evaluation of baseline conditions.

Reference Condition Measured values of the performance measure metric(s) in the historical, natural system or in an ecologically similar but undisturbed system (i.e., a system with ecological integrity).

Remnant Littoral Wetland Former littoral wetland that has been separated from a lake by man-made berming or other intervention.

Research Plan A plan to undertake a scientific evaluation when existing data are not sufficient to develop a performance measure.

Riparian Wetland Palustrine wetland bordering a river that is subject to overbank flooding.

Riverine Wetland Riverine wetlands are contained within a channel where water is usually, but not always, flowing. Upland islands or palustrine wetlands may occur in the channel or floodplain, but they are not considered to be riverine wetlands. Large sloughs may fall within this category, however, sloughs within the KCOL system are usually too small to be considered "riverine."

Rule Of or pertaining to the District's regulatory programs, which are set forth in various rules and criteria.

Runoff That component of rainfall, which is not absorbed by soil, intercepted and stored by surface water bodies, evaporated to the atmosphere, transpired and stored by plants, or infiltrated to groundwater, but which flows to a watercourse as surface water flow.

Secchi Depth A relatively crude measurement of the turbidity (cloudiness) of surface water; the depth at which a Secchi Disc (Disk) can no longer be seen. (A Secchi Disc (Disk) is about 10-12 inches in diameter with a black-and-white pattern.)

Sedimentation The action or process of forming or depositing sediment.

Slough A slowly flowing shallow swamp or marsh.

Stressor A physical, chemical, or biological perturbation that results in changes to an ecological system. Stressors may be foreign to the system (e.g. exotic plants) or natural to the system (e.g. hurricane).

Stage The height of a water surface above an established reference point (datum or elevation).

Staged Drawdown In dewatering systems, the practice of pumping the source unit to discrete, incremental levels.

Subbasin A portion of a subregion or basin drained by a single stream or group of minor streams.

Submerged Aquatic Vegetation (SAV) Wetland plants that grow completely below the water surface.

Submerged Wetland An area that is underwater and where the vegetation is made up mainly of plants that do not break through the surface of the water.

Surface Water Water above the soil or substrate surface, whether contained in bounds, created naturally or artificially, or diffused. Water from natural springs is classified as surface water when it exits from the spring onto the earth's surface.

Surface Water Improvement and Management (SWIM) Plan A plan prepared pursuant to Chapter 373, F.S.

Sustainable Capable of being continued with minimal intervention and minor long-term effects on the environment.

Swamp A frequently or continuously inundated forested wetland.

Threatened Species Any plant or animal species likely to become an "endangered" species within the foreseeable future throughout all of a significant area of its range or natural habitat; identified by the Secretary of the Interior as "threatened," in accordance with the 1973 Endangered Species Act (ESA).

Total Maximum Daily Load (TMDL) The maximum allowed level of pollutant loading for a water body, while still protecting its uses and maintaining compliance with water quality standards, as defined in the Clean Water Act.

Tributary A stream that flows into a larger stream or other body of water.

Trophic Level One of the hierarchical strata of a food web characterized by organisms that are the same number of steps removed from the primary producers.

Turbidity The measure of suspended material in a liquid.

Turion A small shoot, as in certain aquatic plants, from which a new plant can develop.

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.

United States Army Corps of Engineers (USACE) The federal agency responsible for investigating, developing and maintaining the nation's water and related environmental resources.

United States Fish and Wildlife Service (USFWS) A bureau of the U.S. Department of the Interior responsible for conserving, protecting and enhancing fish, wildlife, and plants and their habitats for the continuing benefit of the American people.

Water Conservation Reducing the demand for water through activities that alter water use practices (e.g. improving efficiency in water use, reducing losses of water, waste of water, and water use).

Water Column A hypothetical cylinder of water from the surface to the bottom of a stream, lake or ocean within which the physical and/or chemical properties can be measured.

Water Discharge The amount of water and sediment flowing in a channel, expressed as volume per unit of time. The water contains both dissolved solids (Dissolved Load) and suspended sediment (Suspended Load).

Water Hyacinth (*Eichhornia crassipes*) A floating freshwater plant that was introduced into the United States in the late 19th century and has become a prolific nuisance weed that clogs waterways in the southern part of the country.

Waterfowl A water bird and such birds taken collectively (e.g. swans, geese and ducks).

Water Management The general application of practices to obtain added benefits from precipitation, water or water flow in any of a number of areas, such as irrigation, drainage, wildlife and recreation, water supply, watershed management, and water storage in soil for crop production.

Water Resources Advisory Commission (WRAC) An advisory body to the SFWMD Governing Board. The WRAC is the primary forum for conducting workshops, presenting information and receiving public input on water resource issues affecting central and south Florida.

Water Quality A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.

Watershed A region or area bounded peripherally by a water parting and draining ultimately to a particular watercourse or body of water.

Watershed Management is the analysis, protection, development, operation, or maintenance of the land, vegetation, and water resources of a drainage basin for the conservation of all its resources for the benefit of its residents. Watershed management for water production is concerned with the quality, quantity and timing of the water which is produced.

Watershed Management Goals Goals that encompass any one or all of the major water management district responsibilities: flood protection, water supply, water quality, and environmental system protection and enhancement. The goals provide the general direction for developing cohesive strategies to manage water resources within a drainage basin, subbasin or segment of a drainage basin or subbasin.

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.) Estimates of the percent reduction in demand required to match available supply is required and identifies which phase of drought restriction is implemented. A gradual progression in severity of restriction is implemented through increasing phases. Once declared, the District is required to notify permitted users by mail of the restrictions and to publish restrictions in area newspapers.

Water Shortage Trigger Water shortage triggers are water levels at which phased restrictions will be declared under the SFWMD's Water Shortage Plan. Other considerations associated with the implementation of the water shortage plan are set forth in Rule 40E-8.441(4), F.A.C., and Chapter 40E-21, F.A.C.

Wetland An areas that is inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soils. Soils present in wetlands generally are classified as hydric or alluvial, or possess characteristics that are associated with reducing soil conditions. The prevalent vegetation in wetlands generally consists of facultative or obligate hydrophytic macrophytes that are typically adapted to areas having soil conditions described above. These species, due to morphological, physiological or reproductive adaptation, have the ability to grow, reproduce or persist in aquatic environments or anaerobic soil conditions. Florida wetlands generally include swamps, marshes, bayheads, bogs, cypress domes and strands, sloughs, wet prairies, riverine swamps and marshes, hydric seepage slopes, tidal marshes, mangrove swamps and other similar areas. The landward extent of wetlands shall be delineated pursuant to Rules 62-340.100 through 62-340.550, F.A.C., as ratified by Section 373.4211, F.S. (Basis of Review).

Zooplankton The passively floating or weakly swimming, usually minute, animal life of a body of water.

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Appendix A
SFWMD Resolution

INTRODUCTION

On April 10, 2003, the South Florida Water Management District's (SFWMD) Governing Board adopted resolution number 2003-468 (Appendix A). The recommendations in this resolution were adopted by the Water Resources Advisory Commission (WRAC) on April 3, 2003. This resolution directs SFWMD staff to work with the U.S. Army Corps of Engineers and additional stakeholders to develop a long-term management plan for the Kissimmee Chain of Lakes (LTMP). This resolution is provided below.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

RESOLUTION NO. 2003-468

A RESOLUTION OF THE GOVERNING BOARI) OF THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT ACCEPTING THE KISSIMMEE CHAIN OF LAKES RECOMMENDATIONS DEVELOPED BY THE WATER RESOURCES ADVISORY COMMISSION; PROVIDING AN EFFECTIVE DATE

WHEREAS, the South Florida Water Management District Governing Board ("Governing Board") adopted Resolution 0 1-22 creating the South Florida Water Management District Governing Board's Water Resources Advisory Commission ("Commission"); and

WHEREAS, On January 16, 2002, by consensus of the South Florida Ecosystem Restoration Task Force members, the Commission, became a Task Force Advisory Body pursuant to section 528(f)(2)(E) of the Water Resources Development Act of 1996, Public Law 104-303; and

WHEREAS, The Commission had information on the Kissimmee Chain of Lakes drawdown presented to them on January 16, 2003 and on Much 6, 2003; and

WHEREAS, the Commission provided the opportunity for written or verbal comments from the public and Commission members between the initial presentation on January 16, 2003 and the subsequent meetings in February 6, 2003, March 6, 2003 and April 3, 2003; and

WHEREAS, the Commission provided ample notice to Commission Members that voting would occur on April 3, 2003 so that Commission members could arrange to be present for the vote; and

BE IT RESOLVED BY THE GOVERNING BOARD OF THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT:

Section 1. The Governing Board of the South Florida Water Management District accepts and endorses the Kissimmee Chain of Lakes recommendations adopted by the Water Resources Advisory Commission on April 3, 2003; and directs staff to:

Section 2. Work in conjunction with United States Army Corp of Engineers and other interested parties to ensure that the ongoing Kissimmee Upper Chain of Lakes Comprehensive Environmental Impact Statement is of sufficient scope to develop a Kissimmee Upper Chain of Lakes Long Term Management Plan; and

Section 3. Ensure that to the extent **of** the authority of the Comprehensive Environmental Impact Statement, it develops alternative management scenarios that address stressors that cause environmental harm to the lakes, including but not limited to, restricted lake regulation schedules, nuisance and invasive aquatic plants, and nutrient impacts; and

Section 4. In addition to improving the health and stability of the Upper Chain of Lakes, lake schedules should consider incorporating adaptive protocols that consider long range weather forecasts and downstream conditions in the

Kissimmee River, Lake Okeechobee, the Estuaries, and the Everglades, to provide, windows of opportunity for lake drawdowns that optimize water related benefits, such as water supply and flood protection, opportunities for the restoration of threatened and endangered species, increased opportunities for recreational uses and minimize adverse effects while . . . sitive effects of drawdowns; and

Section 5. Develop a Kissimmee Upper Chain of Lakes Long Term Management Plan that builds on the 1997 Draft Management Plan for the Kissimmee Chain of Lakes prepared by the South Florida Water Management District, Florida Fish and Wildlife Conservation Commission, U.S. Army Corps of Engineers, and the Florida Department of Environmental Protection, by incorporating information from the Upper Chain of Lakes Comprehensive Environmental Impact Statement and the input of other interested parties. Once the study alternatives are completed, they should be brought before the Commission for further consideration.

Section 6. Request that permits and/or funding for activities recommended by the Kissimmee Chain of Lakes Comprehensive Environmental Impact Statement associated with the purpose of Lake drawdowns, be multi-year and consistent with the adaptive protocols proposed in the Kissimmee Upper Chain of Lakes Long Term Management Plan; and

Section 7. Work with the interested parties to facilitate plans for the Lake Toho Drawdowns and ensure the appropriate monitoring plans and research are carculy conducted so that results can be used in the development of the Kissinunee Upper Chain of Lakes Long Tern Management Plan; and

Section 8. Directs the District Clerk to forward the resolution to the South Florida Ecosystem Restoration Task Force;

Section 9. This resolution shall take ewect immediately ul)on adoption **@Ar- c;;P-.h nt.14pr- data a-**

Apr. 1 1 2003.

SOUTH FLORIDA WATER NAGENENT
DISTRICT, BY ITS GOVERNING BOARI @-ZW

BY ______________________
Chairman

Approved as to form:

BY: ATTEST:

____
Assistant Secretarv

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Appendix B
Agency Mission Statements

INTRODUCTION

The agencies that participated in the development of this Planning Document have provided Agency Mission Statements specific to their roles and responsibilities with the KCOL.

KISSIMMEE CHAIN OF LAKES, LONG-TERM MANAGEMENT PLAN MISSION STATEMENTS:

South Florida Water Management District

The SFWMD will:

1. Meet surface and ground water quality criteria for Class III uses: recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife (TMDLs).
2. Identify and reduce phosphorus runoff from properties exceeding phosphorus discharge limitations (Lake Okeechobee Works of the District).
3. Protect the supply and quality of water resources in the KCOL by ensuring future development within the Upper Basin does not impact water quality or the amount and timing of runoff (Basin Rule currently under development).
4. Ensure that water supply withdrawals from the lakes do not cause harm to the water resources of the area and the related natural resources (Florida Statues Chapter 373 Part II).
5. Investigate structural and operational modifications to the C&SF Project that improve the quality of the environment, improve aquifer protection, improve the integrity, capability, and conservation of agricultural and urban water supplies, and maintain current levels of flood protection (Northern Everglades).
6. Provide the surface water and water control structure operations needed to meet the hydrologic criteria of the Kissimmee River Restoration Project (KRRP and KR Water Reservation).
7. Operate Kissimmee Basin water control structures to meet flood control, water supply, aquatic plant management and natural resource requirements for the Kissimmee River and the Kissimmee Chain of Lakes while avoiding downstream impacts to Lake Okeechobee (KBMOS).
8. Improve, enhance/sustain lake ecosystem health while avoiding downstream impacts (KCOL LTMP).

Florida Fish and Wildlife Conservation Commission

The Florida Fish and Wildlife Conservation Commission (FWC) in cooperation with other state and federal agencies will manage, conserve, and regulate the fish and wildlife, including their habitats, of the Kissimmee Chain of Lakes for the benefit of the public. The FWC will also enforce public boating safety.

Specifically:

- The FWC will manage, conserve, and regulate fisheries and listed species on lakes Tohopekaliga, Cypress, Hatchineha, and Kissimmee as the highest priority and secondly alligators and other herpatofauna, waterfowl, and wading birds as a high priority.
- The FWC will manage, conserve and regulate fisheries as a priority on the Alligator Chain of Lakes and Lake Gentry.
- The FWC will manage, conserve, and regulate listed species in East Lake Tohopekaliga, as a high priority and secondarily fisheries and alligators as a priority.

Florida Fish and Wildlife Conservation Commission BUREAU OF INVASIVE PLANT MANAGEMENT MISSION STATEMENT

The FWC Bureau of Invasive Plant Management mission is to manage aquatic plants, especially invasive aquatic plants, to conserve the various combined uses and functions of public lakes within the KCOL management area. These uses include flood control, navigation, recreation, fish and wildlife habitat, and agricultural water supply.

FWC BIPM will:

- Fund and coordinate aquatic plant management activities with agency and public sector stakeholders;
- Provide information and outreach materials that address problems and management strategies;
- Fund and coordinate research to improve aquatic plant management efforts.

Florida Department of Environmental Protection – Water Quality

The FDEP will maintain water quality monitoring activities within the KCOL and a water quality database that will also include data from other agencies and local governments, in compliance with the Florida Watershed Restoration Act and the Impaired Waters Rule.

The FDEP will develop total maximum daily loads (TMDLs) for verified impaired water bodies, to bring those water bodies into compliance with state water quality standards for their designated uses.

The FDEP through the TMDL implementation process will develop Basin Management Action Plans that will include management measures expected to restore water quality in impaired water bodies into compliance with their established TMDLs.

Florida Department of Agriculture and Consumer Services, Division of Agricultural Water Policy

Work with all agricultural landowners within the geographical boundaries of the Northern Everglades and Estuary Protection Act (373.4595 F.S.) to develop land management plans and to implement site-specific agricultural Best Management Practices.

U.S. Army Corps of Engineers

The USACE will provide guidance to the SFWMD for operations of authorized C&SF Project features and investigate operational modifications that will improve the quality of the environment, improve aquifer protection, and improve the integrity, capability, and conservation of agricultural and urban water supplies while maintaining authorized level of flood protection (EIS for Modification of KB Structure Operating Criteria).

Implement Headwaters Revitalization Plan in order to provide flows needed to ensure the success of the Kissimmee River Restoration Project (Kissimmee River Restoration Project, WRDA 1992).

Control obnoxious aquatic plant growth in navigable waterways within the basin in the combined interest of navigation, flood control, drainage, agriculture, fish and wildlife conservation, public health, and related purposes, including continuous research into efficient methods for aquatic plant control (RAG and APC Programs).

Participate with non-federal sponsors through the Water Resources Development Act (WRDA) or other avenues (Section 1135, 205, etc) on water resource projects in the Kissimmee Basin.

U.S. Fish and Wildlife Service

The USFWS will continue to develop mitigation plans that avoid, minimize, or compensate for impacts to wetlands through our authority under the Fish and Wildlife Conservation Act, during our review of federal activities that impact wetlands and waters of the United States.

The USFWS will ensure that fish and wildlife resources receive equal consideration in water resource planning activities.

The USFWS provides recommendations to federal agencies on how they may assist in promoting the recovery of listed species. All federal agencies are required to review programs they administer to use such programs to further the conservation of listed species.

The USFWS will determine if proposed federal activities will or will not jeopardize the continued existence of federally listed species. In the event that proposals will not jeopardize a species, the USFWS will ensure the proposal includes measures to minimize adverse effects to a species through incidental take statements to federal action agencies. In the event a proposal would jeopardize the existence of a species, the USFWS will recommend reasonable alternatives to the proposal that will avoid jeopardy to the species.

Osceola County

Osceola County shall:

- Continue to participate in the development of the KCOL LTMP and will consider adopting appropriate parts of the Plan for inclusion in the Land Development Code (see Policy 1.2.11).

- Aggressively pursue alternative sources of funding for the removal or eradication of hydrilla or other exotic or pest plant vegetation as they interfere with most recreational activities, and alter lake chemistry and fishery population dynamics (see Policy 1.2.11)

- Continue its land acquisition programs to identify potential restoration, enhancement, and preservation projects in the floodplains and wetlands adjacent to surface waters to improve the quality of runoff into these surface water areas (see Policy 1.2.11).

- Assist in the implementation of emergency water conservation set forth by the Water Management District water supply plan.

- Cooperate with state and federal agencies to ensure proper approval is given for any alteration activities adjacent to surface water.

- Support the FWC, USACE, and SFWMD with respect to periodic drawdowns of the KCOL to maintain, enhance, and restore the surface water and fisheries habitats.

- Promote and encourage the use of prescribed and controlled burning to maintain the health and diversity of fire dependent ecosystems to private and public lands.

- Maintain a meaningful NPDES inspection and Best Management Practices program.

- Develop in conjunction with other entities, education and environmental awareness program for citizens, visitors, community leaders, and the business community.

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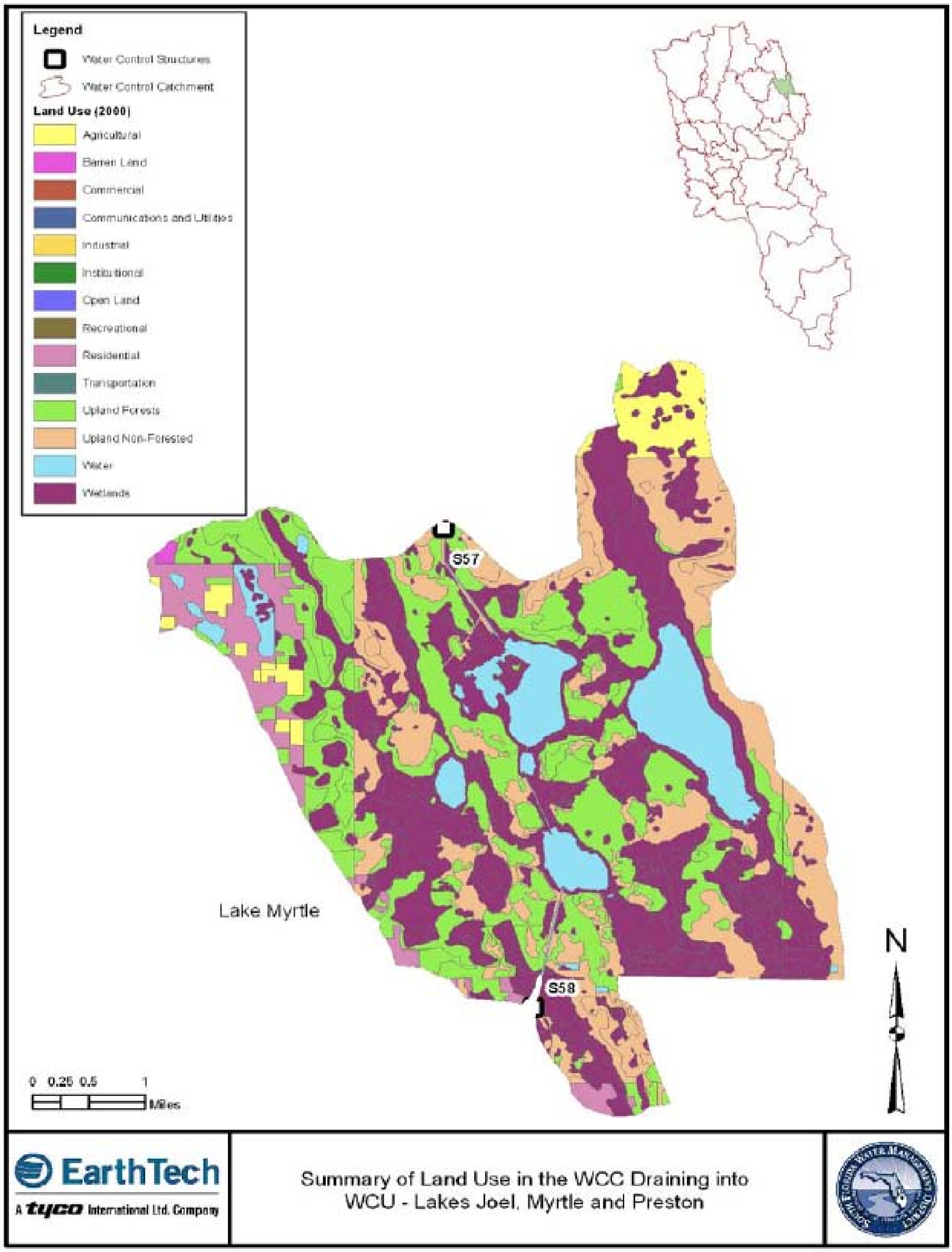
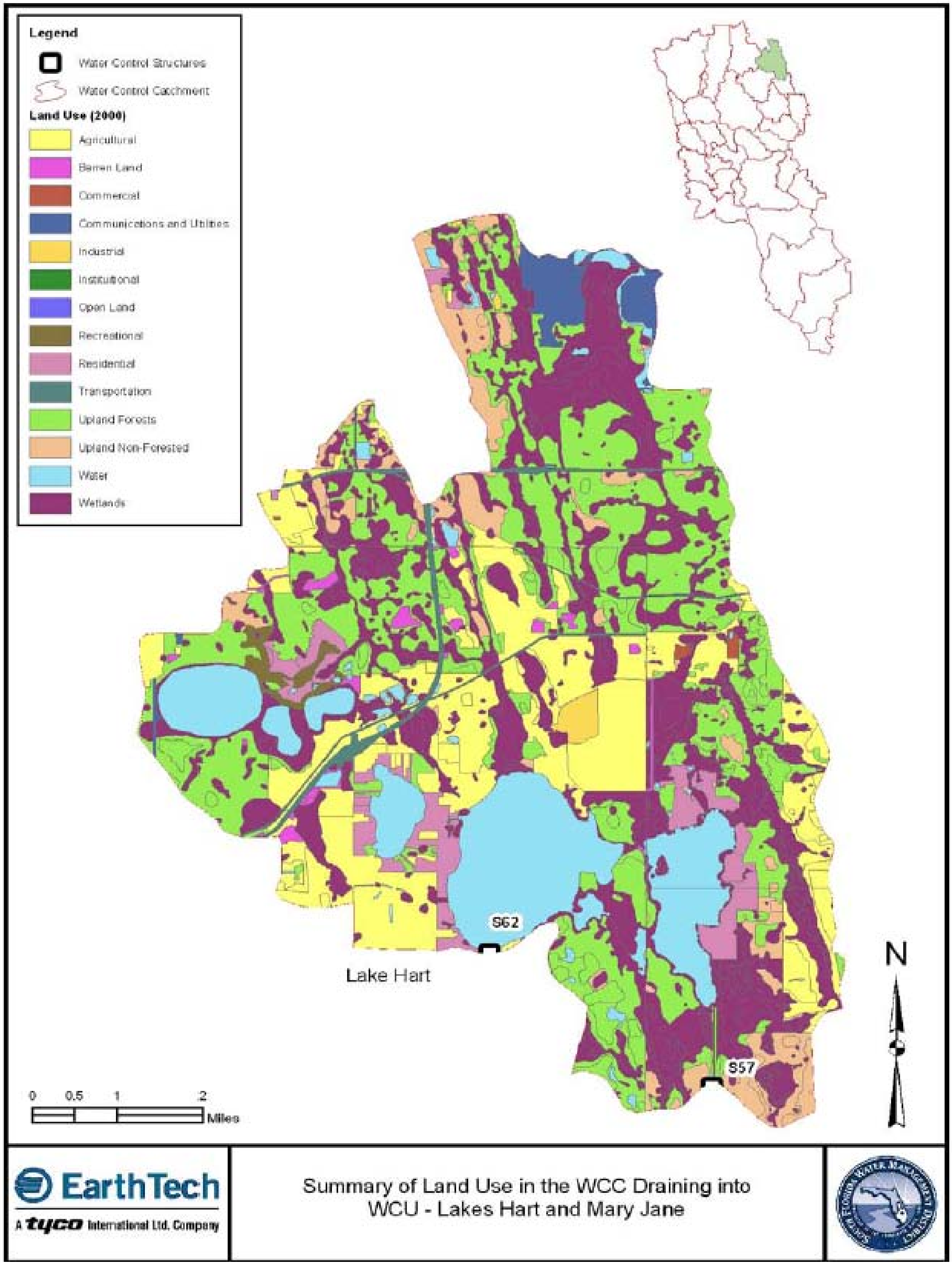
Appendix C
Water Control
Catchment Land Uses

INTRODUCTION

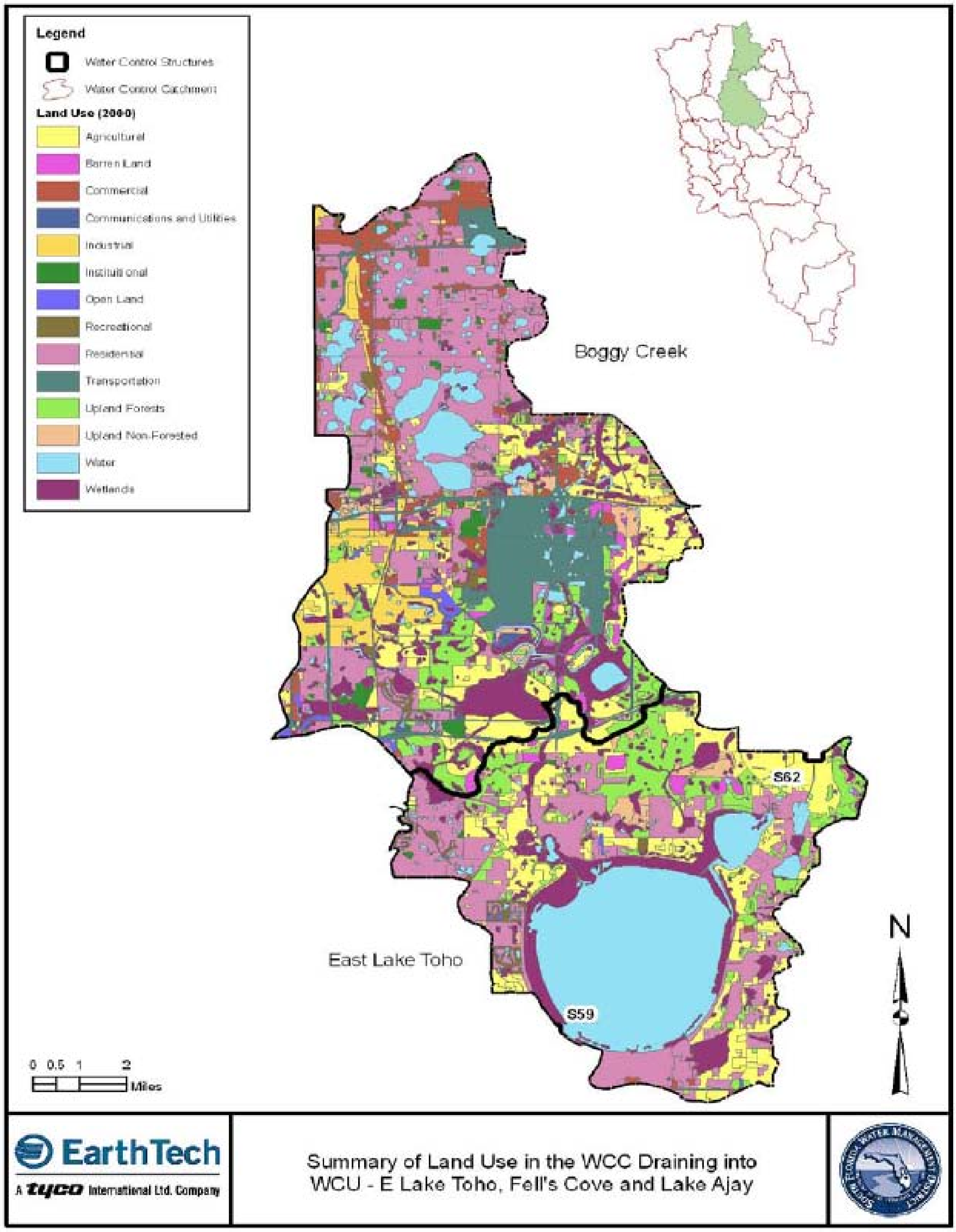
Land uses for the nine water control catchments (WCC) in the KCOL are presented in Appendix C. These data are from the year 2000 land use mapping performed by the SFWMD.



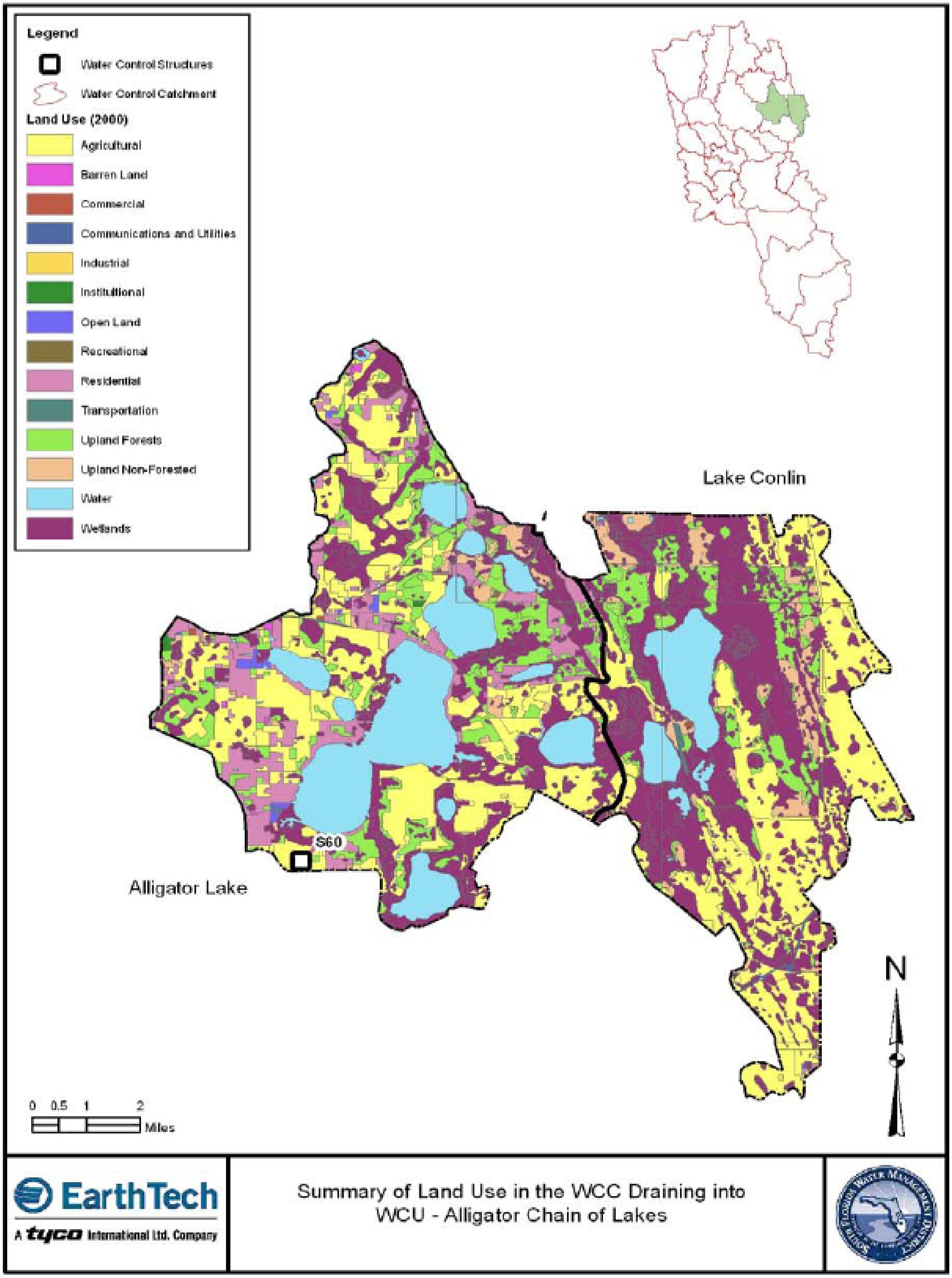
Lake Myrtle, Lake Joel and Lake Preston Land Uses



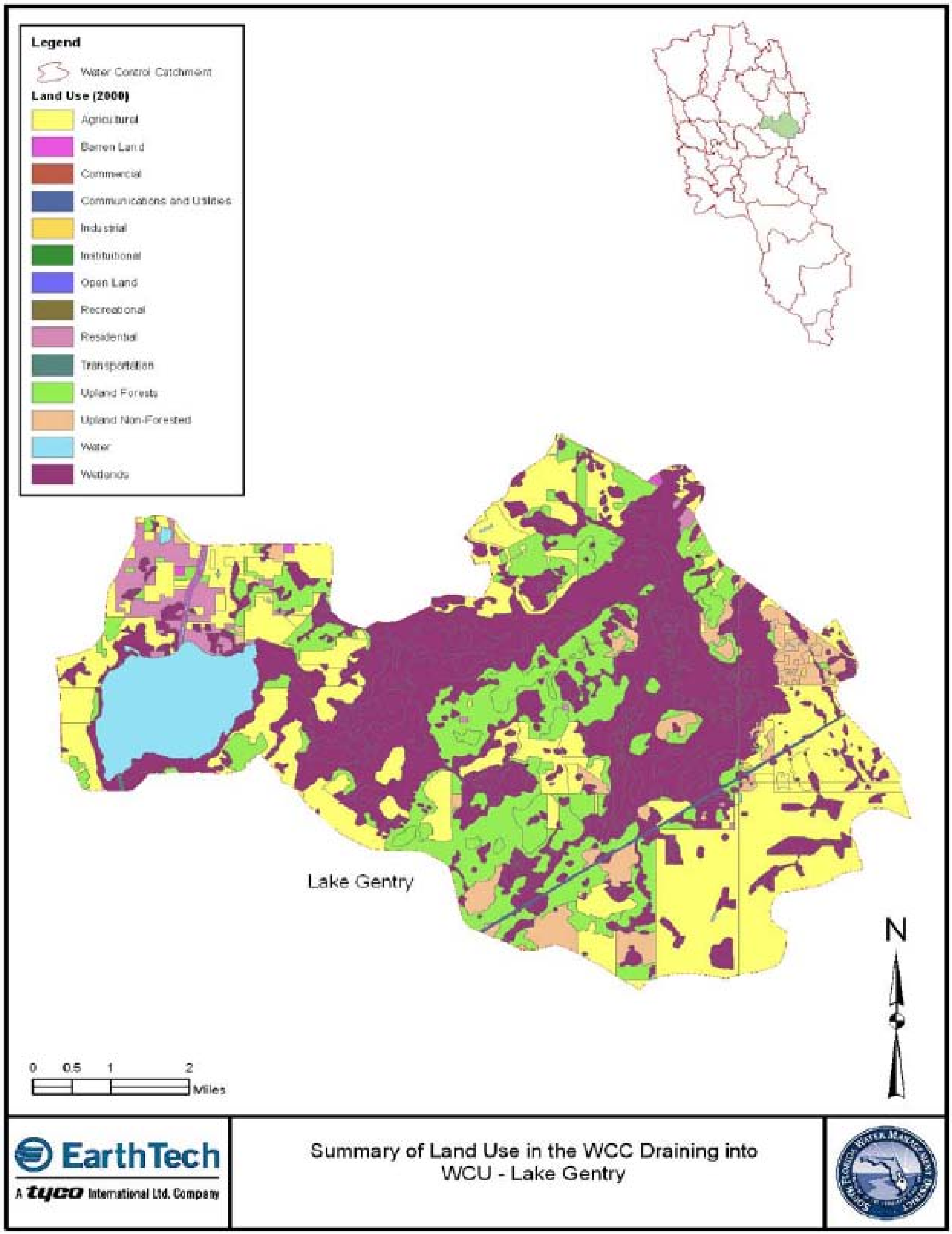
Lake Hart and Lake Mary Jane Land Uses



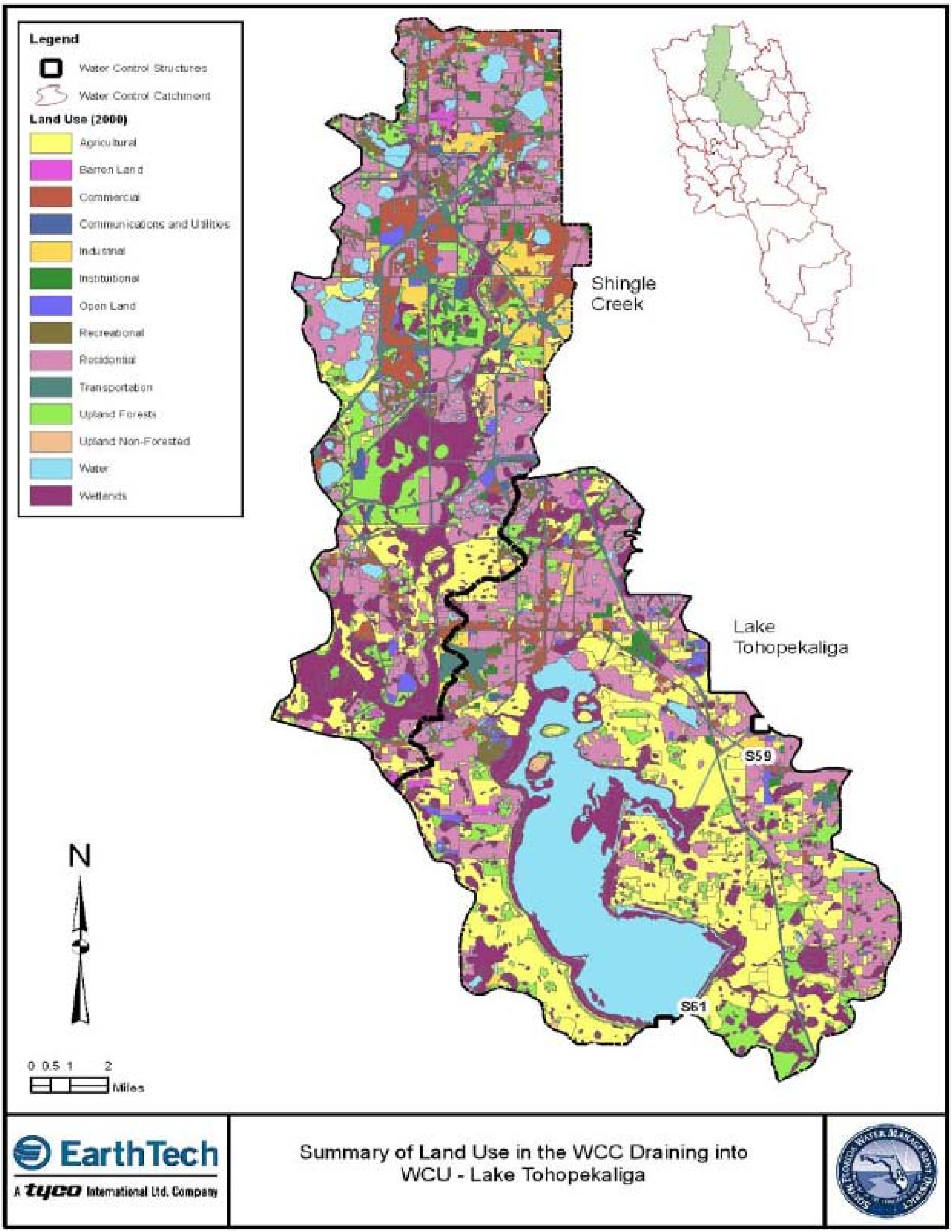
East Lake Tohopekaliga, Fells Cove and Lake Ajay Land Uses



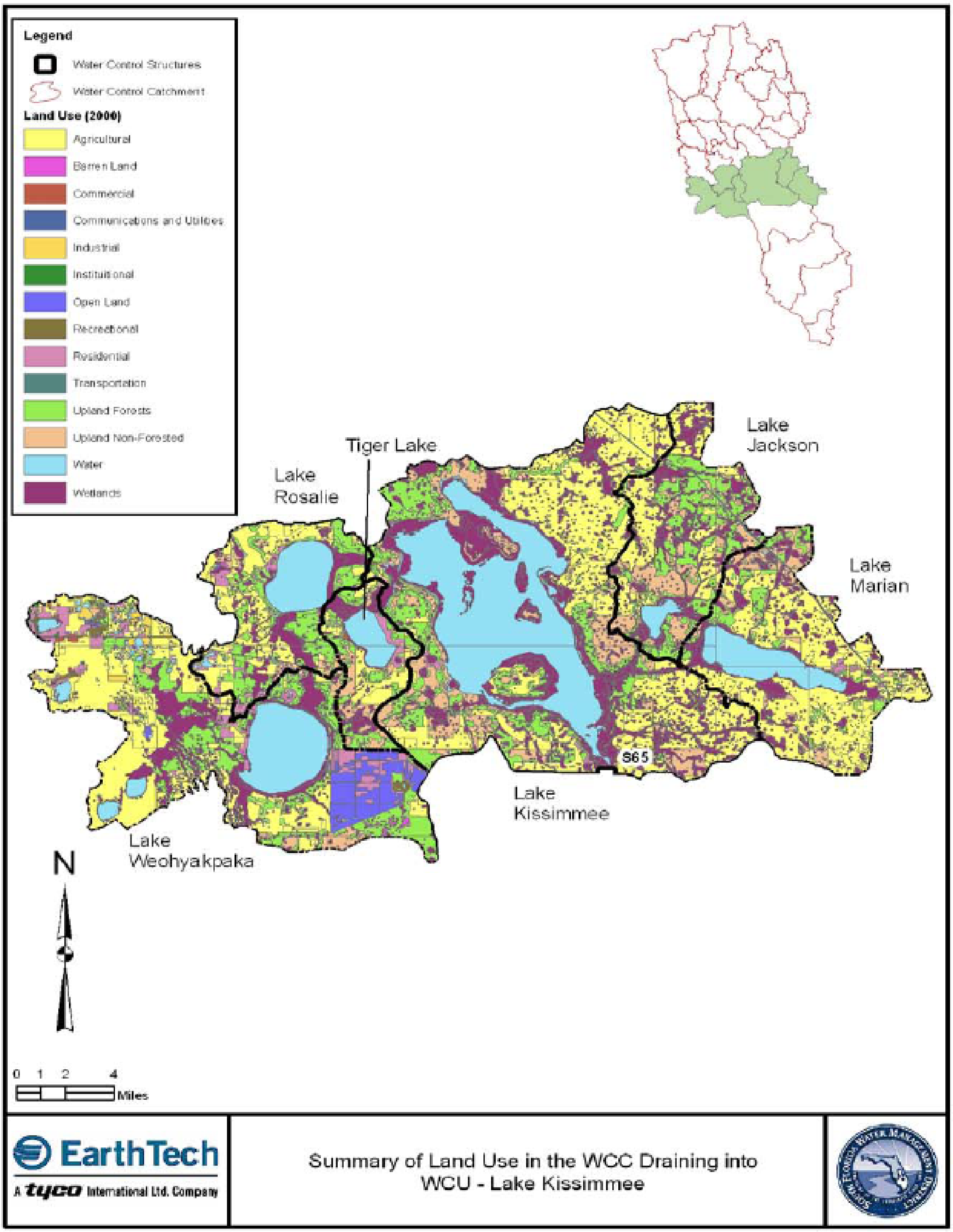
Alligator Chain of Lakes WCU Figure Land Uses



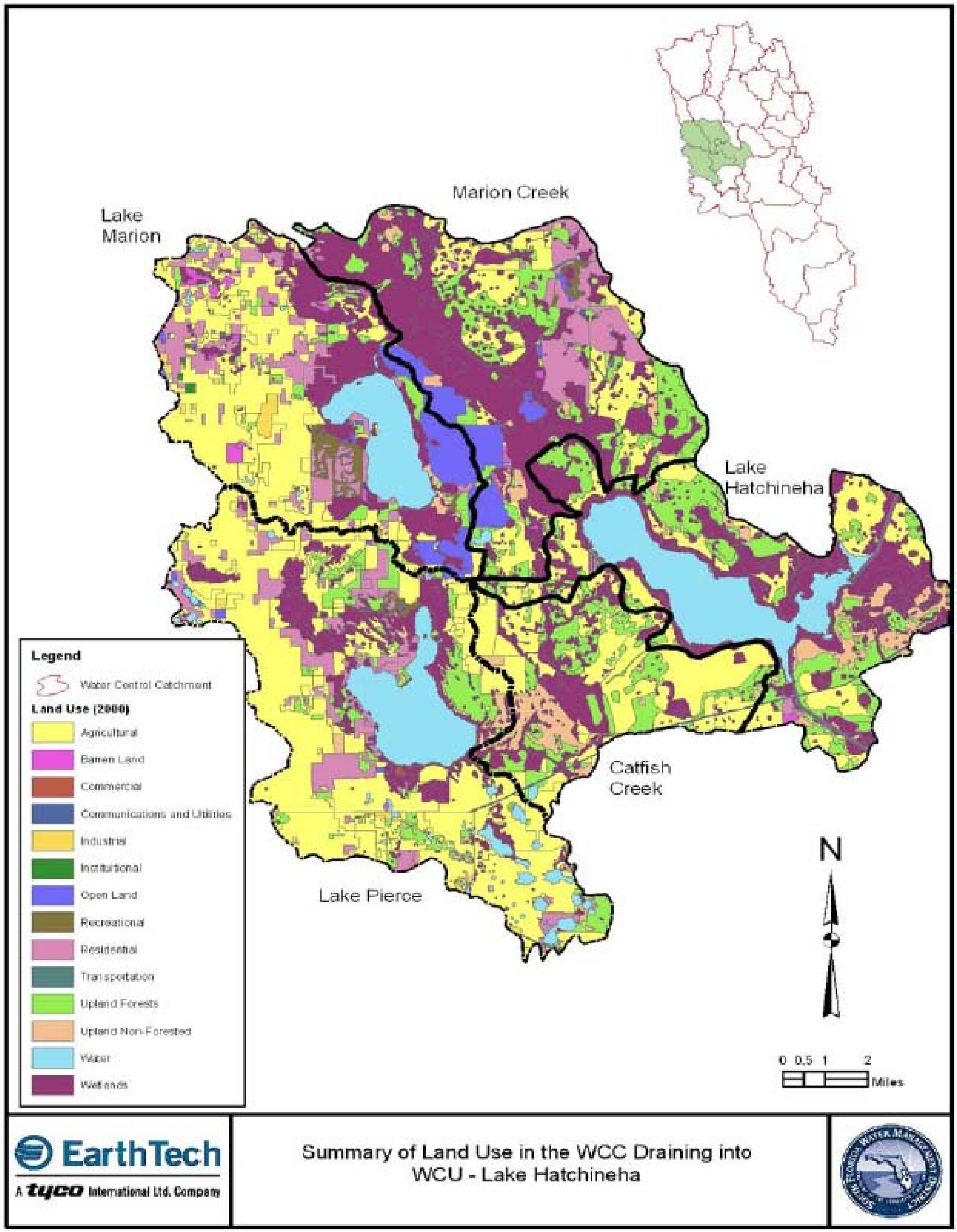
Lake Gentry Land Uses



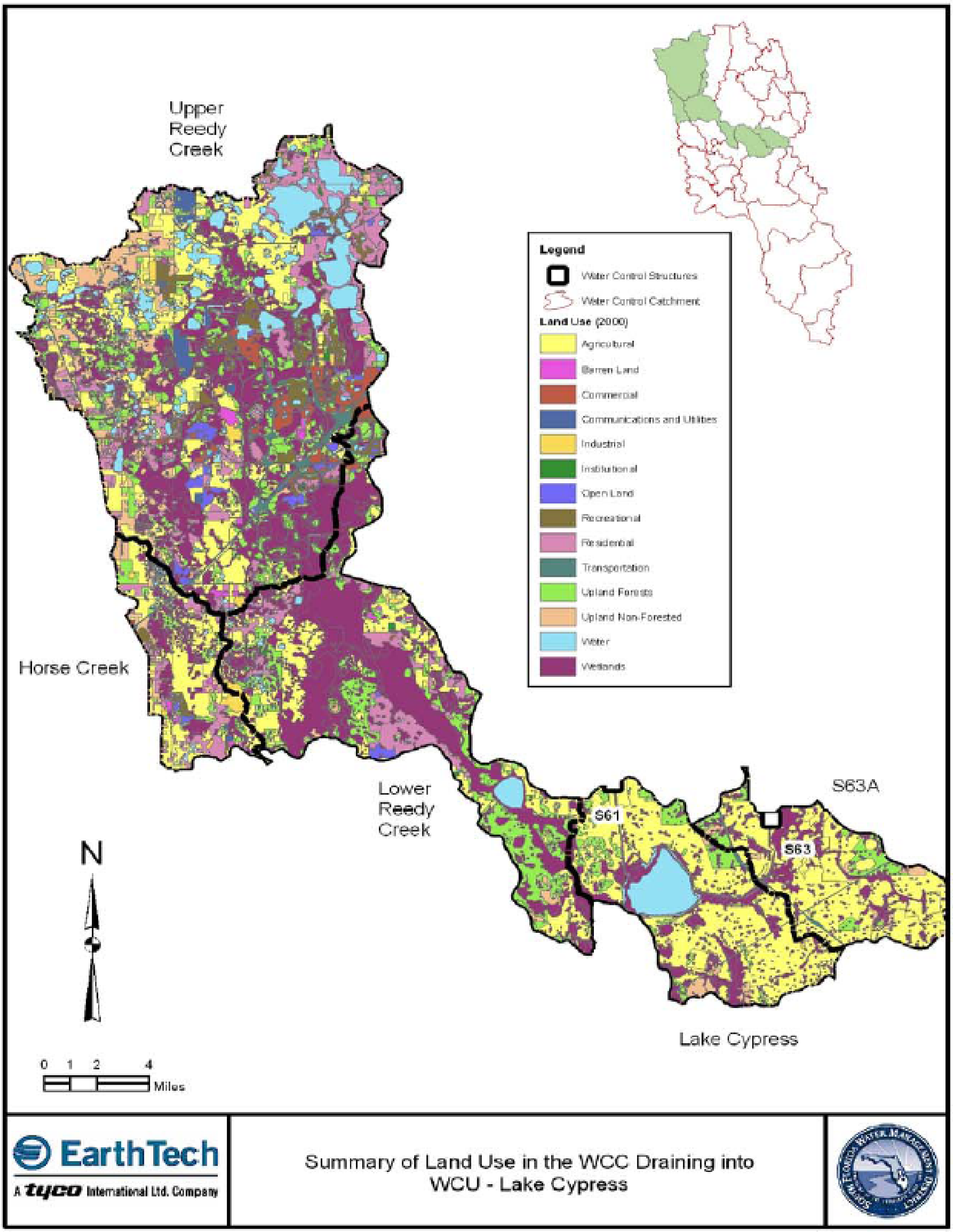
Lake Tohopekaliga Land Uses



Lake Kissimmee Land Uses



Lake Hatchineha Land Uses



Lake Cypress Land Uses

Appendix D
Stakeholder Value Survey Analysis

INTRODUCTION

A survey was conducted to assess the values residents and visitors in Osceola, Polk, Highlands and Okeechobee counties associate with the Kissimmee Chain of Lakes. Results showed that a significant number of people use the lakes and associated uplands for leisure time activities and that protecting water quality is a high priority relative to their continued enjoyment of these activities. In addition, results showed that fish and wildlife habitat preservation was thought to be a higher priority than recreation and access to areas for recreation, suggesting that respondents of the survey place an intrinsic value rather than a utilitarian value on the environment. The survey revealed that activities associated with agency management responsibilities are not widely known, which reinforces the need for continued public outreach. The survey revealed no clear indication of media preference for receiving environmental information, but this does not suggest a lack of interest. Slightly over half of the respondents wanted more information about the Kissimmee Chain of Lakes Long-Term Management Plan and provided contact information.

Kissimmee Chain of Lakes Long Term Management Plan

Stakeholder Survey Evaluation

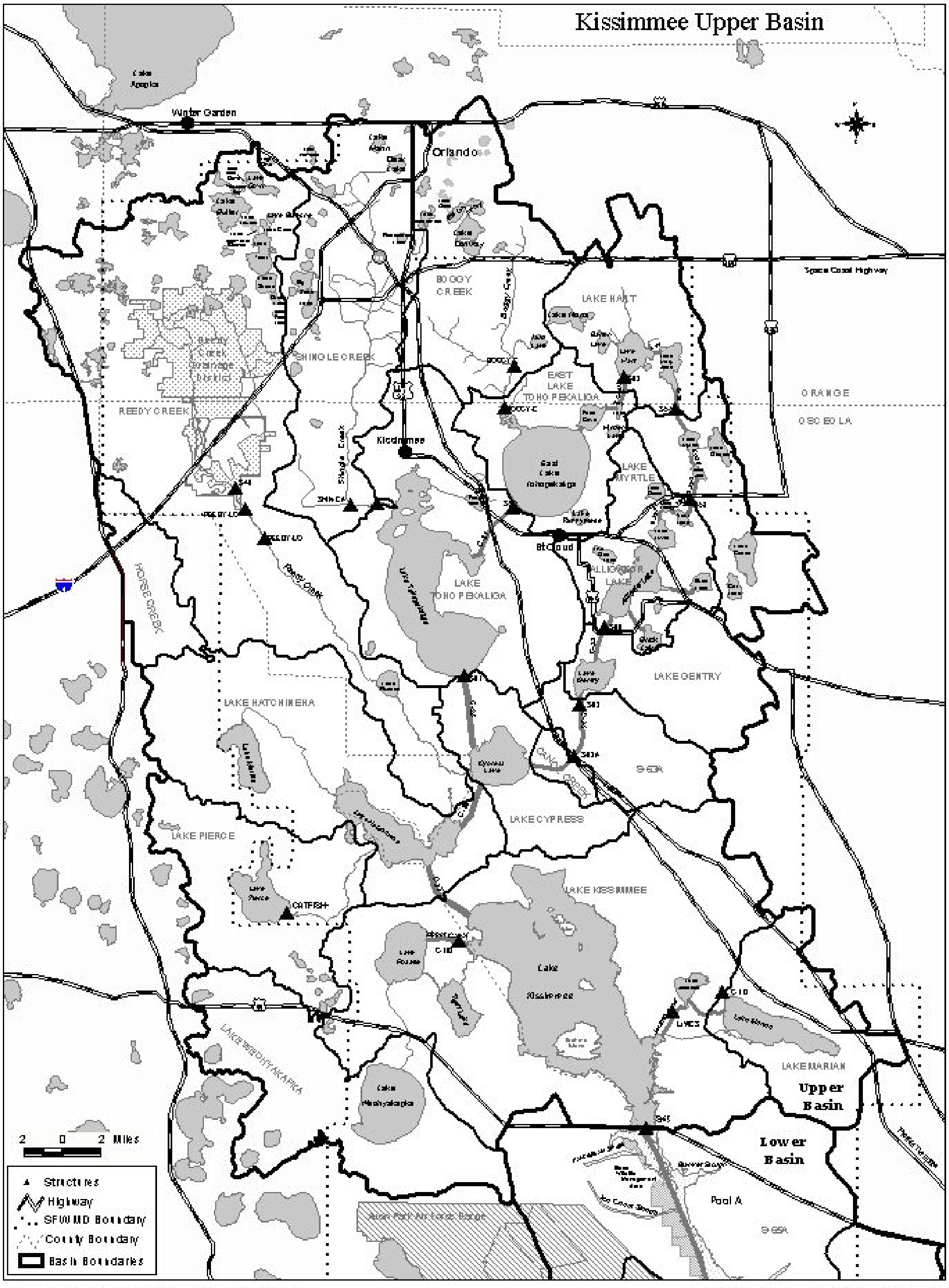
Bridgett Tolley
Sr. Community Outreach/Media Specialist
South Florida Water Management District, Orlando Service Center
407-858-6100, extension 3806

KCOL LTMP Survey Background

The Kissimmee Basin covers approximately 2,300 square miles of south-central Florida and is the largest area draining to Lake Okeechobee. The basin includes the Kissimmee Upper Basin (KUB), located in the northern half of the watershed, and the Lower Kissimmee Basin (LKB), located south of Lake Kissimmee. The KUB is comprised of numerous lakes that were historically connected by streams and sloughs. The LKB includes the Kissimmee River, its floodplain, and the tributaries draining into the river.

The Kissimmee Chain of Lakes provides a variety of economic, recreational and aesthetic benefits including world-class bass fishing and wildlife viewing. These lakes are part of the Central and Southern Florida (C&SF) Project that was authorized by Congress in the 1950s to provide flood protection for the region. In addition, the lakes and associated wetlands provide a variety of environmental services including habitat for fish and wildlife and nutrient removal. The KCOL LTMP was initiated by the South Florida Water Management District (SFWMD) in 2003 to address concerns with lake management practices. Specifically, those practices with the potential to produce positive benefits in one area while, at the same time, conflicting with practices needed to produce desired outcomes in other areas.

KCOL LTMP Location Map



Over the next two years, the SFWMD working in partnership with federal, state, and local agencies will strive to build consensus on what is valued about the Chain of Lakes system and what should be preserved and protected through interagency management practices. The goals that are viewed as important to improving and sustaining the health and values of this system include:

- Hydrologic management
- Habitat preservation and enhancement
- Aquatic plant management
- Water quality improvement
- Recreation and public use

The partners in this effort are:

South Florida Water Management District
Florida Fish and Wildlife Conservation Commission
Florida Department of Environmental Protection
Florida Department of Agriculture and Consumer Services
U.S. Army Corps of Engineers
U.S. Fish and Wildlife Service
U.S. Environmental Protection Agency
Local Governments and Community Leaders
Other stakeholders

To determine what is valued about the Chain of Lakes system, an outreach sub-committee met in June 2004 to discuss the goals of the KCOL LTMP and to determine how to assess stakeholder values about the system.

Methodology

The outreach sub-committee identified 7 stakeholder groups to survey within the four counties (Osceola, Polk, Highlands and Okeechobee) encompassing the Kissimmee Chain of Lakes. The target population in these four counties is 844,860 people, requiring 387 completed surveys to achieve a 95% confidency level with a ±5% confidence interval. The survey results are based on 394 completed surveys.

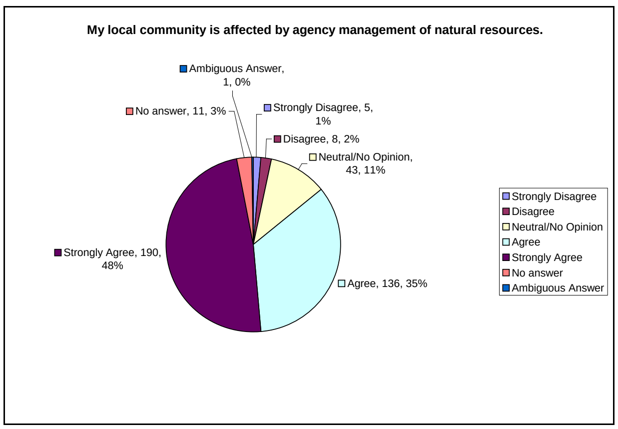
Surveys were taken on a voluntary basis by 228 individuals attending nine community events during the timeframe beginning October 2004 and ending February 28, 2005. Additionally, 166 surveys were returned out of 743 surveys mailed. The mailing list was generated through the South Florida Water Management District's (SFWMD) various stakeholder mailing lists. Because the sample was not random, the findings cannot be translated into conclusive generalizations.

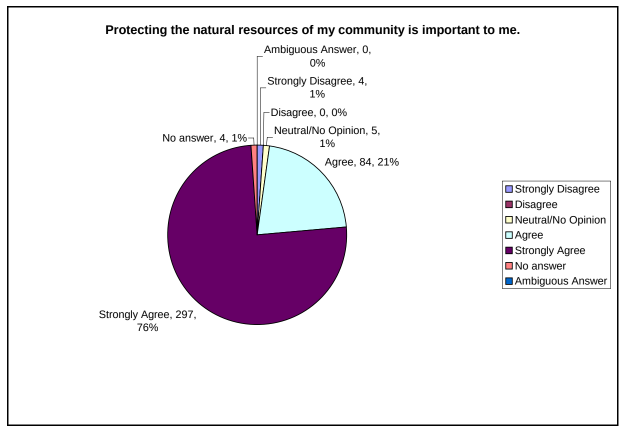
The first section of the survey tried to assess what respondents knew or thought about natural resource management practices. The second section of the survey asked the respondents to categorize themselves into one of the seven stakeholder groups, and further identify themselves within the stakeholder group. The respondent was able to identify with multiple stakeholder groups. The third section of the survey asked the respondents to choose from a list of lakes that they have visited and what types of activities they have participated in. Within this section, the respondents were asked to rate water quality, aquatic plant/weed management, public access, recreation, habitat preservation and fish and wildlife in terms of high, medium or low priority. These aspects were rated individually, and were not ranked against each other. The fourth section of the survey asked respondents about their involvement in environmental issues, their media preference and whether they would like to be contacted in the future about the Kissimmee Chain of Lakes Long Term Management Plan.

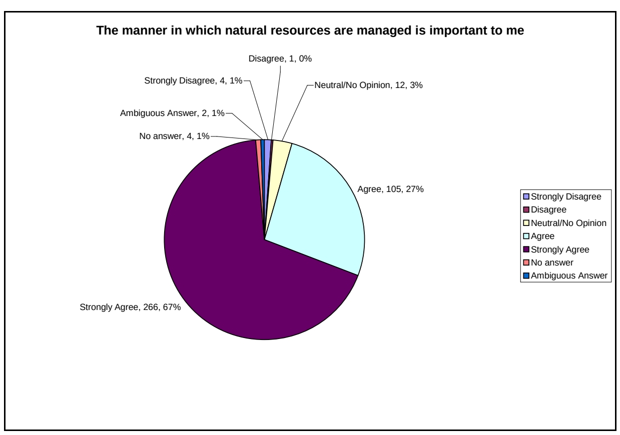
Survey Results

Section 1 - Natural Resources Management Practices

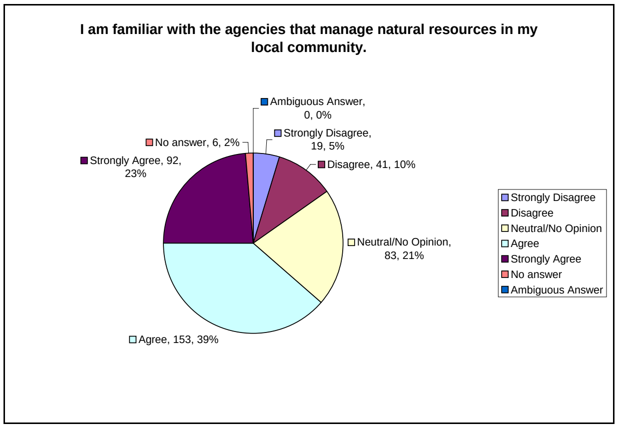
Relative to what respondents knew about natural resource management practices, 83% (those respondents who strongly agree and agree) said that their local community was affected by agency management of natural resources. Ninety-seven percent said that protecting the natural resources of their community is important to them and 94% said that the manner in which natural resources are managed is important to them.

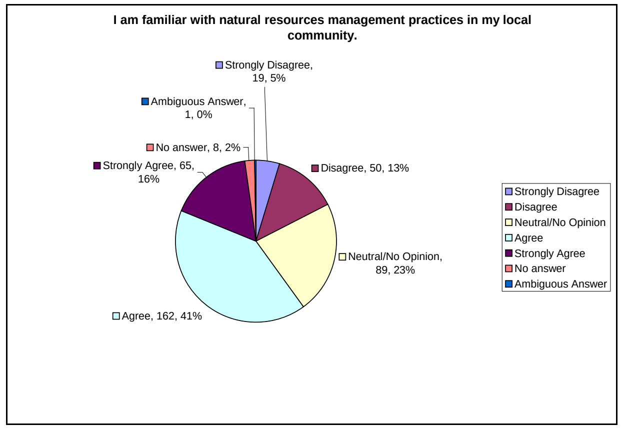




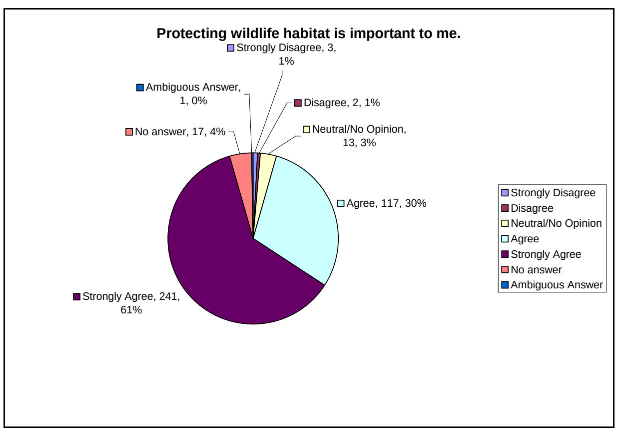


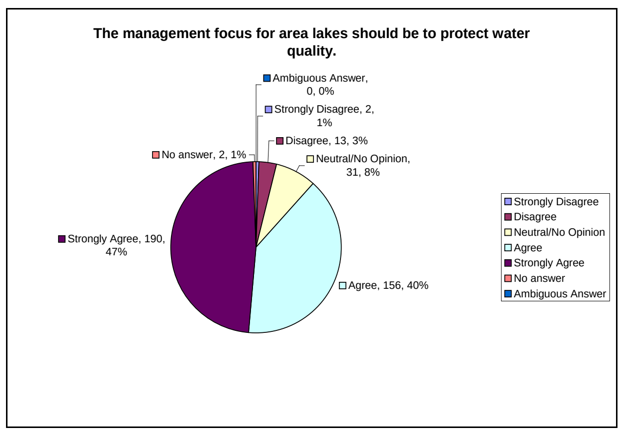
What is significant from an agency public outreach perspective is that only 62% of respondents said they were familiar with the agencies that manage natural resources in their local community and even fewer (57%) said they were familiar with natural resources management practices in their local community.



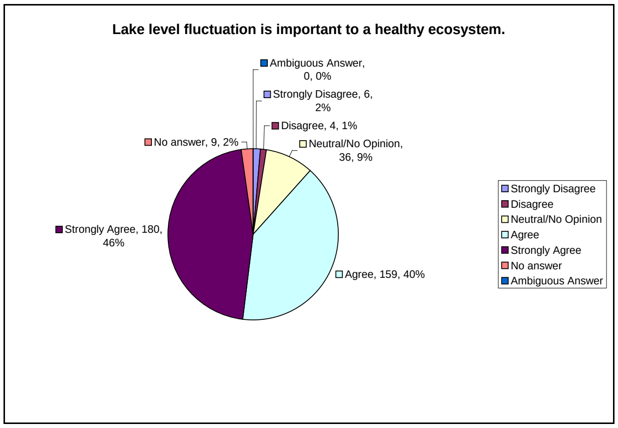


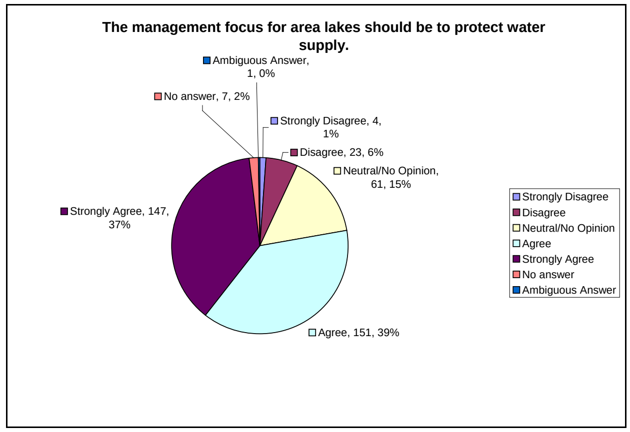
Ninety-one percent of respondents said that protecting wildlife habitat was important to them. In terms of agency management of area lakes, a majority (87%) of respondents said that protecting water quality should be the management focus.



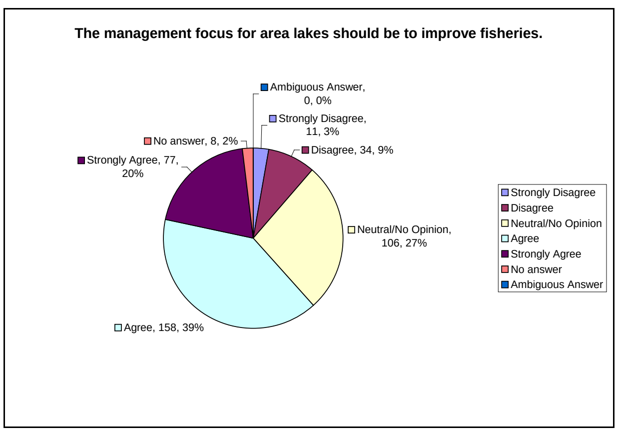


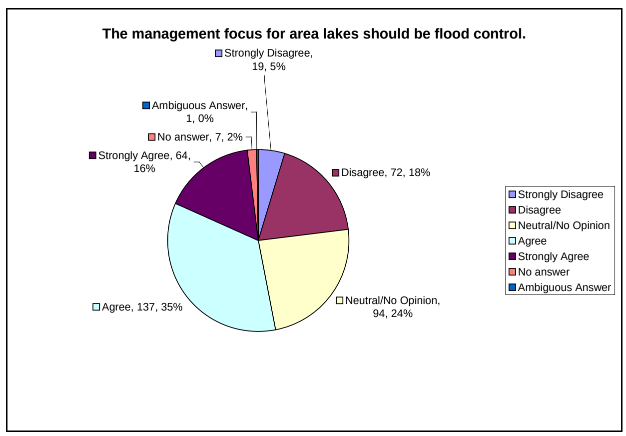
Eighty-six percent of respondents said that lake level fluctuation is important to a healthy ecosystem. Seventy-six percent of respondents said that protecting water supply should be the management focus. The survey did not specify agricultural, public or environmental water supply.



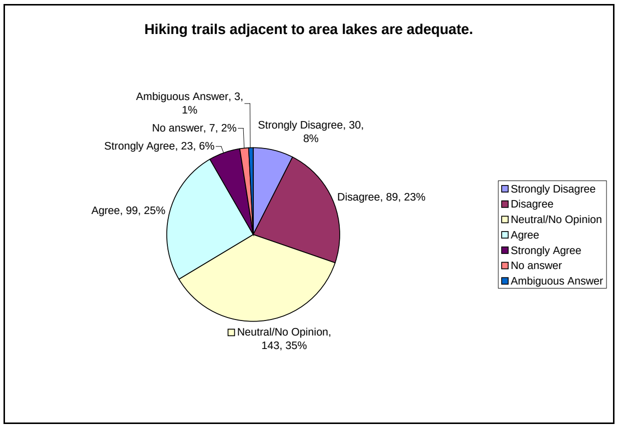


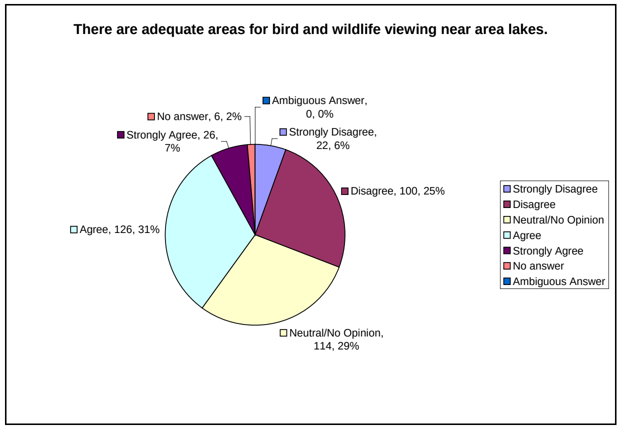
While a slight majority of respondents thought agency management should focus on improving fisheries (59%), a large number of respondents (29%) had no opinion about this statement or did not answer the question, and 12% disagreed (either disagreed or strongly disagreed) with it. Likewise, 51% of respondents said that the management focus should be flood protection, 23% disagreed, 24% had no opinion and 2% did not answer the question.



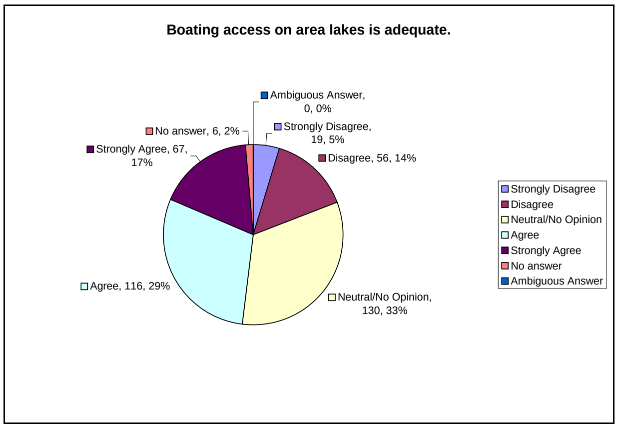


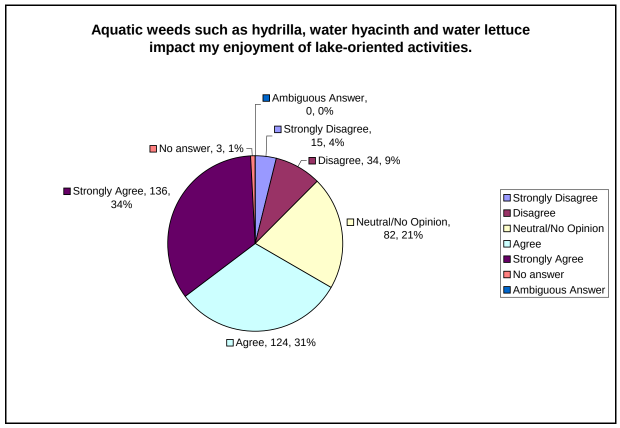
As many people agreed (31%) as disagreed (31%) that hiking trails were adequate with 35% responding that they were neutral about this issue. Adequate areas for bird and wildlife viewing were similarly divided with 38% of respondents agreeing that there were adequate areas for this purpose, 31% disagreeing that there were adequate areas and 29% stating they were neutral on this issue.





Forty-six percent of those surveyed thought that boating access was adequate, but only 19% disagreed with this assertion. Sixty-five percent of respondents reported that aquatic weeds impacted their enjoyment of lake-oriented activities.





Section 2 - Stakeholder Groups

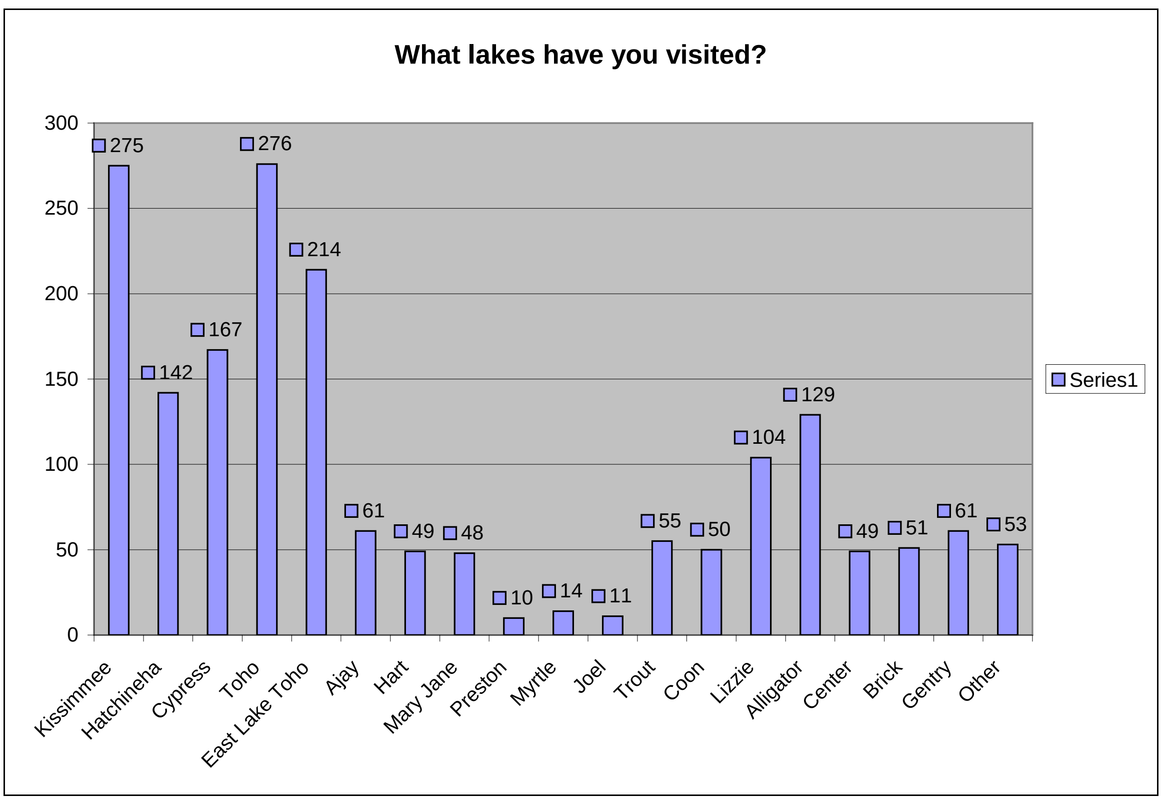
The target audience for the survey was people living in or visiting the Osceola, Polk, Highlands or Okeechobee county area. Seventy-four percent of respondents identified themselves as full time residents of Osceola, Polk, Highlands or Okeechobee counties.

The seven stakeholder groups that the outreach team identified as being important to target are listed below as well as the number of respondents who identified themselves as such. Respondents could identify with more than one stakeholder group, thus the high number of responses within the non-consumptive recreational users group.

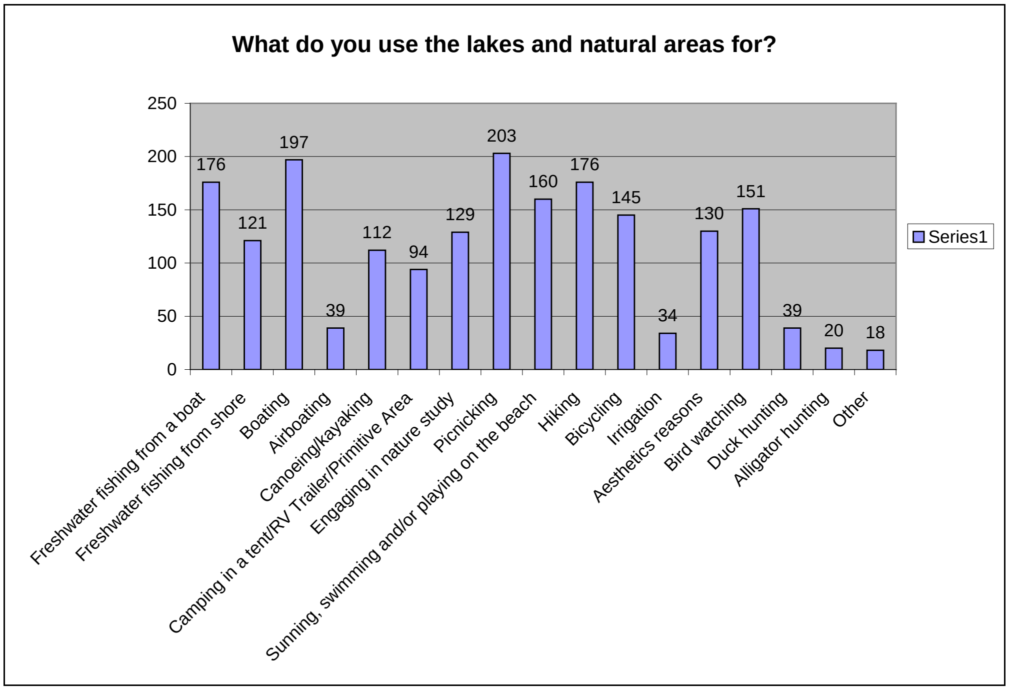
1. Homeowners/Residents - 290
2. Business/Tourism Interests - 164
3. Developers/Planners -149
4. Agricultural Interests - 93
5. Consumptive Recreational Users - 292
6. Non-consumptive Recreational Users - 1412
7. Environmental Groups – 197

Section 3 - Activities

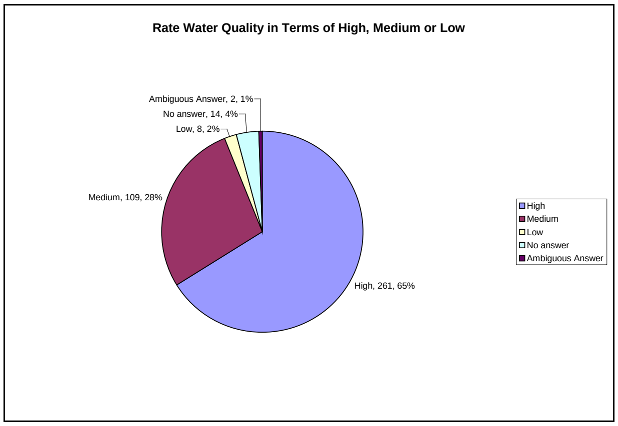
In this section, respondents were asked to identify what lakes associated with the Kissimmee Chain of Lakes they have visited. Most respondents (276) said Lake Tohopekaliga, followed by 275 who said Lake Kissimmee, and then East Lake Tohopekaliga with 214. The following chart summarized all of the responses.



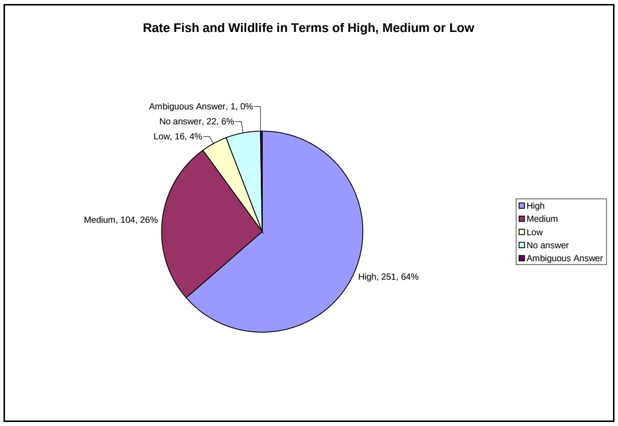
When asked what respondents used the lakes and adjacent areas for, the highest response was picnicking (203), followed by boating (197), then the same number of responses for freshwater fishing from a boat and hiking (176). The following chart summarizes all of the responses.

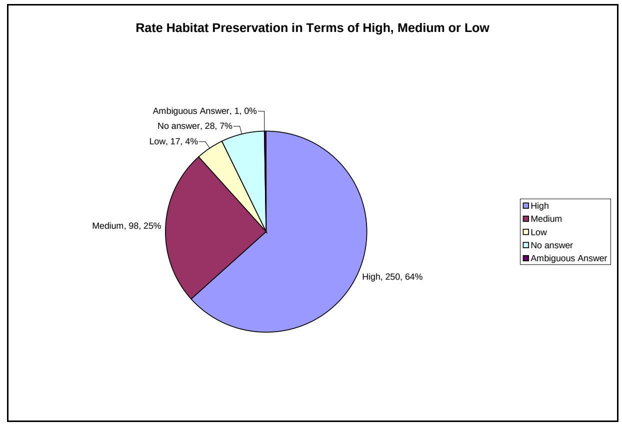


In this section of the survey, respondents were also asked to rate various aspects in terms of high, medium or low priority. When asked, the majority of respondents (65%) rated water quality as a high priority.

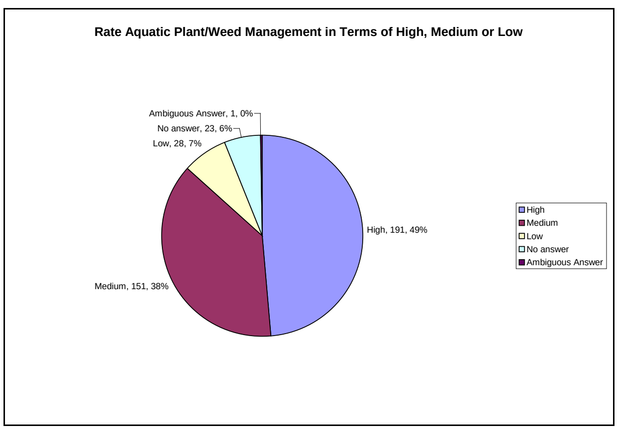


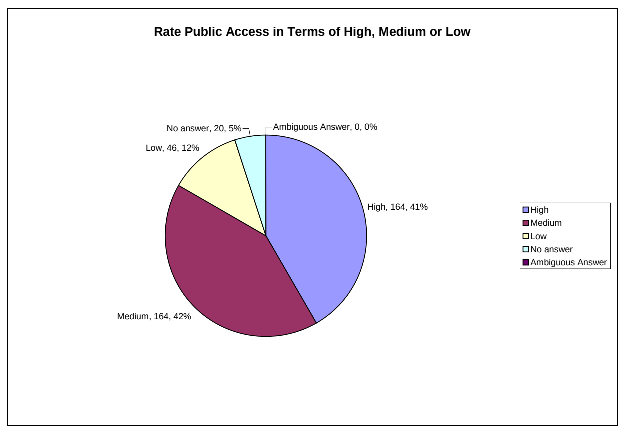
The majority of respondents (64%) rated fish and wildlife as a high priority and a majority (64%) rated habitat preservation as a high priority.

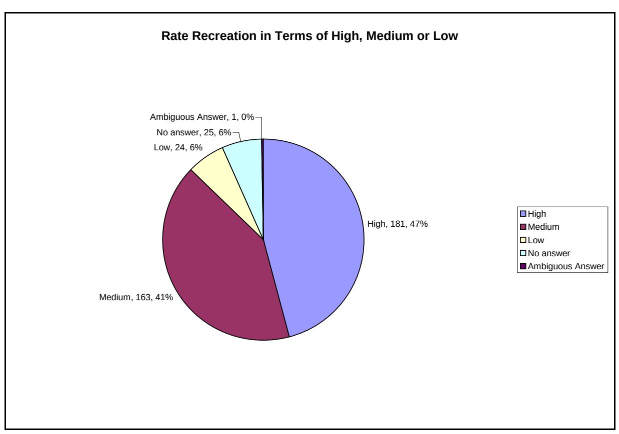




Aquatic plant management was rated as high by only 49% of respondents, with 38% rating it as a medium priority. Similarly, public access was rated as a high priority by only 41% of respondents, with 42% rating it as a medium priority. Finally, 47% of respondents rated recreation as a high priority, with 41% rating it as a medium priority.

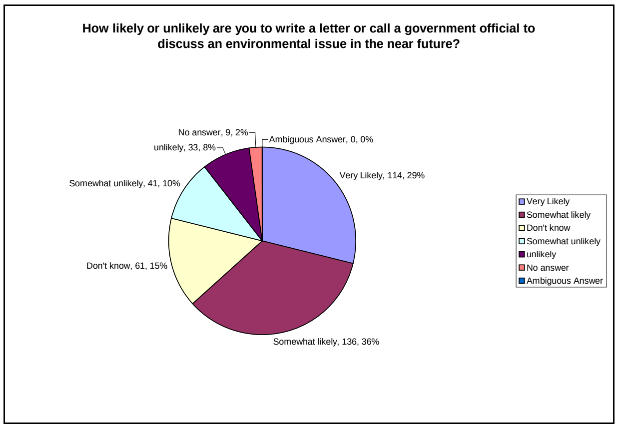


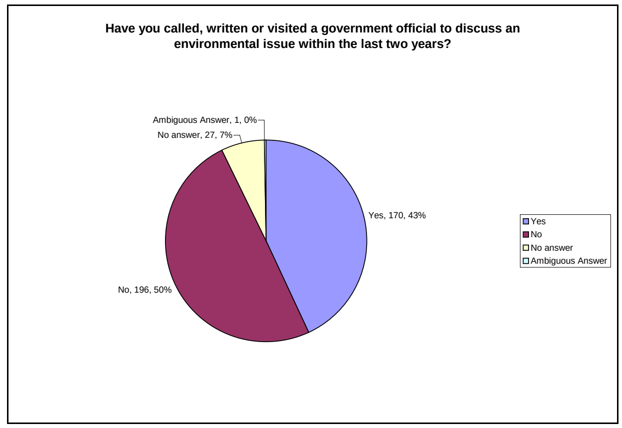


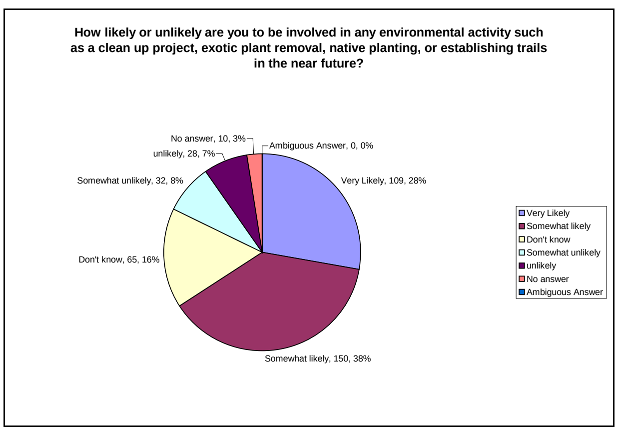


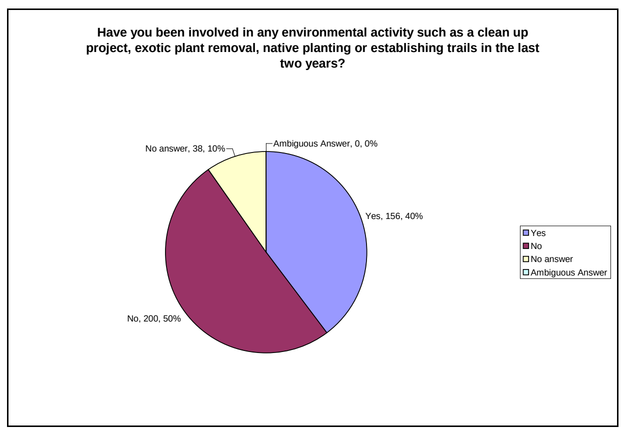
Section 4 – Current involvement in environmental issues

In this section, respondents were asked how likely they were to get involved in an environmental activity and if they have actually done so. Sixty-five percent of those surveyed said they were likely or very likely to write a letter or call a government official to discuss an environmental issue whereas, only 43% had actually done so in the past two years. Similarly, 66% said they were likely or very likely to be involved in an environmental activity such as a clean-up project, but only 40% had actually done so in the past two years.



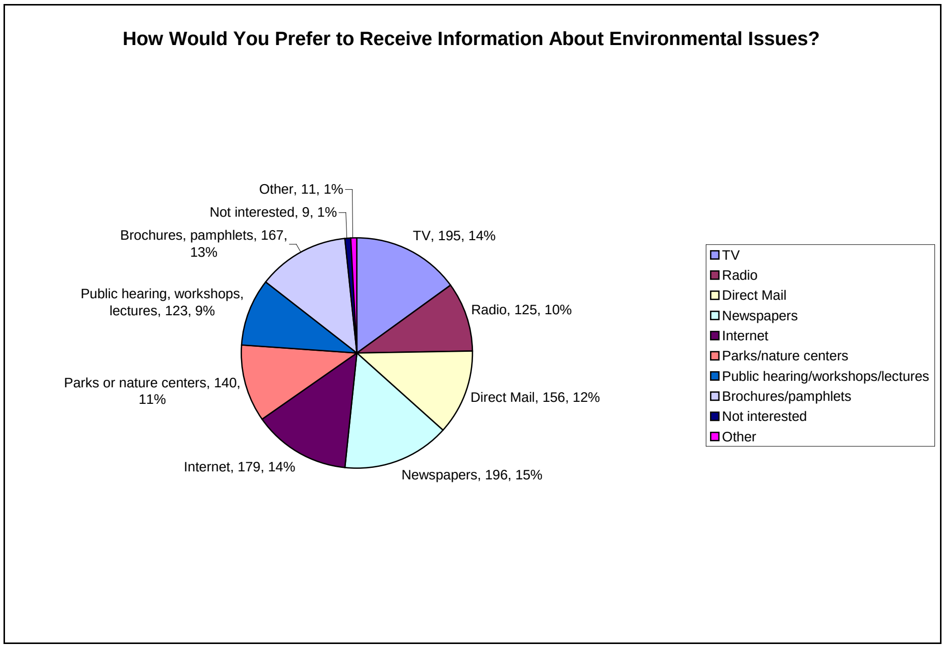






In terms of future interest in the KCOL LTMP, 201 respondents (51%) said they wanted to be contacted about future lake-related agency meetings. This information will be used to update the database for future KCOL LTMP public meetings.

Relative to how respondents want to receive information about environmental issues, the eight choices given were more or less equally rated (see chart below).



Further survey analysis will be conducted to determine if there is a trend by stakeholder group relative to media preference.

Conclusions

Most survey respondents agreed that protecting the natural resources of the community was important to them (97%, page 4), but the number drops significantly when asked if they are familiar with the agencies that manage natural resources (62%, page 5) and what those natural resource management activities are (57%, page 5). This reveals that there may be an opportunity to better inform the public about the agencies involved with the KCOL LTMP and their areas of responsibility.

In terms of agency focus, most survey respondents agreed that water quality (87%, page 5) should be the focus of management agencies. Water quality was also an aspect that was rated as a high priority by a significant majority of respondents (65%, page 9). This information, coupled with the high number of non-consumptive recreational uses in the top 5 lake uses suggests that most people care a great deal about places where they can readily experience and enjoy nature. The top five recreational uses were:

1. Picnicking
2. Boating
3. Hiking and freshwater fishing from a boat (tie)
4. Sunning, swimming, playing on the beach
5. Bird watching

Seventy-six percent of respondents said that water supply should be the focus of agency management (page 6). There may be two interpretations for this number. First, there have been consistent media reports over time that water supply in Central Florida has become a critical growth and development issue and this may be reflected in the responses. Secondly, the response may reflect a perception that our water supply comes from surface rather than groundwater, thus revealing another opportunity for public awareness of water supply.

The results of this survey and analysis will guide the development of two brochures for the KCOL LTMP. One brochure will be a fairly inexpensive, easy-to-produce double-sided sheet which can be updated periodically with the latest developments that come as a result of the progress of the KCOL LTMP.

The other will be a brochure with a longer shelf life. In addition to information about the KCOL LTMP, perhaps this brochure can give an overview of management practices and list the agencies responsible for those practices. Given the high number of responses to questions about water quality and non-consumptive recreational uses, it is suggested that people may respond favorably to a brochure that depicts nature, natural areas, and passive recreational activities.

Appendix E KCOL LTMP Lake Zone and Wetland Definitions

INTRODUCTION

Lake zone and wetland definitions were defined by the interagency team during the development of the KCOL LTMP. The following definitions are based on categories from Cowardin et al. (1979). Wetlands and lake areas have been split into broad categories and further divided into subgroups. The subgroups were defined especially for use in this project.

WETLANDS

Lacustrine Wetlands

Lacustrine wetlands are, or were formerly, situated within lakes. They typically lack trees and shrubs, and are dominated by emergent vegetation or composed of a mix of emergent, floating-leaved, and submergent species. The outer limit of a lacustrine wetland is the boundary where an upland or palustrine wetland dominated by trees, shrubs, and persistent emergent vegetation occurs.

Subgroups

- ***Littoral wetlands*** generally occur below the lake's maximum regulatory stage and are inundated at least part of the year due to fluctuations in lake stage. They occur primarily as emergent marshes.
- ***Remnant littoral wetlands are*** former littoral wetlands that have been separated from a lake by man-made berming or other intervention.

Palustrine Wetlands

Palustrine wetlands are situated further landward of lacustrine wetlands, and include those wetlands separated from lakes that occur as depressional areas surrounded entirely by uplands. The outer limit of a palustrine wetland is the boundary where either uplands or other wetland systems occur. Palustrine wetlands are typically dominated by trees, shrubs, or persistent emergents.

Subgroups

- ***Floodplain wetlands*** are adjacent to a lake and are separated by a natural berm in which flooding occurs during high water events. They may or may not have been littoral wetlands historically.

- ***Riparian wetlands*** border the edge of a stream that is subject to overbank flooding.
- ***Perched depressional wetlands*** occur in depressional areas that hold water due to nonporous soil properties and are hydrologically independent of lake stage.
- ***Non-perched depressional wetlands*** occur in depressional areas that have porous soil properties and may experience stage changes corresponding to those in lakes due to hydrologic connection through the surficial aquifer.
- ***Sloughs*** are slowly flowing shallow swamps or marshes (Mitsch and Gosselink, 2000).

Riverine Wetlands

Riverine wetlands are contained within a channel where water is usually, but not always, flowing. Upland islands or palustrine wetlands may occur in the channel or floodplain, but they are not considered to be riverine wetlands. Large sloughs may fall within this category; however, sloughs within the KCOL system are usually too small to be considered “riverine”.

LAKE ZONES

The **limnetic zone** is the open water zone in lakes, which may be colonized by submergent and floating plant species.

The **littoral zone** is the zone within a lake that is inundated at least part of the year by changes in lake stage and characterized by littoral wetland vegetation (see also Littoral Wetland).

LITERATURE CITED

Cowardin, L. M., V. Carter, F. C. Golet, E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U. S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 131pp.

Mitsch, W.J., and J.G. Gosselink. 2000. Wetlands, 3rd ed. John Wiley & Sons, New York. 920 pp.

Appendix F
Hydrilla Abundance Maps

Introduction

As part of Florida Fish and Wildlife Conservation Commission's management of nuisance plants, maps hydrilla infestation were generated for Alligator Lake (2008), Lake Gentry (2008), Lake Tohopekaliga (2001–2007), Cypress Lake (2005 and 2007), Lake Hatchineha (2005 and 2007), and Lake Kissimmee (2006 and 2007).

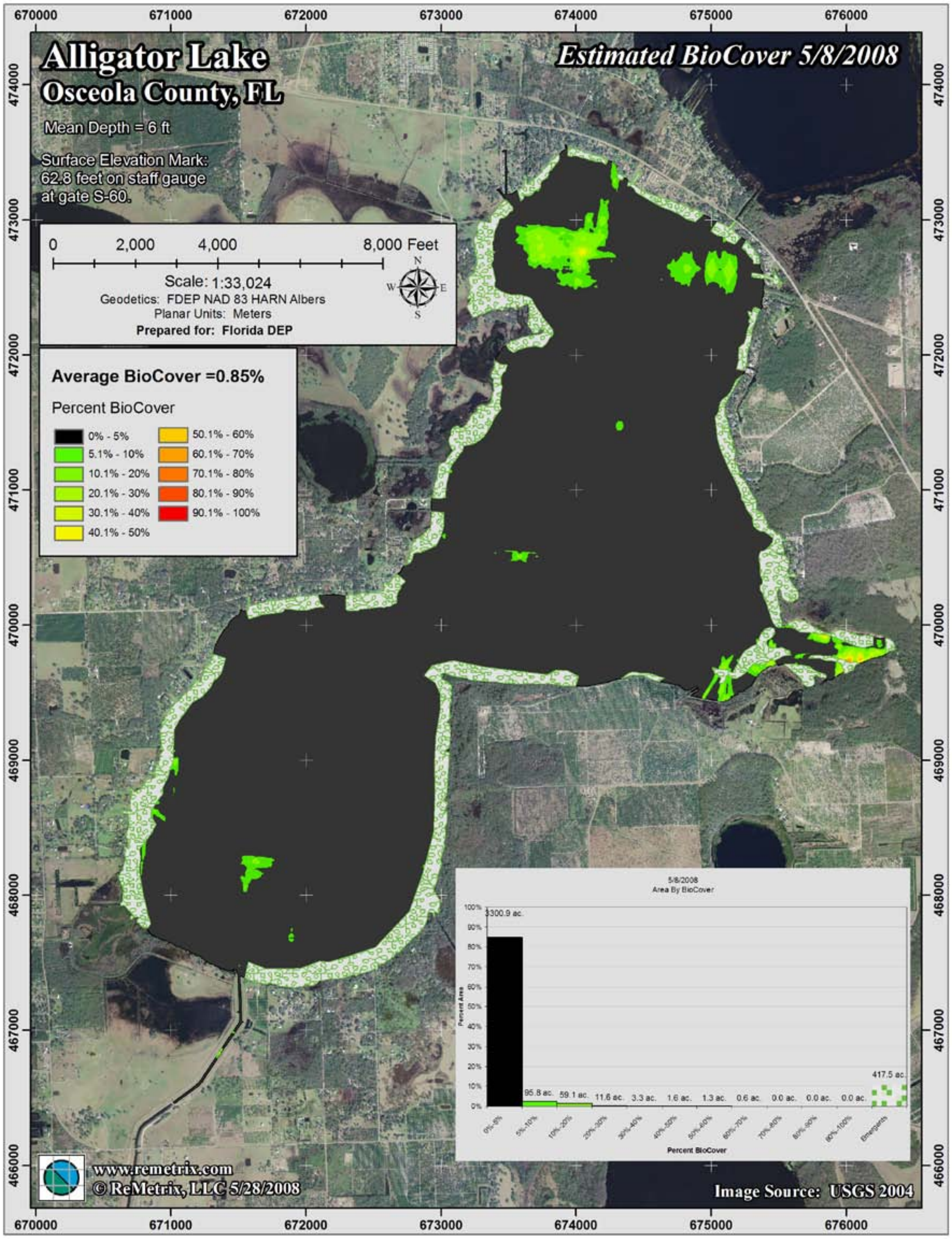


Figure F-1. Alligator Lake 2008 Hydrilla Abundance

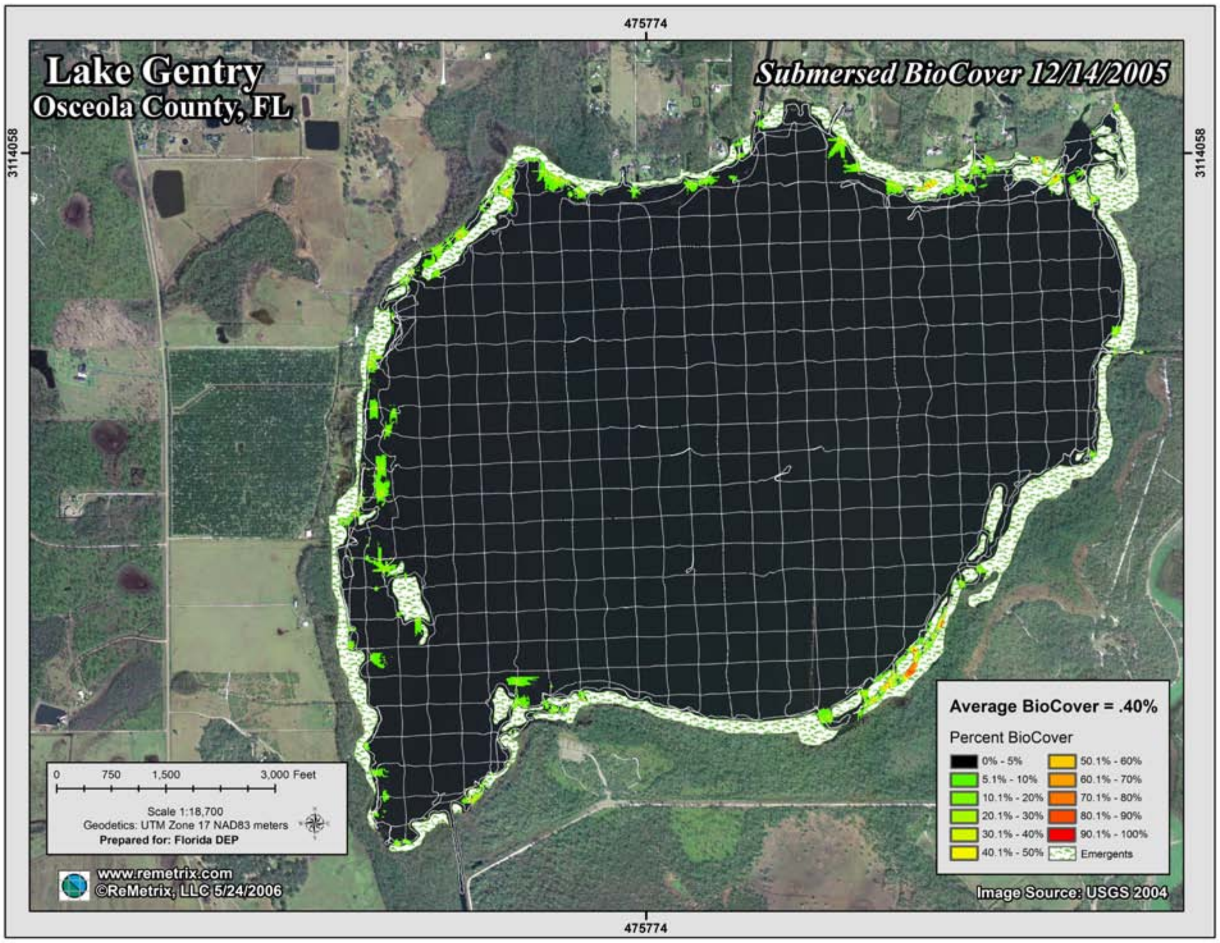


Figure F-2. Lake Gentry 2008 Hydrilla Abundance

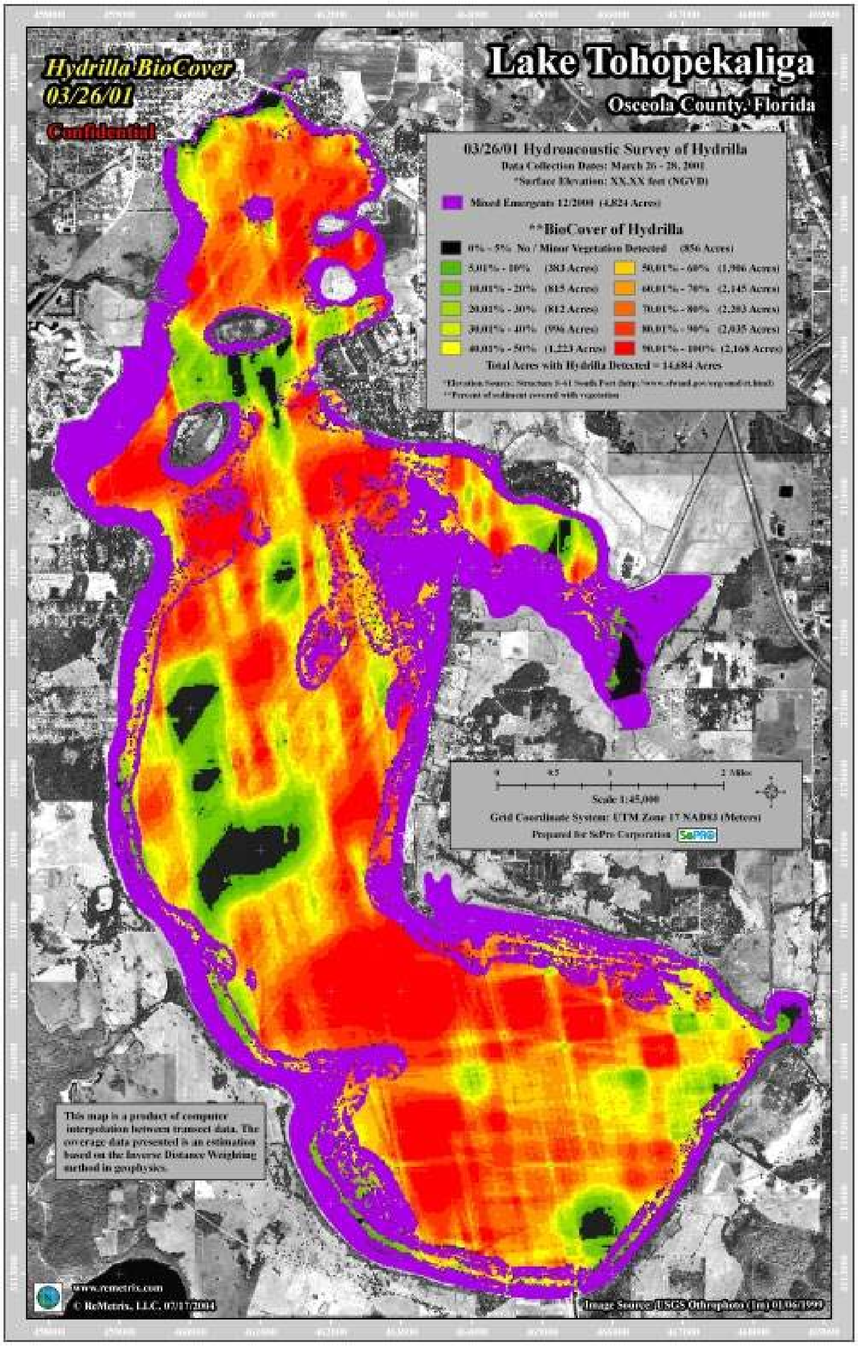


Figure F-3. Lake Tohopekaliga 2001 Hydrilla Abundance

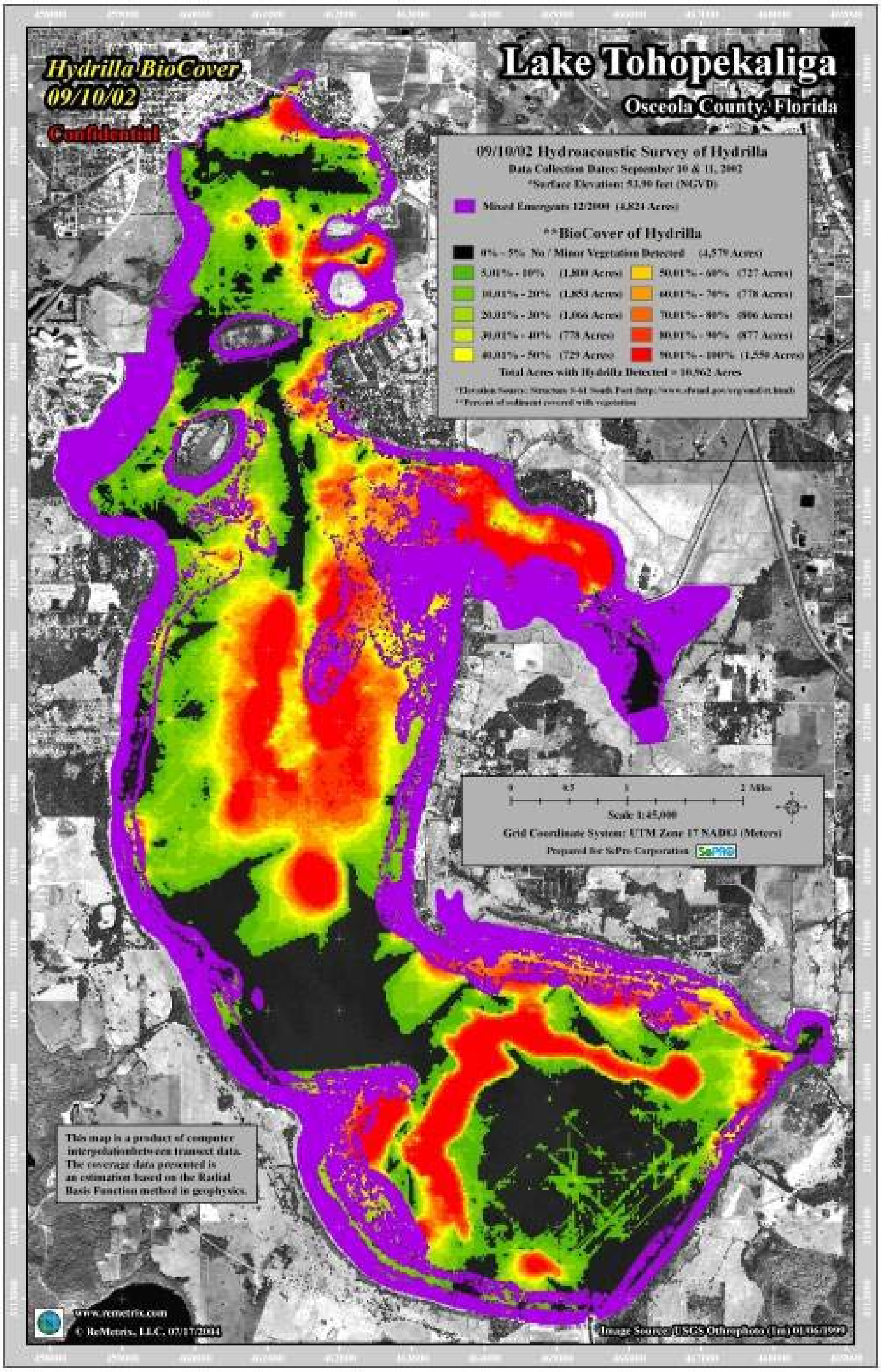


Figure F-4. Lake Tohopekaliga 2002 Hydrilla Abundance

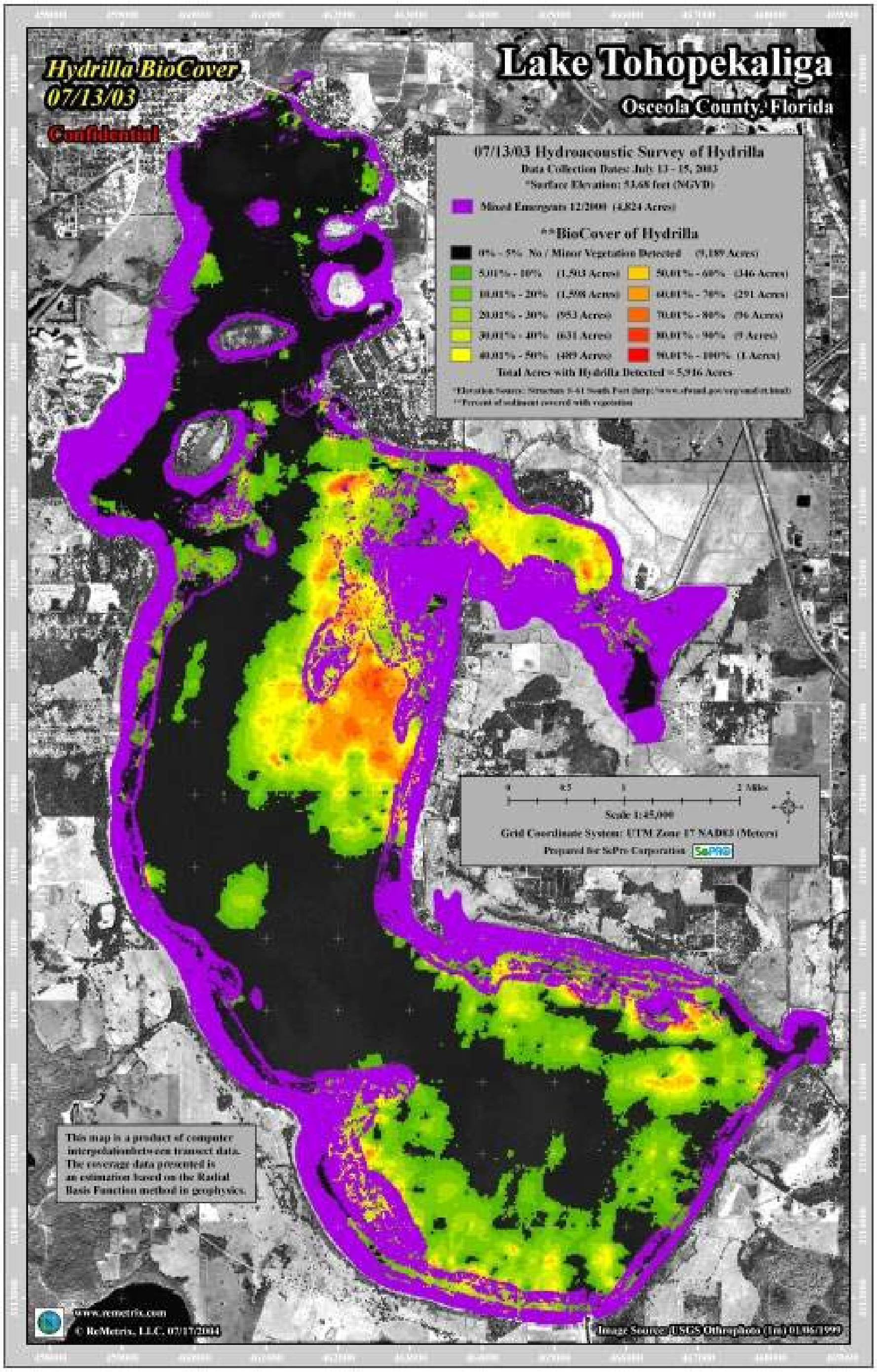


Figure F-5. Lake Tohopekaliga 2003 Hydrilla Abundance

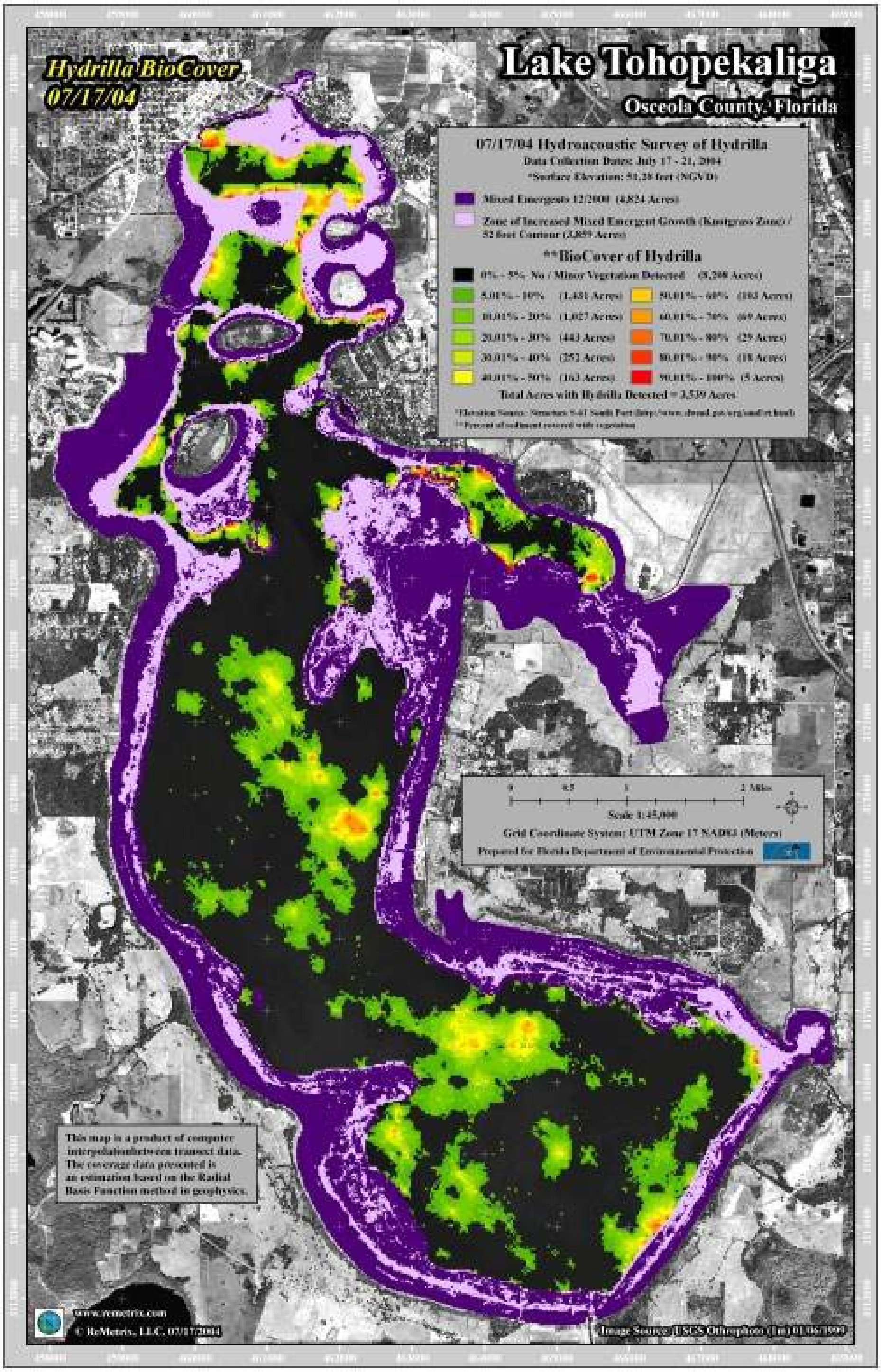


Figure F-6. Lake Tohopekaliga 2004 Hydrilla Abundance

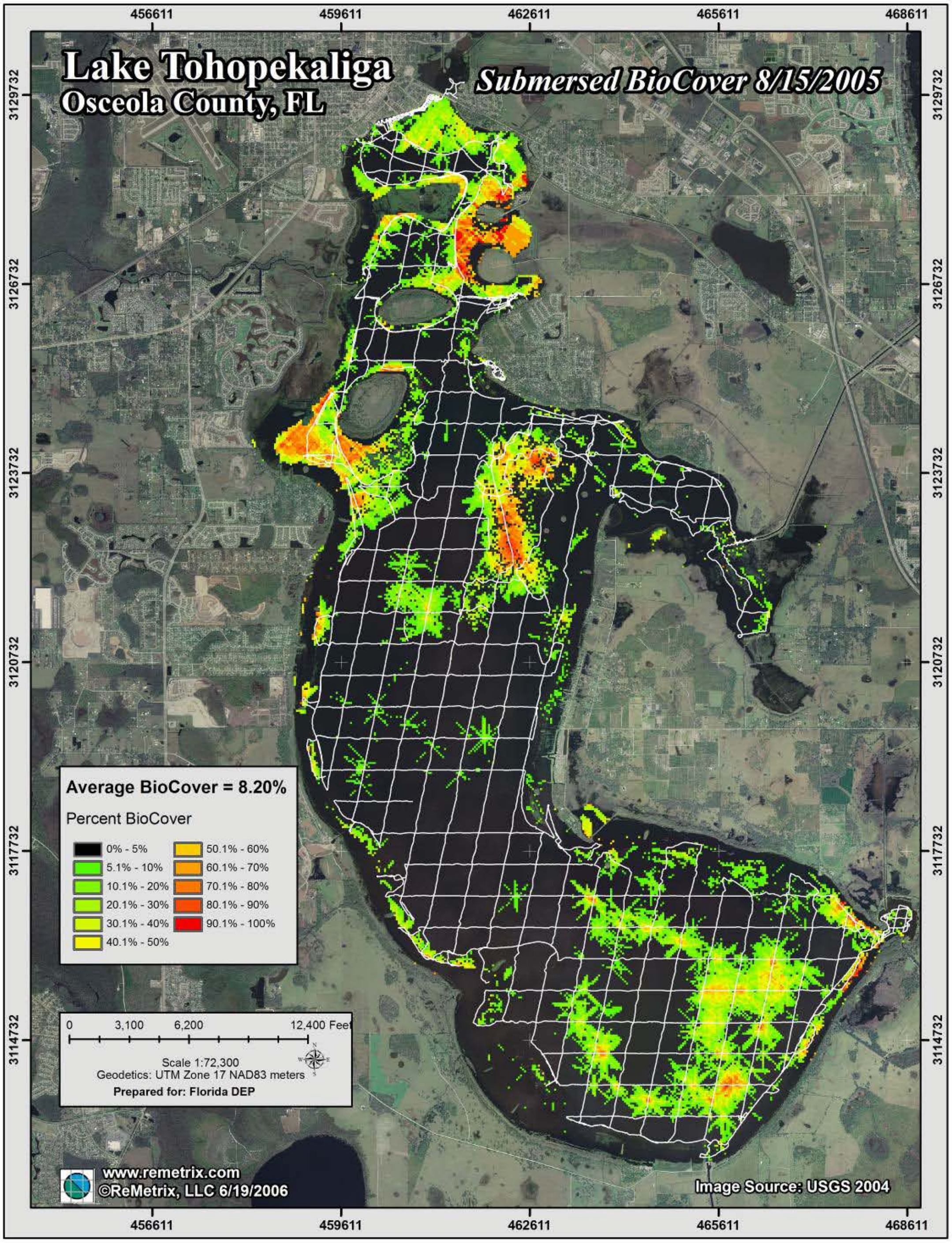


Figure F-7. Lake Tohopekaliga 2005 Hydrilla Abundance

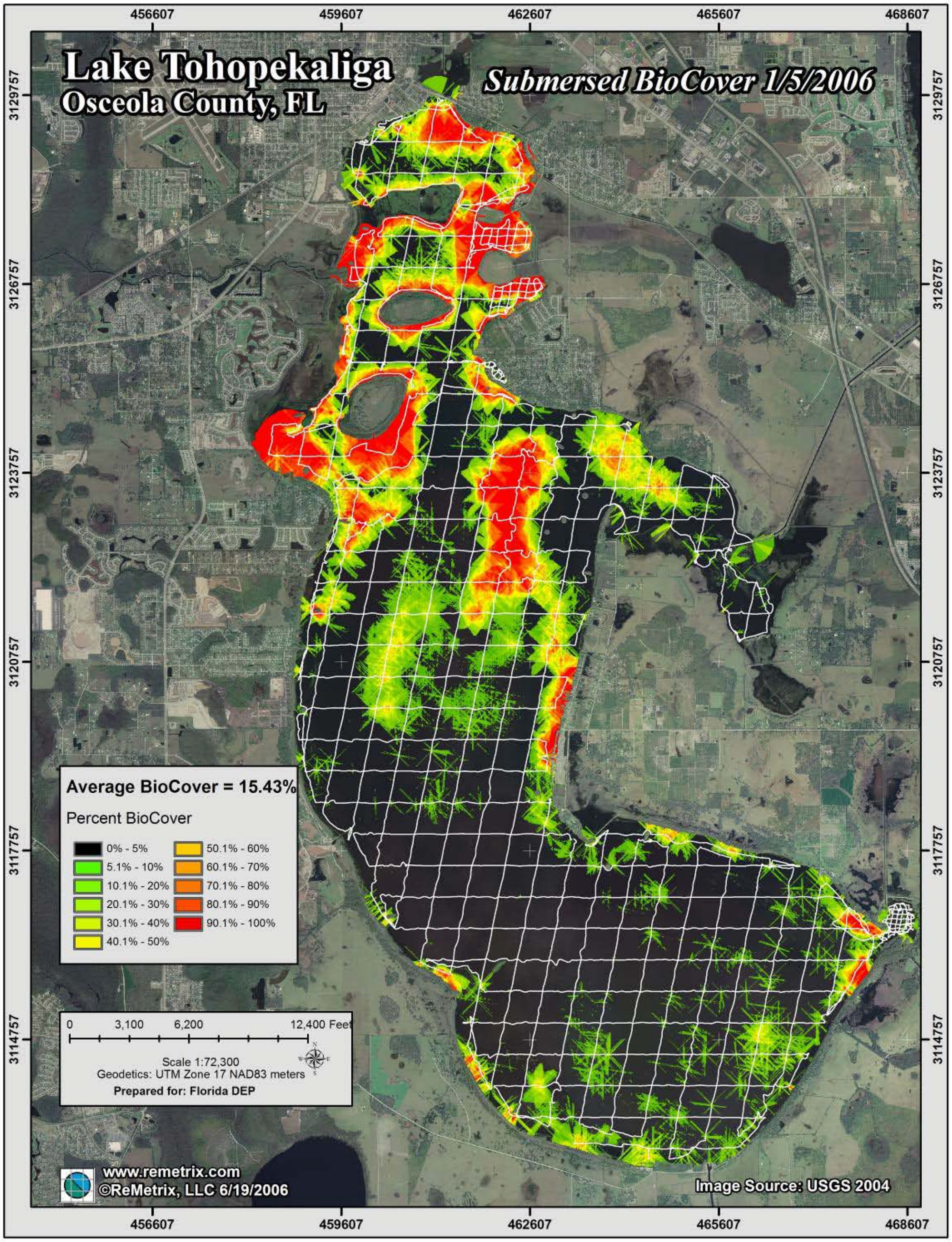


Figure F-8. Lake Tohopekaliga 2006 Hydrilla Abundance

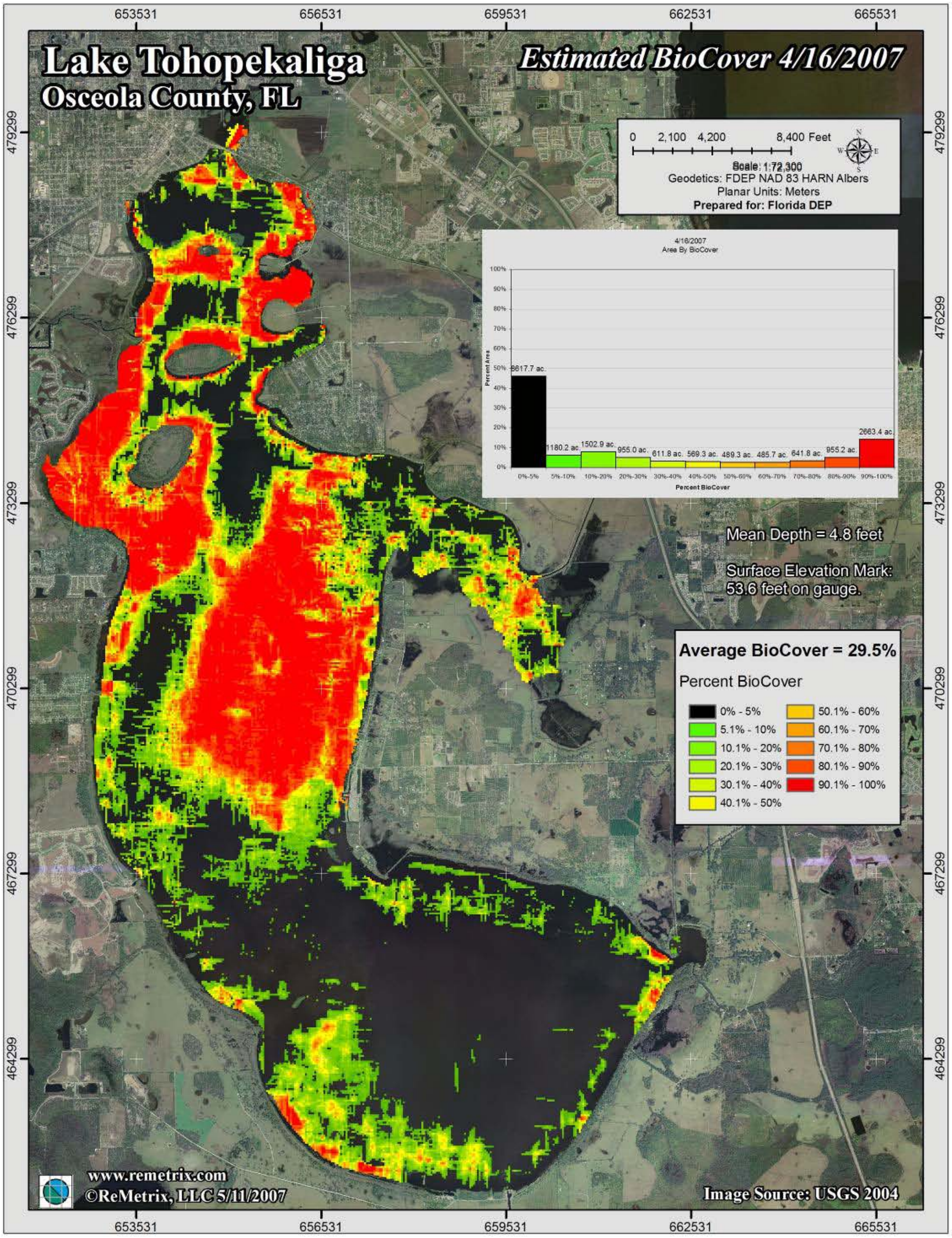


Figure F-9. Lake Tohopekaliga 2007 Hydrilla Abundance

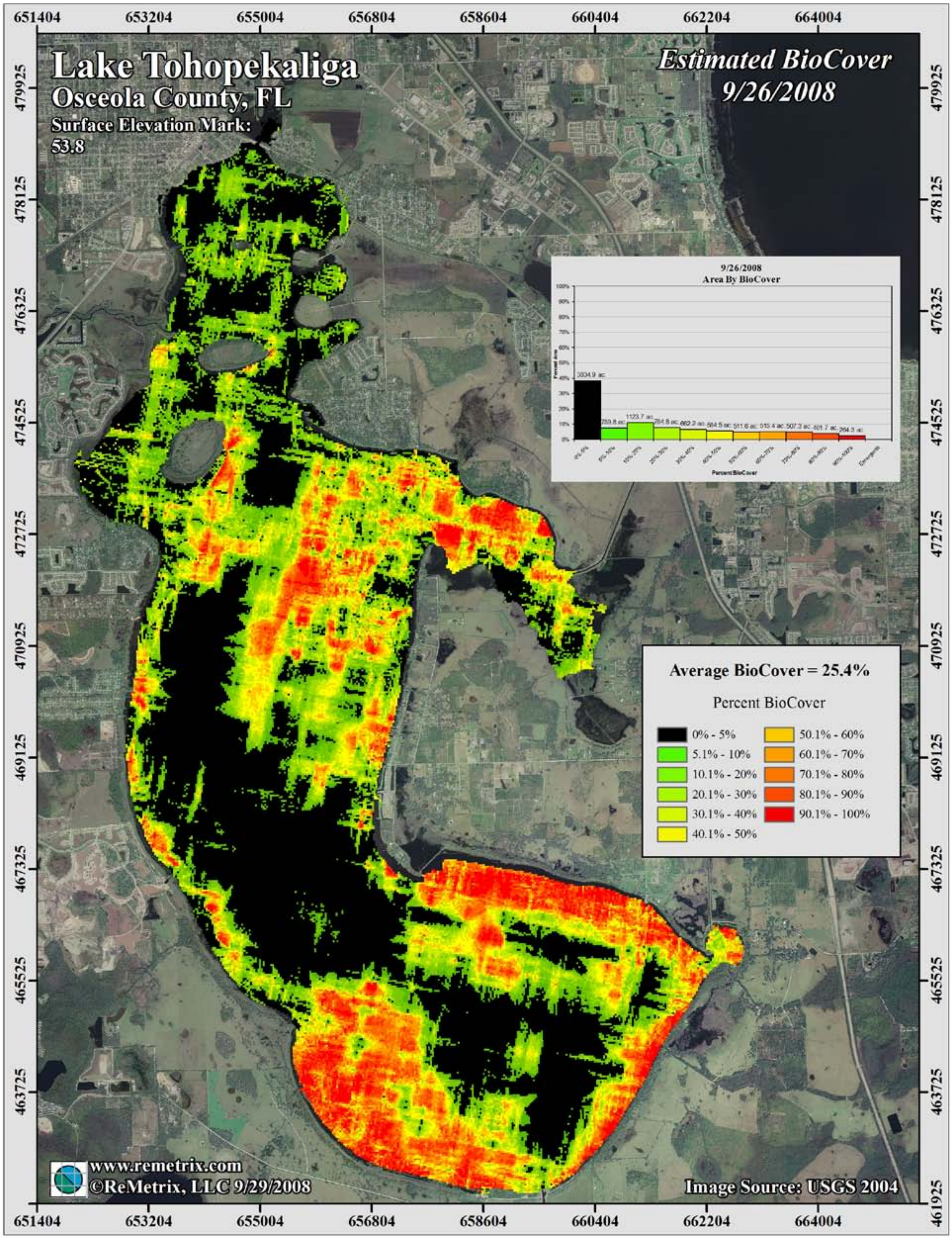


Figure F-10. Lake Tohopekaliga 2008 Hydrilla Abundance

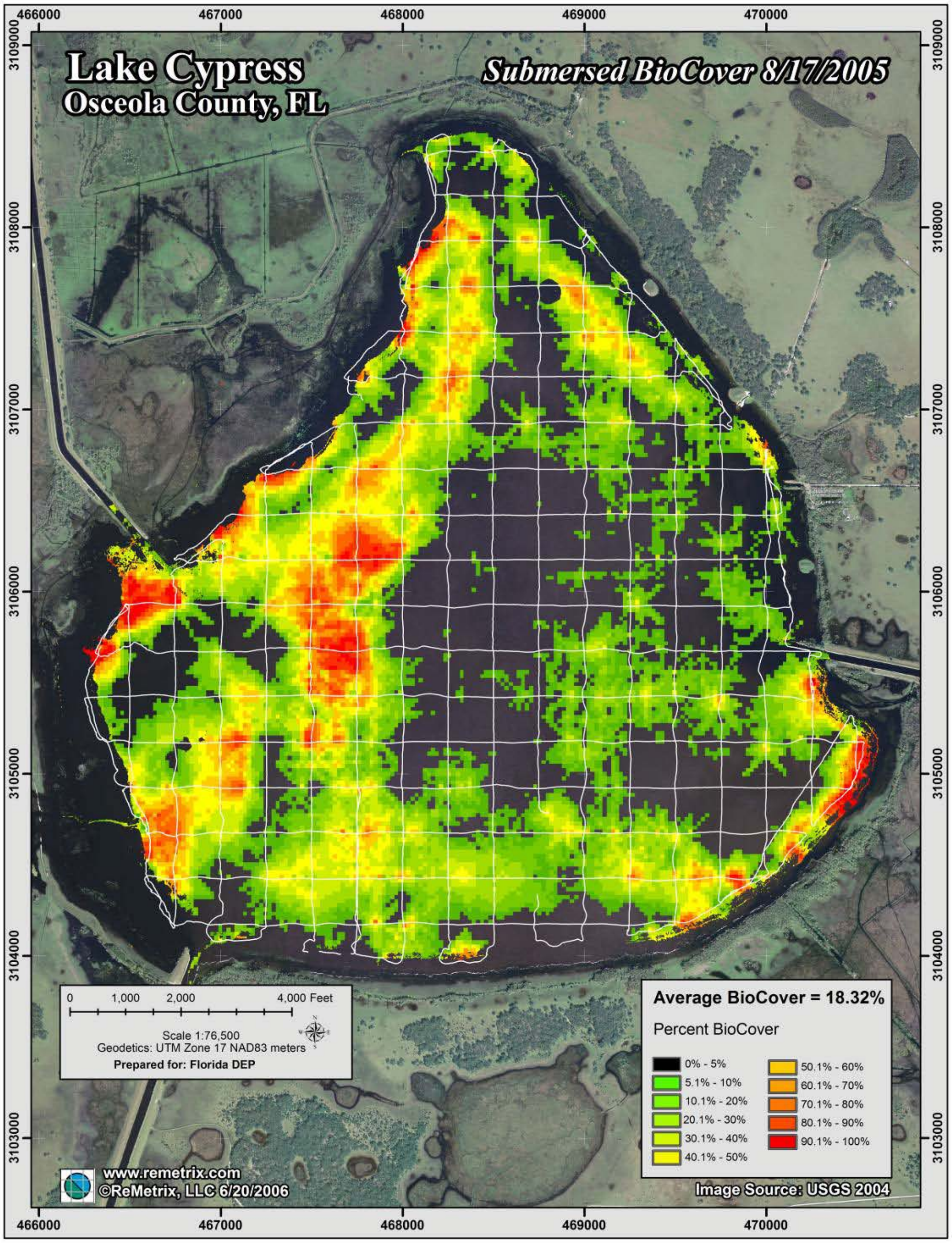


Figure F-11. Cypress Lake 2005 Hydrilla Abundance

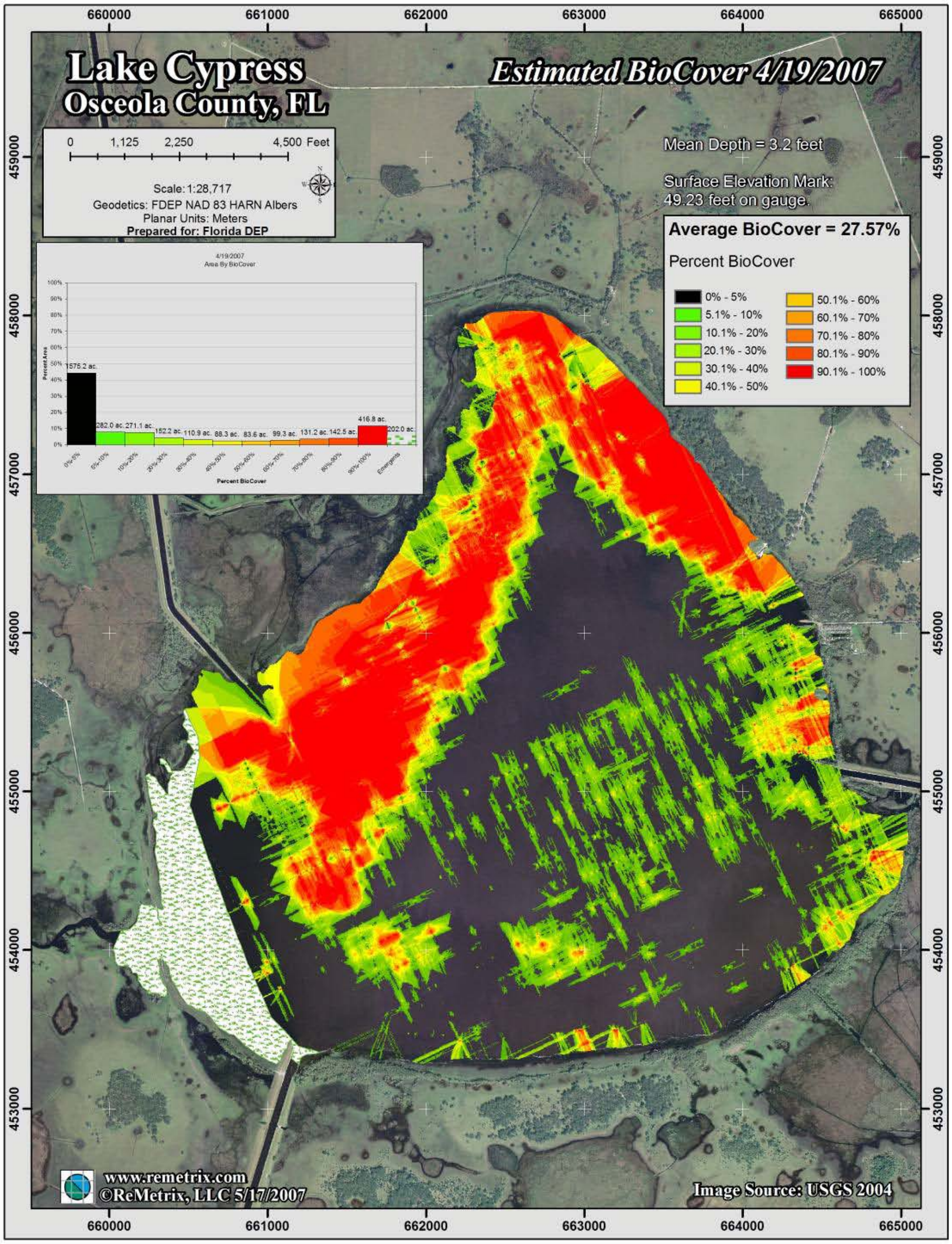


Figure F-12. Cypress Lake 2007 Hydrilla Abundance

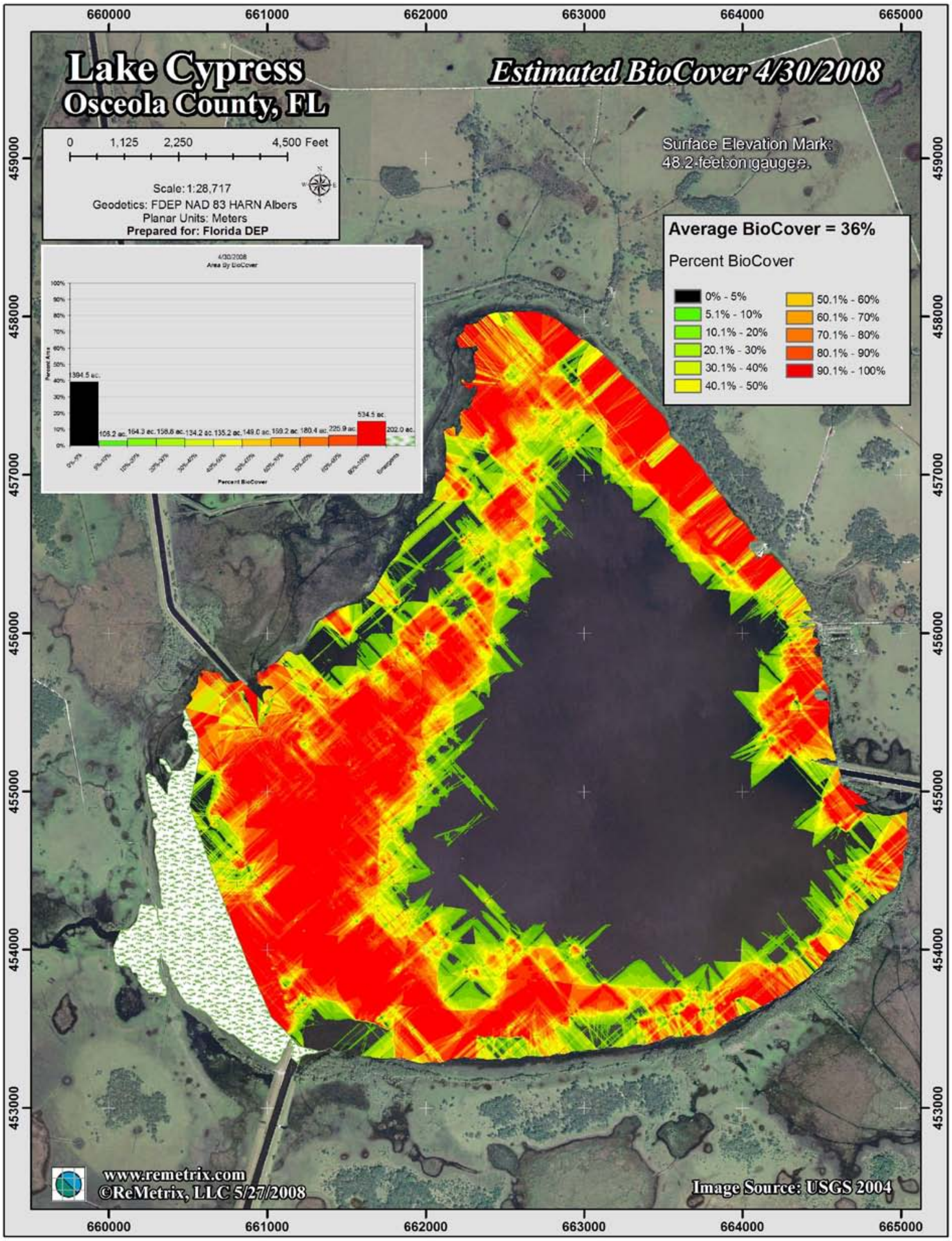


Figure F-13. Cypress Lake 2008 Hydrilla Abundance

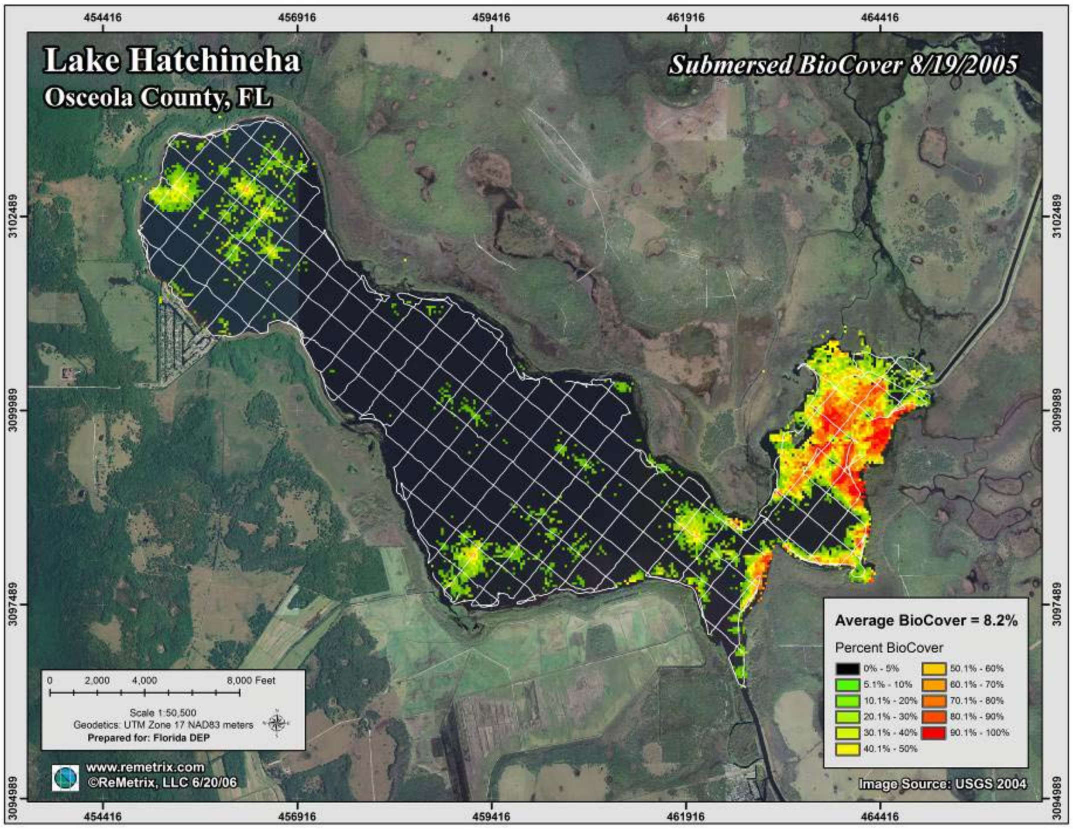


Figure F-14. Lake Hatchineha 2005 Hydrilla Abundance

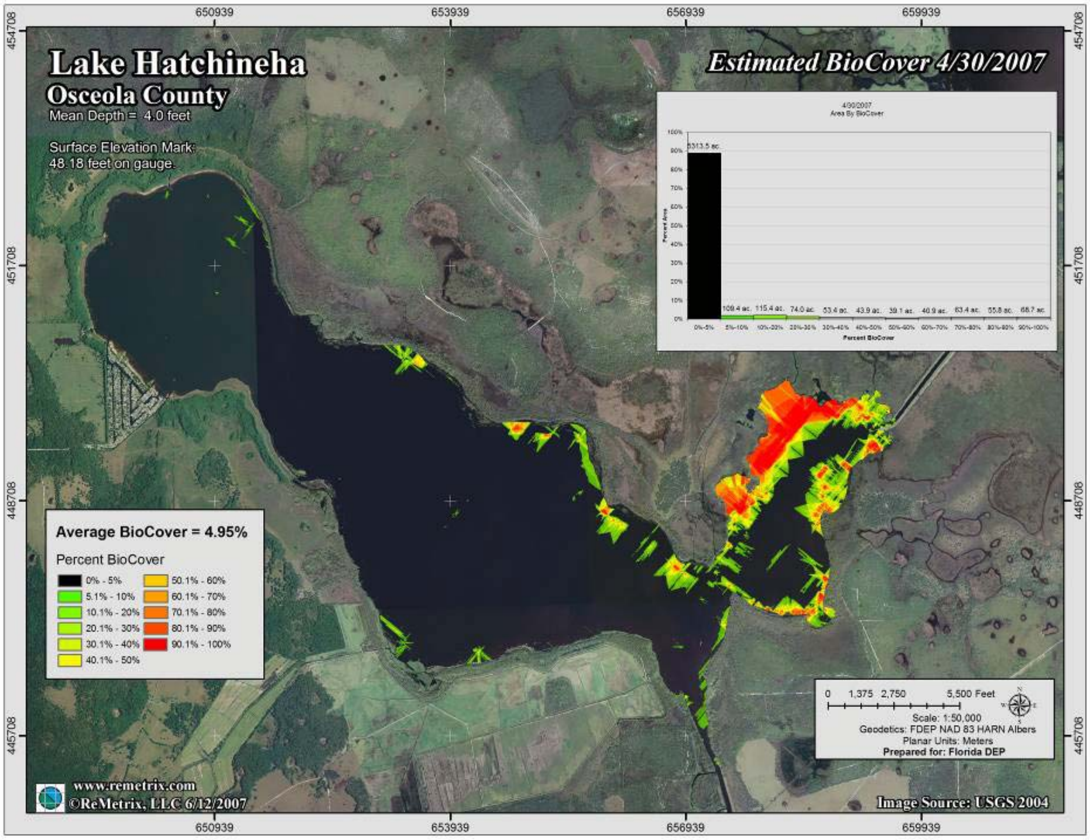


Figure F-15. Lake Hatchineha 2007 Hydrilla Abundance

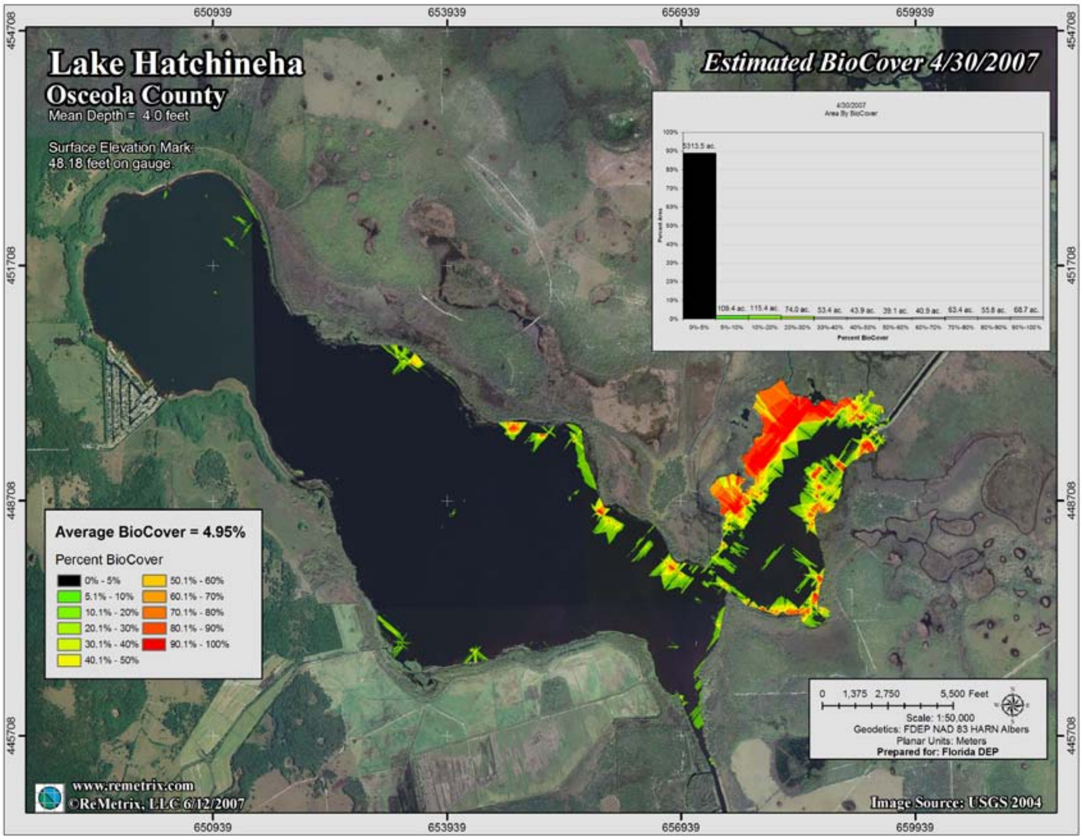


Figure F-16. Lake Hatchineha 2008 Hydrilla Abundance

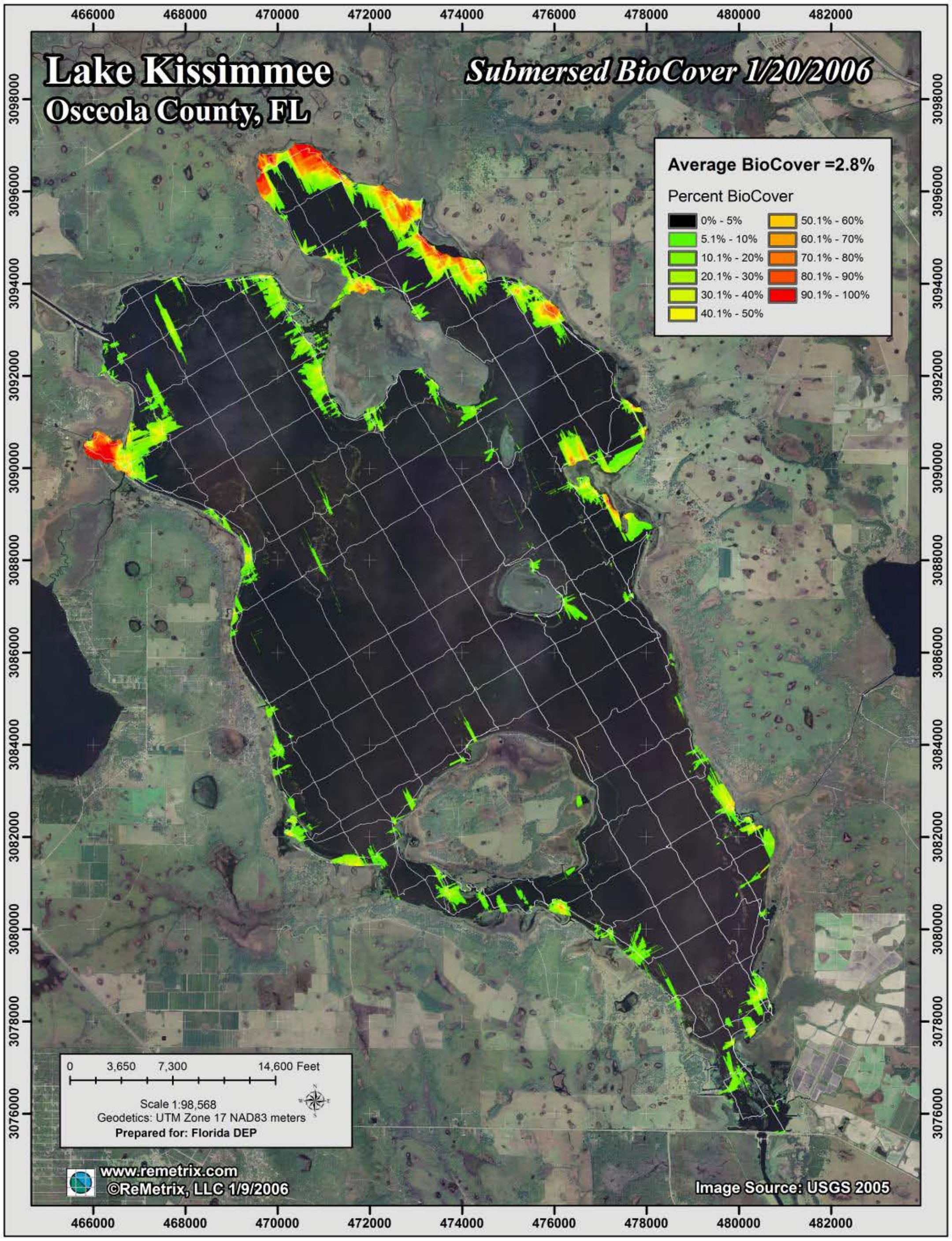


Figure F-17. Lake Kissimmee 2006 Hydrilla Abundance

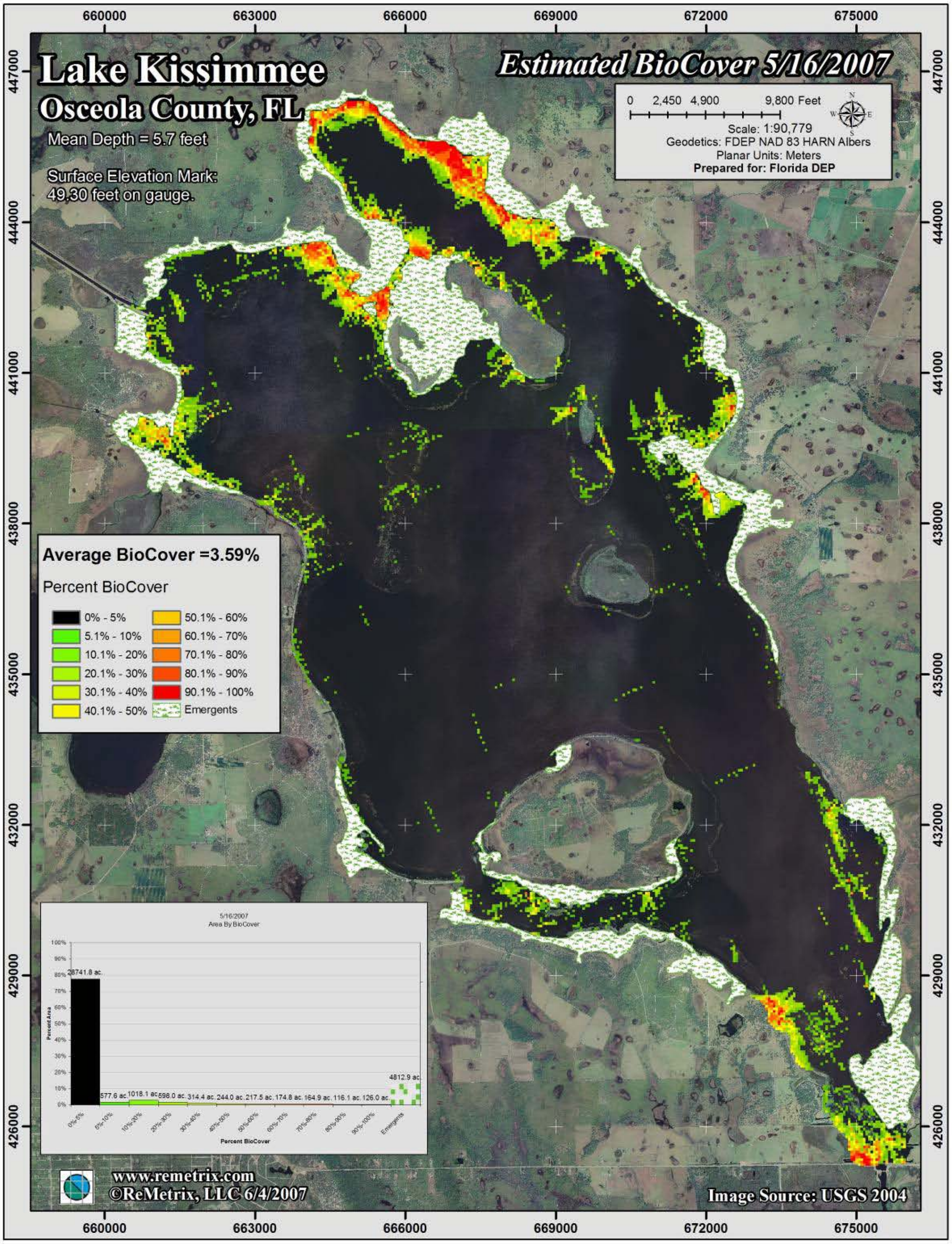


Figure F-18. Lake Kissimmee 2007 Hydrilla Abundance

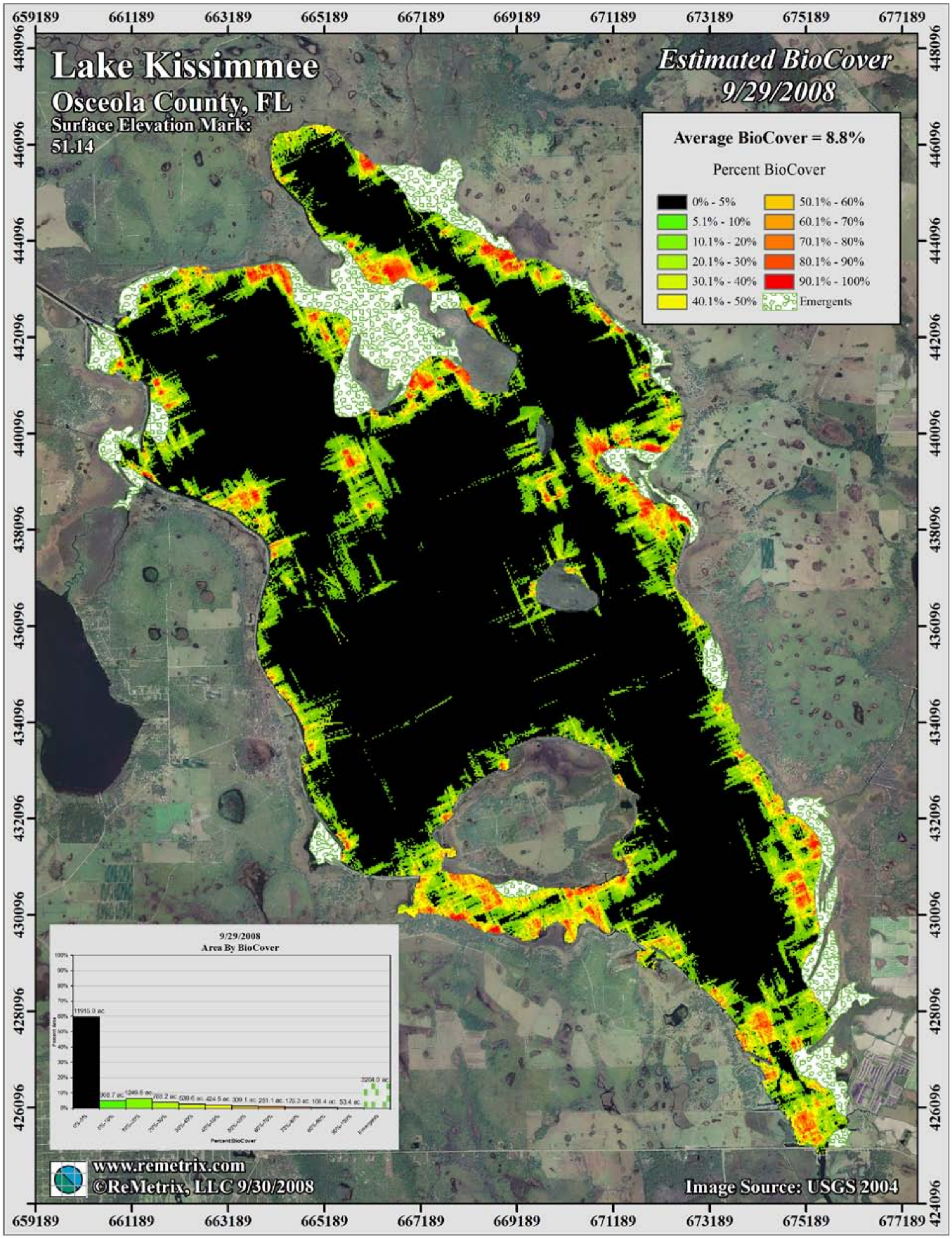


Figure F-19. Lake Kissimmee 2008 Hydrilla Abundance

Appendix G
Snail Kite Nesting Location Maps

Introduction

As part of U.S. Fish and Wildlife Service and Florida Fish and Wildlife Conservation Commission's management of the endangered snail kite, maps of nesting locations in the Kissimmee Chain of Lakes were produced.

Snail Kite Nests and Priority Management Areas, East Lake Tohopekaliga, 03/13/2008

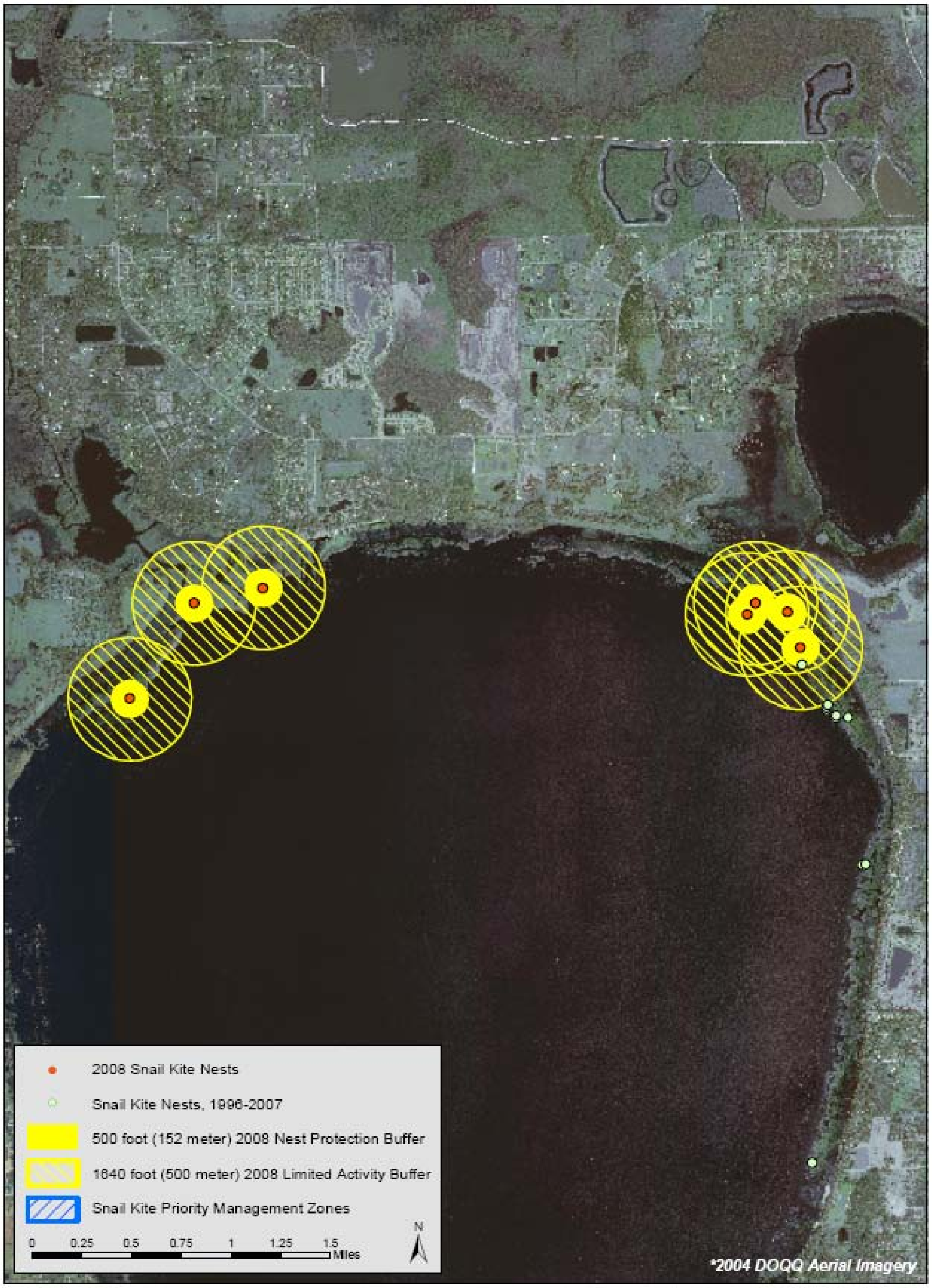


Figure G-1 – East Lake Toho Snail Kite Nesting Locations

Snail Kite Nests and Priority Management Areas, Lake Tohopekaliga, 03/13/2008

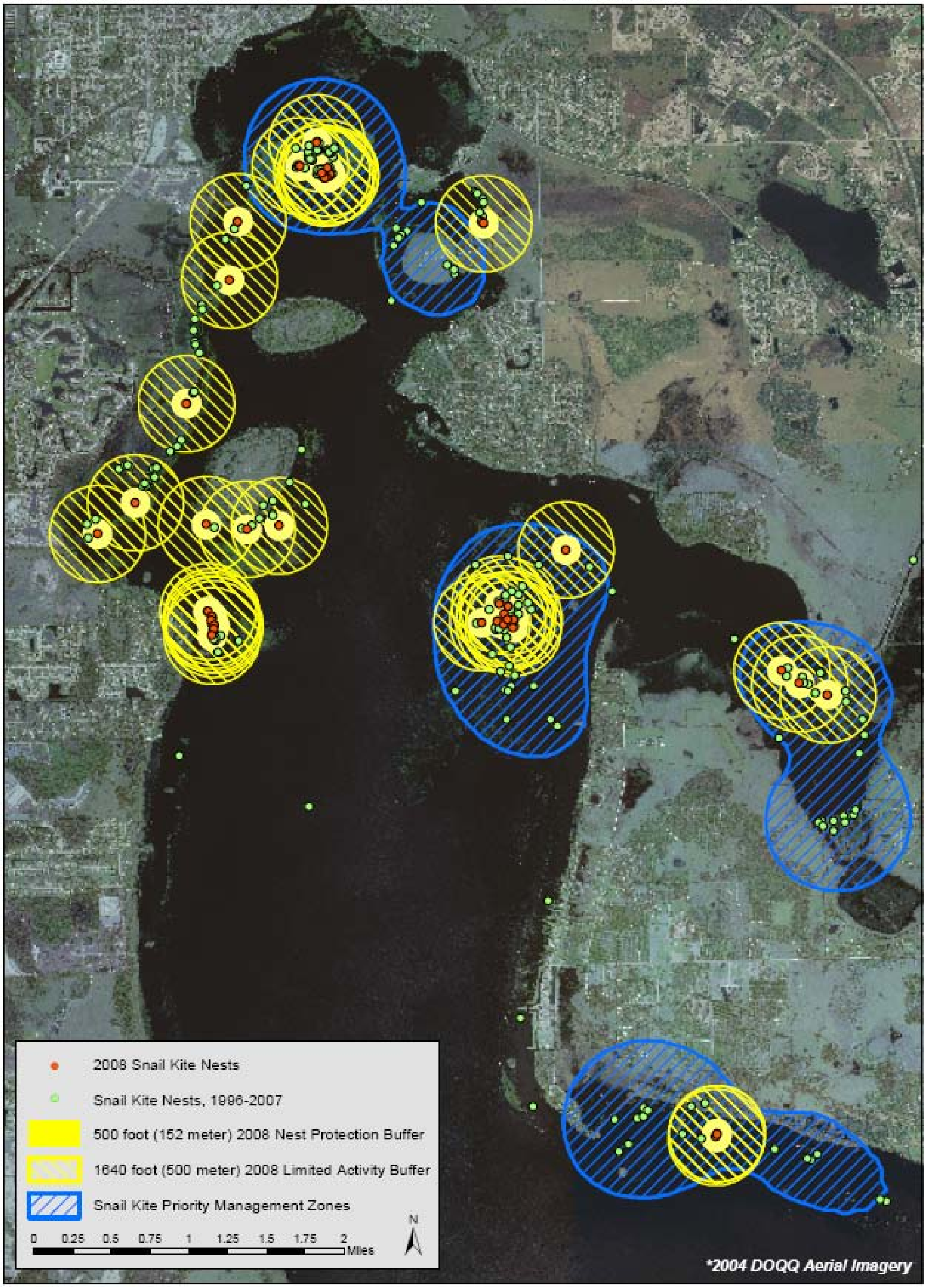


Figure G-2 – Lake Toho Snail Kite Nesting Locations.

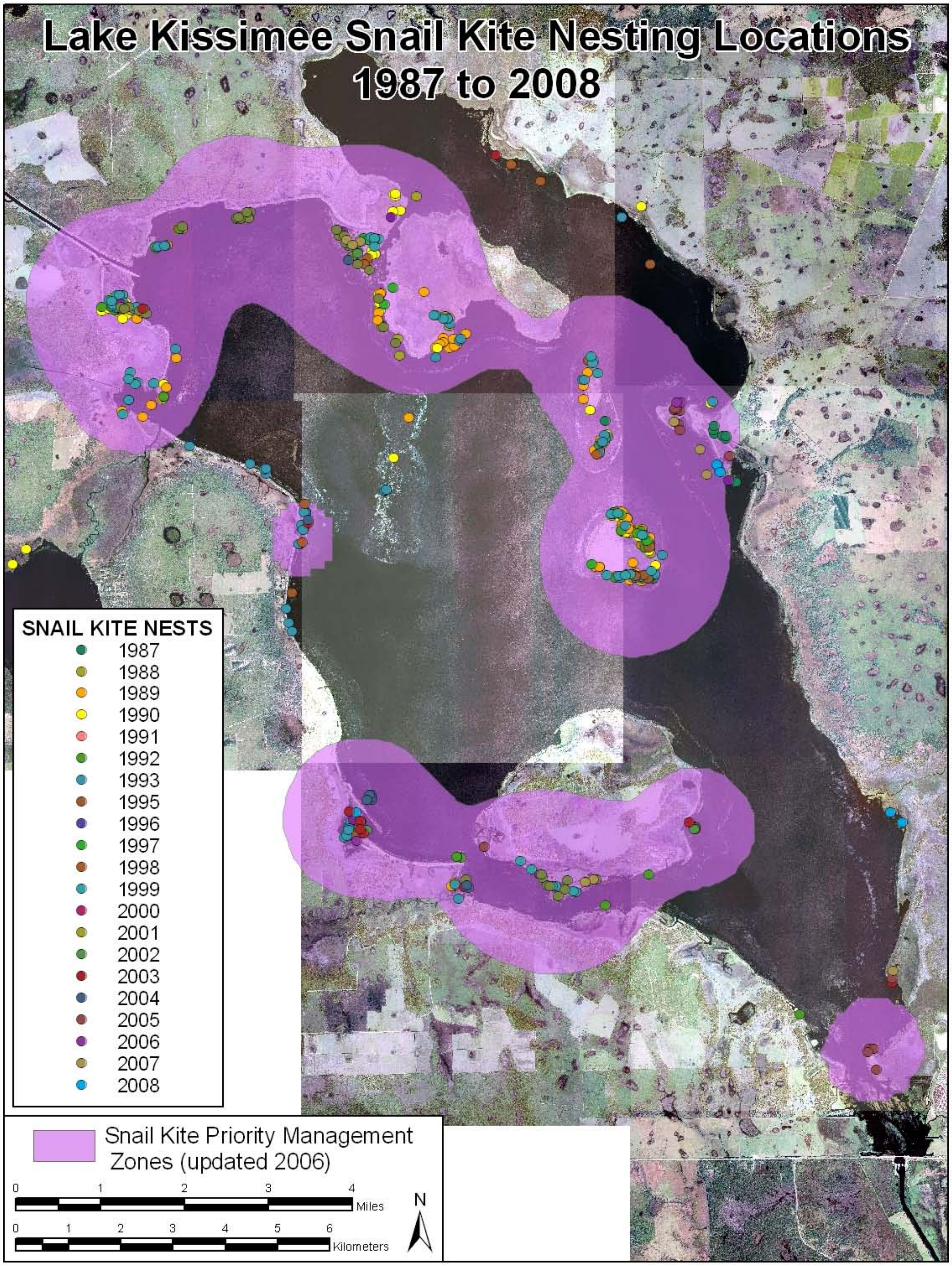


Figure G-3 – Lake Kissimmee Snail Kite Nesting Locations

Appendix H Conceptual Ecological Model

INTRODUCTION

The Kissimmee Chain of Lakes (KCOL) has undergone substantial ecological change due to human modification of the lakes and surrounding watersheds (Bonvechio and Bonvechio 2006, FDEP 2004, Mock Roos 2003, Williams 2001). This appendix presents the partner agencies' understanding of the drivers of these changes and the relationships among the ecological effects.

To aid in their understanding, the partner agencies created a conceptual ecological model (CEM) as a tool to illustrate potential consequences of ecological disturbances and responses to management activities. This model, shown in Figure H.1, is structured around human-caused drivers of change and the stressors resulting from them. These stressors are known or hypothesized to affect various attributes of the ecosystem, which are pooled into the five categories shown at the bottom of the diagram. The CEM represents an initial step toward development of the assessment measures presented in Appendix C.

The objectives of this appendix are to:

- Introduce and describe the CEM developed for the KCOL.
- Present the list of attributes selected as candidates for development into assessment performance measures (APMs) and assessment indicator measures (AIMs). These APMs and AIMs will be used to assess ecosystem health and signal the need for management intervention or modification.
- Describe known and hypothesized relationships among human-related drivers, stressors, and ecosystem attributes.

GENERAL DESCRIPTION OF MODEL

The CEM follows the format used in Lake Okeechobee and other Comprehensive Everglades Restoration Plan (CERP) models (Havens and Gawlik 2005, Ogden et al. 2005). The CEM illustrates how various cultural drivers and stressors are believed to affect components of the KCOL ecosystem that are of natural and societal value. Some of these relationships are supported by years of data collection or experience in managing these lakes. Other relationships are hypothesized and lack supporting data. This model and the narrative descriptions that follow are not intended to present a comprehensive or detailed set of relationships; rather, they illustrate, in a simplified way, important influences and responses as acknowledged by collective experience.

The model depicted in Figure H.1 is for a generalized lake in the KCOL. Some of the drivers, stressors, and ecological effects may differ in importance depending on the characteristics of each lake and its watershed. Consequently, some of the APMs and AIMs shown in Appendix J are specific to individual lakes or groups of lakes depending on their significance for assessing ecological health.

Conceptual Ecological Model Components

The CEM diagram comprises a top-to-bottom hierarchy of drivers, system stressors, ecological effects, and lake attributes. These terms are defined as follows and in the Glossary. Definitions were derived from Gucciardo et al. 2004, and Ogden et al. 2005.

Drivers are external, human-caused, forcing variables that exert a large influence on the lakes. *Stressors* are perturbations within a lake and hydrologically connected adjacent lands that occur in response to drivers. *Ecological effects* are physical, chemical, biological or functional responses to drivers and stressors. *Attributes* are living or nonliving environmental features or processes that can be measured, estimated, or extrapolated from another ecosystem to provide insights into, or serve as indicators of, the state of the ecosystem.

In the CEM diagram, the five drivers (rectangles) are linked to five stressors (ovals), which in turn are connected to various ecological effects (diamonds). Relationships between stressors and ecological effects represent significant management issues. For example, a primary issue in KCOL management is the accumulation of dense stands of littoral vegetation caused by regulation of lake stage. This is represented in the model by an arrow leading from Altered Hydrology (lake regulation – the stressor) to reduced lake fluctuations (the hydrologic effect), which in turn points to unnaturally dense stands of plants (the biological effect). The ecological effects are connected to five categories of lake attributes (hexagons) that are considered representative of the overall ecological condition of a generalized lake within the KCOL. In addition, it should be noted that the dashed arrows represent controlling effects (effects generally considered to be positive). For instance, aquatic plant management is conducted to reduce nuisance growth of littoral vegetation and invasive plants, such as hydrilla and water hyacinth. Likewise, dense growth of exotic plants, specifically hydrilla, has a controlling effect on nutrient concentrations in the upper portion of the water column.

The first driver identified at the top of the CEM diagram is Water Management**,** which includes regulation of water levels and flows in the KCOL. Water Management leads directly to three stressors: Altered Hydrology of the lakes, Drainage of Wetlands, and Fire Suppression (decreased instances of lakeshore fires). These stressors lead to changes in native plant communities and development of unnaturally dense stands of plants. Additional ecological effects include more tussock formation, accumulation of decomposed plant matter, reduced exposure of sandy substrate (less hard sand), and general alteration of fish and wildlife habitat. Littoral vegetation that becomes excessive may require expensive treatment or removal that can disrupt recreational use of the lake.

The next driver, Shoreline Development, leads to two ecosystem stressors: Drainage of Wetlands and Fire Suppression. Again, these stressors can result in the ecological effects mentioned previously, although in some cases, lakefront development has led to clearing of vegetation or even elimination of the littoral plant community entirely.

The third and fourth drivers are Aquatic Plant Management and Introduction of Exotic Plants. Invasive exotic plants produce stress in multiple ways. Numerous exotic plants have become established within the KCOL, with hydrilla being one of the most common and problematic species. Although hydrilla can provide beneficial habitat for fish and waterfowl, the proliferation of this species and other exotic plants impacts native plant communities and contributes to sediment accumulation and biochemical oxygen demand (BOD). Control of these invasive plants has become extremely important to lake management and has shaped the habitat of some lakes in the KCOL. Consequently, Aquatic Plant Management is considered a driver of the ecosystem, although it is unique in that it helps control some sources of stress, thus providing benefits to the system. These benefits include control of overgrowth of native vegetation in addition to exotic plants. However, in the process of reducing the proliferation of exotic plants and native vegetation, Aquatic Plant Management may introduce complications, including negative impacts on non-target plant species and ecological stresses resulting from hydrologic manipulations to facilitate treatments.

The last driver, Intensified Land Use, which includes agricultural and municipal development, is thought to stress the lakes primarily through its effects on various aspects of lake water quality, especially Alterations to Nutrient Levels. Nutrient enrichment leads to multiple ecological effects, including increased prevalence of algal blooms, higher turbidity, decreases in submerged aquatic vegetation (SAV), changes in aquatic plant communities, and more internal nutrient cycling within lakes.

At the bottom of the CEM diagram are five broad categories of attributes that have been or potentially can be affected by human-driven changes to the KCOL system. These attribute categories, which may be considered as end points for lake management, are: 1) Water Quantity; 2) Aquatic and Wetland Vegetation; 3) Birds and Threatened and Endangered Species; 4) Fish and Aquatic Fauna; and 5) Water Quality.

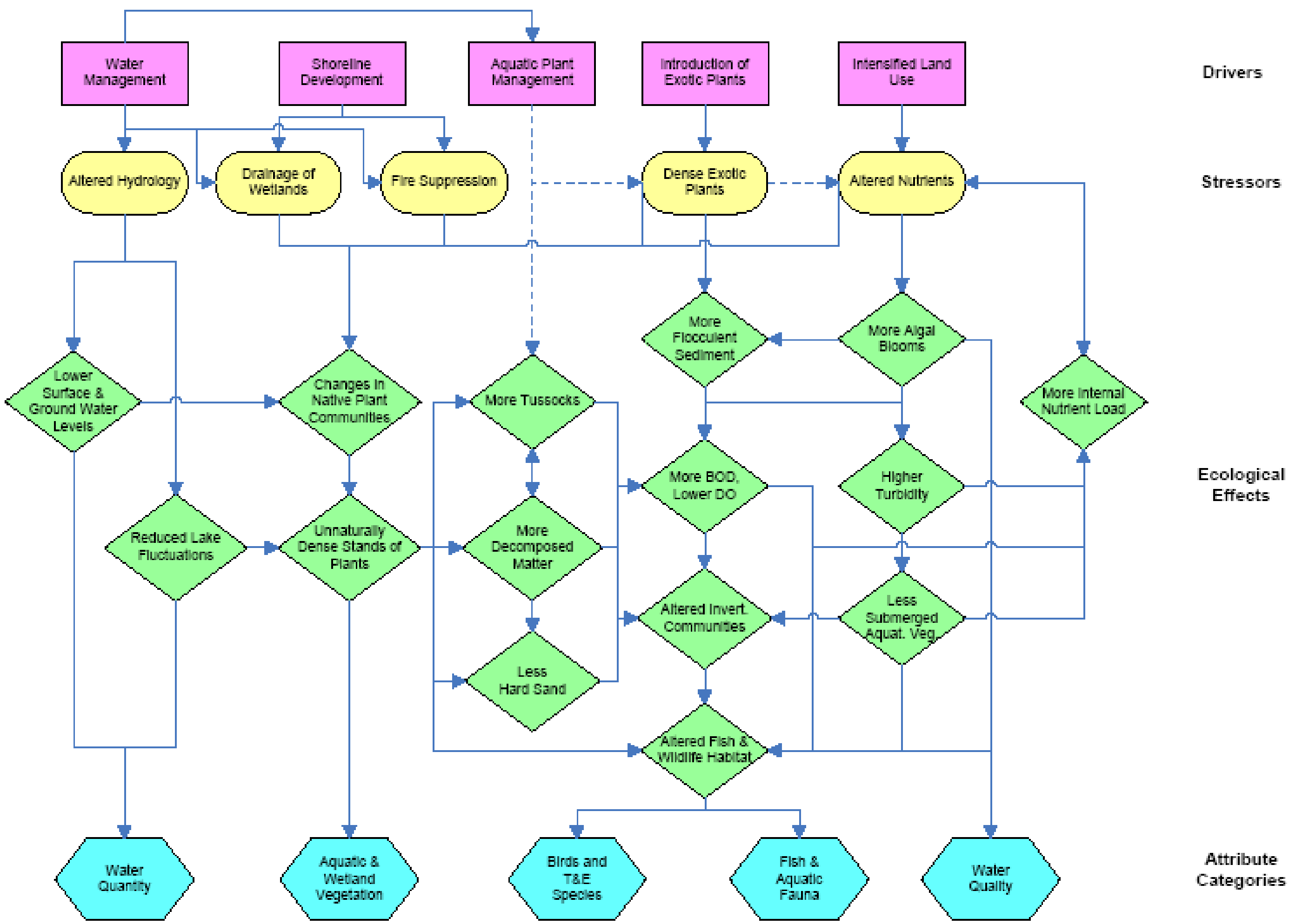


Figure H.1 - Conceptual ecological model (CEM) for a generalized lake within the Kissimmee Chain of Lakes. The top row of boxes shows drivers (sources) of human-caused stress to the lake ecosystem. These drivers lead to stressors, which in turn lead to ecological effects. These effects are associated with lake attributes that have been considered in the development of performance measures and indicator measures for lake management. The arrows represent hypothesized relationships between model components. Dashed arrows represent activities that moderate or control an effect resulting from another driver or stressor. For instance, aquatic plant management is conducted to reduce nuisance growth of littoral vegetation and invasive plants, such as hydrilla.

LITERATURE CITED

Bonvechio, K.I., and T.F. Bonvechio. 2006. Relationship between habitat and sport fish populations over a 20-year period at West Lake Tohopekaliga, Florida. North American Journal of Fisheries Management 26:144-153.

Florida Department of Environmental Protection. 2004. Water quality status report: Kissimmee River and Fisheating Creek. Division of Water Resource Management, Tallahassee, FL.

Gucciardo, S., B. Route and J. Elias. 2004. Conceptual ecosystem models for long-term ecological monitoring in the Great Lakes Network. National Park Service, Great Lakes Inventory and Monitoring Network, Ashland, WI.

Havens, K. E., and D. E. Gawlik. 2005. Lake Okeechobee conceptual ecological model. Wetlands 25:908-925.

Mock, Roos & Associates, Inc. 2003. Lake Istokpoga/Upper Chain of Lakes Basin phosphorus control report. Report submitted to the South Florida Water Management District. South Florida Water Management District, West Palm Beach, FL.

Ogden J.C, S.M. Davis, K.J. Jacobs, T. Barnes and H. E. Fling. 2005. The use of conceptual ecological models to guide ecosystem restoration in south Florida. Wetlands 25:795-809.

Williams, V.P. 2001. Effects of point-source removal on lake water quality: A case history of Lake Tohopekaliga. Lake and Reservoir Management 17:315-329.

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Appendix I
Ecosystem Health

INTRODUCTION

The overall purpose of the KCOL LTMP is to enhance and/or sustain lake ecosystem health through interagency cooperation and coordination. This appendix defines health and related terms, applies those terms to KCOL management, and describes the KCOL LTMP's approach for determining the lake health.

APPLYING THE CONCEPT OF ECOSYSTEM HEALTH TO MANAGEMENT

Since it has come into use, the concept of ecosystem health has been controversial (Carignan and Villard 2002). Although it has been helpful for advocating and communicating ecological policy, scientists have struggled to fit this term into an objective, scientific framework. For many reasons, ecosystem health is necessarily a value-laden concept that does not represent an independent scientific reality (Lackey 2001). Consequently, while scientific methods can be employed to gather data and conduct assessments, choosing targets that represent a "healthy" ecosystem is frequently a matter of preference.

More specific to the KCOL, determining what constitutes a healthy lake is a challenging task because a "healthy" condition can be judged differently by lake users, managers, and other resource professionals. For example, a eutrophic lake with abundant vegetation could produce trophy bass highly valued by fisherman, but swimmers may avoid such lakes because the water is not clear. Likewise, a wildlife manager who values lakeshore tussocks as desirable bird and alligator habitat might need to consider the desires of shoreline residents who may not regard such thick vegetation as a healthy condition and instead want an unobstructed view of the lake and easy access by boat. Therefore, determining whether or not a lake is healthy must take into account the preferences of lake users as well as more objectively determined measures of the lake's environment. In addition, an assessment of health must consider structural modifications, urban and agricultural development, and other changes that have substantially changed the characteristics of the lake. Hence, Lackey (2001) describes ecosystem health as "the preferred state of ecosystems modified by human activity."

DEFINING ECOSYSTEM HEALTH

If the concept of health is to be used as the basis for developing a long-term management strategy and monitoring program, then a clear operational definition of ecosystem health is necessary. Several definitions of ecosystem health have been published. For instance, the Society for Ecological Restoration defined it as "the state or condition of an ecosystem in which its dynamic attributes are expressed within 'normal' ranges of activity relative to its ecological stage of development" (SER 2002). This definition touches on two points that should be emphasized. First, an ecosystem's condition encompasses a variety of attributes (e.g., water levels, productivity, habitat, fish and wildlife species, etc.).

The key attributes of most interest have societal and ecological importance and can be measured and assessed. Second, these attributes are dynamic and exhibit 'normal' ranges of variation. This implies that a healthy ecosystem contains attributes that are sustainable within their ranges of fluctuation. Haskell et al. (1992) has defined a sustainable ecosystem as resilient to stress and capable of maintaining its organization and autonomy over time. Karr et al. (2007) add that the desired ecological condition should be sustainable without or with only minimal management intervention. Therefore, a healthy ecosystem can be considered one in which its vital characteristics and ecological resources are largely self-sustainable.

It is also important to distinguish between ecological health and ecological integrity. Integrity implies an unimpaired condition or the quality or state of being complete or undivided (Karr et al. 2007; Karr 1992). It also implies correspondence with some original condition (Karr et al. 2007). Biological or ecological integrity refers to the capacity to support and maintain a balanced, integrated, and adaptive biological system having the full range of parts (genes, species, assemblages) and processes (mutation, demography, biotic interactions, nutrient and energy dynamics, and metapopulation processes) expected in the natural environments of the region (Frey 1975, Karr and Dudley 1981, Angermeier and Karr 1994, Karr 1996).

The SFWMD has employed a similar definition to describe the goal of restoring the Kissimmee River (SFWMD 2006). To evaluate this project, restoration targets were established using datasets representing the river's natural condition (reference data) and the condition after the river was channelized in the 1960s (baseline data). Success in restoring ecological integrity to this river-floodplain ecosystem is being determined by comparing these datasets to data collected after restoration. The availability of these datasets, as well as a relatively uncomplicated "before-after-control-impact" (BACI) study design, has allowed a rigorous, data-driven approach toward evaluating project success.

In contrast to the Kissimmee River project, restoration of ecological integrity to the KCOL is not possible because the system cannot be returned to its condition prior to the changes that accompanied human settlement and basin development. Nevertheless, despite hydrologic modifications and other human impacts, these lakes are highly valued, and managers and lake users agree that the lakes must be maintained in a healthy condition. However, the KCOL LTMP has adopted less rigorous criteria for developing management targets that represent healthy conditions. Although the targets are sufficient to characterize lake health, they do not attempt to describe a system that possesses ecological integrity. Also, these targets may not be expressed in a high level of detail and may be supported only by sparse information or best professional judgment. They are provided with the recognition that guidance for management is needed now even though available information is currently limited. The KCOL LTMP sets forth a strategy for acquiring additional data to support development of more refined targets, better assessments of management success, and improved understanding of the lakes.

Figure I.1 further illustrates the difference between health and integrity. In this diagram, the biological condition of an ecosystem depends on the degree of human disturbance. The condition at top end of the biological condition gradient has biological integrity. It is pristine or minimally disturbed. The condition at the bottom end of the gradient is so degraded that virtually all life has been eliminated. Between these two extremes, a range of healthy (less impacted) and unhealthy (severely degraded) conditions exist. The healthy and unhealthy zones are separated by a threshold region. Determination of this threshold between healthy and unhealthy inevitably involves social conventions and contexts. Once these conventions are defined, such as for a series of lakes, the lakes' condition can be measured and assessed in the context of the defined conventions (Karr et al. 2007). However, selection of a threshold for health cannot simply be defined by societal desires. The target threshold also must be sustainable without substantial intervention. This is the criterion upon which scientifically-grounded information plays a key role (Karr et al. 2007).

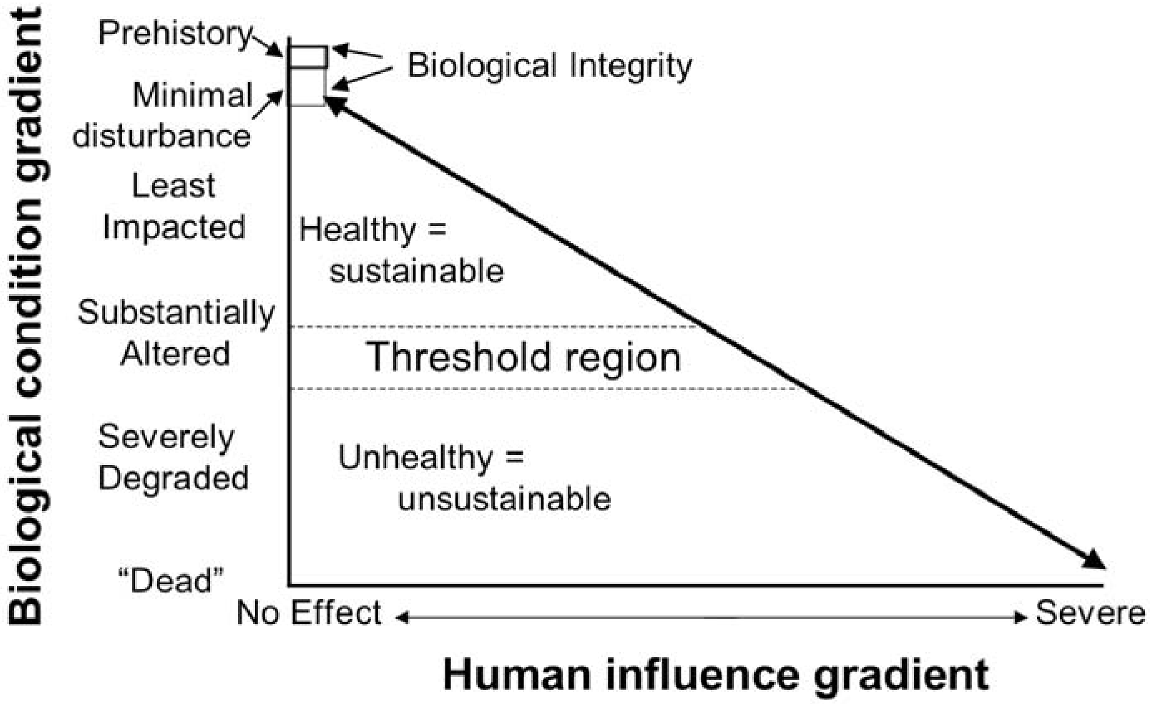

Figure I.1 - Relationship between biological condition and a hypothetical, synthetic, measure of human activity. Different human activities result in biological changes such as different dominant organisms or changing biological diversity along a descending slope of biological condition (Karr et al. 2007; modified from Karr 2004).

KISSIMME CHAIN OF LAKES LONG-TERM MANAGEMENT PLAN APPROACH TO ASSESSING ECOSYSTEM HEALTH

As stated in Karr et al. (2007), the most effective way to evaluate the condition of a place is to employ a variety of indicators that reflect both the richness of the natural system and the special societal goals for the place. The KCOL LTMP seeks to establish management targets at levels in or above the threshold region described in the previous section and based on agreement among the partner agencies and stakeholders. Achievement of these targets should assure that the ecological resources of the lakes will be in a healthy, sustainable condition as determined by the partner agencies and stakeholders.

Rather than developing targets based on integrative biological indices, the partner agencies have chosen to manage and monitor ecosystem health through measurement of individual lake attributes. Thus, ecosystem health will be measured and assessed by several environmental metrics, which will vary in importance depending on the characteristics, uses, and management priorities of each lake. This approach toward determining ecosystem health is embodied in the assessment performance measures and indicator measures in Appendix C.

SUMMARY

The concept of ecosystem health is a subjective term that must be operationally defined if it is to be useful for conveying the objectives and outcomes of environmental management. Ecosystem health is differentiated from ecological integrity in that a healthy ecosystem is sustainable even though it has been modified by human activity. Targets intended to achieve healthy conditions also reflect preferences of stakeholders. Ecological integrity pertains to a natural ecosystem that is pristine or minimally disturbed.

Under the general definition of ecosystem health provided here, the KCOL LTMP seeks to determine health for each of the lakes more specifically through the development of targets for key attributes. These targets define a set of healthy and sustainable conditions, and are based on available data, best professional judgment, stakeholder preferences, and management priorities. Therefore, the KCOL LTMP defines health in terms of the extent to which key lake attributes meet healthy and sustainable conditions. These conditions specified in the targets contained in the assessment performance measures presented in Appendix C. The KCOL LTMP also proposes a strategy for future monitoring and assessment that will help to refine targets, determine management success, and improve understanding of lake ecology and the requirements of lake health.

LITERATURE CITED

Angermeier, P.L. and J.R. Karr. 1994. Biological integrity versus biological diversity as policy directives. Bioscience 44(10):690-697.

Carignan, V. and M.-A. Villard. 2002. Selecting indicator species to monitor ecological integrity: a review. Environmental Monitoring and Assessment 78:45-61.

Frey, D. 1975. Biological integrity of water: an historical perspective. Pages 127-139 in R. K. Ballentine and L. J. Guarraia, editors. The integrity of water. EPA, Washington, D. C.

Haskell, B.D., B.G. Norton and R. Costanza. 1992. What is ecosystem health and why should we worry about it? Pages 3-20 in R. Costanza, B.G. Norton, and B.D. Haskell, editors. Ecosystem health: new goals for environment management. Island Press, Washington, DC.

Karr, J.R. 1992. Ecological integrity: protecting Earth's life support systems. Pages 223-238 in R. Costanza, B. G. Norton, and B. D. Haskell, editors. Ecosystem health new goals for environment management. Island Press, Washington, D. C.

Karr, J. R. 1996. Ecological integrity and ecological health are not the same. Pages 97-109 in P. Schulze, ed., Engineering within ecological constraints. National Academy of Engineering, National Academy Press, Washington, DC.

Karr, J.R. 2004. Beyond definitions: Maintaining biological integrity, diversity, and environmental health in national wildlife refuges. Natural Resources Journal 44:1067-1092.

Karr, J.R., M.S. Allen, and A.G. van der Valk. 2007. Environmental peer review of the scientific and technical basis for management decision-making as described in the Draft Kissimmee Chain of Lakes Long-Term Management Plan (draft dated June 18, 2007). Final pear review report submitted August 28, 2007 to the South Florida Water Management District, West Palm Beach.

Karr, J.R. and D.R. Dudley. 1981. Ecological perspective on water quality goals. Environmental Management 5(1):55-68.

Lackey, R.T. 2001. Values, policy and ecosystem health. Bioscience 51(6):437-450.

Society for Ecological Restoration Science and Policy Working Group. 2002. The SER Primer on Ecological Restoration. www.ser.org.

South Florida Water Management District. 2006. Kissimmee River restoration studies: Executive summary. South Florida Water Management District, West Palm Beach.

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APPENDIX J ASSESSMENT PERFORMANCE AND INDICATOR MEASURES

INTRODUCTION

Assessment performance measures (APMs) and assessment indicator measures (AIMs) were developed by LTMP participating agencies. Assessment performance measures describe metrics that can be obtained through field observation or measurement and will be used to measure/assess key lake attributes. Assessment measures specify targets representing preferred conditions as determined by the participating agencies. Assessment indicator measures were developed similarly to the APMs, but do not have assessment targets or confidence levels. APMs and AIMs together define the ecological health criteria the KCOL.

APMs and AIMs are part of the monitoring and assessment program described in Chapter 4. The monitoring and assessment program will provide the necessary information for identifying whether a problem exists within the system, assessing what types of management intervention may be necessary, and determining the effectiveness of deployed management tools. System assessments will be performed annually to compare ecosystem conditions with performance measurement assessment targets and provide information in a form suitable for decision making, adaptive management, and determination of management success.

APM and API were originally compiled in the Draft KCOL LTMP (SFWMD et al. 2007) and peer reviewed by a panel of ecologists. The panel recommendations are reported in Karr et al. (2007).

A central activity in the development of the APM and API was the selection of metrics. Factors considered in the final choice of metrics included their suitability as indicators of change for the respective attributes; importance to system health or to stakeholders; compatibility with existing or previous data collection efforts; and the ease, cost or practicality of field measurements.

The APMs and AIMs were built around these metrics and, where possible, target values were established to represent system health. Metrics for which target values were established were developed into assessment performance measures. Metrics for which targets were not developed, but were considered by the Inter-Agency Team to be of sufficient importance to justify monitoring, became assessment indicator measures. The LTMP's strategy for future assessments are presented in Chapter 4: Monitoring and Assessment.

PERFORMANCE MEASURES

Assessment Performance Measures (APMs) describe metrics that can be measured or detected through field observation, and are thought to change in some predictable manner in response to management activities.

Assessment Indicator Measures (AIMs) address attributes of the ecosystem known to be important, but for which a lack of reliable information is available for estimating numerical targets.

In addition to describing quantifiable metrics for key system attributes, both kinds of assessment measures specify monitoring programs that will provide data for ongoing evaluations of the health of the KCOL system, and these assessments in turn will inform adaptive management of KCOL resources. Where existing monitoring programs are not suited for LTMP purposes, proposals for new monitoring programs are made. Both APMs and AIMs include initial proposals as to the scope and nature of needed data collection efforts (e.g., metrics, geographic extent, frequency of data collection, etc.).

The assessment measures for each attribute category are presented in a standardized format that includes the following information:

- Assessment Target (APMs only): Describes the value, range of values, or direction of change that expresses the preferred condition for each metric. Describes if and how the target value was adjusted from reference data.
- Confidence Level: Described as High (long-term dataset from rigorous sampling program), Moderate (short-term dataset from a rigorous sampling program, or long-term data from another system), or best professional judgment (BPJ) (target not based on empirical data, but based on best judgment of an expert in a specific discipline).
- Description of Associated Metric(s): This section describes the metrics selected as quantifiable indicators of system health.
- Geographic Scope: Describes the lake(s) or geographic area in which data collection will be conducted.
- Rationale: For both APMs and AIMs, this section discusses why the metrics were selected and/or how their status reflects the health of the associated attribute and the KCOL.
- Data Availability Summary: Summarizes information relevant to the particular measure and its metrics. Also describes the data period and geographic location of the reference data (if any) used to develop the target.
- Status of Current and Future Monitoring: Identifies either a need for a new monitoring program or the existence of a suitable existing data source. In several cases, data for metrics from multiple APMs and AIMs, sometimes within different attribute categories, can be captured within a single monitoring program. Also identifies pilot studies that should take place before development of a new monitoring program, or evaluations needed to ascertain the suitability of an existing program for needs described.

The 22 APMs and AIMs (Table J.1) represent key attributes within the categories of Aquatic and Wetland Vegetation, Birds and Threatened and Endangered Species, Fish and Aquatic Fauna, and Water Quality. These are the same five categories at the base of the CEM diagram (Figure E.1) in Appendix H. Of the 22 assessment measures, 10 are APMs and 12 are AIMs. Attribute categories, attributes and measures are presented in Table J.1 in the same order as in Appendix H. Additional assessment measures will be developed to evaluate lake ecosystem health, including: *foodweb stability, nutrient limitations, and organic matter accumulation.*

Table J.1. – Kissimmee Chain of Lakes, Long-Term Management Plan assessment performance measures (APMs) and assessment indicator measures (AIMs).

<table>
<tr><th>Attribute Category</th><th>Attribute</th><th>Measure</th><th>Measure Number</th><th>Type</th></tr>
<tr><td rowspan="3">Aquatic and Wetland Vegetation</td><td>Palustrine Wetlands</td><td>Palustrine Wetlands</td><td>2-01</td><td>APM</td></tr>
<tr><td>Littoral Zone</td><td>Fish and Wildlife Habitat in Lake Littoral Zones</td><td>2-02</td><td>APM</td></tr>
<tr><td>Invasive Plants</td><td>Hydrilla Abundance and Management</td><td>2-03</td><td>AIM</td></tr>
<tr><td rowspan="5">Birds and Threatened & Endangered Species</td><td>Bald Eagle</td><td>Number of Bald Eagle Nests</td><td>3-01</td><td>APM</td></tr>
<tr><td>Snail Kite</td><td>Snail Kite Nesting Success</td><td>3-02</td><td>APM</td></tr>
<tr><td rowspan="2">Wading Birds</td><td>Wading Bird Nesting Effort</td><td>3-03</td><td>AIM</td></tr>
<tr><td>Wading Bird Abundance</td><td>3-04</td><td>APM</td></tr>
<tr><td>Waterfowl</td><td>Waterfowl Populations</td><td>3-05</td><td>AIM</td></tr>
<tr><td rowspan="9">Fish and Aquatic Fauna</td><td rowspan="3">Largemouth Bass</td><td>Angler Total Catch for Largemouth Bass</td><td>4-01</td><td>APM</td></tr>
<tr><td>Recruitment Model for Largemouth Bass</td><td>4-02</td><td>AIM</td></tr>
<tr><td>Size and Age-0 Distribution for Largemouth Bass</td><td>4-03</td><td>APM</td></tr>
<tr><td>Littoral Fish Assemblages</td><td>Littoral Fish Assemblage Structure – Species Richness, Diversity and Biomass</td><td>4-04</td><td>AIM</td></tr>
<tr><td rowspan="3">Amphibians and Reptiles</td><td>Amphibian Abundance</td><td>4-05</td><td>AIM</td></tr>
<tr><td>Small Reptile Abundance</td><td>4-06</td><td>AIM</td></tr>
<tr><td>Alligator Abundance and Size Distribution</td><td>4-07</td><td>APM</td></tr>
<tr><td rowspan="2">Invertebrates</td><td>Density of Native and Nonnative Apple Snails</td><td>4-08</td><td>APM</td></tr>
<tr><td>Benthic Macroinvertebrates</td><td>4-09</td><td>AIM</td></tr>
<tr><td rowspan="5">Water Quality</td><td rowspan="4">Trophic State</td><td>Trophic State Index</td><td>5-01</td><td>APM</td></tr>
<tr><td>Nutrient Loads</td><td>5-02</td><td>AIM</td></tr>
<tr><td>Frequency and Duration of Algal Blooms</td><td>5-03</td><td>AIM</td></tr>
<tr><td>Phosphorus Assimilation Capacity of Lake Sediments</td><td>5-04</td><td>AIM</td></tr>
<tr><td>Other Water Quality</td><td>Class III Water Quality Parameters</td><td>5-05</td><td>APM</td></tr>
</table>

MEASURE 2-01 - PALUSTRINE WETLANDS

Target

Palustrine wetlands are defined as wetlands that are situated apart from lakes and include wetlands that occur as depressional areas surrounded entirely by uplands. Included with palustrine wetlands in this performance measure are riverine, riparian, floodplain, slough, and remnant lacustrine wetlands, the latter of which are former littoral wetlands that have been separated from a lake by man-made berming or other intervention. This performance measure does not include lake littoral zone wetlands, which are covered by Measure 2-02 (Fish and Wildlife Habitat in Lake Littoral Zones).

Maintain no net loss in area and quality of palustrine, remnant lacustrine, and riverine wetlands in the watersheds of each Lake Management Area. Because data are not currently available to establish reference or baseline conditions for these wetlands surrounding the KCOL, quantitative targets for these wetlands are not yet established.

Confidence Level

Moderate

Description of Associated Metrics

Palustrine Wetland Area: Total area of palustrine wetlands, which can be calculated by lake, lake group, wetland type, and other categories as needed.

Palustrine Wetland Quality: Assessment of current quality will be based on physical and hydrological factors and can be compared to historical data such as aerial images or survey data.

Geographic Scope

Entire KCOL LTMP project area

Rationale

The presence of abundant, high-quality wetlands in the KCOL region is considered an indicator of watershed health. These palustrine wetlands provide recharge for groundwater, detention of surface flow, refuge for birds and aquatic fauna, and benefits to regional water quality. Shrinkage of wetland area over time is an obvious indicator of habitat loss. In addition, the condition of surviving wetlands can be impacted by nearby drainage and development. Studies indicate that when wetlands are in proximity to human development, degradation of their natural condition occurs because of factors such as clearing, drainage, eutrophication, toxicity, and fire suppression (Reiss and Brown, 2007). Therefore, the quality of extant wetlands also should be considered in any management planning.

Data Availability Summary

Maps produced by the SFWMD-FLUCCS Land Use/Land Cover Mapping Update Project may be useful for tracking recent changes in palustrine wetlands. These maps may be compared to black-and-white aerial photography taken prior to C&SF Project construction to assess changes in palustrine wetland area since current water level regulation was implemented. This pre-regulation imagery (previously converted to digital format by the University of Florida) will be geo-referenced by the SFWMD and USGS when funding is available. Federal or state agency wetland permitting databases that record wetland impacts and mitigations may be useful as a supplemental data source.

Status of Current and Future Monitoring

The SFWMD Water Supply Department is assessing palustrine wetlands in the Upper Kissimmee Basin to determine the effects of groundwater withdrawals by municipalities. This assessment is being done as part of the Central Florida Coordination Area (CFCA) project, which is a cooperative effort of the SFWMD, St. Johns River Water Management District, and Southwest Florida Water Management District. The assessment entails site visits of wetlands in the area as well as comparisons of recent and historical aerial photos to assess wetland status. Over 100 wetland areas have been assessed so far as part of this project, although most of these wetlands are north and west of the KCOL.

Palustrine wetland monitoring proposed specifically for the KCOL LTMP would be a new program that would attempt to utilize data gathered through remote sensing techniques (aerial imagery) and ground-based measurements and observations. Although site visits are desirable, funding and time constraints will probably limit the number of sites that can be thoroughly surveyed. Therefore, future monitoring should take the CFCA methods and data into consideration, and site assessments may be supplemented with surveys using less intensive methods similar to those presented by Reiss and Brown (2007).

Before implementing this monitoring program, the responsible agency should explore the feasibility of using the SFWMD-FLUCCS Land Cover/Land Use Mapping Update Project maps for KCOL wetland tracking and the possibility of using federal or state wetland permitting databases that record impacts and mitigations.

MEASURE 2-02 – FISH AND WILDLIFE HABITAT IN LAKE LITTORAL ZONES

Targets

The littoral zone of lakes consists of shallower areas that are inundated at least part of the year and are occupied by wetland vegetation. Many fish and wildlife species utilize littoral habitat for foraging and reproduction. In the KCOL, the lake littoral zone is defined as the area below the maximum regulatory stage that is inundated at least part of the year and is occupied by emergent wetland vegetation. The littoral zone includes the lake floodplain. The water-ward limit of the littoral zone is where emergent plant species no longer grow due to constant inundation and deeper water. For the purpose of the KCOL management, littoral habitat can be categorized into three basic types: shoreline habitat, shallow littoral habitat, and deep littoral habitat. These habitats generally occur along a depth gradient. Habitat found along shorelines and the fringes of some islands consists of dense stands of water-tolerant shrubs and trees mixed with wetland vegetation such as cattail (*Typha* spp.) and bulrush (*Scirpus californicus*, *S. validus*). Shallow littoral habitat occurs in water up to 30 cm deep. Deep littoral habitat occurs in water more than 30 cm deep. Both shallow and deep littoral habitats occur as a mosaic of "open water" (defined as containing no vegetation or submerged vegetation only) and mixed wetland vegetation (emergent, floating-leaved, and submerged plants).

In this performance measure, habitat recommendations are grouped in two sections: (1) a Targets section that lists each target according to a specific measurement (metric) and then by species or guild, and (2) a Guild-Specific Habitat section that gives more detailed habitat recommendations for amphibians, reptiles (alligators), and snail kites. More information is available for alligators and snail kites because they have high visibility within the area.

Littoral habitat targets for key species and guilds have been consolidated into a single performance measure because habitat requirements for many fish and wildlife species overlap considerably. Although some species or guilds may have different habitat preferences, the targets presented here are not mutually exclusive because preferred habitat types will often occur in distinct locations within a given lake.

The habitat targets described here are based on the most current information on habitat composition, structure and function within the KCOL. In many cases, they are based on limited data or best professional judgment and are not specific to the management of individual lakes. More specific targets may be developed as new data become available from new monitoring initiatives (see Chapter 5, Assessment Targets, Existing Information, and Application of Monitoring to Management Needs).

Measures (metrics) important for characterizing habitat quality of the littoral zone include:

- Total surface area of littoral zone in each lake;
- Species composition of littoral vegetation, stratified by water depth;
- Plant composition (percent by cover) of specific plant species or communities (classes), stratified by water depth or specific location;
- Percent cover, dispersion, and interspersion of littoral vegetation;
- Total surface area per plant class;

- Area of shoreline, shallow, and deep littoral habitats;
- Coverage and interspersion of plant classes within grid cells or polygons;
- Depth of organic deposits (detritus and organic sediment);
- Area of tussocks.

Reference Conditions: Fish and wildlife managers have determined that, due to substantial modifications to the lakes and changes in recreational use, the habitat targets should not attempt to return the lakes to their pre-regulation condition. In place of pre-regulation reference conditions as a basis for target development, the targets have been based on existing data and professional judgment.

Total area of littoral zone: Maintain the area of the littoral zone at or above the 2007 level. A reduction of >10% will trigger management action to address loss of littoral area.

Confidence Level

Not yet determined.

Description of Associated Metric(s)

Species composition of littoral vegetation, stratified by water depth: Shallow-water littoral habitat (i.e., 0–30 cm) is used for foraging by wading birds, dabbling ducks, snail kites, fish, amphibians, and reptiles. To promote use by these species, this habitat should be maintained as a mosaic of open water and mixed wetland vegetation. Plants typically present in this habitat include emergent species such as maidencane (*Panicum hemitomon*), Egyptian paspalidium (*Paspalidium geminatum*), beakrush (*Rhynchospora* spp.), spikerush (*Eleocharis* spp.), pickerelweed (*Pontederia cordata*), lance-leaf arrowhead (*Sagittaria lancifolia*), smartweed (*Polygonum hydropiperoides*), bulrush, cattail, and spatterdock (*Nuphar advena*); floating-leaved species such as fragrant water lily (*Nymphaea odorata*) and water-shield (*Brasenia schreberi*); and submergent species such as bladderwort (*Utricularia* spp.), awl-leaf arrowhead (*Sagittaria subulata*), eelgrass (*Vallisneria americana*), and southern naiad or water nymph (*Najas* spp.).

Wading birds forage in small habitat patches (<10 m^2), as well as large (>1000 m^2), continuous areas of wetlands and lake littoral zones within 5-20 kilometers (km) of a nesting colony site. A patchy distribution of emergent aquatic vegetation with approximately ≤50 percent cover per hectare (ha) of marsh is most desirable for foraging wading birds. Smaller (5-10 meters in diameter), irregularly-shaped vegetated regions with a patchy distribution are preferred over a continuous growth pattern. Shallow, open water regions and recently exposed bottom that is sparsely vegetated are used by white and glossy ibises to access benthic invertebrates by probe feeding (Davis and Kricher 2000).

Littoral habitat with water >30 cm is used for foraging by diving ducks, snail kites, fish, amphibians, and reptiles. To promote use by these species, this habitat should be maintained as a mosaic of open water and mixed emergent vegetation. Desirable plants include emergent species such as maidencane, Egyptian paspalidium, spikerush, bulrush, cattail, and spatterdock; floating-leaved species such as fragrant water lily and water-shield; and submergent species such as bladderwort, pondweed (*Potamogeton illinoensis*), eelgrass, southern naiad, and coontail (*Ceratophyllum demersum*).

Shoreline areas and islands with wet shrub and wet forest vegetation, including tussock habitat, are used for breeding by three important guilds: wading birds, amphibians and reptiles, and snail kites. For wading birds, preferred breeding habitat consists of woody shrubs and trees, usually on islands >50 m from shore or >100 m from developed areas. These shrubs and trees are often comprised of species such as cypress (*Taxodium* spp.), red maple (*Acer rubrum*), wax myrtle *(Myrica cerifera*), dahoon holly (*Ilex cassine*), Carolina willow (*Salix caroliniana*), and oak (*Quercus* spp.). Breeding habitat for amphibians and reptiles, especially alligators, can include any vegetation that persists on a deep (>1 m) peat/muck base such as cattail, pickerelweed, water-primrose (*Ludwigia* spp.), and Carolina willow (but <30% primrose and willow combined). For snail kites, woody shrubs are preferred, including willow, buttonbush (*Cephalanthus occidentalis*), cypress, pond apple (*Annona glabra*), and dahoon holly, as well as thick, rank stands of herbaceous species such as cattail and bulrush.

These species composition targets can serve as a guide for maintenance of plant species in lakes with desirable habitat, or enhancement in lakes where habitat has been degraded by disturbance, development, or water level regulation.

Percent cover, dispersion, and interspersion of vegetation: Percent vegetated cover varies as follows for each guild:

- Wading Birds: emergent and floating-leaved vegetation <50% for foraging; 100% for nesting;
- Dabbling Ducks: emergent and floating-leaved vegetation between 30% and 70%;
- Diving Ducks: >40% submersed vegetation; <40% floating-leaved vegetation;
- Fish: 55-65% total vegetation (emergent, floating-leaved, and submersed);
- Amphibians and Reptiles: emergent and floating-leaved vegetation 40-60% for foraging; 100% for breeding;
- Snail Kites: emergent and floating-leaved vegetation 50-80% for foraging; breeding variable, mostly 100%.

Dispersion and interspersion of littoral vegetation influence the quality of habitat for fish and wildlife. This may be quantified with a "contagion value", which is a measure of how "clumped" vegetation is in a given area. The FWC is determining, for each guild, a range of appropriate target contagion values that correspond to desirable vegetation dispersion and interspersion. Further detail on these targets and how they are determined will be included here when available.

Area of habitat types: At a minimum, littoral wetland areas should be maintained at current 2007 levels. Area requirements for some guilds have been developed for several lakes and are described in Table J.2.

Table J.2 – Area requirements for guilds in some Kissimmee Chain of Lakes waterbodies.

Guild	Habitat Type	Kissimmee	Cypress	Hatchineha	Tohopekaliga
Dabbling Ducks	Shallow littoral (depth <30 cm)	380 ha	----	----	180 ha
Diving Ducks	Deep littoral (depth 30–180 cm)	1,060 ha	----	----	740 ha
Fish	Shallow and deep littoral	3,456 ha	----	----	2,230 ha
Alligator Foraging	Shallow and deep littoral	1,800 ha	50 ha	100 ha	700 ha
Alligator Breeding	Shoreline	2,200 ha	250 ha	900 ha	450 ha
Snail Kite Foraging	Shallow and deep littoral	----	----	----	TBD
Snail Kite Breeding	Shoreline	----	----	----	> 650 ha
Wading Bird Foraging	Shallow littoral	----	----	----	----
Wading Bird Breeding	Shoreline	----	----	----	----

These target values are based on a percentage of the entire littoral area as determined by best professional judgment. Plant species composition and percent coverage targets are also based on best professional judgment, although some literature values were incorporated for largemouth bass (Allen and Tugend 2002) and other species.

Depth of organic deposits: Organic detritus and sediment should be maintained ≤8 cm deep in foraging and some breeding locations. However, alligator breeding habitat requires organic deposits of more than 1 m in depth, as do non-woody snail kite nesting areas. Unconsolidated detritus >5 cm thick probably reduces the quality of foraging habitat for herons, but habitat in this condition still may be used by ibis. Ibis will forage for invertebrates on deep, soft, consolidated organic substrates that will support their body weight (800-900 grams). Targets for the percentage of littoral zone bottom with organic materials ≤8 cm deep and targets for the percentage with organic deposits >1 m deep for alligators and snail kite breeding habitat have not been developed yet for individual lakes.

Area of tussocks: Tussocks are important for alligators, which may use them for breeding. Tussocks that are permanent, non-floating, extend greater than 50 meters from shore, and are greater than 5 hectares in size provide good alligator nesting sites. Some wading bird species will use the edges of floating tussocks to access prey in deeper (>30 cm) regions of lakes. However, large (>0.5 ha) tussocks covered with dense vegetation may displace preferred foraging habitat for wading bird species. Tussocks can provide the base for woody plants to colonize. These woody tussocks can act as islands that provide additional quality bird nesting habitat. Targets for the desirable area of tussocks in individual lakes have not been developed yet.

Desired amphibian and reptile (alligator) foraging habitat:

Density: 5-15 kg/m^2

Community composition: A variety of emergent vegetation is acceptable, but on Lake Tohopekaliga, the more desirable species are pickerelweed, spatterdock, and cattail.

Patchiness/interspersion: 40-60% emergent vegetation interspersed within 40-60% open water.

Tussocks: Generally not utilized as foraging habitat.

Organic base: <50 cm in depth.

Acceptable amphibian and reptile (alligator) foraging habitat:

Density: 15-30 kg/m^2

Community composition: Up to 50% Egyptian paspalidium, maidencane, smartweed, and bulrush. The other 50% should be pickerelweed, spatterdock, and cattail.

Patchiness/interspersion: 60-70% emergent vegetation interspersed within 30-40% open water.

Tussocks: Generally not utilized as foraging habitat.

Organic base: 50-75 cm in depth.

Unacceptable amphibian and reptile (alligator) foraging habitat:

Density: >30 kg/m^2

Community composition: >50% Egyptian paspalidium and bulrush.

Patchiness/interspersion: >70% marsh and <30% open water.

Tussocks: Generally not utilized as foraging habitat.

Organic base: >75 cm in depth.

Desired amphibian and reptile (alligator) breeding habitat:

Density: >50 kg/m^2

Community composition: Any vegetation community that persists on areas with a deep (>1 m) peat/muck base. On Lake Tohopekaliga, these communities consist of cattail, pickerelweed, water-primrose, and Carolina willow. With the exception of water-primrose and Carolina willow, percent composition can range from monocultures to any mix of the aforementioned species. Water-primrose and Carolina willow should not comprise more than 30% of the coverage area combined.

Patchiness/interspersion: Contiguous emergent marsh with no open water.

Tussocks: Permanent, non-floating tussocks that extend ≥ 50 m from the shoreline and are ≥ 5 ha in size.

Organic base: A peat/muck base ≥ 1 m in depth.

Acceptable amphibian and reptile (alligator) breeding habitat:

Density: 30-50 kg/m^2

Community composition: Communities consisting of cattail, pickerelweed, water-primrose, and Carolina willow. With the exception of water-primrose and Carolina willow, percent composition can range from monocultures to any mix of the aforementioned species.

Water-primrose and Carolina willow should not comprise more than 60% of the coverage area combined.

Patchiness/interspersion: Emergent marsh with ≤ 20% of the area consisting of open water.

Tussocks: Permanent, anchored (i.e., non-mobile) tussocks that extend ≤ 50 m from the shoreline and are 1-5 ha in size.

Organic base: A peat/muck base of 0.5-1 m in depth.

Unacceptable amphibian and reptile (alligator) breeding habitat:

Density: <30 kg/m^2

Community composition: Communities consisting of lilies and emergent marsh species that grow in open conditions. Examples include Egyptian paspalidium, bulrush, and spatterdock.

Patchiness/interspersion: Emergent marsh with > 20% of the area consisting of open water.

Tussocks: Floating, mobile tussocks, or any tussock < 1 ha in size.

Organic base: A peat/muck base of < 0.5 m in depth.

Desired snail kite foraging habitat: This is a description of areas that kites are known to forage (from the University of Florida Cooperative Unit, Wiley Kitchens, et al.). Emergent vegetation is also required for apple snail oviposition.

Density (in vegetated patch): grass community: average of 50 stems/m^2; broadleaf and floating-leaved community: 150-250 stems or leaves/m^2.

Community composition: varies by water depth (see below), but area of emergent vegetation will be comprised of 70-80% "grasses" and 20-30% broadleaf species.

Shallow littoral zone (0-1.2 m): "grasses" would include maidencane, spikerush, bulrush, sedges; broad-leafed species would include pickerelweed and lance-leaf arrowhead.

Deeper littoral zone (1.2–2 m): "grasses" would be primarily Egyptian paspalidium and bulrush; broadleaf species would include spatterdock, fragrant water lilly, and possibly cattail.

Moderate densities of submersed plants such as hydrilla (*Hydrilla verticillata),* coontail, pondweed, and eelgrass in both shallow and deep open water areas are acceptable as a forage base for apple snails.

Patchiness/interspersion: grasses: 70-90% coverage; broadleaf and floating-leaved species: 10-20% coverage

Location: Foraging habitat should be within 500 m of nesting habitat.

Acceptable snail kite foraging habitat:

Density: grass community: average of 30-49 stems/m^2; broadleaf and floating-leaved community: 50-150 stems or leaves/m^2.

Community composition: varies by water depth (see above in desired habitat), but vegetated area generally will be comprised of 50-70% "grasses" and 30-50% broad-leaved species.

Patchiness/interspersion: grasses: 50-70% coverage; broadleaf and floating-leaved species: 20-50% coverage

Location: Foraging habitat within 500-1000 m of nesting habitat.

Unacceptable snail kite foraging habitat:

Density: grass community: <30 stems/m^2; broadleaf and floating-leaved community: <50 or >250 stems or leaves/m^2.

Community composition: >50% coverage of broadleaf plants or no broadleaf plants and limited coverage of grasses (i.e., primarily open water).

Patchiness/interspersion: grasses: <50% coverage; broadleaf and floating-leaved species: 0-5% or >50% coverage.

Location: Foraging habitat located >1000 m (1 km) from nesting habitat may be of limited use to nesting birds. However, such foraging habitat would likely be used outside the breeding season or by non-breeding birds.

Desired snail kite nesting habitat:

Density: varies by specific habitat, single cypress trees (typically 4-12 m tall), willow stands (13-16 cm at base, 10-20 stems/m^2, 0.02-5 ha; 1.8-6.1 m tall; after roost description in Sykes et al. 1995), cattail (8 kg/m^2 or 15 stems/m^2, where stems at substrate are approximately 16 cm diameter and patches are on average 30 m wide x 100 m long).

Community composition: Large stands (50 m radius) of cattail scattered along 1000 m or more of shoreline that may have 5-10% coverage of woody species, including willow (minimum 13-16 cm at base), buttonbush (*Cephalanthus occidentalis*) and bald cypress (*Taxodium distichum*). Willow stands may have various emergent species in the understory.

Water depth under nesting substrate: Average water depth at nest sites in the KCOL ranged from 36-93 cm. The following depths are recommended throughout the nesting period (December 1 to July 31): willow--59 cm, bulrush--92 cm, cattail--88 cm (James Rogers, unpublished data).

Distance from shore: Nesting substrate should be >50 m from shore or have a "moat" type area of open water shoreward deep enough for alligators to patrol and minimize access by land-based predators (e.g., raccoons).

Acceptable snail kite nesting habitat:

Density: cattail (5 kg/m^2 or 12 stems/m^2 where stems at substrate are approximately 16 cm diameter and patches average 20 m wide x 50 m long); single willow trees with stem diameter 10-13; bulrush with average of 250 stems/m^2.

Community composition: ≤10% of lake-wide nesting habitat acreage provided as dense bulrush (250 stems/m^2). Remaining acreage (90%) of nesting habitat provided as listed in desired habitat above.

Water depth under nesting substrate: same as Desired.

Distance from shore: same as Desired.

Unacceptable snail kite nesting habitat:

Density: anything less than that listed above for each plant species/community.

Community composition: >10% of lake-wide nesting habitat acreage provided as dense bulrush (250 stems/m^2).

Water depth under nesting substrate: any nesting habitat not flooded to the Desirable/Acceptable level throughout the nesting period (December 1 to July 31) or nesting habitat dewatered during nesting season.

Geographic Scope of Targets

The targets for each guild apply to the following Lake Management Areas (LMAs) within the KCOL:

- **Lake Tohopekaliga LMA and Lake Kissimmee, Lake Hatchineha, Cypress Lake LMA:** Fish, amphibians and reptiles, waterfowl, wading birds, and snail kites;

- **East Lake Tohopekaliga LMA:** Fish and snail kites; targets for other guilds will be established as needed after necessary data are collected;
- **Alligator Chain LMA:** Fish only; targets for other guilds will be established as needed after necessary data are collected;
- **Hart and Mary Jane LMA and Myrtle, Joel, Preston LMA:** none; targets for other guilds will be established as needed after necessary data are collected.

Rationale

Lake littoral zones provide crucial habitat features for a number of fish and wildlife species and have been severely impacted since water level regulation began. Maintenance of a diversity of littoral habitat conditions is viewed as an important component of lake health. This performance measure is designed to assess the suitability of lake littoral zones to serve as foraging and breeding habitat for selected species and guilds of fish and wildlife known to use the KCOL. Percent cover, species composition, and interspersion and dispersion of vegetation; water depth; organic substrate depth; and area of lake littoral zone were selected as the primary indicator measures of habitat suitability.

Important metrics for evaluating habitat suitability for all of the species and guilds covered under this measure are as follows:

Wading Birds: The abundance and species of wading birds present in a particular foraging patch can be influenced by regional factors, such as recruitment and post-juvenile dispersal from distant breeding colonies, an influx of seasonal migrants from more northern latitudes, large-scale weather patterns, and degradation or loss of adjacent foraging habitat (Coffey 1943, 1948, Melvin et al. 1999, Frederick and Ogden 2001, Fasola et al. 1996). Thus, measuring only wading bird abundance and diversity is insufficient to assess the availability and relative quality of potential foraging areas within the KCOL. Local factors affecting wading bird foraging are more readily measured and include area of wetlands and lake littoral zones, water depths, aquatic plant species diversity and percent cover, patch size of vegetated and open water areas, presence of tussocks, organic content of foraging substrate, and prey biomass (Kushlan 1978, Gawlik 2002). These factors are most likely to be affected by proposed lake management activities (Johnson et al. 2007).

Waterfowl: The species and numbers of waterfowl within a given area can be strongly influenced by external factors, such as reproductive output on northern breeding grounds, weather, and the availability of quality habitat elsewhere (Bellrose 1980). Thus, current local waterfowl populations are not necessarily indicative of the current quality of local habitat. Characteristics of high-quality waterfowl habitat are well known, however (Chamberlain 1960, Gray 1993, Weller 1999). Water depths, plant species, and the arrangement and percent coverage of plants relative to open water are all key determinants of the suitability of habitat for waterfowl (Chamberlain 1960, Bellrose 1980, Weller 1999). While the characteristics of high-quality waterfowl habitat are known, the amount of habitat needed to consistently attract and support a population of waterfowl is less well understood. Therefore, target acreages of dabbling and diving duck habitat for Lake Tohopekaliga were developed based on the opinions of waterfowl and lake management experts, and represent working hypotheses to be monitored and evaluated.

Amphibians and Reptiles: Habitats used by alligators for nesting and foraging will likely meet the needs of all reptiles and amphibians in the KCOL. Alligators will utilize a variety of substrates for nesting, but the most productive nesting sites are often associated with eutrophic aquatic systems with extensive dense emergent marsh areas. Nest construction is a complex exercise in which the female creates a dome of vegetation, peat, and/or soil by knocking down and mounding the surrounding materials. For foraging, a diversity of wetland habitats is beneficial for alligator populations as a whole. In general, the dominant food type changes from invertebrates to vertebrates as alligators increase in size (Delany and Abercrombie 1986; Delany 1990; Delany et al. 1999; Mazzotti and Brandt 1994). Small alligators feed primarily on invertebrates, small fish, and herptiles. Such prey is often abundant in and near emergent marsh. As alligators grow larger, their diet shifts to larger prey such as turtles and larger fish, most of which are more available in deeper, open water.

Fish: Fish communities may be influenced by the variation in abundance and composition of aquatic plant species in the littoral zone (Hoyer and Canfield 1996). Littoral vegetation provides refuge from predation, substrate for reproduction and increased invertebrate forage (Savino and Stein 1982, Shaeffer and Nickum 1986, Gladden and Smock 1990, Chick and McIvor 1994). In Florida lakes, fish species richness has been found to be positively related to littoral plant abundance (Bachmann et al. 1996). Furthermore, the relative complexity of vegetation types comprising the littoral aquatic plant community has been found to influence fish species richness based on its use by the varied life history stages of fishes. Gregory et al. (1990) found that maidencane (an emergent species) was important to larvae, while the highest numbers of juveniles were collected in emergent/floating leaved plant communities and lower numbers were collected in hydrilla and maidencane habitats. It is believed that littoral fish community metrics likely will be related to large-scale plant community changes in the KCOL, which are affected by water level manipulations and can change as a direct result of water management.

Many fish species typically inhabiting the littoral zone serve as prey for largemouth bass and other important game fish. Therefore, changes to fish assemblages associated with water management could potentially affect performance measures for largemouth bass.

Snail Kites: Snail kites require flooded conditions under nests for reproductive success. Therefore, active nests may be negatively impacted by receding water regulation schedules. Snail kites feed by visually locating their primary prey, Florida apple snails (*Pomacea paludosa*). Therefore, foraging habitat for kites must provide for the life history requirements of apple snails, as well as allow for visual foraging by kites.

Data Availability Summary

Although aerial imagery was captured for certain KCOL lakes during both the pre-regulation and post-regulation periods, an organized littoral vegetation mapping program was not carried out on the KCOL until the Florida Fish and Wildlife Conservation Commission (FWC) started a mapping program in 2005 that initially covered only some of the larger lakes in the system. Since that time, the District has joined FWC as a partner in this mapping program which will have produced at least one map of each regulated water body in the KCOL by December 2011. As part of these endeavors, Lake Tohopekaliga has been mapped three times (2005, 2007, and 2009), Lake Kissimmee twice (2005 and 2009) and other lakes including the Alligator Chain lakes, Lakes Cypress ,Gentry, Hatchineha, Tiger, Mary Jane, Hart, and East Tohopekaliga once (all mapped in 2009 except East Toho which was mapped in 2007). The District is mapping littoral vegetation on Lakes Ajay, Brick, Joel, Myrtle, and Preston in 2011. Each of these maps was delineated based on an FWC modification of the Florida Land Use/Land Cover Classification System (FLUCCS) for littoral vegetation communities. (see Remote Sensing and Vegetation Mapping section above for more details).

Wading Birds: Information on the habitat and resource use patterns for wading birds in Florida is available from several studies (e.g., Kushlan 1981, Fredrick and Ogden 2001, Weller 1995, Strong et al. 1997, Gawlik 2002, Brush 2006). However, little information exists on the long-term use of the KCOL system by foraging wading birds (see discussion in Chapter 5). Additional data on wading bird use and abundances within the littoral zone of Lake Tohopekaliga from 2002 to present are available in Brush (2006).

Status of Current and Future Monitoring

FWC and the District have agreed to a continuing mapping program in the area that will attempt to update littoral vegetation maps of each lake approximately every three to five years depending on funding availability and interest in the lake to be mapped at the two agencies. These updates will include contracted acquisition of imagery for target lakes, and map delineation and ground verification using either contracted or in-house resources.

The FWC's KCOL Standing Team is continuing to develop specific and detailed vegetation targets for various wildlife guilds. The team is also assessing the usefulness of the above-mentioned remote sensing to evaluate characteristics and species composition of the vegetation communities.

There are no existing FWC habitat monitoring programs for wading birds, waterfowl, snail kites, bald eagles, fish, or amphibians and reptiles. Therefore, new monitoring programs will need to be developed.

For baseline, post-regulation data, preliminary evaluation will be needed of the SFWMD-FLUCCS Land Cover/Land Use Mapping Update Project maps. For pre-regulation reference data, evaluation and photointerpretation of pre-regulation black-and-white imagery will be needed.

Most quantitative targets in this performance measure are focused on the larger lakes for which data are available. For other lakes that are not specifically addressed, targets for each of the guilds will be determined as new data become available. Baseline surveys regarding the use of the various LMAs by different guilds need to be conducted to develop these targets.

Because existing target acreages for various guilds' habitats represent working hypotheses, population data for each guild should be collected and analyzed along with habitat data to determine the level of support for these hypotheses. Since a particular guild's use of an area can vary due to factors unrelated to habitat quality (see Rationale) and the vegetation communities are dynamic, multiple years of monitoring are desirable. As empirical support for hypothesized acreages is accumulated (or hypotheses are adjusted based on empirical data), targets can be developed for other KCOL lakes.

MEASURE 2-03 - HYDRILLA ABUNDANCE AND MANAGEMENT

Target

The invasive plant hydrilla (*Hydrilla verticillata*) affects the KCOL through both its presence (competitive dominance over native plants, rapid colonization and expansion habits, formation of habitat unsuitable for native fish), and through herbicide control practices intended to reduce its abundance, which may affect native plants and animals directly through toxicity, or indirectly through associated water level reductions. Aquatic plant managers, biologists and lake users disagree about the practice of using hydrilla as a fishery or waterfowl management tool. Some range of moderate coverage of submerged aquatic vegetation (SAV) is seen as beneficial to fish (Bonvechio and Bonvechio 2006) and waterfowl. However, hydrilla grows prolifically, and can quickly displace native vegetation and invade areas of open water. Native SAV usually grows at or near the lake bottom or sparsely within the water column. Hydrilla, on the other hand, is a canopy-forming plant that can grow from moderate subsurface density to extreme and harmful coverage at the water surface within a single season. High densities of hydrilla over large areas are not desirable and may be an indicator of generally poor lake condition. The increasing difficulty of hydrilla control indicates the necessity of accepting some level of hydrilla coverage in the future.

Target values have not been established for the associated metrics, but the metrics should be monitored as indicators of the health or status of the KCOL.

Confidence Level

N/A, indicator measure.

Description of Associated Metric(s)

- Cover of hydrilla (biocover): Estimate of lake area covered by hydrilla.
- Volume of hydrilla (biovolume): Estimate of the volume of lake water column filled with hydrilla.

Geographic Scope

Lakes Tohopekaliga, Kissimmee, and Hatchineha and Cypress Lake.

Rationale

Cover and volume have been chosen by the FWC Bureau of Invasive Plant Management (BIPM) as suitable estimates of hydrilla abundance in lakes. The BIPM's preemptive, adaptive approach involves evaluation of subsurface cover and volume to estimate surface canopy extents before plants reach the surface. Especially at high levels, hydrilla can negatively impact native populations of plants and animals; can cause wide fluctuations in dissolved oxygen levels, pH and surface water temperatures; and can impair navigation, flood control, water storage and recreational activities.

Management of hydrilla in the KCOL will be coordinated by the BIPM. A working group composed of biologists and water managers led by the BIPM and composed of representatives from the SFWMD, FWC, and USACE will annually determine monitoring needed to estimate hydrilla abundance, review control methodology and determine appropriate management responses.

Data Availability Summary

Past and ongoing hydrilla abundance data are available for the LTMP from FWC's BIPM. Historical hydrilla data may provide a view of the increasing abundance of hydrilla in some KCOL lakes, but are not needed for ongoing control efforts. These efforts must be guided by timely data, usually collected within the same growing season as the planned treatment.

Status of Current and Future Monitoring

Hydrilla biocover and biovolume measurements are currently used for hydrilla assessment by the BIPM. The BIPM's data will be used by the LTMP as the primary indicators of hydrilla abundance and potential for expansion. Additional metrics may be used by the BIPM, such as estimates of turion abundance in the lake bed, estimates of areal distribution, or comparisons of areal change over time. The BIPM's approach is adaptive in that results from data collection are used to guide hydrilla management responses, often within the same season.

MEASURE 3-01 - NUMBER OF BALD EAGLE NESTS

Target

The three-year running average of active bald eagle nests within 2 km of all LTMP water bodies will be ≥80.8 (±0.40 SE). Targets for each Lake Management Area are as follows:

- Lakes Kissimmee, Hatchineha, and Cypress: ≥49.7 (±0.19 SE) nests;
- Lake Tohopekaliga: ≥26.4 (± 0.11 SE) nests;
- East Lake Tohopekaliga, Fells Cove, and Lakes Ajay, Hart, Mary Jane, Joel, Myrtle, and Preston: ≥2.7 (±0.33 SE) nests;
- Alligator Chain of Lakes: ≥2 (±0.00 SE) nests.

Confidence level

High

Description of Associated Metric

The total number of active bald eagle nests within two kilometers of LTMP water bodies will be counted annually. The metric will be the three-year running average of all active nests, including the averages for each LMA. The target for the metric was derived by calculating the mean three-year running average (± SE) of bald eagle nests within 2 km of KCOL LTMP water bodies from 2003–2007 (FWC 2008, FWC Eagle Nest Locator http://myfwc.com/eagle/eaglenests/Default.asp).

Geographic Scope

All LTMP water bodies.

Rationale

Bald eagle nests are typically found within 2 km of water bodies that provide appropriate foraging conditions (Buehler 2000). By tracking the number of bald eagle nests within 2 km of LTMP water bodies, some inference can be made regarding the quality of foraging habitat in these water bodies and the availability of suitable nest trees surrounding them. The use of a multi-year average will lessen the effects of unusual years (droughts, extreme drawdowns, etc.) on monitoring results. Regulated water levels and development around the KCOL has reduced lake fluctuations, which has resulted in unnaturally dense stands of vegetation and more floating tussocks, thereby reducing foraging efficiency for aerial predators such as bald eagles. Efforts to modify lake water regulations and obtain more seasonal variation are expected to improve littoral habitat conditions and support continued high densities of nesting via production and attraction of preferred food items (fish and waterfowl). Invasive aquatic plant growth and shoreline development also can potentially influence bald eagle reproductive success through effects on prey production and availability, and loss of suitable nesting trees. Coverage of dense exotic plants such as hydrilla may reduce bald eagle foraging efficiency by decreasing the visibility of larger fish and providing greater vegetative cover for prey to escape predation. Drainage of adjacent wetlands reduces the areal extent of appropriate foraging habitat and fire suppression can lead to dense closed canopy stands of pine and cypress and reduce the availability of old-growth nesting trees with open access. Bald eagles require mature trees for nesting (nearly always live, old-growth pines in central Florida [Wood et al. 1989]). Thus, tree removal and other human disturbances that limit the availability of appropriate nesting habitat have the potential to limit nesting effort, even if appropriate foraging conditions exist.

Data Availability Summary

No pre-regulation reference data are available for bald eagle reproduction within the KCOL. The earliest available data come from summaries of the field notes of G. Heinz, who monitored bald eagle nesting in the Kissimmee Basin from 1962–1971 (Shapiro et al. 1982). These years represent the time period during which canals and water control structures were being constructed within the KCOL as part of the C&SF Project. It is also important to note that bald eagle populations were low in most areas throughout their range during this time due to eggshell thinning that resulted from exposure to DDT and other organochlorine pesticides (Buehler 2000). During 1962–1971, an average of 33.3 nesting territories/year were found within the Upper Kissimmee Basin (an area that includes, but is larger than, the KCOL region), but locations of individual nests were not reported (Shapiro et al. 1982). In 1972, the FWC began annual, statewide monitoring of bald eagle nesting territories and nesting success. The number of bald eagle territories in Florida increased from the late 1970s through the 1990s before leveling off at approximately 1100 pairs (FWC 2006). Currently, Florida supports the largest nesting population in the lower 48 states, and the LTMP water bodies represent an area of concentrated nesting within the state (FWC 2008, FWC Eagle Nest Locator http://myfwc.com/eagle/eaglenests/Default.asp). During 2003, 2004, 2005, 2006, and 2007, there were 82, 77, 85, 78, and 80 active nests, respectively, within 2 km of LTMP water bodies (see Figure J.1 for nest locations during 2007). However, some nests were not located or their status was unknown during each survey year (e.g., the status of 8 nests/year, on average, was not recorded). Among LTMP water bodies, Lakes Kissimmee, Tohopekaliga, and Hatchineha support the largest number of nests. Coordinates of bald eagle nests can be obtained from the FWC Eagle Nest Locator website.

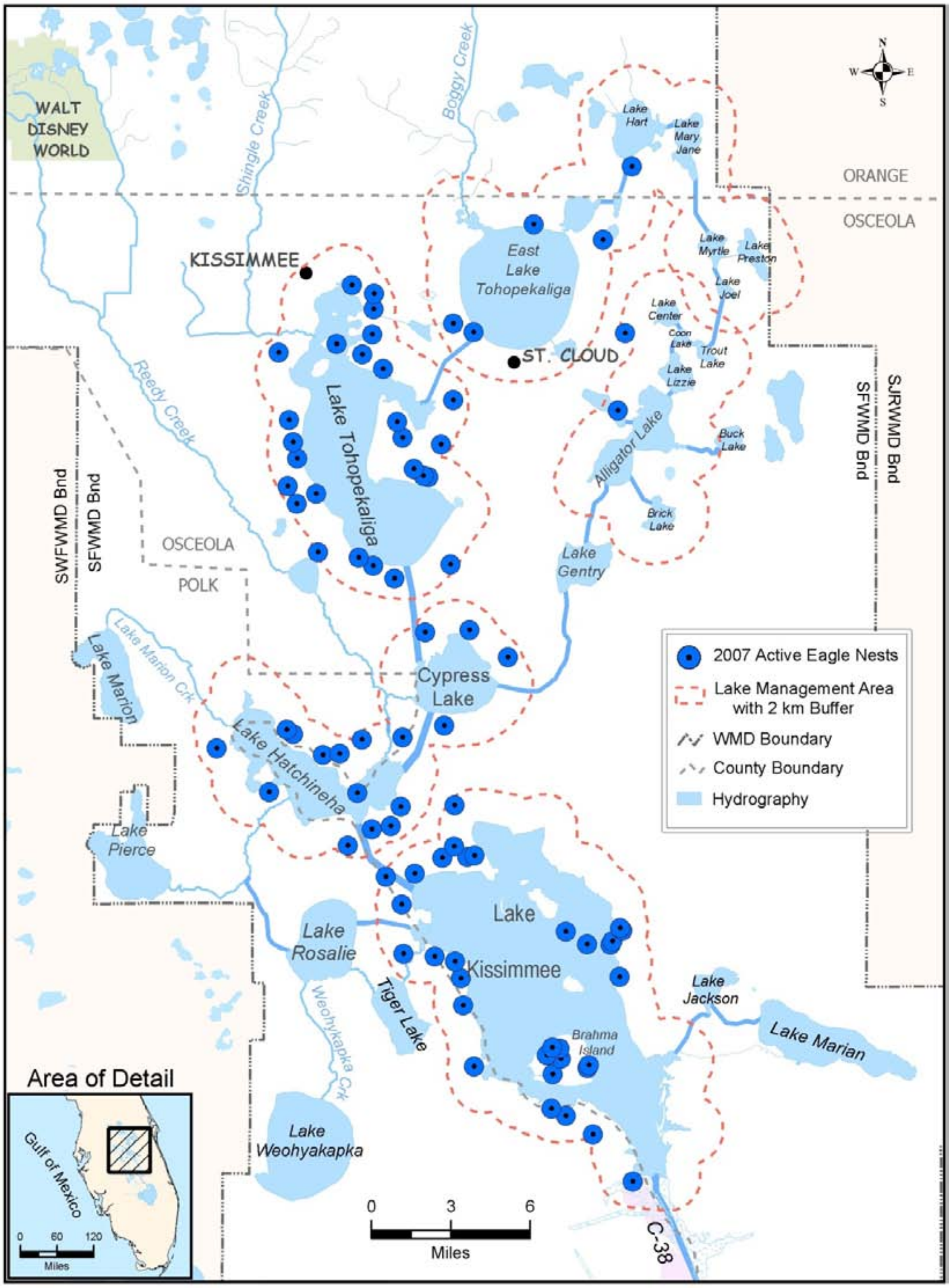

Figure J.1 – Active bald eagle nests within 2 km of KCOL LTMP water bodies during 2007.

Status of Current and Future Monitoring

The existing FWC bald eagle monitoring program, which includes coverage of all LTMP water bodies, is sufficient for tracking the number of eagle nests. No additional monitoring is needed. Annual data is available from 2000-2007 FWC surveys on all LTMP water bodies.

MEASURE 3-02 - SNAIL KITE NEST OCCURRENCE AND SUCCESS

Targets

1. Occurrence of nesting (one or more nest containing eggs) within at least 2 of the 3 primary lakes, in at least 3 of every 5 years.
2. Three year moving average of total number of nests within the three primary lakes ≥37.8 (±27.4 SD), with lake-specific moving averages of ≥18.2 (±13.6 SD) KISS, ≥19.3 (±16.6 SD) TOHO, and ≥2.2 (±2.6 SD) ETOHO.
3. Five year moving average nest success rate ≥0.88 (±1.00 SD) fledglings per nest within at least 2 of the 3 primary lakes.

Geographic Scope

Lakes Kissimmee, Toho, and East Toho

Confidence level

High

Description of Associated Metric(s)

1. Occurrence of nesting
2. Number of nests
3. Nest success (fledgings per nest).

Rationale

Snail kite nesting effort and nest success can be important indicators of habitat suitability within the KCOL. Long-term monitoring of these population parameters can allow lake managers to detect trends in kite use of the lakes that may be indicative of overall lake health (e.g. shifts in vegetation communities, apple snail densities, etc.). However, snail kites are semi-nomadic in response to food availability and their population dynamics are strongly linked to rangewide hydrologic conditions (Beissinger 1986; Sykes et al. 1995). For example, during the 1980s, drought conditions caused breeding and foraging birds to abandon traditional sites in the Water Conservation Areas of the Everglades and Lake Okeechobee and recolonize the KCOL, where nesting had not been previously documented but that is within the historic breeding range of the species (Takekawa and Beissinger 1989). Therefore, as evidenced by the large variation in nest numbers and nest success during the past 20 years (see Table J.3), rangewide habitat conditions for breeding snail kites must be taken into consideration when scientists and lake managers use annual bird data to assess overall lake health relative to the indicator measure targets.

Snail kite nest success on the KCOL has occurred at the target rate and frequency in the past (e.g. Lake Kissimmee 1987–1995). During this period, the number of snail kite nests was also relatively high (average of 47.1 (±58.8 SD) nests per year). This level of nesting effort and success is thought to reflect bird response to favorable nesting conditions.

Lakes Toho, Kissimmee and East Lake Toho were included in the Scope of this performance measure because snail kite nesting occurred in these lakes in at least a quarter of the years monitored. The close proximity of these lakes to each other, their large size, and the fact that they are known to support snail kites and their habitat indicates their relative importance within the KCOL. Taking into account the degree of site fidelity and relatively high likelihood of movement among proximate wetland units (Martin et al. 2006b), adopting targets that address the three lakes will likely maintain sustained snail kite use of the KCOL region. Although other lakes within the KCOL have not supported snail kite nesting with any regularity, they may support snail kites and even snail kite nesting under some conditions.

The snail kite population in Florida has declined by approximately 50 percent within the past few years (Martin et al. 2006a, 2006b). Maintenance of habitats suitable for snail kites throughout their range is important to support the snail kite population in Florida (Bennetts et al. 1997). During drought conditions within the southern portion of the snail kite's range such as those that occurred during 2001 and from 2006 to the present, the KCOL serves as a refugium for large numbers of kites. During these regional droughts, the availability of favorable wetland conditions in the KCOL may lead to improved overall survival of adult snail kites as well as a nesting effort above that which might be expected without favorable conditions within these areas. Achieving the snail kite targets, as well as the associated performance measure targets (i.e., water quantity, water quality, aquatic vegetation, apple snails) will help to ensure that the KCOL can serve as such a refugium.

Data Availability Summary

Snail kite nesting data are available from the Florida Fish and Wildlife Conservation Commission (FWC, 1987-2001; Dr. James Rodgers) and the U.S. Geological Survey/University of Florida (USGS/UF, 1996-2006, Dr. Wiley Kitchens). Both FWC and USGS/UF datasets contain data on nest occurrence, location, fate, and productivity for the KCOL and other areas within the snail kite's range in Florida; these data were used in developing this performance measure.

Both datasets are comparable, and include coordinates of each nest, the vegetation type that the nest was located in (substrate), a reference date (nest initiation date or nest check date), whether each nest was successful, and the number of young fledged from each nest. Minor differences in data collection and recording, such as differences in the frequency of nest checks, may result in slight differences or bias in nest success estimates, but the data used in developing this performance measure were reduced to data that were comparable among the studies. There are no nest data in some years for some lakes, and it is unclear whether this reflects a true absence of nests, or whether reduced nest searching effort may have affected detection of nests in these years. To address this potential limitation, success rates were selected as the parameter of interest, and success rates were only calculated for lakes and years in which at least one nest was reported with a known outcome.

Details about the methods for nest surveying, detection, monitoring, and recording are described in additional detail in Rodgers and Schwikert (2001, 2003) for the FWC dataset, and in Martin et al. (2006a) for the USGS/UF data set.

FWC and USGS/UF nest data were reduced to common and comparable data, which included nest location, year, and number of young fledged. Nest success was summarized within each lake of the KCOL within each year, and was calculated as the proportion of all nests within each lake within each year which fledged at least one young. All nests for which the number of young fledged was not recorded were excluded from the data set so that fledging success was calculated only using known-fate nests. We adjusted the success rates by eliminating rates that were estimated from less than four known-fate nests. This adjustment was selected to remove the disproportionate influence on rates that resulted from low nest numbers, when the outcome of a single nest was sufficient to exceed selected targets (see below). The resulting values are summarized in Table J.3. While the maximum nest success measured in any one lake in any one year was 75 percent (Kissimmee 2002), success in most years was less than 50 percent. The average nest success during the years when there were at least four known-fate nests for Lakes Kissimmee, East Toho, and Toho was 42, 47, and 33 percent, respectively.

Table J.3 – Summarized snail kite nest data for the Kissimmee Chain of Lakes from the Fish and Wildlife Conservation Commission and the U.S. Geological Services and the University of Florida.

	Lake Kissimmee				East Lake Tohopekaliga				Lake Tohopekaliga			
Year	Active Nests	Number Failed	Number Successful	Adjusted Success	Active Nests	Number Failed	Number Successful	Adjusted Success	Active Nests	Number Failed	Number Successful	Adjusted Success
1987	15	8	7	0.47	0	-	-	-	0	-	-	-
1988	21	8	13	0.62	0	-	-	-	0	-	-	-
1989	26	13	13	0.50	9	5	4	0.44	0	-	-	-
1990	58	25	33	0.57	11	8	3	0.27	1	0	1	-
1991	53	26	27	0.51	8	3	5	0.63	134	73	61	0.46
1992	23	14	9	0.39	0	-	-	-	0	-	-	-
1993	41	21	20	0.49	0	-	-	-	0	-	-	-
1994	0	-	-	-	0	-	-	-	0	-	-	-
1995	11	7	4	0.36	1	0	1	1	12	5	7	0.58
1996	0	-	-	-	0	-	-	-	23	19	4	0.17
1997	6	5	1	0.17	0	-	-	-	38	32	5	0.13
1998	5	6	1	0.20	0	-	-	-	2	0	0	-
1999	35	23	12	0.34	0	-	-	-	3	0	1	-
2000	3	3	0	-	0	-	-	-	7	4	2	0.28
2001	29	20	9	0.31	4	4	0	0	15	10	4	0.27
2002	4	1	3	0.75	4	2	2	0.5	22	13	12	0.54
2003	12	1	7	0.58	1	1	0	-	17	5	4	0.24
2004	8	1	4	0.50	1	1	0	-	0	-	-	-
2005	9	12	1	0.11	1	1	0	-	47	43	12	0.26
2006	1	1	0	-	1	0	1	-	28	30	5	0.18
2007	7	5	2	0.29	1	0	1	-	81	39	42	0.52
Avg (stdev)	16.6 (17.2)	10.5 (8.7)	8.7 (9.3)	0.42 (0.17)	2.0 (3.3)	2.3 (2.5)	1.5 (1.8)	0.47 (0.34)	20.5 (33.1)	19.5 (21.5)	11.4 (17.8)	0.33 (0.16)

Note: Active nests are those in which snail kites laid at least one egg. Number of nests indicates the total number of nests for which the outcome (success or failure) is recorded in the data set. Adjusted success is the proportion of nests that fledged at least one chick, calculated only when the number of nests is >3.

Status of Current and Future Monitoring

New Monitoring Program or Existing Data Source: Existing monitoring program by the USGS/UF annual snail kite survey (range-wide in Florida, assumes continued funding). This project is currently funded by several agencies and is expected to continue for at least five years, through 2012.

Pilot and Supporting Studies and Preliminary Work: The life history, habitat requirements and foraging need of snail kites are well documented (Bennetts et al. 1994, Sykes et al. 1995, and others). Survey and monitoring methods for the snail kite, including those addressing demographic parameters and nesting measures have been published historically (Sykes 1979, Rodgers and Schwikert 2001) as well as recently (Martin et al. 2006a, Dreitz et al. 2002).

Monitoring should be conducted in conjunction with ongoing survey efforts by the USGS/UF (Martin et al. 2006a), and subsequent efforts should adopt their survey and monitoring protocols to the maximum extent practicable.

MEASURE 3-03 – WADING BIRD NESTING EFFORT

Target
N/A, indicator measure

Geographic Scope
All LTMP water bodies

Description of Associated Metric(s)
Two metrics are included: number of nests by species and number of colonies.

Confidence level
N/A, indicator measure

Rationale
Nesting wading birds feed at high trophic levels and require concentrated sources of available prey within foraging distance of the rookery for the duration of the nesting cycle (~ 3 mo). Prey availability is affected by numerous factors, including but not limited to water depth, vegetation density, and prey production (Bancroft et al. 1994, Gawlik 2002). Thus, wading bird nesting effort is an indicator of ecological conditions. Spring recessions, combined with appropriate vegetation densities are generally associated with producing appropriate foraging conditions for wading bird nesting (Gawlik 2002). It is expected that efforts to increase fluctuation of lake water levels and obtain seasonal variation that more closely matches historical patterns will support creation of the conditions necessary for wading bird reproduction. Thus, levels of wading bird reproductive effort can provide important feedback for lake management efforts.

Data Availability Summary
There are no known pre-regulation reference data for wading bird rookeries on the KCOL. The FWC conducted statewide surveys of wading bird rookeries during 1976 – 1978, 1987 – 1989, and 1999 (Nesbitt et al. 1982, Runde et al. 1991, FWC 2003). Both aerial and ground surveys were employed, but the majority of surveys were conducted from the air. For each colony, the number of nests by species, and colony coordinates, were recorded. As noted by Runde et al. (1991), caution should be used when interpreting these data because: (1) annual and seasonal differences in the timing and numbers of nests combined with single event surveys can affect the numbers and species of nesters reported for a particular area; (2) since most surveys were conducted by air, it is likely that species with dark coloration, such as little blue herons, were undercounted; (3) observers vary in ability to detect and count nests; and (4) the likelihood of colony detection varies with cover type and placement of nests within vegetation. Thus, the numbers and species of nesters reported for a single survey as well as apparent differences in nesting effort among surveys may be affected by one or more of the factors listed above. In general, colonies are more likely to be found when they are occupied by light-colored species nesting in the vegetation canopy (Nesbitt et al. 1982).

Nine wading bird rookeries were recorded during FWC surveys (Table J.4). The number of rookeries detected per year varied between a minimum of 2 in 1976 and a maximum of 5 in 1988; the mean (± S.D.) per survey was 3.4±1.1 rookeries (Figure J.2). The three-year running average was 3.3±1.2 and 3.7±1.5, during 1976-1978 and 1987-1989, respectively. The target was derived from the mean of these two survey periods (3.5±0.2 S.D.) rounded down to the nearest whole number. The majority of rookeries (5 of 9) were on Lake Kissimmee. Common breeding species included cattle egret, great egret, white ibis, snowy egret, wood stork, great blue heron, tricolored heron, and little blue heron.

Table J.4 - Status of wading bird rookeries monitored by the FWC during statewide surveys conducted from 1976-1978, 1987-1989, and 1999. Note: Inactive colonies are labeled "I"; colonies of unknown status are labeled "U". Unless otherwise noted, numbers represent the maximum number of long-legged wading bird (excluding cattle egret) nests counted during a single survey that year.

Atlas #	Location	1976	1977	1978	1987	1988	1989	1999
612037	Lake Mary Jane	U	250	200+	U	U	751-1000[1]	500-1000[2]
612048[3]	Between Lakes Cypress/ Hatchineha	U	300+	275	101-250	U	11-100	I
612135	Lake Toho/ Runnymede	U	U	U	U	U	501–750[1]	I
616032[4]	Lake Kissimmee Rabbit Island	1250	2300	1200	U	> 1000[1]	U	1000-3000[5]
616033	Lake Kissimmee Three Lakes Ranch	50	I	U	U	11-100	U	I
616037	Lake Rosalie	U	3-4	40	101-250[1]	U	101-250[1]	I
616121	Lake Kissimmee Bird Island #2	U	U	U	U	11-100[1]	U	I
616122	Lake Kissimmee Bird Island #1	U	U	U	U	11-100	U	50-250[3]
616125	Lake Kissimmee Brahma Island	U	U	U	U	11-100[1]	U	I

[1]Nest totals include an unknown number of one or more of the following: cattle egret, anhinga, double-crested cormorant.
[2]Approximately 90% of nests were cattle egret.
[3]Wood stork-only rookery, except during 1987 when anhinga was also present.
[4]Rookery contained at least 1000 white ibis nests each year from 1976 – 1978.
[5]Approximately 41% of nests were cattle egret, anhinga, or double-crested cormorant.

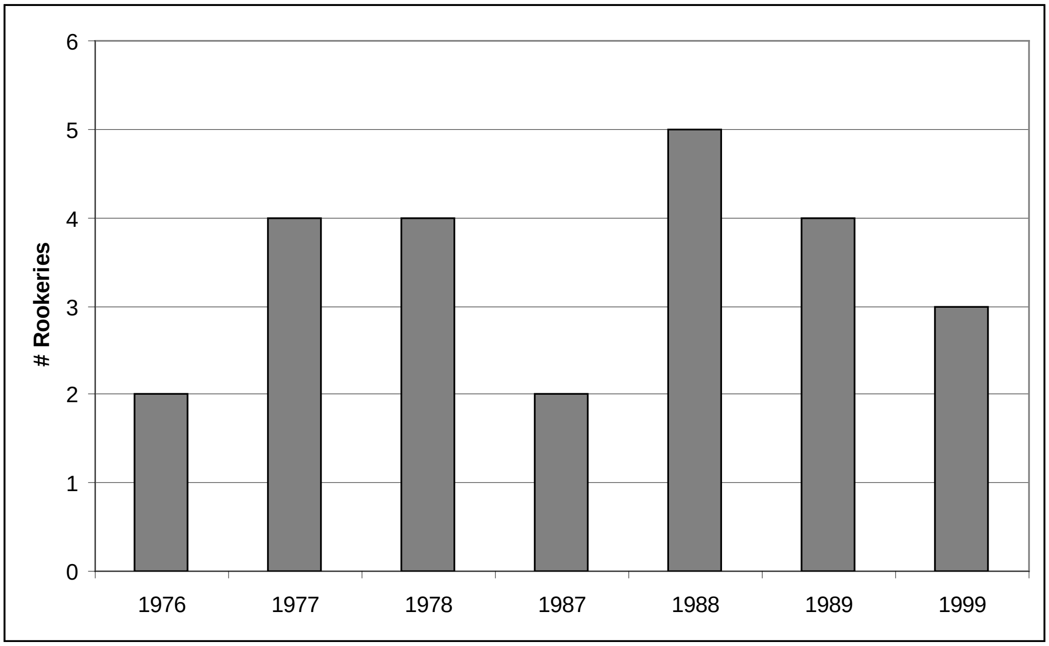

Figure J.2 – Number of wading bird rookeries detected by year during statewide FWC surveys.

Status of Current and Future Monitoring

New Monitoring Program or Existing Data Source: This is a new monitoring program. There is no pre-regulation reference data. Statewide surveys of wading bird rookeries by the FWC have been discontinued.

Pilot and Supporting Studies and Preliminary Work: If possible, monitoring of colonies within the KCOL LTMP area should follow the methods of CERP (RECOVER 2004), which would better equip researchers to distinguish among responses to local lake conditions and regional effects unrelated to lake management (Havens et al. 2005). Rookery data (locations, species, number of nests) should be collected each year via monthly aerial surveys conducted during the breeding season (January – July), and focus on large (> 25 nests) rookeries of white-colored species (wood stork, white ibis, great egret, snowy egret) followed by ground counts of large colonies (see Frederick et al. 1996 for methodological details).

In their examination of large Everglades wading bird nesting events (> one standard deviation above the average number of nests) relative to climatic conditions, Frederick and Ogden (2001) found a strong association between large nesting events and severe droughts. Specifically, during the 38-year period of record, 7 of 8 large nesting events occurred immediately after a drought. Assuming that droughts play a similar role for nesting within the KCOL, it may be possible to develop a future assessment performance measure for wading bird nesting effort for the KCOL by analyzing annual reproductive effort relative to rainfall data.

It is recognized that KCOL wading birds may be utilizing wetlands outside of the lakes as the primary foraging habitat. Therefore, future work on wading bird nesting and nest success will need to consider foraging habitats and regional monitoring to provide a clear assessment of the state of KCOL colonies.

MEASURE 3-04 WADING BIRD ABUNDANCE

Target

The following is applicable to Lake Toho only, targets for other water bodies may be developed in the future as data become available. Acceptable mean densities (birds/km²) for wading birds observed in 2,228 ha (n=26 transects) of littoral zone on Lake Toho are found in Table J.5 (Brush 2006).

Table J.5 – Annual wading bird mean densities in 2,228 ha (n=26 transects) of littoral zone on Lake Toho based on Brush (2006). Target population levels are greater than or equal to the mean, while unacceptable population levels are below the mean.

Species	Mean Density (birds/km^2) ±S.E.
Great egret	1.8 ± 0.0011
Little blue heron	1.5 ± 0.0012
Tricolored heron	4.0 ± 0.0010
Glossy ibis	2.6 ± 0.0020

Confidence Level

Moderate

Description of Associated Metric(s)

Relative abundance of wading birds (order Ciconiiformes), with emphasis on the following four indicator species:

- ***Great Egret.*** The great egret (*Ardea alba*) is a large white wading bird and is the second largest species in North America. The species is a year round resident in Florida. It feeds in a variety of wetlands, including marshes, swamps, streams, rivers, ponds, lakes, tide flats, canals and flooded fields. Their prey include fish, invertebrates, amphibians, reptiles, birds and small mammals (McCrimmon et al. 2001). The great egret prefers to forage in shallower water, but is not constrained by deep water (Gawlik 2002). The great egret is widespread within the littoral zone habitat of Lake Toho. Densities on Lake Toho are fewest during the breeding season (March – June) and increase the rest of the year (Brush 2006).
- **Little Blue Heron.** The little blue heron (*Egretta caerulea*) is a medium-sized wading bird and a year round resident in Florida. It breeds and forages in various wetland and estuarine habitats. It feeds on small fish, aquatic invertebrates, and amphibians by foraging slow and methodically (Rodgers and Smith 1995). The little blue heron is a Florida designated species of special concern. Habitat loss and human-caused changes in local water dynamics are the most serious threats to this species. The little blue heron on Lake Toho usually forages the shallows of the littoral zone habitat and at lower lake stages does not move with the water to deeper water vegetated communities. **Tricolored Heron.** The tricolored heron (*Egretta tricolor*) is a medium-sized wading bird and a year round resident in Florida (Fredrick 1997). They forage in water in wetland habitats and feed on aquatic invertebrates, fish, reptiles and amphibians. The tricolored heron prefers shallow water depths and vegetation communities and does not move with water to deeper water vegetated communities for foraging during low lake stage. Densities on the lake are most influenced by season (Brush 2006). Being

solitary feeders, over short temporal scales, tricolored herons may be better able to forage successfully at decreased prey densities and thus may not be as closely tied to changes in water levels (Strong et al. 1997). They are listed in Florida as a species of special concern.

- **Glossy Ibis**. The glossy ibis (*Plegadis falcinellus*) is a dark, medium-sized wading bird. It is a year round resident in Florida (Davis and Kricher 2000). The glossy ibis probes mud to eat various aquatic prey, small vertebrates, and occasionally vegetation. Birds will travel long distances in response to water conditions that may hinder reproduction (Elphick et al. 2001). The densities of glossy ibis on Lake Toho are influenced by season as well as lake stage (Brush 2006). The species is not mobile within the vegetation communities of the littoral zone and typically forages in the wet ecotone between the littoral habitat and the pastureland around Lake Toho.

Geographic Scope

Lake Tohopekaliga, with the potential to add other lakes in the future.

Rationale

The diversity and number of foraging wading birds utilizing the KCOL, in conjunction with an assessment of wading bird foraging habitat (Measure 2-03), can be used as an index of the amount and quality of foraging habitat for both resident and migratory populations. Selected species of wading birds should be monitored year-round on a monthly basis, taking into account environmental variables (e.g. lake stage, season, vegetation type, etc.) to determine how birds are responding to lake enhancement and management activities and if these actions need to be adjusted to meet vegetative objectives. The Florida Cooperative Fish and Wildlife Research Unit were contracted to monitor avian communities within the littoral zone of the lake from 2002-2099 and established a sampling protocol for avian species. Line-transect distance sampling methods were used to sample the lake at a large scale of resolution. They established 26 line transects 400 m long in length, which were sampled on a monthly basis. The data included identification of all wetland dependent species (except passerines) including the four recommended indicator species (great egret, tricolored heron, little blue heron, and glossy ibis).

Data Availability Summary

Limited data on wading bird use and abundance within the littoral zone of Lake Tohopekaliga is available from 2002-2009 (Brush 2006).

Status of Current and Future Monitoring

New Monitoring Program or Existing Data Source: The FWC study (described above) was designed at two scales of resolution and the regional scale of resolution aspect of the study was completed in July 2007. The landscape level aspect of the study was completed in 2009. No monitoring program exists on other lakes in the KCOL system. A new monitoring program will need to be developed in the near future on a more intensive and long-term basis. This will likely involve a cooperative effort, both for money and manpower, between the FWC and SFWMD.

Pilot and Supporting Studies and Preliminary Work: Survey methods are well established. No pilot study is needed.

MEASURE 3-05 – WATERFOWL POPULATIONS

Target

Because this is an indicator measure (monitoring program), no target has been set for these metrics.

Confidence Level

N/A, indicator measure.

Description of Associated Metric(s)

The number of dabbling and diving ducks observed during fixed-wing aerial surveys of Lakes Tohopekaliga and Kissimmee will be used as the indicator measure. Three surveys each year should be conducted to capture seasonal variation in waterfowl use (mid-December, mid-January and mid-February). The data would be used as an index to waterfowl use of the two lakes.

Geographic Scope

Lakes Tohopekaliga and Kissimmee.

Rationale

The species and numbers of ducks within a given area can be strongly influenced by external factors, such as reproductive output on northern breeding grounds, weather, and the availability of quality habitat elsewhere (Bellrose 1980). Thus, current local duck populations are not necessarily indicative of the current quality of local habitat. For these reasons, duck populations will not be used as an APM. However, all other factors being equal, duck populations are expected to respond to favorable habitat conditions, as described in the Fish and Wildlife Habitat in Lake Littoral Zones APM. Therefore, the basis (hypotheses and assumptions) of the Fish and Wildlife Habitat in Lake Littoral Zones APM should be further assessed by monitoring the use of Lakes Tohopekaliga and Kissimmee by waterfowl populations over the mid- to long-term.

Data Availability Summary

Data from the Midwinter Waterfowl Inventory from 1973–2003 are available from FWC.

Status of Current and Future Monitoring

New Monitoring Program or Existing Data Source: New monitoring program. During 1973–2003, these lakes were part of the FWC's Midwinter Waterfowl Inventory, which was an annual survey in January of traditional waterfowl concentration areas. The FWC no longer has funding to conduct this survey.

Pilot and Supporting Studies and Preliminary Work: Existing data from FWC's Midwinter Waterfowl Inventory (1973–2003) do not reflect within-year variation because the survey was conducted once annually in early January. No pilot study would be necessary.

MEASURE 4-01 – ANGLER TOTAL CATCH FOR LARGEMOUTH BASS

Target

The angler total catch for largemouth bass from Lakes Tohopekaliga and Kissimmee should not be less than 17,500 bass caught during a 12-week period when averaged across 10 years.

Confidence Level

High. The target value is generated from long-term data with a low level of variability.

Description of Associated Metric(s)

Angler total catch is a measure of the number of a targeted fish species caught by anglers within a specific time period. It provides quantifiable data that can be used to assess trends through time.

Reference Condition: Lake Tohopekaliga: Annual data from 1977-2005. Lake Kissimmee: Annual data from 1976-1992 and 2000-2006.

Geographic Scope

Lakes Tohopekaliga and Kissimmee.

Rationale

Largemouth bass fisheries in the KCOL are economically and recreationally important. Estimated benefits provided by the Lake Tohopekaliga and Lake Kissimmee fisheries were approximately $4 million per year and $6 million per year, respectively, in 2004 (Bell 2006). In a recent stakeholder survey, the importance of angling in the KCOL ranked third among recreational uses of the lakes, thereby suggesting that sustaining largemouth bass fisheries is a priority.

To sustain a fishery, age-0 fishes must recruit into the adult population, for it is these fish that participate in reproduction to perpetuate the fishery. Population abundance of adult largemouth bass is influenced by littoral plant abundance and composition (Hoyer and Canfield 1996) and water level fluctuations. Emergent vegetation with 10-25 percent coverage was found to be optimal for abundance and growth of juvenile largemouth bass because it provides effective cover and plentiful invertebrate prey (Miranda and Pough 1997). Similarly, 20 percent to 30 percent coverage of submerged aquatic vegetation (including hydrilla) has been linked to increased foraging success, weight, fecundity, and recruitment of largemouth bass (Colle and Shireman 1980, Durocher et al. 1984, Brown and Maceina 2002) as a result of increased protective cover and optimized food availability (Betolli et al 1992, Trebitz et al. 1997, Valley and Bremigan 2002). Conversely, a high percentage of hydrilla coverage can negatively impact the condition of largemouth bass (Colle and Shireman 1980). Management of water levels in the KCOL affecting aquatic vegetation composition and coverage will influence largemouth bass population dynamics. Angler total catch typically mimics population trends in a fishery and can be used to verify observed trends generated from other sampling methods (i.e., electrofishing).

Data Availability Summary

Fall creel data (angler total catch) for Lake Tohopekaliga ran consecutively from 1977 through 2006 and averaged 17,626 bass caught during the 12 week creel periods (Table J.6). Lake Kissimmee spring creel data ran from 1976 through 1992 and from 2000 through 2006 and averaged 17,415 bass caught during the 12 week creel periods (Table J.7). The target for angler total catch for largemouth bass should not be less than 17,500 bass caught during a 12 week period when averaged across ten years (Lakes Tohopekaliga and Kissimmee).

Status of Current and Future Monitoring

The FWC has a long-term data set of creel surveys for Lake Tohopekaliga and Lake Kissimmee. Data collection is ongoing.

Table J.6 – Angler total catch for largemouth bass on Lake Tohopekaliga (12 week periods).

	1977	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**
TC	8258	10,309	6326	7583	19,702	19,364	13,940	9009	6917	5988	4533	11,390

	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
TC	23,188	10,110	14,607	15,946	12,173	15,675	24,665	15,199	16,339	19,866	26,951	35,011

	2001	**2002**	**2003**	**2004**	**2005**
TC	48,111	49,995	26,400	17,414	16,171

Mean (1977–2005): 17,626

TC = total catch

Table J.7 – Angler total catch for largemouth bass on Lake Kissimmee (12 week periods).

	1976	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**
TC	6220	7348	3808	12,414	15,771	13,157	22,793	11,561	17,107	24,609	12,581	13,568

	1988	**1989**	**1990**	**1991**	**1992**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
TC	29,096	24,176	22,791	19,707	31,297	40,413	2380	10,184	16,074	20,403	23,081	19,385

Mean (1976–2006) 17,415

TC = total catch

MEASURE 4-02 – RECRUITMENT MODEL FOR LARGEMOUTH BASS

Target

Not determined at this time.

Confidence Level

High. The target value will be generated from long-term data.

Description of Associated Metric(s)

This performance measure will be based on a population model that uses age and gender-specific growth and mortality rates to predict population responses to changes in habitat. The model will assess how missing year classes influence adult largemouth bass abundance and angler catch.

Reference Condition: Not determined at this time.

Geographic Scope

Lakes Tohopekaliga and Kissimmee.

Rationale

The population model would be used to predict the effects of changes in largemouth bass recruitment via changes in littoral habitat over time, in largemouth bass abundance and in angler total catch. This approach would include three steps: 1) relate bass recruitment indices to changes in habitat/water levels through time, 2) construct a population model that mimics variation in largemouth bass through time at each lake, and 3) use the population model to predict how changes in largemouth bass recruitment through time would influence adult largemouth bass abundance and angler total catch. This approach would provide a framework for predicting how changes in water level regimes and/or aquatic plant communities would influence largemouth bass in the KCOL.

Data Availability Summary

Data are not summarized at this time.

Status of Current and Future Monitoring

The FWC has a long-term set of electrofishing data and creel surveys for Lake Tohopekaliga and Lake Kissimmee. The recruitment model will be a new effort.

MEASURE 4-03 – SIZE AND AGE-0 DISTRIBUTION FOR LARGEMOUTH BASS

Target

In at least one of four years, at least 30 percent (± 8 percent) of largemouth bass will be in the 0-20 cm size class. (Lakes Tohopekaliga and Kissimmee).

Confidence Level

High. The target value is based on best professional judgment, although data trends are generated from long-term data with a low level of variability.

Description of Associated Metric(s)

The number of individuals in a size or age group illustrates the structure of a population. In the KCOL, age-0 fish are typically less than or equal to 20 cm in length.

Reference Condition: Lake Tohopekaliga: Annual data from 1997–2006. Lake Kissimmee: Annual data from 1997–2006.

Geographic Scope

Lakes Tohopekaliga and Kissimmee.

Rationale

When size/age distributions are evaluated over time, they can identify factors negatively impacting the fish population, such as year-class failures, low recruitment, or slow growth or factors positively impacting the population, including increased recruitment and survival (Anderson and Neumann 1996). In lakes and reservoirs, increased abundance and survival of age-0 largemouth bass have been found to positively correlate with high water levels in spring and summer (Summerfelt and Shirley 1978, Kohler et al. 1993, Bonvechio and Allen 2005), and can be attributed to increases in spawning substrate, protective cover and invertebrate production (Miranda et al. 1984, Meals and Miranda 1991, Sammons and Betolli 2000, Waters and Nobel 2004). Conversely, decreased age-0 largemouth bass recruitment, abundance and survival have been attributed to low and/or fluctuating water levels during summer and spring due primarily to decreased hatching success (Mitchell 1982, Kohler et al. 1993). Thus, abundance of age-0 largemouth bass likely will be affected by water level manipulations in the KCOL. It is believed that effective recruitment or a strong year-class occurring at least one out of four years is requisite to sustain largemouth bass populations (Bonvechio and Allen 2005).

The percent coverage of aquatic vegetation is affected by water levels and also influences largemouth bass population dynamics. Emergent vegetation with 10 percent to 25 percent coverage was found to be optimal for abundance and growth of juvenile largemouth bass because it provides effective cover and plentiful invertebrate prey (Miranda and Pugh 1997). Similarly, 20 percent to 30 percent coverage of submerged aquatic vegetation (including hydrilla) has been linked to increased foraging success, weight, fecundity and recruitment of largemouth bass (Colle and Shireman 1980, Durocher et al. 1984, Brown and Maceina 2002) as a result of increased protective cover and optimized food availability (Betolli et al. 1992, Trebitz et al. 1997, Valley and Bremigan 2002). Conversely, a high percent of hydrilla coverage can negatively impact the condition of largemouth bass (Colle and Shireman 1980). Management of water level fluctuations in the KCOL affecting aquatic vegetation composition and coverage will influence largemouth bass population dynamics.

Data Availability Summary

Although electrofishing datasets on largemouth bass size class distributions date back to the late 1970s, only data from the past 10 years were used to generate the target value. These data span a reasonable length of time to capture annual variability and reflect the most current conditions on both lakes for assessing percent contribution of bass <201 mm. The current condition of largemouth bass fisheries on both lakes is considered to be excellent. Strongest year-classes approximated 30 percent and mean standard errors were 6.9 percent (Lake Tohopekaliga) and 8.1 percent (Lake Kissimmee); therefore, a standard error of 8 percent was chosen for simplicity. A strong year-class every three years is believed to be sufficient to sustain largemouth bass fisheries (Best Professional Judgment), and both lakes had strong year-classes (30 percent + 8 percent, lower end being 22 percent) approximately once every three years.

Table J.8 – Percentage of age-0 (size <201 mm) for largemouth bass.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Lake Tohopekaliga	10	18.3	12.5	28.4	30.1	3.4	2.9	NA	25	22.2
Lake Kissimmee	7.4	21.5	28.6	29.9	19.5	13.2	12.2	9.8	24.6	9.1

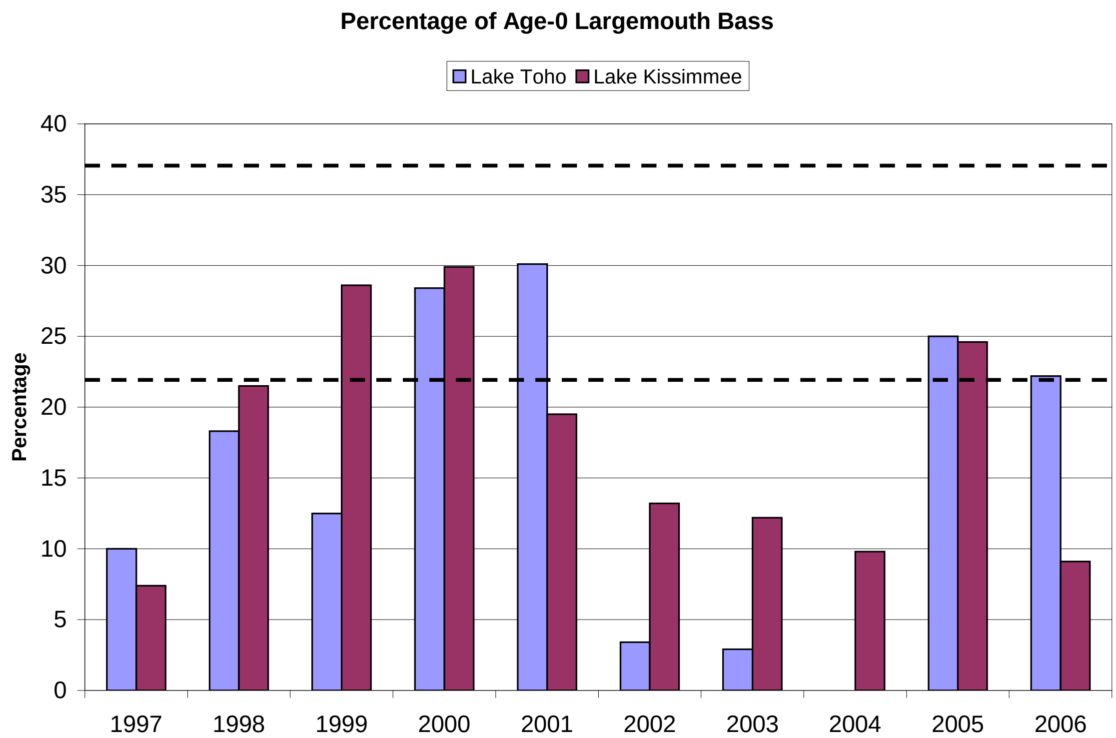

Figure 4.7 – Annual distribution of age-0 largemouth bass in Lake Tohopekaliga and Lake Kissimmee between 1997 and 2006. The area between the dashed lines indicates the target range of 22 percent to 38 percent.

Status of Current and Future Monitoring

The FWC has a long-term electrofishing dataset (most recent 10-year period) for Lake Tohopekaliga and Lake Kissimmee (FWC). The FWC also has long-term, regulated-period data sets (~ 10 years) on fishes collected in the shallow, vegetated littoral zone for Lake Kissimmee and Lake Tohopekaliga. Data collection began in the late 1970s and continues as part of the FWC's management strategy for game fish in the KCOL. Since the early 1990s, data collection for this monitoring program has not occurred on an annual basis. However, habitat data were not collected in conjunction with the fish data and are needed in the future to accurately assess littoral fish assemblages.

MEASURE 4-04 - LITTORAL FISH ASSEMBLAGE STRUCTURE: SPECIES RICHNESS, DIVERSITY AND BIOMASS

Target

In Lake Tohopekaliga, species richness and diversity of littoral fishes will be at least 27 (± 0.6) and 3.25 (± 0.12), respectively, when averaged over 10 years. In Lake Kissimmee, species richness and diversity of littoral fishes will be at least 24 (± 0.9) and 2.89 (± 0.16), respectively, when averaged over 10 years. Biomass estimates are yet to be determined. Target values are unaltered and represent means generated directly from FWC data.

Confidence Level

High. The target value is generated from long-term data with a low level of variability.

Description of Associated Metric(s)

Species richness is a direct measure of the number of individual species comprising a sample or population. Diversity is a measure of the proportional abundance of individual species that collectively comprise a population. Biomass is a quantitative estimate of the total mass of an organism within a given area at given time.

Reference Condition: Lake Kissimmee: Annual data from 1974-1982. Lake Tohopekaliga: Annual data from 1981-1991.

Geographic Scope

Lakes Tohopekaliga and Kissimmee.

Rationale

Changes in community metrics (i.e., species richness, diversity and biomass) of littoral fish species may serve as a measure for how changes in littoral habitat influence this fish community. Fish communities May be influenced by the variation in abundance and composition of aquatic plant species in the littoral zone (Hoyer and Canfield 1996). Littoral vegetation provides refuge from predation, substrate for reproduction and increased invertebrate forage (Savino and Stein 1982, Shaeffer and Nickum 1986, Gladden and Smock 1990, Chick and McIvor 1994). In Florida lakes, fish species richness has been found to be positively related to littoral plant abundance (Bachmann et al. 1996). Furthermore, the relative complexity of vegetation types comprising the littoral aquatic plant community has been found to influence fish species richness based on its use by varied life history stages of fishes. Gregory et al. (1990) found that maidencane (emergent species) was important to larvae, while the highest numbers of juveniles were collected in emergent/floating leaved plant communities and lower numbers were collected in hydrilla and maidencane habitats. It is believed that littoral fish community metrics likely will be related to large-scale plant community changes in the KCOL, which are affected by water level manipulations and can change as a direct result of water management.

Many fish species typically inhabiting the littoral zone serve as prey for largemouth bass and other important game fish and are sampled to provide data on prey availability that might influence observed shifts in game fish populations.

Data Availability Summary

Fish inhabiting the littoral zone were collected in Lake Kissimmee from 1974 to 1982 and in Lake Tohopekaliga from 1981 to 1991 using blocknets. Species richness for each year was calculated by summing the number of species collected. Species diversity was calculated using the Shannon Index (H'), where $H' = -\Sigma\, p_i \ln p_i$ and p_i is the proportional abundance of the ith species. Biomass estimates were not based on the total littoral zone acreage at the time of sampling and were not weighted by habitat types; therefore, a new monitoring program utilizing these additional data should be initiated for the biomass metric. Time periods indicated as the reference condition are based on data availability for each lake.

Status of Current and Future Monitoring

The FWC has conducted littoral fish surveys. A data collection program for species richness, diversity and biomass will need to be developed.

Table J.9 – Lake Kissimmee littoral fish assemblage indices.

	1974	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**
SR	20	22	23	23	28	24	26	25	28
H'	2.073	2.845	3.213	2.344	3.507	2.931	3.356	3.104	2.636

	SR	**H'**
Mean	**24 (± 0.9)**	**2.89 (± 0.16)**

SR = Species Richness H' = Species Diversity

Table J.10 – Lake Tohopekaliga littoral fish assemblage indices.

	1981	**1982**	**1983**	**1984**	**1985**	**1986**	**1988**	**1989**	**1990**	**1991**
SR	23	28	30	29	29	27	27	27	29	23
H'	2.861	3.242	3.643	2.269	2.499	2.422	3.871	3.334	3.086	2.861

	SR	**H'**
Mean	**27 (± 0.6)**	**3.25 (± 0.12)**

SR = Species Richness H' = Species Diversity

MEASURE 4-05 – AMPHIBIAN ABUNDANCE

Target

The abundance of selected amphibian species, as determined by the appropriate sampling scheme and statistical analyses, will remain stable or increase on each of the lakes selected for sampling (Lake Kissimmee, Lake Tohopekaliga, Lake Hatchineha and Cypress Lake).

Confidence Level

Best Professional Judgment.

Description of Associated Metric(s)

Specific sampling techniques and data analyses will need to be investigated before the most appropriate methods can be determined and employed (see last section). This will define to some extent the metrics that will be used. However, a possible metric will include the relative number of selected amphibians assessed in the context of available habitats over time. Selected species include the pig frog (*Rana grylio*), green treefrog (*Hyla cinerea*), greater siren (*Siren lacertian*) and peninsula newt (*Notophthalmus viridescens*).

Geographic Scope

Lake Kissimmee, Lake Tohopekaliga, Lake Hatchineha and Cypress Lake.

Rationale

There is general agreement that reliable estimates of true abundance are very difficult to obtain, and this is probably an unrealistic goal for the purposes of the LTMP. Likewise, determining "percent area occupied" appears to have effort- and money-related limitations with regard to the LTMP's needs. Therefore, an integrated approach using the relationship between trends in abundance (based on captures or call counts) and availability of habitats (based on assessments of the Amphibian and Reptile Habitat performance measure) is proposed as an appropriate strategy for assessing amphibian abundance. The premise of this approach is that the extent of available habitat can serve as a surrogate to abundance estimates, as long as there is some indication that amphibians are using the habitats (including trend information). The amphibians selected for monitoring are expected to be among the most abundant and easily monitored amphibians within the KCOL. These species also reflect an array of habitat and food requirements. Additionally, the pig frog is sought after for human consumption, both for commercial and recreational purposes.

Data Availability Summary

There are no existing or previous long-term monitoring projects for amphibians on the KCOL. Some data on the occurrence of various amphibian species on Lake Tohopekaliga are available in Muench (2004). Other records documenting the occurrence of amphibians within the KCOL can be found in the Florida Museum of Natural History inventory compiled by Dr. Kenney Krysko.

Status of Current and Future Monitoring

No monitoring is being conducted, so a new monitoring program will need to be developed. This will likely involve a cooperative effort in terms of money and manpower between the FWC and SFWMD. Because of the uncertainties associated with the proposed monitoring approach, a pilot study will be required. The pilot study will address the most appropriate sampling techniques, the most efficient sampling scheme (e.g., sample once every three years or every five years), and the statistical analyses that will be used. It is likely that a variety of sampling methods will be used, depending on the species. For instance, frog calls can be used to survey frogs, and dredging or funnel traps can be used to sample newts and sirens. The proposed approach will combine census data of selected species from various habitat types with the availability of those habitats as determined in the evaluation of the Amphibian and Reptile Habitat performance measure.

MEASURE 4-06 – SMALL REPTILE ABUNDANCE

Target

The abundance of selected reptile species, as determined by the appropriate sampling scheme and statistical analyses, will remain stable or increase on each of the lakes selected for sampling (Lake Kissimmee, Lake Tohopekaliga, Lake Hatchineha and Cypress Lake).

Confidence Level

Best Professional Judgment.

Description of Associated Metric(s)

Specific sampling techniques and data analyses will need to be investigated before the most appropriate methods can be determined and employed (see last section). This will define to some extent the metrics that will be used. However, a possible metric will include the relative number of selected reptiles assessed in the context of available habitats over time. Selected species include the black swamp snake (*Seminatrix pygaea*), striped crayfish snake (*Regina alleni*), Florida green water snake (*Nerodia floridana*), stinkpot (*Sternotherus odoratus*), Florida redbelly turtle (*Pseudemys nelsoni*) and Florida softshell (*Apalone ferox*).

Geographic Scope

Lake Kissimmee, Lake Tohopekaliga, Lake Hatchineha and Cypress Lake.

Rationale

There is general agreement that reliable estimates of true abundance are very difficult to obtain, and this is probably an unrealistic goal for the purposes of the LTMP. Likewise, determining "percent area occupied" appears to have effort- and money-related limitations with regard to the LTMP's needs. Therefore, an integrated approach using the relationship between trends in abundance (based on captures or survey data) and availability of habitats (based on assessments of the Amphibian and Reptile Habitat performance measure) is proposed as an appropriate strategy for assessing reptile abundance. The premise of this approach is that the extent of available habitat can serve as a surrogate to abundance estimates, as long as there is some indication that reptiles are using the habitats (including trend information). The reptiles selected for monitoring are expected to be among the most abundant and easily monitored small reptiles within the KCOL. These species also reflect an array of habitat and food requirements. Additionally, the soft-shell turtle is sought after for human consumption, both for commercial and recreational purposes.

Data Availability Summary

There are no existing or previous long-term monitoring projects for reptiles on the KCOL. Some data on the occurrence of various reptile species on Lake Tohopekaliga are available in Muench (2004). Other records documenting the occurrence of reptiles within the KCOL can be found in the Florida Museum of Natural History inventory compiled by Dr. Kenney Krysko.

Status of Current and Future Monitoring

No monitoring is being conducted, so a new monitoring program will need to be developed. This will likely involve a cooperative effort in terms of money and manpower between the FWC and SFWMD. Because of the uncertainties associated with the proposed monitoring approach, a pilot study will be required. The pilot study will address the most appropriate sampling techniques, the most efficient sampling scheme (e.g., sample once every three years or every five years), and the statistical analyses that will be used. It is likely that a variety of sampling methods will be used, depending on the species. For instance, funnel traps can be used to sample snakes and stinkpots, and surveys of commercial turtle trappers could be used for Florida softshell turtles. The proposed approach will combine census data of selected species from various habitat types with the availability of those habitats as determined in the evaluation of the performance measure on Fish and Wildlife Habitat in Lake Littoral Zones.

MEASURE 4-07 – ALLIGATOR ABUNDANCE AND SIZE DISTRIBUTION

Target

Targets are roughly based on the FWC's Alligator Management Program's objectives of managing populations within ±25 percent of the pre-harvest levels. Population estimates are currently based on statistical analyses of alligator survey data using additive models. Population modeling techniques are subject to change in the future. Targets include the following:

- **Lake Kissimmee:** The estimated population of adult-size alligators will be ≥1,900. The estimated population of recruitment-size alligators will be ≥3,500.
- **Lake Tohopekaliga:** The estimated population of adult-size alligators will be ≥5 00. The estimated population of recruitment-size alligators will be ≥900.
- **Lake Hatchineha:** The estimated population of adult-size alligators will be ≥250. The estimated population of recruitment-size alligators will be ≥500.

Targets for Cypress Lake and East Lake Tohopekaliga will be established after more survey data are collected and the data can be analyzed using the same techniques applied to the other lakes.

Confidence Level

High.

Description of Associated Metric(s

Alligator surveys will be conducted annually. Survey data will be analyzed to determine estimated numbers of recruitment size (less than 4 feet) and adult size (6 feet and longer) alligators on each water body. Analyses might change, but Generalized Additive Models are currently used to estimate population trends and numbers.

Geographic Scope

Lake Kissimmee, Lake Tohopekaliga, Lake Hatchineha and East Lake Tohopekaliga.

Rationale

Maintaining the reproductive (adult) segment of a population is one of the most important aspects for ensuring the long-term viability of that population. Alligators reach sexual maturity at about 10-12 years of age, which corresponds to a size of 6 feet or longer. Alligator surveys provide information on the number and size distribution of alligators within a lake, thus serving as a useful tool to monitor the status of adult segment. Likewise, these surveys can serve as a useful tool to monitor the status of recruitment size alligators. Monitoring recruitment will help determine whether the adults are successfully reproducing, and whether early-age survival is sufficient to sustain a viable adult population. The expectation is that sufficient nesting, foraging and cover habitats will exist on each lake to support alligator recruitment and long-term survival.

Data Availability Summary

Alligator population surveys are conducted on public waterways annually throughout the state by FWC staff. Survey data are available for Lakes Kissimmee (1991–present), Tohopekaliga (1995–present), Hatchineha (1988–present), Cypress (2000 and 2005) and East Lake Tohopekaliga (2003–present).

Status of Current and Future Monitoring

The existing FWC alligator population monitoring surveys will be sufficient for tracking the number of recruitment and adult-size alligators. No additional monitoring is needed. Surveys are conducted and data are analyzed annually by the FWC. Results of these analyses include the information needed for performance measure evaluations.

MEASURE 4-08 – DENSITY OF NATIVE AND NONNATIVE APPLE SNAILS

Target

Recent investigations indicate that the three-year average density of native apple snails on Lake Kissimmee should be ≥0.28 (±0.11) snails/m^2. The density of nonnative apple snails on Lake Kissimmee should remain 0 snails/m^2. In addition, the two-year average density of nonnative apple snails on Lake Tohopekaliga should remain ≤0.18 (±0.16) snails/m^2.

Distribution of native apple snails should not be restricted on either Lake Kissimmee or Lake Tohopekaliga. Native apple snails may occur in any aquatic habitat, but seem to prefer habitats dominated by *Pontederia cordata* (Darby 2005). Conversely, an attempt should be made to restrict the distribution of nonnative apple snails to Lake Tohopekaliga.

Confidence Level

Low to Moderate.

Description of Associated Metric(s

Apple Snail Density: A direct measure of the number of organisms present in a defined area or volume (e.g., number/m^2). *Distribution:* The geographic range of an organism within a lake or lakes.

Two metrics have been identified for this performance measure. Density of native and nonnative apple snails in Lakes Kissimmee and Tohopekaliga will be calculated as number/m^2. In order to determine the effects of habitat structure on apple snail density and distribution, sampling may be stratified by habitat (vegetation type). Distribution of apple snails may be displayed graphically as a map (possibly shaded to represent habitat type and species densities). Monitoring results will be used to track native and exotic apple snail abundance and distribution within Lakes Kissimmee and Tohopekaliga.

Geographic Scope

Lake Kissimmee and Lake Tohopekaliga.

Rationale

Although there are no legal mandates to monitor apple snail populations within the KCOL, data on the abundance (density) and distribution of apple snails are important because they are the sole prey of the federally endangered snail kite (*Rostramus sociabilis*) (Bennetts and Kitchens 1997), and can be important in the diets of some wading birds, turtles and small alligators. In addition, information regarding the density and distribution of native apple snail (*Pomacea paludosa*) populations is important in light of the recent introduction of the nonnative Island apple snail (*Pomacea insularum*). This exotic is highly fecund, consumes virtually all types of aquatic plants and has few predators in Florida. Currently, impacts to native apple snail populations by the Island apple snail are unknown and merit specific attention.

Data Availability Summary

No post-regulation schedule data are available for density and distribution of native or nonnative apple snails within the KCOL. Post-regulation ecological studies of apple snails within the KCOL are limited to Lake Kissimmee and Lake Tohopekaliga, and will be used as a baseline measure for assessing responses resulting from changes in lake regulation schedules. These studies have focused on snail movement and survivorship during the extreme drawdown of Lake Kissimmee in 1996 (Darby et al. 2002, Darby et al. 2004) and long-term trends in snail density following the drawdown (Darby 2005). Additionally, Darby (2005) explored (*P. paludosa*) egg cluster patterns on Lake Kissimmee and determined that native apple snails laid eggs at disproportionately high levels in *Pontederia cordata* (pickerelweed), consistently favoring it at all study sites at all times. The greatest egg numbers (45 percent to 61 percent of total egg production) were also consistently found on *P. cordata*. Darby (2005) also reports trends in nonnative snail density on Lake Tohopekaliga and on the relationship between apple snails and habitat structure on Lakes Kissimmee and Tohopekaliga. These studies provide valuable information regarding the timing of hydrologic manipulations and its influence on habitat structure and apple snail density and distributions within these two lakes.

Replicate (three) sites on Lake Tohopekaliga, each containing 400m x 400 m plots were sampled in fall of 2004 following recovery of lake water levels after a lake drawdown and restoration activities in early 2004.

Three similar sites were selected for sampling in Lake Kissimmee. Apple snails were collected from the littoral zone of each lake using 1 m^3 throw traps and dip nets equipped with 13 mm mesh netting. A 30-second hand search also was used following use of the dip net. The number of snails for a given habitat type and associated standard error were estimated following Loery et al (1997).

Table J.11 and Table J.12 present native apple snail density on Lake Kissimmee and nonnative apple snail density on Lake Tohopekaliga, respectively.

Table J.11 – Native apple snail density (number/m^2) (mean ± s.e.) at four sites on Lake Kissimmee.

Site	2002	2003	2004
1	0.45 ± 0.08	0.48 ± 0.06	0.018 ± 0.005
2	0.26 ± 0.06	0.33 ± 0.04	0.30 ± 0.02
4	0.11 ± 0.06	0.62 ± 0.01[a]	0.12 ± 0.01
7	0.17 ± 0.04	NA	0 ± 0

a. Reflects a larger sampling area and possibly patches of habitat with higher snail densities (Darby 2005).

Table J.12 – Nonnative apple snail density (number/m^2) at four sites on Lake Tohopekaliga. No native apple snails were found in any of the 12 plots (sites 103) samples on Lake Tohopekaliga (Darby 2005).

Site	2003	2004
1	0.00	0.975
2	0.00	0.10
4	0.05	0.05
7	0.00	0.225

Status of Current and Future Monitoring

An existing data source is available, which is summarized by Darby (2005) in an annual report prepared for the FWC. Currently, this is the only known data source for density and distribution of native and nonnative apple snails in the KCOL. If this project continues to be funded in the future, these data will likely serve the needs of the KCOL LTMP. The contract under which these data were collected has been managed by the FWC. The baseline period for which targets have been developed occur between 2002–2004 for native apple snails on Lake Kissimmee, and 2003 and 2004 for nonnative apple snails on Lake Tohopekaliga.

MEASURE 4-11 – BENTHIC MACROINVERTEBRATES

Target

N/A, indicator measure.

Confidence Level

N/A, indicator measure.

Description of Associated Metric(s)

Various metrics related to benthic macroinvertebrate assemblages may be considered for use as an indicator performance measure based on the premise that these metrics are thought to change in some predictable way with increased human perturbation, resulting in degraded benthic habitat (e.g., increased sediment accumulation, reduction in dissolved oxygen concentrations). Table J.13 lists several potential metrics and their expected response to increased anthropogenic impacts. The following describes the metrics in Table J.13:

- Total taxa is the total number of aquatic invertebrate taxa present in the sediments of a lake on a given sampling date. This value will likely be a mean value calculated from replicate benthic samples.
- Total Chironomidae is the total number of aquatic invertebrate taxa belonging to the family Chironomidae (Diptera) in the sediments of a lake on a given sampling date. This value will likely be a mean value calculated from replicate benthic samples.
- % Oligochaeta is the percent of aquatic invertebrate taxa belonging to the order Oligochaeta in the sediments of a lake on a given sampling date. This value will likely be a mean value calculated from replicate benthic samples.
- % Ephemeroptera-Odonata-Trichoptera is the total number of aquatic invertebrate taxa belonging to the orders Ephemeroptera (mayflies), Odonata (dragonflies), and Trichoptera (caddisflies) in the sediments of a lake on a given sampling date. This value will likely be a mean value calculated from replicate benthic samples.
- % Pelecypoda is the percent of aquatic invertebrate taxa belonging to the order Pelecypoda (bivalves) in the sediments of a lake on a given sampling date. This value will likely be a mean value calculated from replicate benthic samples.

Conversely, these metrics are likely to respond in the opposite direction with improved habitat quality and lake ecosystem health. The actual suite of metrics may vary once a monitoring program is established and analysis of an initial data set is complete. Table J.14 lists additional potential metrics and expected responses to human impact.

Table J.13 – Proposed metrics and expected response to anthropogenic impacts.

Metric	Expected Response to Anthropogenic Impacts
Total Taxa	Decrease
Chironomidae Taxa	Decrease
% Oligochaeta	Decrease
% Ephemeroptera-Odonata-Trichoptera	Decrease
% Pelecypoda	Decrease

Table J.14 – Potential aquatic macroinvertebrate metrics for assessing lake ecosystem health (Gerritson el al. 2000).

Metric	Expected Response to Anthropogenic Impacts
Total Taxa	Decrease
Shannon Diversity	Decrease
Hulbert Index	Decrease
Florida Index	Decrease
Chironomidae Taxa	Decrease
Odonata, Ephemeroptera, Trichoptera	Decrease
Orthocladinae Taxa	Increase
% Orthocladinae/Total Chironomidae	Increase
% Tanypodinae/Total Chironomidae	Decrease
% Dominance	Increase
% Shredders	Decrease
% Scrapers	Decrease
% Predators	Decrease
% Parasites	Increase
% Surface Gatherers	Decrease
% Filter feeders	Decrease
% Diptera	Increase
% Oligochaeta	Increase
% Ephemeroptera	Decrease
% Trichoptera	Decrease
% Odonata	Decrease
% EOT	Decrease
% Amphipoda	Increase
% Isopoda	Increase
% Gastropoda	Increase
% Pelecypoda	Decrease
% Mollusca	Increase
% Decapoda	Increase

Geographic Scope

Lake Kissimmee and Lake Tohopekaliga.

Rationale

Aquatic invertebrates have a long history of use in biomonitoring (Plafkin et al. 1989, Rosenberg and Resh 1993) and can serve as indicators of biotic integrity and ecological health (Karr 1991). Benthic macroinvertebrate communities are known to respond in a predictable way to human perturbation and/or habitat enhancement. Based on the hypothesis that changes in lake hydrology (increased range of water level fluctuations) will drive changes in benthic habitat structure, resulting in shifts in macroinvertebrate community structure, certain attributes of the aquatic invertebrate community may be useful in determining changes in lake ecosystem health. Although a single-species approach to monitoring can provide some insight into the health of aquatic resources, a multiple metric approach can provide a more comprehensive understanding of changes resulting from human disturbance and/or habitat enhancement efforts. Initial data derived from a new macroinvertebrate monitoring program will provide the necessary information to determine:

- A baseline for comparing future changes in benthic invertebrate community structure as a result of future changes in hydrology.
- Which metrics (Table J.13), if any, that will be useful in tracking responses to modifications of lake regulation schedules and hypothesized habitat enhancement.
- Whether the monitoring of proposed metrics will provide relevant information to lake managers for future decisions regarding lake level manipulations.

Data Availability Summary

Historical (pre-C&SF Project) data on benthic macroinvertebrate community structure in the KCOL is unavailable, and it is currently unclear whether suitable reference sites exist for developing realistic performance measures for assessing responses to future changes in lake operational schedules. Much of the aquatic macroinvertebrate monitoring in the KCOL has been conducted by the FWC. Most studies (Williams et al. 1979, Moyer and Williams 1982, Butler et al. 1992) were conducted in conjunction with habitat restoration (lake drawdown) projects on Lakes Tohopekaliga and Kissimmee. These studies quantified aquatic invertebrates in littoral and/or limnetic habitats prior to, and following, habitat restoration. In general, these studies indicate the importance of littoral vegetative habitat for aquatic macroinvertebrates and present family-level taxonomy and associated densities. One additional study (Milleson, 1975), quantified benthic invertebrate species composition in Lakes Tohopekaliga, Cypress, Hatchineha and Kissimmee. Although this study does not provide a complete representation of the benthic fauna, it appears that the fauna of all four lakes are similar. Data from Milleson (1975) provide some information about species composition and may be used to evaluate whether benthic communities have significantly changed since 1974, and if differences now exist between the lakes. However, existing data do not appear to provide the necessary information for developing an assessment performance measure or evaluating current lake health using benthic macroinvertebrates as an indicator.

Status of Current and Future Monitoring

A benthic macroinvertebrate monitoring program does not currently exist for Lake Kissimmee or Lake Tohopekaliga. Earlier studies by Milleson (1975), Williams et al. (1979), and Moyer and Williams (1982) will likely not provide sufficient baseline data for evaluating changes in proposed metrics resulting from modifications to existing lake regulation schedules. If aquatic benthic macroinvertebrates are to be used as an management response indicator, a monitoring program will be needed to establish a baseline condition for selecting and evaluating changes in macroinvertebrate metrics resulting from modifications to existing lake regulation schedules and the hypothesized enhancement of benthic habitat structure.

MEASURE 5-01 – TROPHIC STATE INDEX

Target

The FDEP is in the process of developing nutrient and Trophic State Index (TSI) targets for lakes it has identified as impaired. Consequently, targets for trophic state are not available yet, but are expected soon. The following discussion explains methods and approaches for developing these targets.

To protect lakes and other waters from excessive nutrient enrichment, Florida currently uses narrative nutrient standards. These standards state, in part, that "in no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna" (Chapter 62-302, Florida Administrative Code, [F.A.C.]). Several ways exist (see last section) to evaluate the degree of nutrient enrichment (trophic state) and test for imbalances in biotic components, but the most common is the TSI, which can incorporate nutrient and/or chlorophyll data. In most cases, phytoplankton chlorophyll is the most responsive and easily measured indicator of biological response to nutrient enrichment.

A variety of approaches can be used by the FDEP to develop trophic state targets for lakes, as long as the targets developed are consistent with the language in Rule 62-303 of the F.A.C., also known as the Impaired Waters Rule (IWR). The IWR also describes methods to evaluate changes in trophic state. Trends are determined using the TSI and annual mean chlorophyll concentrations. For any lake, annual mean TSIs should not increase significantly over the assessment period, or the TSI should not increase by >10 units over historical values.

At least five approaches can be used to develop the TSI: 1) default color approach; 2) modeling approach; 3) paleolimnological approach; 4) combined color and pH approach; and 5) algal-bloom frequency approach.

These approaches are described in the Pilot and Supporting Studies and Preliminary Work section.

Confidence Level

High. Data have been collected from most of these lakes for more than 10 years.

Description of Associated Metric(s

The TSI comprises annual mean concentrations of chlorophyll *a* and either total nitrogen (TP) or total phosphorus (TP), depending on which nutrient is limiting to phytoplankton growth as determined by the ratio between the two nutrient concentrations. The equations used in calculating the TSI are described by the FDEP (1995).

Reference Condition: This performance measure applies to all lakes in the KCOL for which nutrient and chlorophyll data are routinely collected.

Geographic Scope

This performance measure applies to all lakes in the KCOL for which nutrient and chlorophyll data are routinely collected.

Rationale

The TSI is a widely used measure of trophic condition, which the FDEP employs in its TMDL Program to identify lakes that are impaired due to elevated nutrients or chlorophyll concentrations. It is useful in assessing trends in trophic conditions over years or decades.

Data Availability Summary

Chlorophyll *a*, TN and TP data are collected from most lakes in the Kissimmee Chain on a quarterly and/or monthly basis. The SFWMD, the FWC and Florida Lakewatch collect most of the data.

Status of Current and Future Monitoring

The existing water quality monitoring programs are sufficient for determining TSI values, although adjustments to these programs should be considered to maximize efficiency among the collecting agencies and organizations and ensure comprehensive coverage of the KCOL. No monitoring is currently conducted in Lakes Ajay, Myrtle, Preston and Joel. The need for monitoring in these smaller lakes should be determined.

In some lakes, the evidence that nitrogen or phosphorus are currently stressors (i.e., have caused an imbalance in natural populations of aquatic flora or fauna) is not clear. This question could be examined by: a) identifying whether there are documented negative impacts to human uses or fish/wildlife from high nutrient and chlorophyll *a* levels; b) comparing present rates of nutrient loading, concentrations and algal composition to past values inferred from paleolimnological studies on the lakes; and/or c) comparing nutrient and chlorophyll *a* concentrations in the KCOL with water quality identified as typical for the particular lake ecoregion (Griffith et al. 1997). Determination of whether nitrogen or phosphorus limits algal growth can be accomplished using standard whole-community bioassays (Aldridge et al. 1995) or surrogates, such as the dissolved inorganic nitrogen to soluble reactive phosphorus ratio (DIN:SRP).

Trophic state assessments have been done through the FDEP's TMDL Program and will be repeated every five years. The TSI is composed of chlorophyll, and TP or TN concentrations. Therefore, these parameters must be included in water quality monitoring programs. Water color must be monitored as well. Secchi disk transparency, turbidity, and dissolved phosphorus and nitrogen concentrations provide supplementary information. The FDEP may establish other numeric nutrient criteria in the future. For lakes where macrophyte coverage is extensive, TSIs might be evaluated in the winter and spring.

Trophic state may also be evaluated by examining trends in TP and TN concentrations, TN:TP and DIN:SRP ratios, and Secchi disk depths. In addition, the narrative nutrient criterion stated in the Target section may be evaluated using other means, such as: 1) frequency of algal blooms; 2) species richness, diversity, composition and biomass of phytoplankton, including percent cyanobacteria; 3) species richness, diversity and biomass of periphyton (littoral); and (4) dissolved oxygen. Consequently, these metrics should also be considered for inclusion in monitoring programs.

Pilot and Supporting Studies and Preliminary Work: At least five approaches can be used to develop the TSI:

1. **Default Color Approach**
   For lakes with mean color >40 platinum-cobalt units (PCU), the annual mean TSI should not exceed 60. For lakes with mean color ≤40 PCU, the annual mean TSI should not exceed 40.

2. **Modeling Approach**
   This approach relies on using a calibrated watershed model (e.g., WAMView, WMM, HSPF, etc.) and an in-lake water quality model (e.g., Bathtub, WASP, etc.). Once these models are calibrated to current conditions using the measured data (e.g., TP, tTN and chlorophyll *a* concentrations) or best available information, the human land uses within the watershed model are converted to a mosaic of natural land uses (e.g., upland forest, wetlands, wet or dry prairies, etc.). The models are re-simulated using the modified land uses to estimate the background TP, TN and chlorophyll *a* concentrations, which in turn can be used to calculate the background TSI. It should be recognized that the direct application of the background TSI as the target TSI for TMDL development would not allow for any assimilative capacity. The FDEP has assumed that allowing a 5 unit increase in TSI over the background condition would prevent a lake from becoming impaired (changing trophic states), and therefore, reserves 5 TSI units to allow for future changes in the basin. On the other hand, the IWR uses a 10 unit change in TSI from "historical" levels as one measure of impairment in lakes. This 10 unit increase is assumed to represent the transition of a lake from one trophic state (say mesotrophic) to another nutrient-enriched condition (eutrophic).

3. **Paleolimnological Approach**
   This approach is based on an assumption that, for any given lake, the specific deposition rates of TN and TP will remain relatively constant over long periods of time. Therefore, if the specific deposition rate of TN and TP can be determined using the existing data, and TN and TP deposition rates for the pre-development period can be determined, the TN and TP concentration for the pre-development period also can be determined. Then, using an empirical relationship between the nutrient concentration and chlorophyll *a* concentration, the pre-development chlorophyll *a* concentration can be estimated. With these pre-development period TN, TP and chlorophyll *a* concentrations, a pre-development TSI can be calculated. This TSI can be used as the background TSI of the lake. Information required for this approach would be the existing in-lake TN and TP concentration and TN and TP accumulation rate in the sediment for both the existing condition and the pre-development period.

4. **Combined Color and pH Approach**
   The TN and TP targets for a given lake also could be derived using the approach from a Tetra Tech, Inc. study that collected data from 200 Florida lakes between 1993 and 1997 (Paul and Gerritsen, 2002). A variety of exploratory analyses of these data suggested that the strongest organizing forces on the biota of the relatively undisturbed lakes were water color and pH (Gerritsen et al. 2000). On the basis of these results, the sampled lake regions were aggregated into five lake biological classes, such that the lakes within each class have similar biological assemblages. The lake classes were divided on water color (greater than or less than 20 PCU), pH (greater than or less than 6.5), and ecoregion for acid clear lakes only (Omernik 1987: Region 65 in northwest Florida and Region 75 in peninsular Florida).

Several techniques were used in each lake class to establish TN and TP target concentrations. These included the reference lake technique, sediment diatom reconstructions, morphoedaphic indices, LOESS regression of lake trophic condition index (tLCI) vs. nutrients, and multiple linear regression (Paul and Gerritsen, 2002). Among all the techniques used, the reference lake technique, LOESS regression of tLCI vs. nutrients, and diatom reconstruction based on paleolimnological data provided meaningful results (see Table J.15).

Table J.15 – Summary of phosphorus/nitrogen concentrations (micrograms per liter [µg/L]) suggested as potential criteria for five different lake classes in Florida.

	Methodological Approach		
Lake Class	75th Percentile of Reference Distribution	LOESS Regression (tLCI vs. Nutrients)	Paleolimnology (TROPH1 Model)
Acid Clear Lakes			
Ecoregion 65	10/330	21/473	4*/N/A
Ecoregion 75	10/470	23/776	67*/N/A
Acid Colored Lakes	42/910	43/1202	17*/N/A
Alkaline Clear Lakes	10/750	17/692	25/N/A
Alkaline Colored Lakes	73/1110	40/1148	32/N/A

* = N < 6, N/A = Not applicable.

5. **Algal-Bloom Frequency Approach**

Potential TN and TP targets have also been derived based on a relationship developed by Bachmann et al. (2003) between the frequency of algal blooms and TN and TP concentrations. These authors analyzed 1,473 lake-years of data on 438 Florida lakes to develop a series of tables. These tables can be used to predict the frequencies that phytoplankton chlorophylls will exceed concentrations of 10, 20, 30, 40, 50 and 60 µg/L in Florida lakes, based on the annual average concentrations of chlorophyll, TP or TN. In their studies, the authors created different tables for lakes grouped by TN/TP ratios of >17, <17 but >10, and <10. Since the TN/TP ratio for Lake Jesup appears to fall between 10 and 17 most of the time, suggesting that the lake's phytoplankton community is co-limited by nitrogen and phosphorus, the target TN and TP concentrations for Lake Jesup were developed based on the table for lakes with the corresponding TN/TP ratio.

Table J.16 shows the frequency of algal blooms at different TN and TP concentrations. These are some of the approaches that the FDEP may use to develop the TSI target for lakes in the Kissimmee River basin. Exactly which approach will be used depends on the information and resources available. Some of the information required by these methods could be provided by studies proposed under other AIMs for water quality (Nutrient Loading, Frequency and Duration of Algal Blooms, and Phosphorus Assimilation Capacity in Lake Sediments). These indicator measures will support the targets developed under this trophic state performance measure.

Table J.16 – Estimated percent of the time that chlorophyll concentrations will exceed the listed concentrations in lakes with a TN/TP ratio between 10 and 17. Concentrations of chlorophyll (CHL), TN and TP are in µg/L (Bachmann et al. 2003).

TP	CHL > 10	CHL > 20	CHL > 30	CHL > 40	CHL > 50	CHL > 60
10	19	3	0	0	0	0
25	23	4	0	0	0	0
35	73	32	6	0	0	0
40	79	47	15	6	2	1
45	85	53	21	11	6	2
50	87	61	27	17	10	5
55	90	67	32	22	15	7
60	92	70	38	30	19	10
65	94	74	44	35	25	14
70	95	78	48	40	28	17
75	96	81	53	46	33	20
80	96	85	60	52	38	24
85	96	90	68	58	44	27
90	96	92	72	64	49	32
95	96	95	77	68	55	38
103	96	95	85	78	65	44
127	96	95	86	79	69	58
139	96	95	86	80	70	65
157	96	95	86	81	72	68
197	96	95	86	82	75	73
TN	**CHL > 10**	**CHL > 20**	**CHL > 30**	**CHL > 40**	**CHL > 50**	**CHL > 60**
124	10	2	0	0	0	0
372	32	4	1	0	0	0
500	74	38	12	4	1	1
600	82	48	24	10	4	2
700	85	55	35	16	10	3
800	89	62	41	22	15	6
900	93	69	46	26	22	11
1,000	95	76	50	33	28	17
1,100	97	81	58	44	40	26
1,200	99	87	65	53	48	30
1,221	99	89	70	55	50	32
1,292	100	94	81	65	56	37
1,400	100	100	96	84	67	46
1,600	100	100	96	89	78	59
1,800	100	100	96	89	78	67
2,000	100	100	96	89	78	71
2,491	100	100	96	89	78	73

MEASURE 5-02 – NUTRIENT LOADS

Target

Acceptable nutrient loading rates for the KCOL and watersheds of the Upper Kissimmee Basin are in the process of being determined by the FDEP, the SFWMD and the FDACS. (See discussion under the Pilot and Supporting Studies and Preliminary Work section for a description of these activities.)

Confidence Level

N/A, indicator measure.

Description of Associated Metric(s)

Nutrient loads for each lake or group of lakes are calculated from available data on total nitrogen (TN) and total phosphorus (TP) concentrations and discharges, or estimated from rainfall-runoff relationships and land use data. Nutrient budgets (an accounting of sources and movement of N and P) are calculated for each lake, and include total input, output and in-lake volumetric storage. Direct precipitation, lake evaporation, nutrient residence time and hydraulic detention time are also calculated. Annual flow-weighted mean concentrations can be calculated from annual loads and discharges for the purpose of tracking trends.

Reference Condition: No reference data from the KCOL are available. Acceptable nutrient loading rates will be developed using methods determined by the FDEP.

Geographic Scope

Entire KCOL, with particular focus on the portion of the KCOL from Lake Tohopekaliga to Lake Kissimmee.

Rationale

Reliable nutrient budgets are essential for establishing targets for nutrient loading and TMDL allocations.

Data Availability Summary

Although daily discharge data is recorded by the SFWMD for each of its nine water control structures, discharge data is unavailable for many lake tributaries. Discharge is recorded for three major streams (Shingle Creek, Boggy Creek and Reedy Creek), but must be estimated for others. Nutrient budgets for the lower lakes (Cypress, Hatchineha and Kissimmee) are difficult to estimate and interpret due to the lack of critical discharge data and the short-circuiting of flow through Lake Cypress and Lake Hatchineha.

The SFWMD has also contracted studies to determine current land use in the Upper Kissimmee Basin and nutrient runoff associated with different land uses.

Status of Current and Future Monitoring

The SFWMD monitors nutrient concentrations at the S-65 Structure (Lake Kissimmee outlet), the S-59 Structure (East Lake Tohopekaliga outlet), Shingle Creek, Boggy Creek and Reedy Creek. Nutrients are sampled monthly at the S-59 Structure and the three creeks, and bi-weekly at the S-65 Structure. In addition, TP is sampled several times daily at the S-65 Structure and composited into a seven-day sample. Grab samples are also collected for other nutrient analyses, including soluble reactive phosphorus and dissolved inorganic nitrogen (nitrate, nitrate and ammonium). Because the lakes are connected by short stretches of canal, sampling sites within the lakes can also represent suitable sites for inflow/outflow data. Sampling within Lakes Tohopekaliga, Cypress and Hatchineha serve as inflow monitoring sites for their respective lakes downstream. Most of the sampling and analysis conducted under these monitoring programs is currently done by Polk County and Orange County under contracts with the SFWMD.

Historical data are also available from the SFWMD for the S-61 Structure (Lake Tohopekaliga outlet) and many more minor tributaries around these lakes and additional lake stations. Most of these historical data are from the 1980s.

Daily discharge data are collected by the SFWMD from each of the nine water control structures in the KCOL. A software program developed by the SFWMD is used to estimate daily nutrient loads from its water quality and discharge database.

The Florida Lakewatch Program samples monthly in 12 of the 19 lakes (Alligator Lake, Brick Lake, Lake Lizzie, Coon Lake, Lake Center, Ajay Lake, Fells Cove, Lake Gentry, East Lake Tohopekaliga, Lake Tohopekaliga, Lake Cypress and Lake Kissimmee) for TN and TP. These data also can be used in the estimation of nutrient inputs and outputs.

The FWC also samples TN and TP in several lakes, but sampling is conducted quarterly, and therefore, less suited for estimation of nutrient loads.

Pilot and Supporting Studies and Preliminary Work:

<u>SFWMD</u>

In response to increased TP loading from Lake Kissimmee in recent years, the Lake Okeechobee Protection Program (LOPP) (Section (3)(d)4) (SFWMD 2004; Section (3)(d)(4)) mandated a detailed accounting of watershed point, nonpoint and in-lake sources of phosphorus that can be used to identify optimal methods for controlling TP discharges from the Upper Kissimmee Basin. This project focuses on estimating TP budgets in the watersheds.

To determine the watershed TP budgets, it is important to understand how land use activities relate to the amounts of phosphorus brought into and carried out of various areas either directly (as in waste removal) or indirectly (as in surface or subsurface water flows). This information will help the SFWMD model both current conditions and develop predictive models for potential future conditions. From these models, predictive management scenarios can be evaluated and the best alternatives implemented.

The SFWMD is documenting the general characteristics of land use activities with regard to phosphorus imports and exports, and will employ basic mass-balance models to describe the movement of phosphorus within subbasins. This assessment will identify existing conditions and how different land use activities currently contribute to KCOL phosphorus loading. Phosphorus reduction alternatives for various land use activities can then be planned. Implementation of these management activities will reduce the phosphorus loads to the KCOL and potentially reduce excessive phosphorus loading to Lake Okeechobee.

In the Lake Okeechobee Protection Plan Update (SFWMD et al. 2007), phosphorus load reductions under various best management practices (BMPs) have been estimated based on land uses in the Upper Kissimmee Basin (updated by the SFWMD in May 2006) and existing practices and BMPs for each land use (Bottcher 2006).

The FDEP will establish target nutrient loads for certain lakes under its TMDL program. When TMDLs are established, general allocations of pollutant load reductions are identified, at least to the level of point and nonpoint source categories. The TMDL development involves determining the maximum amount of a given pollutant that a water body can assimilate and still meet the applicable numeric or narrative water quality criterion for the pollutant. In most cases, this "assimilative capacity" will be determined using computer modeling (both hydrodynamic and water quality models) that predicts the fate and transport of pollutants in the receiving waters. In addition to identified point and nonpoint sources of nutrients, initial allocations of nutrient loadings will be made for historical sources (e.g., phosphorus-laden sediments at the bottom of a lake) and upstream sources (those entering an impaired water body).

The FDEP plans to use the Watershed Assessment Model (WAMview), a GIS-based tool, to identify current land use and estimate nutrient loading and flows. Acceptable nutrient targets for the lakes will be determined through application of BATHTUB, a mixed reactor model. Historical land use also will be examined to estimate background loading and flows, and determine if the nutrient targets are reasonable.

The FDEP will develop TMDLs for water bodies it has verified as being impaired. According to the FDEP's Water Quality Assessment Report (FDEP 2006), these water bodies include Lake Cypress and Lake Kissimmee. The TMDLs for these water bodies were originally scheduled for completion in 2010, but they have been accelerated for completion in 2007 as part of the state's Lake Okeechobee and Estuary Recovery (LOER) Action Plan.

MEASURE 5-03 – FREQUENCY AND DURATION OF ALGAL BLOOMS

Target

N/A, indicator measure.

Confidence Level

N/A, indicator measure.

Description of Associated Metric(s)

Metrics include phytoplankton chlorophyll *a* and other measures of phytoplankton abundance.

Reference Condition: No reference data on KCOL phytoplankton are available. Frequency and duration of algal blooms prior to human influences might be approximated from estimates of pre-development trophic state and empirical relationships in similar lakes (e.g., Bachmann et al. 2003).

Geographic Scope

Entire KCOL, with focus on portion of chain from Lake Tohopekaliga to Lake Kissimmee.

Rationale

Although the State of Florida has adopted numeric criteria for a wide array of pollutants, the existing criterion for nutrients is narrative—"…in no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna." (Chapter 62-302, F.A.C.). The FDEP is endeavoring to improve upon this standard by identifying science-based numeric criteria for nutrients. A technical advisory committee has been formed by the FDEP for this purpose.

One example of an approach for developing nutrient criteria for individual lakes or groups of lakes was proposed by Havens (2003). Measures of trophic state usually include mean concentrations of total phosphorus (TP), total nitrogen (TN), and/or chlorophyll *a*. However, as stated by Havens and others cited in his paper, the public's perception of lake water quality is more closely linked to the frequency and intensity of algal bloom conditions than to yearly chlorophyll averages. Blooms also are the events that can have adverse impacts on native flora and fauna. Therefore, Havens focused on the frequency of bloom occurrence, defined as high concentrations of chlorophyll *a*, rather than on chlorophyll averages. Havens and Walker (2002) used this approach to identify a TP goal for Lake Okeechobee.

Havens evaluated data from seven south Florida lakes, including Lake Istokpoga and six lakes from the KCOL (Fells Cove, East Lake Tohopekaliga, Lakes Tohopekaliga, Cypress, Hatchineha and Kissimmee), to determine how general the TP vs. algal bloom relationship is for lakes in this region of the state, and identify environmental factors that might influence any observed differences in the TP vs. bloom relationship among lakes. He found a highly significant relationship between chlorophyll *a* and TP in these lakes, although multiple regression models that include TP and TN, or TP and color, provide the best predictions of chlorophyll *a*.

Havens' approach should be useful for setting lake-specific TP standards in lakes within the context of sound decisions about reasonable levels of chlorophyll within a particular lake region and information on the impacts of blooms upon the main uses of the lakes.

In addition, Bachmann et al. (2003) examined a large data set of Florida lakes and developed tables that can be used to estimate algal bloom frequencies from average chlorophyll or nutrient data.

Data Availability Summary

The SFWMD and FWC have collected chlorophyll *a* data from the five major lakes in the chain for over two decades. The SFWMD data is collected monthly and the FWC data is collected quarterly. The Florida Lakewatch Program also collects chlorophyll data monthly from 12 of the 19 KCOL water bodies.

In recent years, the SFWMD has also collected samples for phytoplankton identification and enumeration. These data are suitable for calculating percent dominance of cyanobacteria and identifying species responsible for algal blooms.

Status of Current and Future Monitoring

Existing monitoring programs for nutrients, chlorophyll and phytoplankton identification and enumeration can be used in this assessment.

Pilot and Supporting Studies and Preliminary Work: As mentioned by Havens, the level of chlorophyll that represents what might be called a nuisance algal bloom depends on perceptions of the observers. A person in a region of eutrophic lakes who uses the lakes for fishing might identify a nuisance bloom at a higher level of chlorophyll than someone in a region of oligotrophic lakes who enjoys contact water sports. A decision also needs to be made about acceptable bloom frequency and duration. Therefore, the first step in using the approaches of Havens (2003) and Bachmann et al. (2003) is to define acceptable magnitude, frequency and duration for algal blooms in an individual lake or group of lakes. While some long-time residents may recollect the appearance of a lake decades ago, quantitative data are usually unavailable. In the case of the KCOL, no chlorophyll data were collected prior to cultural eutrophication, so reference conditions are unknown. A paleolimnological study may indicate the prior condition of the lakes, but the sediments may be too well mixed in these shallow lakes for such an analysis. From a lake manager's point of view, it may be just as important to determine the desired state of the lakes, even if that differs from an estimate of the prior condition. For this determination, lake professionals and stakeholders familiar with the lakes could be consulted to determine levels at which algae are ecologically or recreationally undesirable (for example, see work on Lake Tohopekaliga by Bonvechio and Bonvechio 2006). A survey of lake users (e.g., Hoyer et al. 2004) could also be helpful in this regard. If an appropriate bloom end point can be identified, the TP criteria can be determined on a lake-by-lake basis using routine water quality monitoring data and the methods proposed by Havens (2003).

MEASURE 5-04 – PHOSPHORUS ASSIMILATION CAPACITY OF LAKE SEDIMENTS

Target

Phosphorus assimilation capacity is an internal characteristic of the lake and is affected by phosphorus loading. Because eutrophication control focuses on reducing nutrient inputs from the watershed, targets will be developed for external nutrient loading rather than internal recycling. Nevertheless, an understanding of phosphorus in the sediments is important for understanding the degree of nutrient enrichment and how much assimilation capacity is left in these lakes. Therefore, the metrics associated with this attribute have been designated as an assessment indicator measure.

Confidence Level

N/A, indicator measure.

Description of Associated Metric(s

This evaluation involves several different analyses of the physical and chemical characteristics of lake sediments, as well as various tests conducted within the lakes and in the laboratory to determine characteristics of lake sediment, especially with regard to phosphorus assimilation capacity. Metrics will possibly include:

- Distribution of mud and other sediment types (limnetic zone only);
- Depth of mud sediment;
- Physical and chemical composition of surficial sediment, including phosphorus (P) and nitrogen (N), chemical fractionation of these nutrients, redox potential, bulk density, organic content, aluminum, iron, manganese and calcium;
- Determination of equilibrium phosphorus concentration;
- Structure of sediment, including depths of flocculent mud layer, consolidated mud layer, sand layer, etc;
- Paleolimnology, including ^{210}Pb and diatom analysis.

Reference Condition: No reference data from the KCOL are available. Prior conditions of sediment characteristics can sometimes be obtained through examination and dating of subsurface sediment layers obtained through coring, but the bottoms of these lakes may be too disturbed by high winds (hurricanes, etc.) to provide a useful history of the sediments.

Geographic Scope

Lakes Tohopekaliga, Cypress, Hatchineha and Kissimmee. Other lakes may be included.

Rationale

Excessive inputs of nutrients from lake watersheds drive long-term increases in trophic state. A portion of the incoming phosphorus settles out of the water column and accumulates in the sediment over time. Therefore, in accounting for movement of phosphorus into, through and out of the lake water column, there is a net loss of phosphorus to the sediment. However, in shallow, enriched lakes, the sediment can interact strongly with the water column and become a significant source of phosphorus. Resuspension of sediments is a particularly important nutrient recycling mechanism in shallow, completely mixed lakes. Consequently, for some lakes with enriched sediments, a reduction in external nutrient loads may delay improvement in water quality.

As the sediment becomes more enriched with phosphorus, it loses its assimilative capacity. Attempts to reverse eutrophication become more difficult, as internal nutrient cycling determines the degree to which lake trophic state responds to reduction in nutrient inputs. Lakes with sediment P concentrations that have reached or are near the equilibrium concentration (e.g., Lake Apopka and Lake Okeechobee) will not respond to reduced inputs within desirable time frames, and may require expensive corrective measures to achieve lake restoration goals. Therefore, knowledge of the sediment's assimilation capacity is critical for determining how long the lake can assimilate phosphorus before reaching the threshold at which control of external P inputs becomes less effective.

Understanding the internal cycling of P is important not only for managing the trophic state of the KCOL, but also for managing phosphorus reductions to Lake Okeechobee, because the KCOL is a major phosphorus contributor.

Data Availability Summary

White et al. (2004) collected samples of the major sediment types in Lakes Tohopekaliga, Cypress, Hatchineha and Kissimmee and analyzed them for P flux and sorption. They concluded that reductions in watershed inputs of P will not result in immediate reductions in P loading downstream to Lake Okeechobee due to internal loading in the lakes. They also provided answers to five questions, which are summarized as follows:

Question 1: What are the physical and chemical characteristics of surficial sediments, with particular emphasis on the forms of P and compounds that can affect P sorption and release?

Answer 1: These sediments range from sand with low organic matter content to organic mud. They were analyzed for total carbon, total nitrogen (TN), and total phosphorus (TP) and also for selected metals (Ca, Mg, Fe, and Al), which represent potential chemical binding sites for soluble reactive P (SRP) in the surface waters, as well as potential sources for release of P. Bulk density tests indicated that the muds are quite fluid and susceptible to resuspension, which could lead to release of SRP from sediments into the surface waters. Muddy sediments also contained more P than sandy sediments, and the TP was well correlated with Ca, Mg, Fe, and Al, which increases the capacity of the sediment to bind or retain P.

Question 2: What is the current contribution of phosphorus (internal loading) from the sediments to the water column of these lakes?

Answer 2: The internal nutrient load potential was examined through in situ porewater profiles and laboratory analysis of intact sediment cores. The porewater profiles showed that the highest P flux rates were associated with muddy sediments. However, the porewater profile and intact sediment core techniques produced contradictory results regarding relative nutrient loading among the four lakes. In addition, past lake concentrations do not appear to predict current internal nutrient load potential. Consequently, the study does not appear to answer the question adequately. Further work probably should be done to clarify relationships between eutrophication history and internal loading estimates and to reconcile the results of the two techniques.

Question 3: What are the Equilibrium Phosphorus Concentrations (EPCs) of sediments in these lakes?

Answer 3: The EPC is that concentration of P where there is no net exchange of P between the sediment and water column. This equilibrium point is also important for predicting nutrient release as water column concentrations change over time. Water column P concentrations above the EPC will lead to P moving from the water column to the sediments where it becomes stored. Over time, excessive input of P from the surrounding watershed leads to both higher water column concentrations and sediment enrichment, and results in a higher EPC. If external loads are reduced, water column concentrations can drop below the EPC. Then, P will be released from the sediments, thereby causing response of the lake to be slowed or delayed. In this case, more expensive in-lake remediation may be required to attain restoration of the desired trophic condition. In the four lakes examined, EPCs are generally low and indicate a low potential for release of P from the sediments if water column concentrations decrease in the future. The sediments should not act as a considerable source of P if concentrations in the water remain above 40 parts per billion (ppb) unless environmental conditions (runoff events, severe algal blooms, hydrilla coverage) cause anaerobic conditions in the surficial sediments and consequent mobilization of P.

Question 4: What is the assimilative capacity of each lake?

Answer 4: The assimilative capacity, or maximum sorption of P (S_{max}), was determined on batch incubations of sediments exposed to a range of P concentrations. White et al. concluded that sediments in these four lakes could potentially sorb P for another nine to 11 years before reaching their maximum capacity.(However, these estimates have been reassessed by B. Jones and R.T. James [SFWMD, personal communications]. They estimate that the period until maximum capacity is reached is much longer.)

Question 5: If external inputs to these lakes are reduced, will the phosphorus output to Lake Okeechobee become lower?

Answer 5: Reduction of P loads will reduce the rate of sediment enrichment, which will allow the sediments to continue to act as a P sink for a significantly longer period of time. Reduction of P inputs will not only prevent eutrophication of these lakes, but will preserve the sediments as a P sink for an indefinite period of time.

Status of Current and Future Monitoring

An investigation of sediment characteristics and phosphorus assimilation capacity would be a new study following the study of White et al. (2004).

Pilot and Supporting Studies and Preliminary Work: The investigation by White et al. (2004) can serve as a pilot study and a baseline for future data collection. Accordingly, their results summarized in the previous sections demonstrate what future evaluations might entail. Future studies might employ some of the same techniques while collecting representative sediment samples throughout the lakes to examine spatial variability. Sediments in less-impacted lakes in the eastern part of the KCOL may differ significantly from the larger eutrophic lakes and may serve as reference sites. Sampling of these lake sediments may also offer insight into their historical condition. In addition, other techniques could be considered, such as measuring settling of organic-rich particles from the water column using sediment traps. The use of sediment traps could provide a comparison of particle flux rates and net sediment accumulation rates, and quantify the resuspension of bottom sediments. These future studies may help support the establishment of target Trophic State Indices for these lakes.

MEASURE 5-05 – CLASS III WATER QUALITY PARAMETERS

Target

Dissolved oxygen (littoral and limnetic), fecal coliforms, and certain trace metals, pesticides, and polyaromatic hydrocarbons and phenols shall meet standards established in the FDEP IWR (FDEP 2005). For example, fecal coliforms should not exceed 800 most probable number (mpn). Support for Class III designated uses (percent exceedances over a designated period) will be determined by procedures described in the IWR.

Confidence Level

High. Water quality criteria are established by state law.

Description of Associated Metric(s)

- Dissolved Oxygen (DO) (littoral and limnetic).
- Fecal coliforms.
- Trace metals.
- Pesticides.
- Polyaromatic hydrocarbons and phenols.

Reference Condition: Reference conditions do not apply to this performance measure as the targets are based on state water quality standards.

Geographic Scope

This performance measure will be restricted to selected lakes and to parameters for which baseline data have been collected.

Rationale

The KCOL LTMP goal for water quality is to "meet or maintain state water quality standards" in the 19 water bodies of the KCOL. All lakes in the KCOL are designated by the FDEP as Class III water bodies, which means that they must meet water quality criteria suitable for fish and wildlife propagation and contact recreation. Most lakes in the KCOL are used primarily for boating, fishing and hunting. Consequently, water quality criteria mostly emphasize potential ecological impacts in these lakes. However, a few lakes are also used for waterskiing, jet skiing and swimming, which puts users into closer contact with the water. In these lakes, the consequences to human health rise to higher importance.

The FDEP has established Class III criteria for many water quality parameters. A subset of these parameters is identified in this performance measure based on the parameters that have impaired or could potentially impair water quality in the KCOL as determined by the FDEP's Verified List and Planning List.

In addition to eutrophication issues related to nutrient runoff, the FDEP's Water Quality Assessment Report (FDEP 2006) concludes that major water quality problems in the Upper Kissimmee Basin include low DO and mercury in fish tissue. Also, there were several detections of heavy metals at various locations, and a concentration of pesticides in the Reedy Creek drainage. Elevated heavy metals and pesticides can be attributed to urban and/or agricultural land uses. Mercury contamination is thought to result from atmospheric deposition. Water bodies that are potentially impaired or verified as impaired for specific water quality parameters are listed in the FDEP Water Quality Assessment Report.

Among the KCOL and its direct tributaries, the FDEP verified that Lake Cypress and Lake Kissimmee are impaired for nutrients (Total N and Total P) according to Impaired Waters Rule (IWR) criteria. The Kissimmee City Ditch is verified as impaired for DO. Lake Center is potentially impaired for DO. The Dead River and Reedy Creek are potentially impaired for turbidity. Boggy Creek and Shingle Creek are potentially impaired for copper, iron and DO. Ten lakes (Hart, Mary Jane, Russell, Brick, Alligator, East Tohopekaliga, Tohopekaliga, Cypress, Hatchineha and Kissimmee) are verified as impaired for mercury in fish tissue. The St. Cloud Canal is potentially impaired for iron. Lake Mary Jane is verified as impaired for lead. Finally, Reedy Creek (located north of Lake Russell) is listed as potentially impaired for silver and several organic chemicals. Coliform bacteria and turbidity were noted on the 1998 303(d) list as parameters of concern in upper Reedy Creek.

The impairments identified here may change if new methodology and processes incorporated into the recent revision to the IWR are applied to the FDEP's assessment of these water bodies.

Data Availability Summary

In addition to data gathered for assessment of trophic state, such as nutrients, phytoplankton chlorophyll and Secchi disk depth, the SFWMD and FWC routinely collect data for other water quality parameters, including turbidity, total suspended solids, DO, and pH. Historical data also exist for biochemical oxygen demand (BOD), coliforms and several trace metals.

Status of Current and Future Monitoring

Some of the water quality parameters listed above have been monitored in the past, but may not be monitored currently. The FDEP, along with other state and local agencies, will determine future monitoring needs.

LITERATURE CITED

Aldridge, F.J., Phlips, E.J., Schelske, C.L., 1995. The use of nutrient enrichment bioassays to test for spatial and temporal distribution of limiting factors affecting phytoplankton dynamics in Lake Okeechobee, Florida. Archiv fur Hydrobiologie, Advances in Limnology 45, 177–190.

Allen, M. S. and K. Tugend. 2002. Effects of a large-scale habitat enhancement project on habitat quality for age-0 largemouth bass at Lake Kissimmee, Florida. Pages 265-276. In D. Phillipp and M. Ridgeway (eds.) Black Bass: Ecology, Conservation and Management. American Fisheries Society, Bethesda, Maryland.

Anderson, R.O. and R.M. Neumann. 1996. Length, weight, and associated structural indices, In: B.R. Murphy and D.W. Willis (eds), Fisheries Techniques, Second Edition. American Fisheries Press, Bethesda, Maryland.

Bachmann, R.W., B.L. Jones, D.D. Fox, M. Hoyer, L.A. Bull, and D.E. Canfield, Jr. 1996. Relations between trophic state indicators and fish in Florida (U.S.A.) lakes. J. Can. Fish. Aquat. Sci. 53:842-855.

Bachmann, R. W., M. Hoyer, and D E. Canfield. 2003. Predicting the frequencies of high chlorophyll levels in Florida lakes from average chlorophyll or nutrient data. Lake and Reservoir Management 19(3): 229-241

Bancroft, G.T., A.M. Strong, R.J. Sawicki, W. Hoffman, and S.D. Jewell. 1994. Relationships among wading bird foraging patterns, colony locations, and hydrology in the Everglades, in: Everglades: the ecosystem and its restoration. Eds. S. Davis, and J.C. Ogden, St. Lucie Press, Delray Beach, FL., 615-87.

Bellrose, F.C. 1980. Ducks, geese and swans of North America. Stackpole Books, Harrisburg, PA.

Bennetts, R.E. and W.M. Kitchens. 1997. Population dynamics and conservation of snail kites in Florida: the importance of spatial and temporal scale. Colonial Waterbirds 20(2):324-329.

Bennetts, R.E., M..W. Collopy, and J.A. Rodgers, Jr. 1994. The Snail Kite in the Florida Everglades: a food specialist in a changing environment. Pages 507-532 in Everglades: the ecosystem and its restoration (S.M. Davis and J.C. Ogden, eds.). St. Lucie Press, Delray Beach, FL. 848pp.

Beissinger 1986. Demography, environmental uncertainty, and the evolution of mate desertion in the Snail Kite. Ecology 67: 1445-1459.

Bettoli, P. W., M. J. Maceina, R. L. Noble and R. K. Betsill. 1992. Piscivory in largemouth bass as a function of aquatic vegetation abundance. North American Journal of Fisheries Management 12:509-516.

Bonvechio, T. F. and M. S. Allen. 2005. Relations between hydrological variables and year-class strength of sportfish in eight Florida water bodies. Hydrobiologia 532:193-207.

Bonvechio, K. I. and T. F. Bonvechio. 2006. Relationship between habitat and sport fish populations over a 20-year period at West Lake Tohopekaliga, Florida. North American Journal of Fisheries Management 26:124-133.

Bottcher, A.B. 2006. Phosphorus Reduction Performance and Implementation Costs under BMPs and technologies in the Lake Okeechobee Protection Plan Area. Letter Report to South Florida Water Management District, West Palm Beach, FL.

Brown, S. J. and M. J. Maceina. 2002. The influence of disparate levels of submersed aquatic vegetation on largemouth bass population characteristics in a Georgia reservoir. J. Aquat. Plant Manage. 40:28-35.

Brush, J. M. 2006. Wetland avifauna usage of littoral habitat prior to extreme habitat modification in Lake Tohopekaliga, Florida. M.S. Thesis. University of Florida, Gainesville, Florida, USA.

Buehler, D.A. 2000. Bald Eagle (Haliaeetus leucocephalus). In A. Poole and F. Gill (eds). The Birds of North America, No. 506. The Birds of North America, Inc., Philadelphia, PA.

Butler, R.S., E.J. Moyer, M.W. Hulon and V.P. Williams. 1992. Littoral zone invertebrate communities as affected by a habitat restoration project on Lake Tohopekaliga. Journal of Freshwater Ecology 7:317-327.

Chamberlain, E.B., 1960. Florida waterfowl populations, habitats and management. Florida Game and Fresh Water Fish Commission, Technical Bulletin 7.

Chick, J.C. and C.C. McIvor. 1994. Patterns in the abundance and composition of fishes among beds of different macrophytes: viewing the littoral as a landscape. Canadian Journal of Fisheries and Aquatic Sciences 51:2873-2882.

Coffey, B.B., Jr. 1943. Post-juvenile migration of herons. Bird-banding 14:34-39.

Coffey, B.B., Jr. 1948. Southward migration of herons. Bird-banding 19:1-5.

Colle, D. E. and J. V. Shireman. 1980. Coefficients of condition for largemouth bass, bluegill, and redear sunfish in hydrilla-infested lakes. Transactions of American Fisheries Society 109: 521-531.

Darby, P.C., P.L. Valentine-Darby, H.F. Percival and W.M. Kitchens. 2002. Florida apple snail (Pomacea paludosa SAY) responses to lake habitat restoration activity. Archiv Fur Hydrobiologie 161:561-575.

Darby, P.C., R.E. Bennetts, S.J. Miller and H.F. Percival. 2004. Movements of Florida apple snails in relation to water levels and drying events. Wetlands 22:489-498.

Darby, P.C. 2005. Apple snail habitat relationships on central Florida lakes. Annual report prepared for Florida Fish and Wildlife Conservation Commission, Tallahassee, FL.

Davis, W. E., Jr., and J. Kricher. 2000. Glossy ibis (*Plegadis falcinellus*). *In* The Birds of North America, no. 545 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA and the American Ornithologists Union, Washington, D.C.

Delany, M.P. 1990. Late summer diet of juvenile American Alligators. Journal of Herpetology 24:418-421.

Delany, M.P., and C.L. Abercrombie. 1986. American Alligator food habits in northcentral Florida. Journal of Wildlife Management 50:348–353.

Delany, M.P., S.B. Linda, and C.T. Moore. 1999. Diet and condition of American Alligators in four Florida lakes. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 53:375–389.

Dreitz, V.J., J.D. Nichols, J.E. Hines, R.E. Bennetts, W.M. Kitchens, and D.E. DeAngelis. 2002. The use of resighting data to estimate the rate of population growth of the snail kite in Florida. Journal of Applied Statistics 29(4):609-623.

Durocher, P. P., W. C. Provine, and J. E. Kraai. 1984. Relationship between abundance of largemouth bass and submerged vegetation in Texas reservoirs. North American Journal of Fisheries Management 4:84–88.

Elphick, C., J.B. Dunning, JR., and D.A. Sibley. 2001. National Audubon Society The Sibley Guide to Bird Life and Behavior. Alfred A. Knopg, New York.

Fasola, M., L. Canova, and N. Saino.1996. Rice fields support a large portion of herons breeding in the Mediterranean region. Colonial Waterbirds 19 (Special Publication 1):129-134.

Florida Department of Environmental Protection (FDEP). 1996. Water Quality Assessment for the State of Florida. Main report submitted in accordance with the Federal Clean Water Act Section 305(b). Bureau of Watershed Management, Division of Water Resource Management, Florida Department of Environmental Protection, Tallahassee, FL.

Florida Department of Environmental Protection (FDEP). 2005. Chapter 62-303 Identification of Impaired Surface Waters. Bureau of Watershed Management, Division of Water Resource Management, Florida Department of Environmental Protection, Tallahassee, FL.

Florida Department of Environmental Protection (FDEP). 2006. Water Quality Assessment Report: Kissimmee River and Fisheating Creek. Bureau of Watershed Management, Division of Water Resource Management, Florida Department of Environmental Protection, Tallahassee, FL.

Frederick, P.C. and J.C. Ogden. 2001. Pulsed breeding of long-legged wading birds and the importance of infrequent severe drought conditions in the Florida Everglades. Wetlands 21:484-491.

Florida Fish and Wildlife Conservation Commission (FWC). 2006. Unpublished Catch Data for Lakes Kissimmee and Lake Tohopekaliga provided by Tim Coughlin in 2006.

Florida Fish and Wildlife Conservation Commission, 2003. Eagle Nest Locator, http://myfwc.com/eagle/eaglenests/nestlocator.aspx. Accessed May 10, 2007.

Florida Fish and Wildlife Conservation Commission, 2008. Eagle Nest Locator, http://myfwc.com/eagle/eaglenests/Default.asp. Accessed May 10, 2007.

Frederick, P. C. 1997. Tricolored heron (*Egretta tricolor*). In The Birds of North America, no. 306 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA and the American Ornithologists Union, Washington, D.C.

Frederick, P.C. T. Towles, R. Sawicki, and G.T. Bancroft. 1996. Comparison of aerial and ground techniques for discovery and census of wading bird (Ciconiiformes) nesting colonies. The Condor 98:837-841.

Gawlik, D.E. 2002. The effects of prey availability on the numerical response of wading birds. Ecological Monographs. 72(3): 329-346.

Gerritsen, J.B., B.K. Jessup, E. Leppo, and J. White. 2000. Development of lake condition indexes (LCI) for Florida. Prepared for the Florida Department of Environmental Protection, Tallahassee, Florida.

Gladden, J. E. and L. A. Smock. 1990. Macroinvertebrate distribution and production on the floodplains of two lowland headwater streams. Freshwater Biology 24:533–545.

Gray, P.N. 1993. Biology of a southern mallard: Florida's mottled duck. Dissertation, University of Florida, Gainesville, FL.

Gregory, R.W., A.V. Zale and R. Conrow. 1990. Distributions and abundances of early life stages of fishes in a Florida lake dominated by aquatic macrophytes. Transactions of the American Fisheries Society 119:521-528.

Griffith, G.E., D.E. Canfield, Jr., C.A. Horsburgh and J.M. Omernik. 1997. Lake Regions of Florida. EPA/R-97/127 U.S. Environmental Protection Agency, Corvallis, OR.

Havens, K.E. 2003. Phosphorus-algal bloom relationships in large lakes of South Florida: Implications for establishing nutrient criteria. Lake and Reservoir Management 19:222-228.

Havens, K.E. and W.W. Walker. 2002. Development of a total phosphorus concentration goal in the TMDL process for Lake Okeechobee, Florida (USA). Lake and Reservoir Management 18: 227-238.

Havens, K. E., D. Fox, S. Gornak, and C. Hanlon. 2005. Aquatic vegetation and largemouth bass population responses to water-level variations in Lake Okeechobee, Florida (USA). Hydrobiologia 539:225-237.

Hoyer, M. V., and D. E. Canfield, Jr. 1996. Largemouth bass abundance and aquatic vegetation in Florida lakes: An emperical analysis. Journal of Aquatic Plant Management 34:23-32.

Hoyer, M. V., C. D. Brown, and D. E. Canfield, Jr. 2004. Relations between water chemistry and water quality as defined by lake users in Florida. Lake and Reservoir Management 20:240-248.

Johnson, K.G., M.S. Allen, and K.E. Havens. 2007. A review of littoral vegetation, fisheries, and wildlife responses to hydrologic variation at Lake Okeechobee. Wetlands 27(1):110-126.

Karr, J. R. 1991. Biological integrity: A long-neglected aspect of water resource management. Ecological Applications 1: 66–84.

Karr, J., M.S. Allen and A.G. van der Valk. 2007. Environmental Peer Review of the Scientific and Technical Basis for Management Decision-Making as Described in the Draft Kissimmee Chain of Lakes Long-Term Management Plan. Final Peer Review Report. Prepared for the South Florida Water Management District, West Palm Beach, FL.

Kohler, C. C., R. J. Sheehan, and J. J. Sweatman. 1993. Largemouth bass hatching success and first-winter survival in two Illinois reservoirs. North American Journal of Fisheries Management 13:125–133.

Kushlan, J.A. 1978. Feeding ecology of wading birds. pp. 249-296 in Wading birds, A. Sprunt, IV, J. C. Ogden and S. Winckler, eds. Natl. Audubon Soc., New York, New York.

Kushlan, J.A. 1981. Resource use strategies of wading birds. Wilson Bulletin 93(2):145-163.

Loery, G., J. Nicholas, and J. D. Hines. 1997. Capture-recapture analysis of a wintering Black-capped Chickadee populationin Connecticut, 1958 1993. Auk 114:431-442.

Martin, J., W. Kitchens, C. Cattau, A. Bowling, M. Conners, D. Huser, and E. Powers. 2006a. Snail kite demography annual report 2005. Unpublished report to the Fish and Wildlife Service; Vero Beach, FL.

Martin, J., J.D. Nichols, W.M. Kitchens, and J.E. Hines. 2006b. Multiscale patterns of movement in fragmented landscapes and consequences on demography of the snail kite in Florida. Journal of Animal Ecology 75:527-539.

Mazzotti, F.J., and Brandt, L.A., 1994, Ecology of the American alligator in a seasonally fluctuating environment; in S. Davis and J. Ogden, (eds.), Everglades: The Ecosystem and its Restoration: Delray Beach, Florida, St. Lucie Press, p. 485-505.

Meals, K. O. & L. E. Miranda, 1991. Variability in abundance of age-0 centrarchids among littoral habitats of flood control reservoirs in Mississippi. North American Journal of Fisheries Management 11: 298–304.

Melvin, S.L., D. Gawlik, and T. Scharff. 1999. Long-term movement patterns for seven species of wading birds. Waterbirds 22(3):411-416.

McCrimmon, D. A., Jr., J. C. Ogden, and G. T. Bancroft. 2001. Great egret (*Ardea alba*). In The Birds of North America, no. 570 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA and the American Ornithologists Union, Washington, D.C.

Milleson, J.F. 1975. Progress Rreport Upper Kissimmee Chain of Lakes Water Quality and Benthic Invertebrate Sampling. Technical Publication 75-2. Central and Southern Florida Flood Control District. West Palm Beach, FL.

Miranda, L. E., and L. L. Pugh. 1997. Relationship between vegetation coverage and abundance, size, and diet of juvenile largemouth bass during winter. North American Journal of Fisheries Management 17:601–610.

Miranda, L. E., W. L. Shelton, and T. D. Bryce. 1984. Effects of water level manipulation on abundance, mortality, and growth of young-of-year largemouth bass in West Point Reservoir, Alabama–Georgia. North American Journal of Fisheries Management 4:314–320.

Mitchell, D.F. 1982 Effects of water level fluctuation on reproduction of largemouth bass, Micropterus-salmoides, at Millerton Lake, California in 1973. CCalifornia Fish and Game 68(2): 68-77.

Moyer, E.J. and V.P. Williams. 1982. Effects of lake bottom channelization on invertebrate fish food organisms on Lake Tohopekaliga, Florida. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 36:294-304.

Nesbitt, S. A., J. C. Ogden, H. W. Kale, B. W. Patty, and L. A. Rowse. 1982. Florida atlas of breeding sites for herons and their allies, 1976-1978. U. S. Fish and Wildlife Service, Office of Biological Services.

Omernik, J.M. 1987. Ecoregions of the conterminous United States. Map (scale 1:7,500,000). Annals of the Association of American Geographers 77(1):118-125.

Paul, M. J., and J. Gerritsen. 2002. Nutrient criteria for Florida lakes: A comparison of approaches. Prepared for the Florida Department of Environmental Protection, Tallahassee, Florida.

Plafkin, J.L, et al. 1989. Rapid Bioassessment Protocols for Use in Streams and Rivers; Benthic Macroinvertebrates and Fish. U.S. E.P.A., Cincinnati, OH (Publ No. EPA/440/4-89/001).

RECOVER. 2004a. CERP Monitoring and Assessment Plan: Part 1 Monitoring and Supporting Research. Restoration Coordination and Verification Program, c/o United States Army Corps of Engineers, Jacksonville District, Jacksonville, Florida, and South Florida Water Management District, West Palm Beach, FL.

Reiss, C.R. and M.T. Brown. 2007. Evaluation of Florida Palustrine Wetlands: Application of USEPA Levels 1, 2, and 3 Assessment Methods. Ecohealth 4:206-218.

Rodgers, J.A., Jr. 2007. Breeding success of Rostrhamus sociabilis (snail kites) at two Florida lakes. Southeastern Naturalist 6:35-46.

Rodgers, J.A., and S.T. Schwkert. 2001. Effects of Water Fluctuations on Snail Kite Nesting on Lake Kissimmee. Unpublished report, Florida Fish and Wildlife Conservation Commission. Gainesville, FL.

Rodgers, J.A., and S.T. Schwkert. 2003. Breeding chronology of snail kites (Rostrhamus sociabilis plumbeus) in central and south Florida wetlands. Southeastern Naturalist 2(2):293-300.

Rodgers, J. A., Jr., and H. T. Smith. 1995. Little blue heron (*Egretta caerulea*). In The Birds of North America, no. 145 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA and the American Ornithologists Union, Washington, D.C.

Rosenberg, D.M. and V.H. Resh. 1993. Introduction to freshwater biomonitoring and benthic macroinvertebrates, p. 1-9. In: D.M. Rosenberg and V.H. Resh (eds.) Freshwater biomonitoring and benthic macroinvertebrates. Chapman and Hall, New York.

Runde, D.E., J.A. Gore, J.A. Hovis, M.S. Robson, and P.D. Southall. 1991. Florida atlas of breeding sites of herons and their allies: update 1986-1989. Non-game Wildlife Program Technical Report No. 10, Florida Game and Freshwater Fish Commission, Tallahassee, FL.

Sammons, S.M. and P.W. Bettoli. 2000. Population dynamics of a reservoir sportfish community in response to hydrology. North American Journal of Fisheries Management 20, 791–800.

Savino, J.F. and R.A. Stein. 1982. Predator-prey interactions between largemouth bass and bluegills as influenced by simulated, submersed vegetation. Transactions of the American Fisheries Society 111:255-347.

Shapiro, A.E., F. Montalbano, III, and D. Mager. 1982. Implications of Construction of a Flood Control Project Upon Bald Eagle Nesting Activity. Wilson Bull., 94(l): 55-63.

Sheaffer, W. A. and J. G. Nickum. 1986. Relative abundance of macroinvertebrates found in habitats associated with backwater area confluences in Pond 13 of the Upper Mississippi River. Hydrobiologia 136: 113-120.

South Florida Water Management District (SFWMD). 2007. Draft Kissimmee Chain of Lakes Long Term Management Plan. South Florida Water Management District, West Palm Beach, FL.Strong, A.M., G.T. Bancroft, and S.D. Jewell. 1997. Hydrological constraints on tricolored heron and snowy egret resource use. The Condor 99:894-905.

Strong, A.M., G.T. Bancroft and S.D. Jewell. 1997. Hydrological constraints on tricolored heron and snowy egret resource use. The Condor 99:894-905.

Summerfelt, R. C. and K. E. Shirley. 1978. Environmental correlates to year-class strength of largemouth bass (Micropterus salmoides) in Lake Carl Blackwell. Proceedings of the Oklahoma Academy of Science 58: 54-63.

Sykes, P.W., Jr. 1979. Status of the Everglade Kite in Florida, 1968-1978. Wilson Bulletin 91:495-511.

Sykes, Jr., P. W., J. A. Rodgers, Jr. and R. E. Bennetts. 1995. Snail Kite (Rostrhamus sociabilis), The Birds of North America Online Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/171doi:10.2173/bna.171.

Takekawa, J. and S. Beissinger. 1989. Cyclic drought, dispersal, and the conservation of the Snail Kite in Florida: Lessons in critical Habitat. Conservation Biology 3(3): 302-311.Buehler, D. A. 2000. Bald Eagle (Haliaeetus leucocephalus). In The Birds of North America, No. 506 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Trebitz, A. S., and eleven coauthors. 1997. A model of bluegill–largemouth bass interactions in relation to aquatic vegetation and its management. Ecological Modelling 94:139–156.

Valley, R. D., and M. T. Bremigan. 2002. Effects of macrophyte bed architecture on largemouth bass foraging: implications of exotic macrophyte invasions. Transactions of the American Fisheries Society 131:234-244.

Waters, D.S., and R.L. Noble. 2004. Spawning season and nest fidelity of largemouth bass in a tropical reservoir. North American Journal of Fisheries Management 24: 1240-1251.

Weller, M.W. 1995. Use of two waterbird guilds as evaluation tools for the Kissimmee River restoration. Restoration Ecology 3(3):211-224.

Weller, M.W. 1999. Wetland Birds: Habitat Resources and Conservation Implications. Cambridge University Press, Cambridge, UK.

White, J., M. Belmont, K.R. Reddy and C. Martin. 2004. Phosphorus sediment water interactions in Lakes Istokpoga, Kissimmee, Tohopekaliga, Cypress and Hatchineha. University of Florida-IFAS. Contract report to the South Florida Water Management District, West Palm Beach, FL.

Williams, V.P., E.J. Moyer and M.W. Hulon. 1979. State of Florida Game and Fresh Water Fish Commission 1974-1979 Water Level Manipulation Project F-29-8 completion report for study III Lower Kissimmee Basin Study. Florida Game and Fresh Water Fish Commission, Kissimmee, FL.

Wood, P.B., T.C. Edwards, and M.W. Collopy. 1989. Characteristics of bald eagle nesting habitat in Florida. Journal of Wildlife Management 53(2):441-449.Reiss, K.C., and M.T. Brown. 2007. An evaluation of Florida depressional wetlands: application of USEPA Levels 1, 2, and 3 assessment methods. EcoHealth 4:206-218.

Appendix K
Management Tools

Introduction

Long-term management of the KCOL watershed to enhance and/or sustain lake ecosystem health will require a variety of management tools designed to address the landscape changes and water supply demands expected under projected population growth within the region. Impacts frequently associated with landscape change are habitat loss and fragmentation and degradation of water, natural resources, and water quality through changes in drainage patterns and increases in the volume, timing, distribution, and rate of surface water runoff. These types of impacts have the potential to prevent the achievment long-term fish and wildlife, water quality, and water supply objectives.

This chapter summarizes existing tools available to federal, state, and local government agencies within the KCOL to address the management challenges that were described in Chapter 4. Where no tools exist, recommendations are made to fill management gaps.

Management Tool Set

Management tools for the KCOL are grouped into two categories: watershed management and in-lake management tools. The watershed management tools are used to manage the landscape surrounding the lakes and the quantity and quality of the water flowing into the lakes. In-lake management tools are used to manage the water and habitat within the C&SF Project lakes and associated fish and wildlife resources.

Watershed Management Tools – Planning

The protection of natural resources through planning is based on the principle that the inherent environmental characteristics render particular sites more suitable for some land uses than for others. While both planning and the environmental resource permitting process (described below) seek to eliminate resource impacts, the planning review process does this up-front, usually prior to site selection. Permitting processes are typically reactive and are limited to a proposed plan of development at a specific site.

Comprehensive Planning

Comprehensive planning is intended to guide future growth and development within counties and municipalities. Comprehensive plans contain chapters or "elements" that address future land use, housing, transportation, infrastructure, coastal management, conservation, recreation and open space, intergovernmental coordination, and capital improvements (http://www.dca.state.fl.us/fdcp/dcp/compplanning/index.cfm).

Federal Role: Although the federal government does not control land use planning or growth management, federal agencies work with local and state governments, consulting engineers, and environmental consultants to avoid, minimize, or compensate for environmental impacts of development plans. For example the U.S. Fish and Wildlife Service is encouraged to engage in early coordination to assist an applicant in determining if wetlands or federally endangered or threatened species could be impacted by the proposed activity. The intent is to provide early notification of potential issues before an applicant has committed significant resources toward specific plans or designs. This has an effect on the ultimate design of projects with the intent of protecting natural resources.

State Role: The Growth Management Act authorizes the Florida Department of Community Affairs (FDCA), Division of Community Planning, to review comprehensive plans and plan amendments for compliance with the Act. Other review agencies, including the regional planning councils; water management districts; the Departments of State, Transportation, Environmental Protection, and Agriculture and Consumer Services; and the Florida Fish and Wildlife Conservation Commission review comprehensive plans and amendments and issue recommended objections to FDCA.

The FDEP's Office of Intergovernmental Programs (OIP) and the SFWMD's Department of Intergovernmental Programs coordinate each agency's involvement in statewide planning activities, although the nature and level of participation varies. While local government comprehensive plans have already been adopted, hundreds of plan amendments are reviewed by OIP and the SFWMD Department of Intergovernmental Programs each year. In addition, local governments must update their comprehensive plans every seven years through the Evaluation and Appraised Report (EAR) process. The FDEP and SFWMD have the opportunity to review proposed amendments that are based upon the local government's EAR to ensure they are consistent with the agencies' statutory and regulatory authorities. In addition to these formal review processes, the FDEP and SFWMD can informally communicate issues and concerns to the FDCA, the Regional Planning Councils (RPC), local governments, and other stakeholders.

Local Role: Florida's Growth Management Act (Chapter 163, Part II, F.S.) requires all of Florida's 67 counties and 410 municipalities to adopt Local Government Comprehensive Plans that guide future growth and development. Local government comprehensive plans provide the policy foundation for land use decisions on capital improvements, conservation, intergovernmental coordination, open space, recreation, future land use, housing, traffic circulation, coastal management, water supply, and public facilities.

Most of the FDEP's and SFWMD's comprehensive plan review activity involves amendments to adopted plans. The agencies' reviews provide an opportunity to inform local decision makers of state initiatives and encourage local development to be consistent with the agencies' rules, programs, and policies. Proposed amendments can be in the form of: (1) map amendments that propose changes to a local government's future land use map; (2) text amendments that propose changes to the goals, objectives, and policies of the adopted comprehensive plan; or (3) EAR-based amendments resulting from the evaluation and update of a local government's comprehensive plan. As part of the Osceola County Comprehensive Plan, goals have been established for habitat conservation and management.

Development of Regional Impacts

Developments of Regional Impact (DRI), as defined by Chapter 380.06(1), Florida Statutes (F.S.), are any development that would have a substantial impact on the health, safety, or welfare of citizens in more than one county. The state has established thresholds to determine when a development must undergo the DRI review process. These determinations are made by the Florida Department of Community Affairs using Chapter 28-24, Florida Administrative Code (F.A.C.).

Several types of developments may be treated similarly to a DRI, including specially defined DRI types, Florida Quality Developments (FQDs), and those reviewed under the Florida Expedited Permitting program. All DRIs and FQDs are regulated by Chapter 380.06, F.S.

Federal: Both the USACE and the USFWS review permit applications if they have been submitted at the time of the DRI review process. These reviews are consistent with the USFWS Coordination Act to comment on fish and wildlife impacts and the Section 7 Endangered Species Act consultations. If a permit application has not been submitted, the federal agencies provide technical assistance to local counties, as appropriate.

State: The DRI review process is a state planning tool. This process, which is led by the local regional planning council, was established to identify issues early in the planning process, provide for an extra-jurisdictional approach, allow for state and regional agency expertise and technical assistance, and to assess and mitigate project impacts to state and regional resources and facilities. Three main entities are involved with the implementation of the DRI process: the local government, the Regional Planning Council (RPC), and the Department of Community Affairs.

Typical DRI requirements include water and wastewater planning, storm water management performance expectations, low impact design (minimize clearing of native vegetation, minimize soil compaction, minimize imperviousness, minimize directly connected impervious area), Florida Friendly Landscaping, Florida Friendly fertilizers, landscaping per the Florida Green Industry best management practice (BMP) program, and golf course BMPs.

The RPC coordinates the multi-agency review activities at the regional level and reviews the application for consistency with adopted state and regional plans. The RPC holds a public hearing to adopt recommendations on the application, which then are forwarded to the local government of jurisdiction for its consideration. The RPC is an advisory body to the local government, and so does not approve or deny applications.

Local: The local planning agency (LPA) plays a lead role in identification of local issues or concerns relative to the project and will take the Regional Planning Council's recommendations and combine them with other recommendations to construct an overall development order. The local government's governing body also will hold a public hearing on the project, at which time it will consider the reports of the RPC and LPA. If the local government decides to approve development, it will issue a Development Order.

The Development Order is the binding order that authorizes and formally approves the DRI. It is executed between the applicant and the local government. The Development Order spells out most, if not all, of the binding conditions to be imposed upon the DRI and usually includes any separate agreements made to resolve specific regional issues. At a minimum, conditions of approval would include mitigation requirements, monitoring procedures, Development Order compliance, commencement and termination dates, requirements for the annual report, and a legal description of the property.

There are a number of upcoming large development projects adjacent to Lake Toho that are currently in plan review by the SFWMD and Osceola County. There is an ongoing coordination process involving Osceola County, the East Central Florida Regional Planning Council, SFWMD, FWC, and USFWS whose purpose is to shape the county's ongoing policy regarding its role in habitat conservation and management. This process originated with the Toho Environmental Working Group as a means to address habitat conservation and lake protection issues related to several Developments of Regional Impact located along the eastern shore of Lake Toho. This coordination process is evaluating the potential impacts of these projects on shoreline habitat, snail kites, boating pressure, and water quality.

Water Supply Planning

Recognizing the importance of an adequate water supply to Florida's future, the legislature has established a process for water supply planning through Florida's Growth Management Act (Chapter 163, Part II, F.S.) and the Water Protection and Sustainability Program (Chapter 373, F.S.). The precedent-setting law encourages cooperation between municipalities, counties, and the state's five water management districts in the protection and development of water supplies. More specifically, the law requires the regional water supply planning function of water management districts to promote alternative water supply projects – for example tapping reclaimed and storm water – both to accommodate growth and to reduce the use of traditional ground and surface water supplies, such as aquifers and lakes.

Federal: No federal agencies currently provide input into the water supply planning process.

State: One of the SFWMD's core mission elements, as mandated by the Water Resources Act (Chapter 373, F.S.) and the Water Resources Implementation Rule (Chapter 62-40, F.A.C.) is the conservation and development of water supply. Under these mandated activities, Florida's five water management districts are required to periodically evaluate whether adequate water supplies exist to meet the needs of their areas. If a district finds that the water supply will not be adequate, it must prepare regional water supply plans for those areas, identifying how water supply needs can be met for the next 20 years.

The FDEP is responsible for overseeing water supply conservation and development and ensuring that water management programs, rules, and plans seek to:

- Assure availability of an adequate and affordable supply of water for all reasonable-beneficial uses;
- Restore and protect the quality of ground and surface water by solving current problems and ensuring high quality treatment for storm water and wastewater;
- Identify existing and future public water supply areas and protect them from contamination;
- Encourage nonstructural solutions to water resource problems and give adequate consideration to nonstructural alternatives whenever structural works are proposed;

- Manage the construction and operation of facilities that dam, divert, or otherwise alter the flow of surface waters to minimize damage from flooding, soil erosion, or excessive drainage;
- Encourage the management of floodplains and other flood hazard areas to prevent or reduce flood damage, consistent with establishment and maintenance of desirable hydrologic characteristics and associated natural systems;
- Encourage the development and implementation of a strict floodplain management program by state, regional, and local governments designed to preserve floodplain functions and associated natural systems;
- Avoid the expenditure of public funds that encourage or subsidize incompatible new development or significant expansion of existing development in high-hazard flood areas;
- Minimize flood-related emergencies, human disasters, loss of property, and other associated impacts;
- Establish minimum flows and levels to protect water resources and the environmental values associated with marine, estuarine, freshwater, and wetlands ecology;
- Mitigate adverse impacts resulting from prior alteration of natural hydrologic patterns and fluctuations in surface and groundwater levels;
- Utilize, preserve, restore, and enhance natural water management systems and discourage the channelization or other alteration of natural rivers, streams, and lakes; and
- Protect the water storage and water quality enhancement functions of wetlands, floodplains, and aquifer recharge areas through acquisition, enforcement of laws, and the application of land and water management practices that provide for compatible uses.

Local: Local governments that fall within the area of a regional water supply plan are required to ensure that adequate water supplies will be available to meet future demand by developing 10-year water supply facilities work plans. These work plans include alternative water supplies and water reuse and conservation programs, and are incorporated into the local governments' comprehensive plans. In addition, all local governments – regardless of whether they are in one of these planning areas – must address water supply in their concurrency management programs.

Since July 2005, the FDCA has required that local governments submitting comprehensive plan amendments include data and analysis to demonstrate that water supplies are sufficient to support development.

Water Supply Concurrency

After uncontrolled growth in Florida required expensive public works improvements to provide facilities for communities built far from existing urban centers, the concept of concurrency was developed (Stuart 1994). Section 163.3180(2)(a), F.S., requires local governments to consult with water suppliers to ensure that adequate water supplies will be in place and available to serve new development no later than the date when the local government issues a certificate of occupancy or its functional equivalent. The premise of concurrency is that the public facilities will be provided to achieve and maintain the adopted level-of-service standard (S. 163.3180(13)(c), F.S.). Concurrency is now a central component of land planning.

Water supply utilities in central Florida are projecting water deficits in the future. The utilities are working in close cooperation with the state's water management districts to identify alternative water supply projects. Water supply concurrency provides an incentive for utilities to work closely with local planning agencies to find innovative solutions to meet these future demands.

Federal: No federal agencies currently provide input into the water supply concurrency evaluation process.

State: The state's water management districts have updated their regional water supply plans, which identify areas where water supply shortages are projected to occur within the next 20 years. The regional water supply plans identify alternative projects to be implemented by local governments in these areas to supplement their traditional sources of water to meet projected demand.

Local: Section 163.3180(2) (a), F.S., requires local governments to consult with water suppliers to ensure that adequate water supplies will be in place and available to serve new development no later than the date when the local government issues a certificate of occupancy or its functional equivalent.

Watershed Management Tools – Environmental Regulations and Permitting

The permitting process generally identifies site-specific resource constraints and results in permit approval, denial, or approval-with-conditions, which often consists of actions aimed at eliminating or reducing negative impacts. For example, once an applicant for an ERP demonstrates that impacts to wetlands and other surface waters cannot be eliminated and further reductions are not practicable, then mitigation may be considered. Permitting is, therefore, more limited than planning in its ability to assess where development might best be located.

Environmental regulations are intended to minimize the impacts of new development on wetlands, surface water flows, and/or water pollution. Dredge and fill permits, ERPs, and Municipal Separate Storm Water System (MS4) permits regulate urban development in various degrees, as described below.

Dredge and Fill Permits

Dredge and fill permits are required for construction, excavation, or deposition of materials in any navigable water of the United States.

Federal: Enabling legislation is provided by the Rivers and Harbors Acts of 1890 (superseded) and 1899 (33 U.S.C. 401, et seq.). Various sections establish permit requirements to prevent unauthorized obstruction or alteration of any navigable water of the United States. The most frequently exercised authority is contained in Section 10 (33 U.S.C. 403), which covers construction, excavation, or deposition of materials in, over, or under such waters, or any work which would affect the course, location, condition, or capacity of those waters. In 1972, amendments to the Federal Water Pollution Control Act added what is commonly called Section 404 authority (33 U.S.C. 1344) to the program. The Secretary of the Army, acting through the Chief of Engineers, is authorized to issue permits, after notice and opportunity for public hearings, for the discharge of dredged or fill material into waters of the United States at specified disposal sites. Selection of such sites must be in accordance with guidelines developed by the United States Environmental Protection Agency (USEPA) in conjunction with the Secretary of the Army; these guidelines are known as the 404(b)(1) Guidelines. The discharge of all other pollutants into waters of the United States is regulated under Section 402 of the act. The Federal Water Pollution Control Act was further amended in 1977 and given the common name of the "Clean Water Act" and was again amended in 1987 to modify criminal and civil penalty provisions and to add an administrative penalty provision.

State: Section 373.414, F.S., designates the FDEP and the SFWMD as the agencies responsible for processing applications for dredging, filling, and construction activities in wetlands or surface waters of South Florida.

Under Section 373.414, F.S., as part of an applicant's demonstration that an activity will not be harmful to water resources or be inconsistent with the overall objectives of the water management district, applicants must demonstrate that the proposed activity will not adversely affect water flow or impede navigation.

Section 373.414, F.S., 18.21 F.S. (if SSL), 18-20 F.S. (if AP), and Section 267.061, F.S. concern dredging of natural waterways and regulation of wetlands. In determining whether an activity is in the public interest, the FDEP must consider whether the activity will: 1) adversely affect the public health, safety, or welfare or the property of others, 2) adversely affect the conservation of fish and wildlife, including endangered or threatened species, or their habitats, 3) adversely affect navigation or the flow of water or cause harmful erosion or shoaling, 4) adversely affect the fishing or recreational values in the vicinity, 5) be of a temporary or permanent nature, 6) adversely affect or enhance significant historical and archaeological resources under the provisions of Section 267.061 F.S. The FDEP also must consider the current condition and relative value of functions being performed by areas affected by the proposed activity.

Sections 373.414, F.S., and 267.061, F.S., address impacts from aquatic plant beds, tussocks, and muck berms on dissolved oxygen. Also, Sections 373.414, F.S., and 403.031(13), F.S., require that water quality impacts be considered in project design. As part of an applicant's demonstration that an activity will not be harmful to water resources, the FDEP requires the applicant to provide reasonable assurance that state water quality standards applicable to waters as defined in Section 403.031(13), F.S., will not be violated.

Local: No local agencies currently provide input into the evaluation of drege and fill permits..

Environmental Resource Permits

Environmental Resource Permits ensure that alteration of surface water flows, changes in uplands that alter stormwater runoff, and dredging and filling in wetlands and other surface waters. The program’s purpose is to ensure that alterations do not degrade water quality, compromise flood protection, or adversely affect the function of wetland systems.

Federal: The United States Army Corps of Engineers has been involved in regulating activities by others in navigable waterways through the granting of permits since passage of the Rivers & Harbors Act (Section 10) of 1899. Passage of the Clean Water Act (Section 404) in 1972 greatly broadened this role by giving the USACE authority over dredging and filling in the waters of the United States, including many wetlands. There are generally two types of activities that require a permit from the USACE. The first includes activities within navigable waters. Activities such as dredging, construction of docks and bulkheads, and placing navigation aids require review under

Section 10 of the Rivers and Harbors Act of 1899 to ensure that they will not cause an obstruction to navigation. The second part of the program, Section 404 of the Clean Water Act of 1972 regulates other activities in waters of the United States. A major aspect of the regulatory program under Section 404 of the Clean Water Act is determining which areas qualify for protection as wetlands. In reaching these decisions, the USACE uses its 1987 Wetland Delineation Manual.

The USFWS reviews ERPs and wetland permits and provides biological opinions regarding habitat impacts of proposed projects on rare, threatened, and endangered species. This review is in compliance with the Endangered Species Act (16 U.S.C. 1531-1544, 87 Stat. 884, as amended – Public Law 93-205, approved December 28, 1973). Section 7(a)(2) requires federal agencies to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of listed species or modify their critical habitat.

Section 10(a)(2)(A) requires applicants seeking permits to "take" listed species to submit a conservation plan specifying impacts to listed species, steps taken to minimize and mitigate impacts to listed species, alternative actions considered and reasons why alternatives were not utilized, and other such measures that the Secretary of the Interior may require as necessary or appropriate for purposes of the conservation plan.

State: The Environmental Reorganization Act of 1990 granted the water management districts (WMD) independent authority to regulate stormwater quality under the ERP program. Prior to this act, ERP program authority was held solely by the FDEP. This program covers the entire state and regulates activities involving the alteration of surface water flows, changes in uplands that alter stormwater runoff, and dredging and filling in wetlands and other surface waters. The program's purpose is to ensure that alterations do not degrade water quality, compromise flood protection, or adversely affect the function of wetland systems. ERPs are issued pursuant to the provisions of Chapter 373, F.S., and applicable rules under the F.A.C. The FDEP coordinates the review of all projects with the USACE, the FWC, and the USFWS. All projects requiring an ERP permit must:

- Not cause adverse water quantity impacts to receiving waters and adjacent lands;
- Not cause adverse flooding to on-site or off-site property;
- Not cause adverse impacts to existing surface water storage and conveyance capabilities;
- Not adversely impact the value of functions provided to fish and wildlife and listed species by wetlands and other surface waters;
- Not adversely affect the quality of receiving waters such that state water quality standards will be violated;
- Not cause adverse secondary impacts to water resources;
- Not adversely impact the maintenance of surface or groundwater levels or surface water flows;
- Not adversely impact a work of a water management district;
- Be capable; based on generally accepted engineering and scientific principles, of being performed and of functioning as proposed;

- Be conducted by an entity with the financial, legal, and administrative capability of ensuring that the activity will be undertaken in accordance with the terms and conditions of the permit, if issued; and
- Comply with applicable special basin or geographic area criteria adopted by rule.

More information is available at http://www.dep.state.fl.us/water/wetlands/erp/index.htm.

Since 1993 existing urban developments in excess of 100 acres are required to comply with the existing stormwater requirements for ERPs, which are usually:

- Storage of 1 inch of runoff from impervious surfaces within a site to address water quality concerns;
- Attenuation of the 10-year, 3-day peak flow to the pre-development peak flow;
- Minimize impact to wetlands with mitigation required for destruction of more than 1 acre, cumulatively across the site; and
- Agricultural lands are required to maintain 15 percent of the site in natural cover and route of farm runoff through these natural lands prior to discharge (SFWMD 2006a).

Local: No local agencies currently provide input into the ERP evaluation process.

National Pollutant Discharge Elimination System Permits

MS4 permits regulate stormwater discharges from municipal separate storm sewer systems (MS4s) to surface waters of the state.

Federal: In October 2000, the USEPA authorized the FDEP to implement the National Pollutant Discharge Elimination System (NPDES) stormwater permitting program in Florida (in all areas except tribal lands).

State: The FDEP's authority to administer the NPDES program is set forth in Section 403.0885, F.S. A MS4 is a publicly-owned conveyance or system of conveyances (i.e., ditches, curbs, catch basins, underground pipes, etc.) that is designed or used to collect or convey storm water and that discharges to surface waters of the state. An MS4 can be operated by municipalities, counties, drainage districts, colleges, military bases, or prisons, to name a few examples.

As implemented by Chapter 62-624, F.A.C., Phase I addresses discharges of stormwater runoff from "medium" and "large" MS4s (i.e., those MS4s located in areas with populations of 100,000 or greater). Under Phase II, the program regulates discharges from certain MS4s not regulated under Phase I and that meet designation criteria set forth in Chapter 62-624, F.A.C. Regulated MS4 operators must obtain an NPDES stormwater permit and implement a comprehensive stormwater management program to reduce the contamination of stormwater runoff and prohibit illicit discharges to the MS4.

The following links provide more detailed information:

- http://www.dep.state.fl.us/legal/rules/shared/62-624.pdf
- http://www.dep.state.fl.us/water/stormwater/npdes/MS4_2.htm

- http://cfpub.epa.gov/npdes/stormwatermonth.cfm

Local: No local agencies currently provide input into the NPDES evaluation process.

Regulations Under Development

Basin Rule: ERP regulations have been reviewed for adequacy as part of the Northern Everglades Lake Okeechobee Watershed Construction Project Phase II Technical Plan (SFWMD 2008). The Phase II Technical Plan has additional requirements in development for both urban and agricultural lands. These new regulations are intended to require new development projects to demonstrate that post-development pollutant loads will be less than pre-development pollutant loads and runoff volumes following development will be no greater than pre-development volumes. The ERP basin rule will require applicants to provide reasonable assurances that they will appropriately improve the hydrology within the Lake Okeechobee watershed in accordance with Chapter 272.4595, F.S. The basin rule will be supplemental to existing criteria. Average annual discharge volumes and specific storm event discharge volumes will be addressed. Methods for estimating storage capacities in typical water BMPs and in low impact design type water BMPs will be included in the rule (SFWMD Northern Everglades Phase II Technical Plan, page 3-5).

Statewide Unified Stormwater Rule: Chapter 17-25, F.A.C. (now Chapter 62-25, F.A.C.), the original statewide stormwater rule, was promulgated in 1982. Since its creation, the rule has been amended to incorporate research findings. However, most of the state's stormwater criteria are based on research that predated 1995 and focused on an 80 percent average annual load reduction in total suspended solids (TSS). Research has indicated that current design and performance criteria fail to properly address nutrient loadings resulting from typical stormwater runoff conditions.

As a result, the FDEP is in the process of revising this rule. As part of the rule revision, the FDEP contracted Environmental Research & Design, Inc. to submit the *Evaluation of Current Stormwater Design Criteria within the State of Florida: Final Report* in 2007. This report, which can be accessed on the FDEP website (http://www.dep.state.fl.us/water/wetlands/erp/rules/stormwater/index.htm), found that the current stormwater rules do not achieve the 80 percent reductions in TSS. Based on these findings, the proposed statewide stormwater rule provides for the following objectives:

- To update the water quality treatment rules of the ERP program to increase the effectiveness of new stormwater treatment systems for removing nutrients and reducing nutrient loads;
- To reduce the number of water bodies that become impaired by nutrients in the future (currently, about 45 percent of Florida's verified impaired waters are nutrient-related impairments);
- To meet the goal of the Water Resource Implementation Rule, Chapter 62-40, F.A.C., to assure that post-development stormwater characteristics do not exceed pre-development stormwater characteristics (e.g., peak discharge rate, pollutant load, volume); and
- To streamline stormwater permitting and to make stormwater regulatory requirements more consistent throughout the state.

Consumptive Use Permitting

A Water Use Permit is a conditional right to use water for reasonable beneficial purposes which is granted for a finite period of time. Reasonable beneficial purposes include efficient and environmentally protective use types such as public water supply, irrigation (agricultural, nursery landscape), commercial/industrial, dewatering, recreation, diversion and impoundment and livestock. There are two types of Water Use Permits: general, which are issued by District staff and are mostly issued for uses under 500,000 gallons per day (gpd), and individual, which are issued by the District's Executive Director for larger uses.

Federal: No federal agencies currently provide input into the consuptive use permit evaluation process.

State: Responsibility for consumptive use permitting is shared between water management districts and the FDEP. Consumptive use permitting rules were revised in 2003 regarding the 1-in-10 year level of certainty, resource protection criteria, water shortage triggers, saltwater intrusion, special designations, and permit duration. These changes were included in the SFWMD's Basis of Review for Water Use Permit Applications (SFWMD 2003), which requires that withdrawals of water must not cause adverse impacts to environmental features that are sensitive to magnitude, seasonal timing, and duration of inundation.

Local: No local agencies currently provide input into the consuptive use permit evaluation process.

Consumptive Use Regulations under Development

Kissimmee Basin Water Reservation: The SFWMD Governing Board approved initiation of rule development for a water reservation for the Kissimmee Basin in June 2008. This reservation is intended to reserve water in the Kissimmee River, its floodplain, and the KCOL that is required for protection of fish and wildlife. The reservation will define a specific amount of water based on scientifically based targets developed through a public process.

Watershed Management Tools – Programs

There are a number of programs that address watershed management, including: Total Maximum Daily Load (TMDL) Program, FDACS Agricultural Best Management Practices Program, the Northern Everglades and Estuaries Protection Program (NEEPP), and the FDEP Green Yards Program.

Total Maximum Daily Load Program

Waters within the KCOL are subject to Section 303(d) of the Clean Water Act, which requires states to submit lists of surface waters that do not meet applicable water quality standards (impaired waters) after implementation of technology-based effluent limitations, and establish TMDLs for these waters on a prioritized schedule. TMDLs establish the maximum amount of a pollutant that a water body can assimilate without causing exceedances of water quality standards. As such, development of TMDLs is important for restoring waters to their designated uses. To achieve the water quality benefits intended by the Clean Water Act, it is critical that TMDLs, once developed, be implemented as soon as possible. Currently, Cypress Lake and Lake Kissimmee are verified impaired for nutrients and are within the Lake Okeechobee watershed that has a TMDL for phosphorus. Efforts are underway to reduce phosphorus loading in this watershed, including BMP implementation as described in the Lake Okeechobee Protection Plan.

Federal: Clean Water Act TMDL requirements were delegated to the state.

State: The Florida legislature enacted the Florida Watershed Restoration Act (FWRA) in 1999 to protect Florida's waters with the development of a TMDL program for state ground and surface waters as required by the Clean Water Act. The TMDL implementation process is summarized below.

Chapter 99-223, Laws of Florida, sets forth the process by which the 303(d) list of impaired waters is refined through more detailed water quality assessments. It also establishes the means for adopting TMDLs, allocating pollutant loadings among contributing sources, and implementing pollution reduction strategies.

Implementation of TMDLs is referred to as a Basin Management Action Plan (BMAP) and involves any combination of regulatory, non-regulatory, or incentive-based actions that attain the necessary reduction in pollutant loading. Non-regulatory or incentive-based actions may include development and implementation of BMPs, pollution prevention activities, and habitat preservation or restoration. Regulatory actions may include issuance or revision of wastewater, stormwater, or environmental resource permits to include permit conditions consistent with the TMDL. These permit conditions may be numeric effluent limitations or, for technology-based programs, requirements to use a combination of structural and non-structural BMPs needed to achieve the necessary pollutant load reduction.

As a part of Rule 62-303.600, F.A.C., upon determining that a water body is impaired, the FDEP evaluates whether existing or proposed technology-based effluent limitations and other pollution control programs under local, state, or federal authority are sufficient to attain of applicable water quality standards. If the water body is expected to attain water quality standards in the future and is expected to make reasonable progress towards attainment of water quality standards by the time the next 303(d) list is scheduled to be submitted to the USEPA, the water body can be removed from the verified list and a TMDL will not need to be developed for that water body. Therefore, there is an incentive to proactively implement voluntary pollution control programs to take advantage of this provision.

This TMDL program protects waters by coordinating the control of point source and non-point source pollution. The FWRA also establishes a process to identify and list impaired waters throughout the state. The TMDL program has developed a list of impaired waters in the KCOL and is using a watershed hydrologic and water quality model for determining the TMDL for listed impaired waters. Further information on this effort was presented in Chapter 3.

Local: The FDEP coordinates with local governments and stakeholders in the development of TMDLs. Local governments currently regulate stormwater runoff as described above and may implement stormwater retrofit projects in response to the TMDL established by the state. Additionally, the FDEP coordinates with local governments and stakeholders in the development of TMDLs.

Agricultural Best Management Practices Program

The FDACS Agricultural BMP Program provides assistance in developing conservation and nutrient management plans for individual farms and is implementing projects to reduce phosphorus loads from dairy farms, restore isolated wetlands, and enhance water storage on ranchlands.

Federal: The National Resource Conservation Service (NRCS) supports this program and provides supplemental funding and technical assistance.

State: The Florida Watershed Restoration Act (section 403.067, F.S.), first enacted in 1999, authorized the FDACS to develop, adopt by administrative rule, and implement agricultural BMPs statewide. Through the Office of Agricultural Water Policy (OAWP), FDACS develops, adopts, and implements agricultural BMPs to reduce water quality impacts from agricultural discharges and enhance water conservation.

The OAWP's role involves assisting agricultural producers in selecting, funding, properly implementing, and maintaining BMPs. The OAWP employs field staff and contracts with service providers to work with producers to identify and implement BMPs appropriate for their operations.

The two major categories of commonly used BMPs are nutrient management and irrigation management. Nutrient management is the amount, timing, placement, and type (source) of fertilizer. Irrigation management is the maintenance, scheduling, volume, and overall efficiency rating of irrigation systems.

The key to successful BMP implementation is educating landowners about integrating BMPs into their daily routine to reduce pollutant loading. A detailed explanation of adopted agricultural BMPs can be found at http://www.floridaagwaterpolicy.com, and printed BMP manuals can be obtained in local extension offices at county agricultural centers or by contacting OAWP field staff.

The OAWP has adopted by rule BMPs that address the following operations in the basin:

- Container Nurseries (Chapter 5M-6, F.A.C.);
- Vegetable and Agronomic Crops (Chapter 5M-8, F.A.C.); and
- Citrus (Chapter 5M-2, F.A.C.).

The OAWP is currently developing and will be adopting BMP manuals of statewide application for cow/calf, equine, and sod operations.

Local: Local governments, including soil and water conservation districts, are partners in assisting farmers with developing farm plans to reduce nutrient runoff.

Northern Everglades and Estuaries Protection Program

The Northern Everglades and Estuaries Protection Program (NEEPP) provides a platform for ensuring that future Lake Okeechobee restoration and protection efforts are holistically aligned and built upon the success of past and current initiatives. The NEEPP brings the Comprehensive Everglades Restoration Plan (CERP) and the Lake Okeechobee Protection Program (LOPP) under one umbrella, initiates two new estuary programs for the St. Lucie and Caloosahatchee estuaries, and recognizes the importance and connectivity of the entire system – from the KCOL south to Florida Bay. Specifically, the legislation requires an assessment of the sources of phosphorus from the KCOL and Lake Istokpoga, and their relative contribution to the water quality of Lake Okeechobee. The results of the assessment are to be used by coordinating agencies to develop interim measures, best management practices, or regulations.

Federal: The federal government is a 50/50 partner with the state in the CERP, and therefore is a partner in the execution of portions of the NEEPP that are also part of the CERP.

State: The Phase II Technical Plan (P2TP) for the Lake Okeechobee Watershed Construction Project has been developed in response to the 2007 Florida State legislation that authorized the NEEPP (Section 373.4595, F.S.). A number of ongoing state watershed management efforts are coordinated through the NEEPP, such as the TMDL Program and the FDACS agricultural and non-agricultural programs. The P2TP is quantifying the nutrient reductions for a wide range of projects being implemented or are under evaluation for implementation in the Lake Okeechobee watershed to meet the Lake Okeechobee TMDL. The P2TP has established that 1.3 million acre-feet of storage are needed for reducing nutrient loads. Public and private approaches are being pursued as part of the P2TP.

As part of that process, the NEEPP will utilize efforts of the FDEP Basin Management Action Plans (BMAP), which are the implementation arm of the TMDL Program. BMAPs include detailed pollutant source identification, pollutant load allocations, and specific projects that will be implemented by local stakeholders, WMDs, and others.

FDACS passed a new urban turf fertilizer rule in 2007 that limits fertilizer applications to urban turf to the amount of nitrogen and phosphorus available to support healthy turf maintenance. Maximum application rates have been established for Bahia, Bermuda, Centipede, St. Augustine, and Zoysia grasses.

Local: Local governments, including soil and water conservation districts, are partners in implementation of the NEEPP.

Florida Department of Environmental Protection's Green Yards Program

The FDEP's Green Yards program certifies auto salvage yards that use accepted green and environmentally friendly practices. In an industry known for environmental challenges, the Green Yards pilot program helps automotive recyclers understand and comply with environmental regulations.

Federal: No federal agencies currently provide collaborate on the Green Yards Program.

State: FDEP orgainizes and conducts educational workshops for auto salvage yard facility operators. Afterward operators are required to submit a series of six modules documenting compliance. Of the 93 salvage yards in Orange County, 52 are in the Green Yards program and 9 are Green Yard facilities. Polk County has 43 salvage yards with 5 facilities in the program and 1 is a Green Yard facility. Osceola has 6 salvage yards with none of the facilities participating in the program. Automotive recyclers that achieve Green Yards designation demonstrate environmental compliance with over 35 best management practices that range from proper container labeling to developing and implementing a Stormwater Pollution Prevention Plan. More information on the FDEP Green Yards Program is available at http://www.dep.state.fl.us/central/Home/Green_Auto/default.htm.

Local: Counties can adopt language that requires salvage yards to comply with the state's Green Yard Program.

Other Conservation Assistance Programs

Federal: U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) programs offer technical assistance for conservation plans. In addition, local USDA Farm Service Agency (FSA) offices provide cost sharing on approved conservation practices through various federal programs. Soil and water conservation districts assist agricultural producers in developing conservation plans to enhance habitat and reduce nutrient runoff.

State: The FWC offers the Landowner Incentive Program (LIP). The FWC provides science-based recommendations and financial assistance for conserving and enhancing the state's habitat resources on private lands. The Florida Department of Agriculture and Consumer Services (FDACS) Division of Forestry also provides technical assistance for private non-industrial forest landowners through the Forest Stewardship Program. For more information regarding this program, contact 407-847-4465 to speak to John White, Osceola County Soil and Water Conservation District (SWCD), Chuck O'Rourke for NRCS, or Ken Windsor for FSA, or access the program's website at http://sfrc.ifas.ufl.edu/extension/florida_forestry_information/additional_pages/forest_stewardship_program.html

Watershed Management Tools – Education and Outreach

Florida Yards and Neighborhoods Education Program: Florida Yards & Neighborhoods (FYN), a University of Florida Extension program, partners with national, state, and local agencies to teach Florida-friendly landscaping. Local UF/IFAS Extension FYN faculty offer educational programs to assist homeowners, landscaping professionals, builders, and developers to conserve water, keep it clean, and protect native plant and wildlife resources including proper application of fertilizers and pesticides.

Green Building and Sustainable Development Education: The University of Florida's Program for Resource Efficient Communities (PREC) offers continuing education for licensed building professionals at various locations in Florida in association with local UF/IFAS Extension Offices. Build Green and Profit – Green Advantage and Low Impact Development for Policy Makers are examples of programs that help practitioners and decision makers understand downstream impacts of development and implement strategies to avoid or minimize environmental consequences. The local UF/IFAS Extension offers consulting services and educational programs for building professionals, government staff, and residents on green building and sustainable development.

Agriculture and Agribusiness Education: The UF/IFAS Extension utilizes research-based information to help local agribusinesses understand environmental consequences of agricultural practices. UF/IFAS faculty provides education that supports implementation of BMPs to reduce on-site and downstream environmental impacts.

Watershed Management Tools –Best Management Practices

Federal: The USEPA has developed guidelines for BMPs that are consistent with green building practices. These include "Using Smart Growth Techniques as Stormwater Best Management Practices" (EPA 231-B-05-002) and numerous publications from the Smart Growth Network, which is supported by the USEPA (Smart Growth Network 2002, 2003, 2006).

State: The SFWMD is working with local governments to assist in implementing stormwater retrofit projects in the KCOL watershed. One such program is the Florida Ranchlands Environmental

Services Project (FRESP). Launched in October 2005, the FRESP will design a program under which ranchers in the northern Everglades watersheds can sell environmental services of water retention, phosphorus load reduction, and wetland habitat expansion to agencies of the state and other willing buyers. To document the level of environmental services provided by ranch water-management projects, FRESP will field test different methods of using monitoring and modeling of hydrology, water and soil chemistry, and vegetation change.

These ranchers will bring such services on line quickly as compared to other options because land purchase is not required, and the program will complement public investment in regional water storage and water treatment facilities. The sale of the water retention services will add income for ranchers and will provide an incentive to combat the conversion of land uses for more intensive agriculture and urban development, which may increase stormwater flow, pollution, and habitat impacts.

The FRESP is being implemented through a collaboration of the World Wildlife Fund (WWF), eight participating ranchers, NRCS, FDACS, SFWMD, and FDEP. Technical support is being provided by scientists from the MacArthur Agro-Ecology Research Center and the University of Florida. Funding from federal, state, and private sources exceeds $5 million for the first phase, which includes pilot project implementation and program design.

Local: Osceola and Orange Counties and the Cities of Orlando, Kissimmee, and St. Cloud have implemented stormwater retrofits to reduce pollutant loading to the lakes. Many of these projects have received grant funding from the SFWMD and/or FDEP. Examples of these projects include:

- Toho Water Authority developed a 6 million gallon per day stormwater treatment system in Shingle Creek upstream of Lake Toho for irrigation use to reduce groundwater withdrawals.
- Kissimmee is designing stormwater treatment systems to reduce nutrient loads from East City Ditch to Lake Toho.
- Orange County evaluated storage and treatment of runoff from the Orange County Convention Center for subsequent treatment and reuse for irrigation.
- Orange County designed a stormwater detention pond to treat runoff from a tributary of Shingle Creek upstream of Lake Valerian.
- St Cloud expanded an existing dry pond and converted it to a wet pond to improve treatment of stormwater runoff prior to entry to East Lake Toho.
- Orange County constructed stormwater outfall treatment facilities to reduce nutrient discharges to Lake Tyler, which is in the Shingle Creek basin.
- Orange County also constructed approximately 250 stormwater outfall treatment facilities within the watersheds of Lakes Conway, Tibet, Sheen, and Jessamine.
- Orange County constructed retention ponds and converted septic systems to sewers in the Clear Lake watershed. This project reduced nutrient loads to Clear Lake, which improved the quality of lake discharges to Shingle Creek.
- Orlando installed 152 catch basin inlet basket filters to reduce nutrient loads to Clear Lake and the following closed lakes: Rock Lake, Lake Lorna Doone, and Lake Mann.

- Orange County and Orlando are conducting stormwater management planning in the Boggy Creek and Shingle Creek basins to evaluate stormwater discharges and reduce nutrient loads through a variety of projects, such as Buenaventura Lakes' stormwater reuse and stormwater treatment facilities in the Ox Pond Ditch Basin.

The UF/IFAS Extension offers training and workshops for corporate, governmental, environmental, and landscape professionals in BMPs for the protection of water resources in Florida. This program is endorsed by the FDEP. The UF/IFAS Extension will take a lead in providing education for landscape professionals, government staff, and local residents on emerging water quality issues in the basin such as the FDACS fertilizer rule. The UF/IFAS faculty develops curricula and offer training and continuing education regarding pesticide safety to support various pesticide licenses.

Watershed Management Tool Gaps

Although many watershed management tools exist, there are gaps that need to be addressed through policy revisions or the introduction of new programs that would assist in meeting water quantity, water quality, and fish and wildlife management objectives for the KCOL. Management gaps include the following:

- **Regulatory Gap #1:** Existing regulations do not cover development of existing platted properties less than 10 acres. There are no current flood control or water quality requirements for these types of future developments.

- **Regulatory Gap #2:** Standards need to be developed for MS4 exempt developments, municipalities, and individually-owned properties to align stormwater management facilities with basin restoration/enhancement goals.

- **Urban BMP Program Gap:** Septic system retrofit projects should be considered as part of the nutrient reduction goals associated with basin TMDLs and the NEEPP. This will address septic systems in urban/residential areas developed prior to implementation of the Water Quality Assurance Act of 1983 that mandated increased distances to groundwater, lower densities of septic systems, and greater setbacks from surface waters.

- **Management Measures to Achieve NEEPP Nutrient Reduction Goal in UKB Not Identified:** The Northern Everglades P2TP calls for significant nutrient reductions in the KCOL as part of complying with the Lake Okeechobee TMDL for TP which is set at 105 metric tons per year (mt yr^{-1}), approximately 400 mt yr^{-1} less than the existing load. The tributary TMDL load is 113 mt yr^{-1}. Table 8.1 of the Northern Everglades P2TP assumes that the nutrient reduction goal for the UKB will be 57 mt yr^{-1}. The Northern Everglades P2TP alternatives did not achieve the 57 mt yr^{-1} nutrient reduction goal for the UKB. Additional planning will be conducted as the P2TP evolves to determine which specific nutrient reduction activities will be employed in the UKB.

- **Land Acquisition:** Development within the watershed is rapidly urbanizing the basin. Lakeshore lands, lands that fill gaps associated with wildlife corridors, and lands for stormwater treatment and storage should be identified and prioritized for acquisition.

- **Regional Storm Water Retention and Treatment Facilities:** Stormwater runoff in the more urbanized portions of the watershed results in variable lake water levels. This flashiness is undesirable from both a flood protection and a fish and wildlife perspective. Regional stormwater facilities should be considered to meet the needs of future development, collect basin storm water from existing developments, address the irrigation demands of future development, improve flood control, and improve lake water level conditions.

Lake Management Tools

Lake Management Tools – Aquatic Plant Management

Aquatic Plant Management Program

Aquatic plant management in the waters of the KCOL is coordinated through the FWC AHRES. Management teams comprised of members from federal, state, and local agencies with responsibilities in these waters develop integrated aquatic plant management plans considering biological, chemical, mechanical, and physical means. Plans are chosen that provide the most cost-effective methods to control target plants while providing the greatest protection to human health and safety and non-target plants and animals. When developing control plans, managers also consider water levels, volumes and flow rates, water chemistry, sediment types, irrigation demands, recreational uses and restrictions, and possible weather patterns that may impact management success.

Federal: The River and Harbor Act of 1958, as amended, Section 104 authorizes the U.S. Army Corps of Engineers (USACE) to cooperate with state and local government agencies in the Aquatic Plant Control Program. This authority is granted under the Removal of Aquatic Growth (RAG) Project and covers designated federal navigation projects under USACE jurisdiction. Funding under the RAG Project has been appropriated annually since 1900. The RAG Project is funded at 100 percent federal cost for control of aquatic vegetation in eligible federal waters. Eligible Florida water bodies treated under this program include the St. Johns River, Withlacoochee River, Crystal River, Ocklawaha River, Kissimmee River and headwaters, and Okeechobee Waterway. The Rivers and Harbors Act was amended to allow hydrilla control in federal navigation projects as an eligible project to receive 100 percent federal funding.

State aquatic plant managers coordinate closely with the USACE to address emerging issues and concerns in aquatic plant management. Most recently, the USACE Environmental Research and Development Center initiated research on the friction effects of hydrilla accumulations at the C&SF Project structures.

State: The FWC is designated by the Florida legislature as the state's lead agency for aquatic plant control. The FWC's authorities are addressed in Chapter 369 Part I, Aquatic Plant Control (SS. 369.20 – 369.255, F.S.). These statutes provide the framework for the FWC to direct the control, eradication, and regulation of noxious weeds to protect human health, safety, recreation, and property. The FWC conducts surveys of noxious plants in the public KCOL lakes and determines control strategies based on those surveys.

Local: Osceola County works with the FWC on aquatic vegetation control and contributes financial resources to the FWC to assist in noxious weed control. Osceola County is supporting research on treatment methods for hydrilla and hygrophila (*Hygrophila polysperma*).

Aquatic Plant Management Permits

Florida Statutes (Sections 369.20, 369.25, 369.251) require permits for any activity that involves the control, removal, collection, sale, or possession of aquatic plants for business purposes.

Demonstration Project on Hydrilla and Hygrophila in the Upper Kissimmee Chain of Lakes

Osceola County was awarded a $2.881 million dollar grant by the USEPA to find new and alternative ways to manage hydrilla and hygrophila in the KCOL. The project is funded through September 2010. The UF/IFAS Osceola County Extension is the project manager. The objectives of the project are:

1. To evaluate the effectiveness of Experimental Use Permit (EUP) herbicides and biological controls in the treatment of hydrilla and hygrophila;
2. To evaluate new technology processes or practices, or a new combination or uses of technologies, processes or practices for the control of hydrilla and hygrophila using small-scale field work;
3. To implement and monitor successful practices and processes identified in objectives 1 and 2 using large-scale field demonstrations; and
4. To demonstrate the project efforts in alternative technologies to manage hydrilla and hygrophila and disseminate to the public the results of this project (http://plants.ifas.ufl.edu/osceola).

Lake Management Tools – Fish and Wildlife

The Migratory Bird Treaty Act

Ecosystems associated with the KCOL provide important feeding, nesting, roosting, and wintering areas for a variety of migratory bird species. Modifications of water regulation schedules, water quality issues, and habitat enhancement projects will directly impact (adversely or beneficially) migratory birds and their habitats. The Migratory Bird Treaty Act of 1918 (16 U.S.C. 703) provides for the protection of migratory birds, including any "part, nest or egg of any such bird."

The Non-game Act provides for the conservation of migratory non-game birds. Public Law 100-653 (102 Stat. 3825), approved November 14, 1988, amended the act to require the USFWS to monitor and assess migratory non-game birds, determine the effects of environmental changes and human activities, identify those likely to be candidates for endangered species listing, identify appropriate actions, and report to Congress one year from enactment. It also requires the USFWS to report at 5-year intervals on actions taken. Public Law 101-233, signed into law on December 13, 1989 (103 Stat. 1977), amended the act to require the USFWS to identify lands and waters in the United States and other nations in the Western Hemisphere whose protection, management, or acquisition will foster the conservation of migratory non-game birds.

Aquatic Habitat Restoration / Enhancement

The FWC has responsibility and authority for restoration/enhancement of Florida's fish and wildlife habitat, monitoring of fish and wildlife resources, and management of lands for fish and wildlife. The FWC receives spending authority of approximately $1.5 million annually from the State Game Trust Fund. These funds are approved by the state legislature and are derived from fishing and hunting license sales. In addition, approximately $6.4 million can be appropriated by the state legislature from funds generated by state documentary stamps through the Florida Forever legislation. These two sources make up the FWC- AHRES funds. AHRES funds are used for restoration and enhancement projects for Florida's fish and wildlife and are also used for recreational improvements such as construction of fishing piers, wildlife viewing towers, and other similar projects. The FWC Division of Habitat & Species Conservation receives funding to conduct wildlife surveys throughout the KCOL region for waterfowl, alligators, whooping cranes, wading birds, and other wildlife species.

Lake Restoration 2020 Program

The Lake Restoration 2020 Program is conducted under F.S. 269.20. Funds are documentary stamp funds (1/2 of 1%) with the language in the statute established as part of the Preservation 2000 program. These funds are deposited directly into the FWC Trust Fund "to be used exclusively for the purpose of implementing the Lake Restoration 2020 Program." This program is administered by the FWC AHRES subsection. The statute not only provides funding but gives the FWC authorization to conduct enhancement/restoration work for the benefit of fish and wildlife in aquatic resources of Florida. The funds cannot be used to purchase land, but must be used for habitat work. This program was used for the drawdown and muck removal in Lake Toho in 2004.

Largemouth Bass Population Management

The FWC has an active program for monitoring and managing largemouth bass in Lakes Kissimmee and Toho through the use of creel census surveys and lake level drawdowns. The FWC also employs transect electroshocking to monitor black crappie, largemouth bass, bluegill, and sunfish populations in Alligator Lake, East Lake Toho, Lake Toho, Lake Hatchineha, Cypress Lake, and Lake Kissimmee. These data are used to assist in tracking the size and structure of fish populations for KCOL fish management areas. With current management efforts (aquatic plant management and periodic lake level drawdowns), the fish populations in the KCOL require very little direct management such as stocking.

Alligator Population Management

The FWC has an active program for managing alligator populations on Lakes Kissimmee, Hatchineha, and Toho using alligator surveys and then adjusting alligator hunting licenses. This program has kept alligator populations at acceptable levels in the three lakes. Management of Cypress Lake alligator populations is expected in the future.

Lake Management Tools – Enforcement

The FWC provides protection and enforces laws related to all aquatic resources of the state. The FWC also provides boating safety enforcement on the state's waters.

Federal: The Migratory Bird Treaty Act of 1918 (16 U.S.C. 703) provides for the protection of migratory birds, including any "part, nest or egg of any such bird." This Act established a federal prohibition, unless permitted by regulations, to "pursue, hunt, take, capture, kill, attempt to take, capture or kill, possess, offer for sale, sell, offer to purchase, purchase, deliver for shipment, ship, cause to be shipped, deliver for transportation, transport, cause to be transported, carry, or cause to be carried by any means whatever, receive for shipment, transportation or carriage, or export, at any time, or in any manner, any migratory bird, included in the terms of this Convention . . ."

State: The Florida Constitution, Article IV, Section 9, Florida Statutes, Chapter 372, and Florida Administrative Code, Chapter 68A mandates the FWC to manage, conserve, and regulate all fish and wildlife within Florida including fish and wildlife within the boundaries of the KCOL.

Local: Local governments may adopt ordinances that govern uses and utilization rates.

Lake Management Tools – Projects

Kissimmee Basin Modeling and Operations Study

The KBMOS will identify a set of improved operating criteria for C&SF Project structures in the Kissimmee Basin. The SFWMD Governing Board will recommend that the USACE implement these operational changes to improve plant diversity, substrate quality, and fish and wildlife productivity within the lake littoral zones. These operational changes are intended to address the hydrologic management objectives defined for the KCOL LTMP.

Federal: Engineer Regulation 1110-2-240, 33 CFR 222.5, Water Control Management requires the USACE to develop operations and maintenance criteria for water control plans and to continually study and revise the plans as necessary. This Engineer Regulation provides authority for the restudy of the water control plan containing regulation schedules for the KCOL.

The USACE Draft Environmental Impact Statement (EIS) for Modification of Kissimmee Basin Structure Operating Criteria is a parallel project with the KBMOS. This EIS is authorized and funded under the Kissimmee River Restoration Project. The notice of intent was published in the Federal Register in May 2005 and revised in July 2005. The Project Management Plan (PMP) was signed by the USACE and the SFWMD in July 2005. The EIS is required under the National Environmental Policy Act (NEPA) to implement changes to C&SF Project operating criteria. NEPA requires that the impacts associated with the modification of federal projects be identified and evaluated prior to implementation. The KBMOS will develop the modeling tools needed to formulate and evaluate alternative operations. The EIS will perform NEPA evaluations and recommend an alternative for implementation. The EIS is scheduled for completion in 2014.

State: The KBMOS supports the District’s Water Management Plan (DWMP) responsibilities associated with the protection and restoration of natural features and functions of the 100-year floodplain.

Local: Local governments have participated in the development of evaluation performance measures and indicators.

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Appendix L
Fish and Wildlife Reference Documents

INTRODUCTION

The following reference documents were produced as part of Florida Fish and Wildlife Conservation Commission's management of fish and wildlife in Florida and the Kissimmee Chain of Lakes.

Life History Requirements of American Alligator (*Alligator mississippiensis*)

Life History Requirements

The American alligator was chosen as an indicator species because of the significant and important role it has in Florida's natural resources and culture. This species has a well established history dating back thousands of years. Ecologically, the alligator is known as a top predator in freshwater aquatic habitats. It also has helped shape some wetland ecosystems and affected the associated wildlife with activities such as nest construction and the creation and use of "gator holes." Culturally, including economically, this species has played an important role with early European as well as Native American civilizations, which utilized alligators and their hides for food and trade. The importance of the alligator is evident even today in Florida with recreation, tourism, and business. In 2001, more than 13,000 wild alligators were harvested in Florida by nuisance, recreational, and commercial trappers for an estimated meat and hide value in excess of $4.3 million (Dutton et al. 2002). Also in 2001, 63 alligator farms in Florida harvested over 25,000 alligators with an estimated value in excess of $3.8 million (Dutton et al. 2002). The significance of this species is also recognized symbolically as Florida's official state reptile.

Alligators begin breeding activities in April and May as the weather warms up and they emerge from the winter period of relatively little activity. After mating, females move into available marsh habitat to construct a nest and deposit eggs. Nest construction consists of the female forming a dome-shaped mound of vegetation, muck, peat, and soil by using her tail and mouth as construction tools. Typical nests are approximately two feet high and five or six feet wide. Suitable nesting habitat includes dense emergent marsh, such as cattail (*Typha spp.*) or sawgrass (*Cladium jamaicensis.*), with an organic or soil substrate that is sufficient to support the majority of the nest above the water line. Alligator nests are also used by other reptiles for nesting sites, further supporting their use as an indicator species. In particular, Florida red-bellied turtles (*Chrysemys nelsoni*) frequently use alligator nests as nesting sites (Goodwin and Marion 1977; Kushlan and Kushlan 1980).

A nesting female will deposit 20-60 eggs into a hole in the top of the nest and cover the clutch with nest material. After egg deposition, the eggs will incubate for approximately 65 days. The emergence of hatchling alligators from their eggs begins in early or mid-August, and continues through early September. Hatchlings will remain near the nest, taking refuge in the water and vegetation, and feeding on small prey such as insects and minnows. During this period, the adult female will also remain in the vicinity of the nest.

Hatchlings will begin to disperse after about a year. Because of their small size (approximately 30-40 cm), they will continue to spend most of their time in or near dense emergent vegetation. As they grow larger, they spend more time utilizing deeper and more open waters where adequate food sources can be found.

Life History Links to Habitat

An important consideration for maintaining a sustainable wild alligator population is ensuring adequate nesting habitat. Alligators will utilize a variety of substrates for nesting, but the most productive nesting sites are often associated with the more eutrophic aquatic systems with extensive dense emergent marsh areas. Nest construction is a complex exercise in which the female creates a dome of vegetation, peat, and/or soil by knocking down and mounding the surrounding materials. Percival et al. (1992) found alligators constructing nests from a variety of plants, but dominant species on their study sites included sawgrass, giant reed (*Phragmites spp.*), and cattail. However, they also suggest that nest material might affect the viability of eggs. They found that the viability of eggs was lower in nests composed of arrowhead (*Sagittaria latifolia*) than other nest materials, possibly because of its relatively higher water content, decomposition, and compaction than other materials.

One of the threats to alligator nesting success is nest flooding (Goodwin and Marion 1978; Mazzotti and Brandt 1994). Joanen et al. (1977) found that eggs submerged in water for more than 48 hours resulted in 100% embryo mortality. Such conditions could occur in the wild if water levels rise too high before the eggs are able to hatch. Dense emergent marsh at higher elevations likely contributes to increased survival of alligator eggs. Such habitat is created over time by organic build up. Rice (1992) found that alligators nested at higher elevations on Lake Okeechobee. He noted that these areas provide a buffer from high waters, which could flood nests and increase mortality of the embryos.

Another factor that has an impact on the survival of wild alligator eggs is predation. Common predators of alligator eggs include raccoons (*Procyon lotor*), river otters (*Lutra canadensis*), and wild hogs (*Sus scrofa*). Studies have reported raccoons to be the primary predators of alligator eggs (Deitz and Hines 1980; Goodwin and Marion 1978). It is suggested that nests constructed in marsh locations, away from levees and the shoreline, are less likely to be destroyed by raccoons (Kushlan and Kushlan 1980; Mazzotti and Brandt 1994).

Dense emergent marsh might also be important for the survival of hatchling alligators. In the process of constructing a nest in this type of habitat, the female often creates a small pool of water around the nest, as well as one or more water trails created by her movement to and from the nest. Woodward et al. (1987) noted that these pools and trails might increase the survival of hatchlings by providing a refuge for them during their first few months. The open water of the pools and trails provide the hatchlings opportunities to feed on small fish and insects without straying far from the cover of the dense vegetation.

Although dense emergent marsh provides good nesting habitat for alligators and cover for hatchlings, a diversity of wetland habitats is beneficial for alligator populations as a whole. In general, the dominant food type changes from invertebrate to vertebrates as alligators increase in size (Delany and Abercrombie 1986; Delany 1990; Delany et al. 1999; Mazzotti and Brandt 1994). Small alligators feed primarily on invertebrates, small fish and herptiles. Such prey is often abundant in and near emergent marsh. As alligators grow larger, their diet shifts to larger prey such as turtles and larger fish, most of which are more available in deeper, open water. Adult male alligators (>180 cm) have been shown to spend more time in open water than swamps during the summer (Goodwin and Marion 1979), possibly influenced by the availability of the preferred prey in this habitat.

Life History Links to Water Levels

As noted earlier, flooding is one of the greatest threats to the survival of alligator eggs. Alligators begin constructing nests in late May and early June. Peak nesting occurs during mid-June to early July (Deitz and Hines 1980; Goodwin and Marion 1978). Eggs incubate for approximately 65 days before hatching in August through early September. Although female alligators might adapt nesting heights to water levels at the time of nest construction, significant increases in water levels during the nesting period can flood nests and increase mortality of embryos.

Low water levels can also affect survival. Normal and high water levels allow alligators to disperse into their preferred habitats. Under these conditions, they will typically remain spatially distributed by size, with smaller alligators inhabiting marsh habitats and larger alligators spending more time in open water. Low water levels such as during droughts however, concentrate alligators of all sizes into the remaining water, resulting in increased fighting and vulnerability to cannibalism (Mazzotti and Brandt 1994; Woodward et al. 1987). The increased stress associated with these conditions could potentially have negative impacts on the reproductive cycle of female alligators if low water occurs during the fall. Although most of the obvious reproductive activity (i.e., mating, gravidity, and nesting) occurs during the spring, Guillette et al. (1997) found that vitellogenesis (synthesis of the yolk protein vitellogenin and its incorporation in the cytoplasm of the oocyte) and associated processes occur in September and October. Therefore, it is possible that extreme low water levels during this time would increase stress for reproductively active female alligators and disrupt the reproductive cycle.

Literature Cited

Deitz, D. C. and T. C. Hines. 1980. Alligator nesting in north-central Florida. Copeia 1980(2):249-258.

Delany, M. F. 1990. Late summer diet of juvenile American alligators. J. Herpet. 24(4):418-421.

Delany, M. F., S. B. Linda, and C. T. Moore. 1999. Diet and condition of American alligators in 4 Florida lakes. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 53:375-389.

Delany, M. F. and C. L. Abercrombie. 1986. American alligator food habits in northcentral Florida. J. Wildl. Manage. 50(2):348-353.

Dutton, H. J., A. Brunell, D. Carbonneau, L. Hord, S. Stiegler, C. Visscher, J. White, and A. Woodward. 2002. Florida's Alligator Management Program: An update 1987 to 2001. Pages 23-30 *In:* Crocodiles. Proceedings of the 16th Working Meeting of the Crocodile Specialist Group, IUCN – The World Conservation Union, Gland, Switzerland.

Goodwin, T. M. and W. R. Marion. 1977. Occurrence of Florida red-bellied turtle eggs in north-central Florida alligator nests. Florida Sci. 40(3):237-238.

Goodwin, T. M. and W. R. Marion. 1978. Aspects of the nesting ecology of American alligators (*Alligator mississippiensis*) in north-central Florida. Herpetologica 34:43-47.

Goodwin, T. M. and W. R. Marion. 1979. Seasonal activity ranges and habitat preferences of adult alligators in a north-central Florida lake. J. Herpetol. 13(2):157-164.

Guillette, L. J., Jr., A. R. Woodward, A. D. Crain, G. R. Masson, B. D. Palmer, M. C. Cox, Y.-X Qui, and E. F. Orlando. 1997. The reproductive cycle of the female American alligator (*Alligator mississippiensis*). General and Comparative Endocrinology 108: 87-101.

Joanen, T., L. McNease and G. Perry. 1977. Effects of simulated flooding on alligator eggs. Proc. Ann. Conf. Southeastern Assoc. Fish and Wildl. Agencies 31:33-35.

Kushlan, J. A. and M. S. Kushlan. 1980. Everglades alligator nests: nesting sites for marsh reptiles. Copeia 1980(4):930-932.

Mazzotti, F. J. and L. A. Brandt. 1994. Ecology of the American alligator in a seasonally fluctuating environment. Pages 485-505 *in* S. Davis and J. Ogden, (eds.), Everglades: The Ecosystem and its Restoration. St. Lucie Press, Delray Beach, Florida.

Percival, F. H., G. R. Masson and K. G. Rice. 1992. Variation in clutch viability among seven American alligator populations in Florida. Final Report, Florida Coop. Fish and Wildl. Res. Unit, Gainesville.

Rice, K. G. 1992. Alligator nest production estimation in Florida. M.S. Thesis, Univ. of Florida, Gainesville, 57 pp.

Woodward, A. R., T. C. Hines, C. L. Abercrombie and J. D. Nichols. 1987. Survival of young American alligators on a Florida lake. J. Wildl. Manage. 51(4):931-937.

Life History Requirements of Snail Kite

Life History Requirements and Links to Habitat

The snail kite (Rostrhamus sociabilis) is an endangered raptor whose distribution in the United States is restricted to the South Florida Ecosystem, including waters of the Everglades, Lake Okeechobee, Kissimmee River, Upper Kissimmee Chain of lakes (KCOL), and Upper St. Johns River. Prior to 1996, most kite nesting in the KCOL occurred on Lake Kissimmee (average of 31 nests/year), with lesser numbers on Lake Tohopekaliga (Lake Toho) and East Lake Tohopekaliga. Large influxes of kites have been observed nesting on Lake Toho primarily during drought events on Lake Okeechobee and the water conservation areas of southern Florida (e.g., 1991 with 182 of 223 nests recorded during 1987-1993; Rodgers, unpublished data).

Nesting occurs primarily from January through August. Egg-laying takes place from 14 January to 8 July and young are typically fledged from March 28 to September 16. Snail kites nest in flooded vegetation, of either woody (southern willow, *Salix sp.*; buttonbush, *Cephalanthus occidentalis;* cypress, *Taxodium* sp.) or non-woody (cattail ,*Typha* sp.; bulrush, *Scirpus* sp.) species. Water depth at nest site varies by lake and substrate. Average water depths at nest sites ranged from 36-93 cm and were recorded as follows: East Lake Toho: bulrush 53 cm, cattail 93 cm, willow 71 cm; Lake Toho bulrush 92 cm, cattail 88 cm, willow 59 cm; Lake Kissimmee bulrush 93 cm, cattail 87 cm, willow 57 cm, buttonbush 36 cm.

Historically, cattails were not present in substantial acreage in the KCOL, and kites nested in woody vegetation. Currently, only high lake levels (14.75 m and above) provide notable access to flooded woody vegetation (along the lake margins) on all lakes. During normal pool and low lake levels (14.5 m or below), most nesting occurs in non-woody species (cattail and bulrush) farther out in the littoral zone or, on Lake Kissimmee, in woody species in regions around Bird and Rabbit Islands. Large, dense stands of cattail can provide protection/buffer from human disturbance (recreational activities) and from wind and wave action. Nests located in dense, matted cattail stands have reduced risks of nest failure due to collapse as compared with nests in less dense or smaller patches of cattail. The average clutch size for kites is 2.77 (± 0.50), but varies among lakes and years. Average fledgling success is 0.87 (± 1.00)/nest, but again there is considerable inter-year and inter-lake variation.

Snail kites feed primarily on Florida apple snails (*Pomacea paludosa*) that are present in the upper 5 cm of the water column, typically attached to emergent vegetation. Typical foraging habitat for kites consists of large expanses of spikerush (*Eleocharis* sp.) or maidencane (*Panicum hemitomon*) interspersed with open water, such that kites are able to visually locate snails.

Impacts of Low and High Water

Impacts of Low Water

Low water levels impact kites directly (via nesting substrate) and indirectly (via access to snails). Low water levels do not provide nesting kites access to flooded woody vegetation, which is less likely to collapse during high winds. Nesting in non-woody substrates, such as cattail or bulrush, increases the probability that the nest will either collapse during windy conditions or fall over when the stem buoyancy is lost. Low water levels also reduce access to snails by either causing the snail to burrow in the bottom sediments or matting down the emergent vegetation and reducing the visual location of snails by the kites. Finally, lack of water or lower lake levels may provide predators (snakes and raccoons) access to the nests, which might be reduced by either deeper water or the presence of alligators (in deeper water).

Impacts of High Water

High water has both positive and negative effects on kites. Higher water levels provide flooded woody nesting substrates, such as willow, buttonbush and cypress. However, prolonged inundation will ultimately weaken and cause the death and reduce germination of these aquatic woody species.

Specific Recommendations

Lake water levels should fluctuate from year to year to allow both access to flooded woody vegetation and adequate foraging habitat as described above. These fluctuations should be similar to normal drawdown schedules of unregulated lakes so that water levels are high in the late winter and early spring and decrease during the dry season of the year. Extreme high or low water events are not incompatible with snail kites, provided that they are infrequent (i.e., they do not occur in multiple years). Kites have demonstrated an ability to cope with these events by adjusting the location then nest in a particular lake or by nesting in other wetlands during these years.

Apple Snail

Life History Requirements and Links to Habitat

The primary food source of the endangered snail kite (*Rostrhamus sociabilis*) is the Florida apple snail (*Pomacea paludosa*). This operculate gastropod inhabits a variety of aquatic habitats, but primarily occurs in wetlands that experience periodic dry downs (Cowie 2002). Ongoing water level and aquatic plant manipulations have direct impacts on apple snail populations, which in turn affect snail kite populations.

Although egg clusters can often be found from February – November, the majority of egg production occurs from March –June and in central Florida most often peaks in April-May (Darby et al. 1999). Female apple snails deposit (oviposition) their 3-6-mm diameter eggs in clusters on emergent substrates above the water surface (Hanning 1979, Turner 1996). Egg clusters are laid approximately 9-25 cm above the water surface which reduces the potential for eggs to become submerged should water levels rise during the two to three week incubation period. Flooded eggs do not develop (Turner 1994).

Snail eggs can be found on a variety of substrates ranging from emergent vegetation with thick stems (such as *Cladium, Sagittaria,* and *Typha*) and less frequently on species with thinner stems, like *Panicum* (Wallace et al. 1956) and *Paspalidium* (Darby, unpublished data). Turner (1996) thought that narrow stems bend under the weight of the apple snail, especially in the aerial part of the stem. In cases where female snails have deposited eggs on narrow stems (< 6-mm in diameter), egg clusters are located closer to the water surface, even though the thin emergent stems have a greater height (Turner 1996). This may increase the likelihood of flooding and subsequent destruction of the eggs. Therefore, the particular structure of the emergent species available may affect the suitability of a habitat to support apple snails, at least for oviposition. More robust emergent vegetation likely provides better oviposition substrate than thin-stemmed plants.

Little conclusive evidence exists on the food preferences of apple snails (Sharfstein and Steinman 2001). Some authors classify them as consuming macrophytes (Sheldon 1987), and others indicating they are microphagous grazers and scavengers (Branson 1961), or zoophagous (Estebenet

1995). Apple snails have been observed eating *Echhornia crassipes* (Talbot 1970), *Chara* (Hurdle 1973), *Naias marina* (Hurdle 1973), and *Utricularia* sp. (Martin 1973). However, Darby (pers. com.) points out that apple snails in aquaria eat most any macrophyte provided, including spinach and lettuce. In terms of availability, wetlands in peninsular Florida that support a variety of submerged and emergent species coated with varying amounts of periphyton should provide adequate forage for apple snails as Sharfstein and Steinman (2001) recognized that grazing periphyton would result in macrophyte consumption as well.

Apple snails in Florida routinely experience fluctuating water levels and dry down conditions under natural hydrologic regimes (Darby et al. 2002). As the water levels in wetlands recede, the apple snails are subjected to higher water temperatures and low dissolved oxygen levels, and in extreme cases they experience desiccation during dry downs as noted for other species of apple snails (Burky et al. 1972, Haniffa 1978, Aldridge 1983). Faced with a drying event, apple snails must acclimate, migrate, or aestivate (Aldridge 1983). In general, freshwater snails collectively employ all of these strategies to survive harsh environmental conditions (Burky et al. 1972, Medcof 1940, Haniffa 1978). Although Florida apple snails experience these conditions, how they adapt to them has only recently been studied. Darby et al. (2002) studied snails bearing transmitters and discovered that apple snails move sufficient distances to potentially find deep water refugia as water levels decline, but they were not successful at avoiding dry downs, as many were subsequently stranded. When waters receded to a depth of 10-cm, apple snails responded by stopping all movements and soon become stranded in dry marsh (Darby et al. 2002).

Some species in the apple snail family (Ampullariidae) are known to aestivate for 3 to 25 months during dry conditions (Little 1968, Burky et al. 1972, Haniffa 1978, Chandrasekharam et al. 1982, Cowie 2002). During aestivation, the operculum serves as a barrier to water loss (Meenakshi 1964). Several reports indicated that *P. paludosa* is incapable of tolerating dry downs (Little 1968, Kushlan 1975, Turner 1994), and this has been one reason snail kite researchers have called for avoiding drying events (Beissinger 1988, Sykes et al. 1995). Recently, however, Darby et al. (2003) found that earlier reports of a lack of dry down tolerance in Florida apple snails was confounded by an annual spring die-off (regardless of hydrologic conditions). Through a series of simulated marsh drying events in a laboratory setting, Darby and Percival (2000) reported that 75% of adult apple snails survived 3 months of exposure to dry down conditions; 50% survived up to 4 months.

Impacts of Low and High Water

Impacts of Low Water

Dry downs that would likely have a substantial negative impact on apple snails would be those that either (1) take place during the breeding season (March – July), especially during April-May or (2) exceed 3 months in duration. Darby et al. (2004) concluded that the 6-month drying event in the majority of the Lake Kissimmee littoral zone resulting from the 1995-1996 drawdown exceeded the capacity for apple snails to survive by aestivation. Apple snails cease moving (and therefore laying eggs) when water levels fall below approximately 10 cm. This drying event encompassed nearly the entire breeding season for apple snails and resulted in a decline in snail abundance of up to 80% (Darby et al. 2004). As a result, recruitment of juveniles in to the Lake Kissimmee snail population was also dramatically reduced.

During extreme dry downs, the primary emergent vegetation available is *Paspalidium*. This habitat (1) has a limited number of snails (as compared with higher elevation littoral zone habitat), (2) is less than ideal for oviposition due to structural weakness, as described above, and (3) snails in this habitat lay fewer eggs (Darby, unpublished data**)**. Snails in areas of the littoral zone with less than 10 cm of water are essentially unproductive, and if these areas dry out for > 4 months, then over 50% of the snail population will likely die. These impacts on the overall snail population would be proportional to the percent of the littoral zone dried out (Darby et al. 2002).

Impacts of High Water

High water can impact apple snails in two ways. First, eggs on emergent vegetation in the littoral zone may be flooded and destroyed, resulting in lower recruitment. Second, emergent vegetation ideal for oviposition may be flooded such that it becomes unavailable for oviposition, resulting in reduced egg-laying.

Specific Recommendations

We recommend that in most years during the breeding season (March – June) the littoral zone elevations that support *Pontederia cordata* be flooded ≥10cm and not fluctuate more than 15cm in a two or three week period. This would make available the best oviposition habitat that is most common in the littoral zone, and would keep eggs from being flooded and breeding snails from being caught in dropping water levels and forced to aestivate.

Evidence from the Everglades suggests that areas with snail densities below approximately 0.15 snails/m^2 are not used by foraging snail kites (Darby, unpublished data). We recommend that habitats be managed to provide for snail abundance in excess of this level, preferably > 0.25 snails/ m^2. Darby et al. (2004) reported snail densities ranging from 0.22 – 2.84 snails/ m^2 on Lake Kissimmee prior to the 1995 drawdown.

Literature Cited

Aldridge, D. W. (1983). Physiological ecology of freshwater prosobranchs. Pp. 330-358, *in* The mollusca, vol. 16 (E. D. Russell-hunter, ed.). Academic Press, London.

Beissinger, S. R. (1988). Snail Kite. Pp. 148-165 *in* Handbook of North American Birds, vol. 4 (R. S. Palmer, ed.) Yale Univ. Press, New Haven, CT.

Branson, B. A. (1961). Recent Gastropoda of Oklahoma. Part II: Distribution, ecology and taxonomy of fresh-water species, with description of Helisoma travertina sp. nov. Oklahoma State University Publication 58(17):1-72.

Burky, A. J., Pacheco, J. and Pereyra, E. (1972). Temperature, water, and respiratory regiemes of an amphibious snail, Pomacea urceus (Müller), from the Venezuelan savannah. Biological Bulletin 143:304-316.

Chandrasekharam, V., Satyam, P., Srikanth, N. S., Naidu, K. A., Raghavaiah, K. and Ranamurthi, R. (1982). Retention of label of Leucine-U-^{14}C in the haemolymph of *Pila globosa* (Swainson) as a function of sex and long term aestivation. The Veliger 24:373-374.

Cowie, R. H. (2002). Apple snails (Ampullariidae) as agricultural pests: their biology, impacts and management In: Molluscs as Crop Pests (ed.G.M. Barker), p. 145-192. CABI Publishing, Wallingford.

Darby, P. C., Croop, J. D., Bennetts, R. E., Valentine-Darby, P. L. and Kitchens, W. M. (1999). A comparison of sampling techniques for quantifying abundance of the Florida apple snail (*Pomacea paludosa*, Say). Journal of Molluscan Studies 65:195-208.

Darby, P. C. and Percival, H. F. (2000). Dry down tolerance of the Florida apple snail (*Pomacea paludosa* Say): effects of age and season. Final report. U. S. Geological Survey, Research Work Order 182.

Darby, P. C., Bennetts, R. E., Miller, S. J. and Percival, H. F. (2002). Movements of Florida apple snails in relation to water levels and drying events. Wetlands 22:489-498.

Darby, P. C., Valentine-Darby, P. L. and Percival, H. F. (2003). Dry season survival in a Florida apple snail (*Pomacea paludosa* Say) population. Malacologia 45:179-184.

Darby, P. C., Valentine-Darby, P. L., Percival, H. F. and Kitchens, W. M. (2004). Florida apple snail (*Pomacea paludosa*) responses to lake habitat restoration activity. Archiv fur Hydrobiologie 161:561-575.

Estebenet, A. L. 1995. Food and feeding in *Pomacea canaliculata* (Mollusca, Gastropoda). The Veliger, 38(4): 277-283.

Haniffa, M. A. (1978). Energy loss in an aestivating population of the tropical snail *Pila globosa*. Hydrobiologia 61 (2): 169-189.

Hanning, G. W. (1979). Aspects of reproduction in *Pomacea paludosa* (Mesogastropoda: Pilidae). Masters Thesis, Florida State University. Tallahassee. 138 pp.

Hurdle, M. T. (1973). Life history studies and habitat requirements of the apple snail (*Pomacea paludosa*) at Lake Woodruff National Wildlife Refuge. Refuge Management Study Progress Report 2. Lake Woodruff National Wildlife Refuge, DeLeon Springs, Florida.

Kushlan, J. A. (1975). Population changes in the apple snail, *Pomacea paludosa*, in the southern Everglades. The Nautilus 89:21-23.

Little, C. (1968). Aestivation and ionic regulation in two species of *Pomacea* (Gastropoda, Prosobranchia). Journal of Experimental Biology 48:569-585.

Martin, T. W. (1973). Management for the Everglades Kite (*Rosthamus sociabilis*). Report of Refuge Management Study, Progress Report No. 2, Loxahatchee Wildlife Refuge.

Medcof, J. C. (1940). On the life cycle and other aspects of the snail *Pila virens*. Current Science 10:321-322.

Meenakshi, V. R. (1964). Aestivation in the Indian apple snail *Pila* – 1. Adaptation in natural and experimental conditions. Comparative Biochemistry and Physiology 11:379-386.

Sharfstein, B. and A. D. Steinman. (2001). Growth and survival of the Florida apple snail (*Pomacea paludosa*) fed 3 naturally occurring macrophyte assemblages. Journal of North American Benthological Society 20(1):84-95.

Sheldon, S.P. (1987). The effects of herbivorous snails on submerged macrophyte communities in Minnesota lakes. Ecology 68:1920-1931.

Sykes, P. W., Rodgers, J. A. and Bennetts, R. E. (1995). Snail Kite (*Rostrhamus sociabilis*). Number 171, *in* The birds of North America. Pp……, (A. Poole and F. Gill, eds.). The academy of natural sciences, Philadelphia and the American Ornithologists' Union, Washington, D. C.

Talbot, S. (1970). A study of *Pomacea paludosa* and *Lepomis macrochirus* as a possible strand of the food web of the *Eichhornia crassipes* community. Unpublished. Stetson University, Deland, Florida.

Turner, R. (1994). The effects of hydrology on the population dynamics of the Florida apple snail (*Pomacea paludosa*). Contract 91D192. St. Johns River Water Management District, Palatka, Florida.

Turner, R. (1996). Use of stems of emergent plants for oviposition by the Florida apple snail *Pomacea paludosa* and implications for marsh management. Florida Scientist 59:35-49.

Wallace, H. E., C. M. Loveless, F. J. Ligas, and J. A. Powell. (1956). Wildlife investigation of the central and southern Florida flood control project. Annual progress report for Investigations Project as required by Federal Aid in Fish and Wildlife Restoration Acts. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida 36 pp. (Unpublished).

Life History Requirements of Four Candidate Fish Indicators Dependent on Lake Littoral Habitat

Life History Requirements of Candidate Indicators

The four candidate fish indicators examined include largemouth bass *Micropterus salmoides*, bluegill *Lepomis macrochirus*, Seminole killifish *Fundulus seminolis*, and bluespotted sunfish *Enneacanthus gloriosus*. The type and level of dependence on littoral habitats by the four candidate indicators varies, but is critical for the maintenance of their respective populations. Life history requirements are provided for each species and critical linkages of particular life history stages to littoral habitat (vegetation type, substrate type, areal coverage, etc.) are described.

Largemouth Bass

Largemouth bass spawn in Florida from January through May (Hoyer and Canfield 1994). Males excavate shallow nests in littoral zone substrate and remain at the nest through the first few days after hatching to guard eggs and fry from predation. Preferred spawning substrate in Florida is sand; however, firm structure such as aquatic plant roots may be used. Newly hatched fry and juveniles gain protection from predation by associating with both emergent and submergent littoral vegetation. Early life stages feed primarily on small aquatic insects and crustaceans, but undergo an ontogenetic switch to fish prey at about 50 mm TL. Each prey type can be abundant in and adjacent to littoral vegetation. Adult bass most often are found in association with littoral vegetation or with some type of structure in the limnetic zone. Because adult largemouth bass are a sit and wait predator, associating with structure and vegetation aids in success of their ambush feeding strategy.

Bluegill

Bluegill spawn throughout the year, typically from February through October (Hoyer and Canfield 1994). Male bluegill excavate nests in colonies in littoral zone substrate such as sand or other firm structure and guard the eggs to decrease predation. Both juveniles and adults typically associate with littoral vegetation as a refuge from predation. Bluegill are omnivorous and consume a wide range of forage including algae, vascular plants, zooplankton, aquatic and terrestrial insects, and small fish (Hoyer and Canfield 1994). Additionally, much of the forage (particularly invertebrates) that bluegill require are most abundant within littoral vegetation and can therefore be heavily dependent on such habitat.

Seminole Killifish

Seminole killifish are most often associated with the shallow water area (< 1 meter) of the littoral zone. They are often associated with sandy substrate. Seminole killifish spawn primarily in April and May, but spawning can occur throughout the summer months. They feed primarily in mid-water or near the bottom on ostracods, cladocerans, and chironomid larvae (Hoyer and Canfield 1994).

Bluespotted Sunfish

Bluespotted sunfish may spawn through the year. Eggs are laid in thick vegetation or filamentous algae. Major food items are small crustaceans, aquatic insects, plants, worms and mollusks (Hoyer and Canfield 1994). Reproductive strategies for bluespotted sunfish require vegetation, primarily submersed. Food availability and survival from predation due to their small size is heavily dependent on vegetation, primarily submersed. Submersed vegetation is critical in maintaining a large population of bluespotted sunfish.

General relationships between candidate indicators and required habitat

Lake trophic state of a water body is a critical habitat component for fish production. Trophic state (i.e. fertility) of a lake is determined according to Forsberg and Ryding's (1980) water quality parameters which include Chlorophyll-*a*, Total Phosphorus, and Total Nitrogen. Fish abundance has been found to be directly related to the trophic state of a lake (Melack 1976); McConnell et al. 1977; Jones and Hoyer 1982; Hanson and Leggett 1982; Bays and Crisman 1983; Hoyer and Canfield 1996). For example, Hoyer and Canfield (1996) found adult largemouth bass abundance and standing crop in 56 Florida lakes to have a positive linear relationship with lake trophic state up to the eutrophic range. Additionally, lake trophic state is a factor to consider when attempting to predict relationships between the abundance of aquatic macrophytes (vegetation) and the abundance of largemouth bass (Hoyer et al. 1985).

Vegetation coverage within lakes is critical to population dynamics for largemouth bass, bluegill, and redear sunfish. Recruitment (Aggus and Elliot 1975; Durocher et al. 1984; Wiley et al. 1984; Maceina et al. 1995; Hoyer and Canfield 1996; Paukert and Willis 2004) and growth (Colle and Shireman 1980; Trebitz and Nibbelink 1996) of these species can be directly affected.

Maceina et al. (1995) found recruitment for largemouth bass to age-1 in Guntersville Reservoir, Alabama was greatest in vegetated habitats. Relative abundance of largemouth bass tended to increase with emergent vegetation coverage in shallow Nebraska lakes (Paukert and Willis 2004). Durocher et al. (1984) found that submersed vegetation up to 20% coverage resulted in a positive relationship with largemouth bass standing crop recruitment to harvestable size in Texas reservoirs. Wiley et al. (1984) found a parabolic relationship between largemouth bass and aquatic macrophyte standing crop, in which intermediate macrophyte biomass levels produced maximum total yield to the fishery in Illinois ponds. They also found a positive correlation between macrophyte density and invertebrate production, which has a strong implication for fishery productivity since most freshwater fish species consume invertebrates during some part of their life cycle (McKinney and Durocher, date unknown).

Fish growth and condition can be positively or negatively affected by macrophyte coverage. Colle and Shireman (1980) found that high coverage of aquatic macrophytes resulted in lower condition factors for largemouth bass, bluegill and redear sunfish *Lepomis microlophus*. They hypothesized that this was a result of decreased foraging efficiency due to excessive plant cover for forage species. Trebitz and Nibbelink (1996) found that intermediate coverage is optimal for fish growth.

Allen and Tugend (2002) found that largemouth bass abundance increased when plant biomass was less than 5 kg/m^2. Additionally, largemouth bass abundance was higher at an intermediate percent area coverage (PAC) of aquatic macrophytes of 5-90%. They also reported that plant biomass greater than 50 kg/m^2 and 100% PAC resulted in low dissolved oxygen (mean < 2 mg/L), absence of centrarchids and low species richness with only a few species adapted to surface respiration such as the sailfin molly (*Poecilia latipinna*).

Tugend and Allen (2004) reported abundance of seminole killifish increased following a drawdown of lake Kissimmee in 1996 through 2000. Diverse fish communities were present all years as well. They attributed the increase to restoration of quality habitat (i.e. sandy substrate and moderate coverage of aquatic macrophytes) in enhanced areas of the littoral zone.

Aquatic plant species considered to be desirable by FWC fisheries biologists include maidencane *Panicum hemitomon*, Egyptian paspalidium *Paspalidium geminatum*, bulrush *Scirpus californicus*, eleochris *Eleochris* spp., pondweed *Potamogeton illinoensis* and eelgrass *Vallisneria americana* as they provide refuge for fish to spawn, forage and avoid predation. These plant species are also less likely to become invasive (i.e. high density and biomass) and are often rooted in firm substrate. On the contrary, aquatic plant species such as pickerelweed *Pontederia cordata*, cattail *Typha spp.* and tussock plant communities (floating plant communities with organic material associated with them) tend to become invasive under stabilized conditions, resulting in low dissolved oxygen and poor fish habitat. Although these species should be represented in the plant community to increase plant diversity, they must be managed at desirable densities and biomass to achieve optimal littoral zone habitat.

Linkages between candidate indicators, habitat and water level fluctuations

Adequate water level fluctuation including timing, frequency, range and duration, in and of itself, should provide many benefits to fish habitat. Both high and low water events are important for maintaining healthy populations of the candidate indicators as well.

During high water (i.e. flood events) habitat improvements occur when organic material and detritus that had formed within the lake are transported to the floodplain. Additionally, high water combined with wind and wave action often reduces high plant density and biomass. As the water recedes that material remains in the floodplain where it oxidizes and decomposes.

In addition to habitat improvements, high water can have direct effects on fish populations. Potential mechanisms resulting in positive recruitment of indicator species due to higher water levels include an increase in the amount and availability of juvenile fish habitat and food resources through increased inundation of shoreline vegetation (Jenkins 1970; Aggus & Elliot 1975; Keith 1975; Timmons et al. 1980, Miranda et al. 1984; Meals & Miranda 1991; Bonvechio & Allen 2005). Bonvechio and Allen (2005) found that largemouth bass year-class strength was positively correlated with water levels in three central Florida lakes. Potential reasons for these strong year-classes included increased coverage of littoral habitat that resulted in increased availability of habitat, increased food resource (zooplankton, insects and small forage fish), and decreased predation. Furthermore, water level increases during the spawning season is a potential management tool for stimulating largemouth bass spawning in systems where water temperature is suitable (Ozen and Noble 2002). Estes and Myers (1996) found that harvestable bluegill standing crop was positively related to characteristics of water level fluctuations for three Florida lakes.

High water can have indirect effects on fish populations as well. High water resulting in inundation of oxidized soils causes nutrient releases into the water column. This release of nutrients can temporarily stimulate a robust food web that can result in increased growth and high survival of fish species. For example, Estes and Myers (1996) found young-of-the-year black crappie densities were related to annual changes in water levels, but thought this relationship was more the result of incoming nutrients than actual water level changes. Allen and Tugend (2002) reported exceptional growth rates for largemouth bass following a drawdown and refill of Lake Kissimmee in 1996. This increased growth is most likely attributed to increased food availability as a result of increased productivity. Fish survival can be improved by increased growth rates and/or increased vegetation coverage. This can result in strong year classes that can be found within the population for up to ten years or longer. This can indirectly cause a positive effect not only on the fish population, but the fishery as well.

Similar to high water events, low water events (i.e. droughts) are essential to the maintenance of dynamic, healthy fish habitat. During frequent drying events reproduction of plants can be limited and organic material/detritus that had accumulated on the lake bottom oxidizes and decomposes, leaving mineralized soil as the dominant substrate type which is found within the Kissimmee Chain of Lakes. During and soon after a drying event occurs, terrestrial, semi-aquatic, and desirable aquatic macrophytes (such as bulrush, maidencane, eelgrass, and egyptian paspalidium) germinate within the littoral zone.

In addition to habitat improvements, low water events temporarily reduce availability of vegetated littoral habitats, concentrate forage, and increase forage availability for predators such as largemouth bass. This may result in a short or long-term increase in condition and/or growth. Conversely, forage fish such as seminole killifish may be more vulnerable to predation, possibly resulting in a short term reduction in population abundance. As in high water events, nutrients are released to the water column upon refill. The combination of available nutrients and a diverse plant community stimulates a robust food web that positively affects populations of fish and aquatic oriented wildlife.

Drawdowns have been used to mimic historical low water events within the Kissimmee Chain of Lakes since 1971. Effects of drawdowns include a reduction in invasive aquatic macrophyte biomass/monocultures by exposing and consolidating organic sediment and destroying the reproductive parts of plants (Cooke 1980), and expanding desirable littoral habitats (Holcomb and Wegener 1972) which provide foraging and nursery areas.

Drawdowns have had impacts to various fish populations. Increased recruitment among sportfish species have been documented (Allen and Tugend 2002; Hulon et al. 1999; Benton et al. 1994; Lantz et al. 1967); however, survivorship over time has varied. Additionally, abundance of individual fish species have varied in their responses to drawdowns (Moyer et al. 1996; Moyer et al. 1982; Williams et al. 1982; Wegener and Williams 1975). Increased growth for different age classes of sportfish have been documented (Allen and Tugend 2002; Hulon et al. 1997). However, similar growth over time (Allen et al. 2003) or even decreased growth has also been observed (Hulon et al. 1997). Positive trends in the fishery (i.e. creel) were usually observed following a drawdown, although individual species often responded differently (Moyer et al. 1996; Wegener and Williams 1975; Heman et al. 1969; Lantz et al. 1967).

Generally, positive but variable effects occur between species and among lakes over time. Even though the long-term influence of low water events and/or drawdowns can be variable, it is clear that many benefits to habitat and the fish community can be derived in the short-term and possibly long-term as well.

Literature Cited

Aggus , L. R. and G. V. Elliot. 1975. Effects of cover and food on year-class strength of Largemouth bass. In Stroud, R. H. &H. Clepper (eds), Black Bass Biology and Management. Sport Fishing Institute, Washington, D.C: 317-322.

Allen, M. S., and K. Tugend. 2002. Effects of a large-scale habitat enhancement project on habitat quality for age-0 largemouth bass at Lake Kissimmee, Florida. Pages 265-276. In D. Phillipp and M. Ridgeway (eds.) Black Bass: Ecology, Conservation and Management. American Fisheries Society, Bethesda, Maryland.

Allen, M. S., K. I. Tugend, and M. Mann. 2003. Largemouth bass abundance and angler catch rates following a habitat enhancement project at Lake Kissimmee, Florida. North American Journal of Fisheries Management. 23: 845-855.

Bays, J. S. and T. L. Crisman. 1983. Zooplankton and trophic state relationship in Florida lakes. Canadian Journal of Fisheries and Aquatic Sciences 40:1813-1819.

Benton, J. W., W. E. Johnson, and D. R. Douglas. 1994. Lake drawdown as a strategy for restoring sportfish populations and aquatic vegetation in a hypereutrophic central Florida lake. Lake and Reservoir Management 9:56.

Bonvechio, T. F., & M. S. Allen. 2005. Relations between hydrological variables and year-class strength of sportfish in eight Florida water bodies. Hydrobiologia 532:193-207.

Colle D. E. and J. V. Shireman. 1980. Coefficients of condition for largemouth bass, bluegill, and redear sunfish in hydrilla infested lakes. Transactions of the American Fisheries Society. 109:521-531.

Cooke, G. D. 1980. Lake level drawdown as a macrophyte control technique. Water Resources Bulletin 16:317-322.

Durocher, P. P., W. C. Provine, and J. E. Kraai. 1984. Relationship between abundance of largemouth bass and submerged vegetation in Texas Reservoirs. North American Journal of Fisheries Management. 4:84-88.

Estes, J. R. and R. A. Myers. 1996. Lower Ocklawaha Basin Fisheries Investigations: Fish Population and Fishery Response to Habitat Change. Final Report. Wallop-Breaux F-55-9. 42 pgs.

Forsberg, C. and S. O. Ryding. 1980. Eutrophication parameters and trophic state indices in 30 Swedish waste-receiving lakes. Archives fur Hydrobiologia 88:189-207.

Hanson, J. M. and W. C. Leggett. 1982. Empirical prediction of fish biomass and yield. Canadian Journal of Fisheries and Aquatic Sciences 39:257-263.

Heman, M. L., S. Campbell, and L. C. Redmond. 1969. Manipulation of fish populations through reservoir drawdown. Transactions of the American Fisheries Society 2:293-304.

Holcomb, D. and W. Wegener. 1972. Hydrophytic changes related to lake fluctuation as measured by point transects. Annu. Conf. Southeast. Assoc. Fish and Wildlife Agencies. 25:663-674.

Hoyer, M. V., D. E. Canfield Jr., J. V. Shireman, and D. E. Colle. 1985. Relationship between abundance of largemouth bass and submerged vegetation in Texas reservoirs: A critique. North American Journal of Fisheries Management 5:613-616.

Hoyer, M. V. and D. E. Canfield Jr. 1994. Handbook of Common Freshwater Fish in Florida Lakes. University of Florida Press. Gainesville, FL.

Hoyer, M. V., & D. E. Canfield Jr. 1996. Largemouth bass abundance and aquatic vegetation in Florida Lakes: An empirical analysis. Journal of Aquatic Plant Management 34:23-32.

Hulon, M. W., C. K. McDaniel, A. S. Furukawa, J. Buntz, C. S. Michael, D. C. Arwood, and A. C. Jasent. 1999. 1994-1999 Completion Report for Kissimmee Chain of Lakes Studies. Study IV. Lakes Jackson and Marian Investigations. State of Florida Fish and Wildlife Conservation Commission, Tallahassee.

Hulon, M. W., J. J. Sweatman, A. S. Furukawa, J. Buntz, C. S. Michael, D.C. Arwood, and A.C. Jasent. 1997. 1992-1997 Completion Report for Kissimmee Chain of Lakes Studies. Study I . Lake Tohopekaliga Investigations. State of Florida Game and Fresh Water Fish Commission, Tallahassee.

Jones, J. R. and M. V. Hoyer. 1982. Sportfish harvest predicted by summer chlorophyll *a* concentration in Midwestern lakes and reservoirs. Transactions of the American Fisheries Society 111:176-79.

Jenkins, R. M. 1970. The influence of engineering design and operation and other environmental factors on reservoir fishery resources. Water Resources Bulletin 6:110-119.

Keith, W. E., 1975. Management by water level manipulation. In Stroud, R. H. &

H. Clepper (eds), Black Bass Biology and Management. Sport Fishing Institute, Washington, D.C: 489-497.

Lantz, K. E., J. T. Davis, J. S. Hughes, and H. E. Schafer, Jr. 1967. Water level fluctuations - its effects on vegetation control and fish population management. Proceedings of the Annual Conference Southeastern Association of Game and Fish Commissioners 18:483-494.

Maceina, M. J., S. J. Rider, and S. T. Szedlmayer. 1995. Density, temporal spawning patterns and growth of age-0 and age-1 largemouth bass in vegetated and unvegetated areas of Lake Guntersville, Alabama. Pages 497-511 in D. H. Secor,

J. M. Dean, and S. E. Campana, editors. Recent developments in fish otolith Research. University of South Carolina Press, Columbia.

McConnell, W. J., S. Lewis, and J. E. Olsen. 1977. Gross photosynthesis as an estimator of potential fish production. Transactions of the American Fisheries Society 106: 417-423.

McKinney, L. D. and P. P. Durocher. No date. Aquatic vegetation management in Texas: a guidance document. Texas Parks and Wildlife Department Inland Fisheries.

Meals, K. O, & L. E. Miranda. 1991. Variability in abundance of age-O centrarchids among littoral habitats of flood control reservoirs in Mississippi. North American Journal of Fisheries Management 11:298-304.

Melack, J. M. 1976. Primary productivity and fish yields in tropical lakes. Transactions of the American Fisheries Society 105:575-580.

Miranda, L. E., W. L. Shelton T. D. Bryce, 1984. Effects of water level manipulation on abundance, mortality, and growth of young-of-the-year largemouth bass in West Point Reservoir, Alabama-Georgia. North American Journal of Fisheries Management 4:314-320.

Moyer, E. J., M. W. Hulon, R. W. Hujik, J. C. Buntz, J. J. Sweatman, A. S. Furukawa, D. C. Arwood, and A. C. Jasent. 1996. 1992-1996 Completion Report for Kissimmee Chain of Lakes Studies. Study III. East Lake Tohopekaliga/Alligator Lake Chain Investigations. State of Florida Game and Fresh Water Fish Commission, Tallahassee.

Moyer, E. J., M. W. Hulon, and G. L. Zuhl. 1982. 1979-1982 Completion Report for Water Level Manipulation Project. Study V. Lake Kissimmee Monitoring. State of Florida Game and Fresh Water Fish Commission, Tallahassee.

Ozen, O., & R. L. Noble. 2002. Relationship between water level fluctuations and largemouth bass spawning in a Puerto Rico Reservoir. American Fisheries Society Symposium 31:213-220.

Paukert, C. P. and D. W. Willis. 2004. Fisheries Management and Ecology. 11:345-352.

Timmons, T. J., W.L. Shelton & W. D. Davies, 1980. Differential growth of largemouth bass in West Point Reservoir, Alabama-Georgia. Transaction of the American Fisheries Society 109:176-186.

Trebitz, A.S. and N. Nibbelink. 1996. Effect of pattern of vegetation removal on growth of bluegill: a simple model. Can. J. Fish. Aquat. Sci. 53:1844-1851.

Tugend, K. I. and M. S. Allen. 2004. Changes in the plant and fish communities in enhanced littoral areas of Lake Kissimmee, Florida, following a habitat enhancement 20(1):54-64.

Wiley, M. J., R. W. Gorden, S. W. Waite, and T. Powless. 1984. The relationship between aquatic macrophytes and sport fish production in Illinois Ponds: a simple model. North American Journal of Fisheries Management. 4:111-119.

Wegener, W., and V. Williams. 1975. Fish population responses to improve lake habitat utilizing an extreme drawdown. Proceedings of the Annual Conference Southeastern Association of Game and Fish Commissioners 28 (1974): 144-161.

Williams, V. P., E. J. Moyer, and M. W. Hulon. 1982. 1979-1982 Completion Report for Water Level Manipulation Project. Study IV. Lake Tohopekaliga Drawdown. State of Florida Game and Fresh Water Fish Commission, Tallahassee.

Life History Requirements of Wading birds

Life History Requirements and Links to Habitat

Wading birds (waders) include a wide variety of species from the families Ardeidae (herons, egrets, and bitterns), Threskiornithidae (ibis and spoonbills), and Ciconiidae (storks and jabirus). The only federally listed species found in Florida is the wood stork (*Myceteria americana*) which is listed as Endangered. State-listed Species of Special Concern inhabiting freshwater wetlands in central Florida include the tricolored heron (*Egretta tricolor*), white ibis (*Eudocimus albus*), little blue heron (*Egretta caerulea*), and snowy egret (*Egretta thula*) (FWC 2003; FWC 2004).

Waders are dependent on wetlands throughout their life cycle for foraging and nesting. They are a diverse group with many species utilizing different water depths, consuming different prey, and nesting at different times. Their primary habitat is highly productive and somewhat open wetlands.

Most wading birds nest in colonies in flooded woody vegetation (willow, *Salix* sp.; buttonbush, *Cephalanthus occidentalis*; Brazilian pepper, *Schinus terebinthifolus*; guava, *Psidium guajava*; cypress, *Taxodium* sp.) or in upland sites on islands within lake sites. Nesting over water reduces predation by providing a water barrier to terrestrial predators or allowing alligators to move beneath the nest trees, thereby further dissuading predators (Rodgers 1987). The large colony that once nested on Lake Kissimmee until the lake was drawn down in 1996 nested primarily in guava and buttonbush (Bird Island) and willow (Rabbit Island) (Rodgers, pers. comm.). During years of high lake levels (>14.5 meters)**,** wading birds nested in the flooded willow-buttonbush thickets of interior Lemon Point/Sturm Island. The occasionally active colony on Mackinson Island or Paradise Island of Lake Toho nested mostly in willow (Rodgers, pers. comm.).

Solitary and semi-colonial nesting species (least bittern, *Ixobrychus exilis*; green-backed heron, *Butorides virescens*) nest in flooded dense cattail (*Typha* sp.), bulrush (*Scirpus* sp.), or occasionally in *Ludwigia*. Colonies populated by a mixed-species assemblage of anhingas, cormorants, herons, egrets, and ibises nested at wooded sites. No data are available on minimum water depth beneath nest trees or minimum size of plant species for nesting in the KCOL. However, water depths of 25-30 cm at nest sites may be sufficient to dissuade terrestrial predators from accessing nest trees (Rodgers, pers. comm.). The limb structure is another important factor in determining suitability of trees as nest sites for wading birds.

There is considerable variation among the timing of nesting seasons for wading bird species and occasionally inter-year variation in the timing of nest initiation. The dates presented here are based on data from nests in similar latitude to the KCOL. Larger species (great blue heron, *Ardea herodias*; great egret, *Casmerodius albus*; anhinga, *Anhinga anhinga*) typically begin nesting earlier (January-February) than the smaller day herons (little blue heron; tri-colored heron ; snowy egre*t*; cattle egret, *Bubulcus ibis*; March-April) within the same colony. In general, wading bird colonies remain active from as early as late December until at least August, sometimes later if the nesting season begins late.

Modal clutch size for all wading birds is 3 eggs, range 1-5 eggs, with minor inter-year and inter-lake variation (Rodgers, pers. comm.). Fledging success is generally variable among years and lakes, probably reflecting amount and distribution of prey. Based on data from other lakes, nest success (>1 young per nest) ranged from 55-88%. A study of Lake Okeechobee water levels and wading bird abundance suggests that numbers of foraging wading birds increased when moderately high winter lake levels were followed by a moderately steady, protracted (5-6 months) drawdown of lake levels beginning in December or January (David 1994).

Lake stage determines the upper and lower regions of the littoral zone used for foraging by wading birds. As their collective name implies, wading birds forage in shallow water (0-20 cm for smaller species, 5-35 cm for larger species) (Comiskey et al. 1998). Specific optimal depth is determined by the length of the legs of each species. Preferred feeding habitat consists of a mosaic of open water and emergent vegetation, dominated by *Eleocharis, Rhynchospora, Panicum, Nymphaea, and Pontederia*. No data are available on optimal stem densities, but percent coverage above 50% probably is sufficient to reduce foraging efficiency and access to aquatic prey (Rodgers, pers. comm.). Dense wooded (willow, buttonbush) areas and *Pontederia* and *Typha* regions are under utilized for foraging, relative to their availability (Smith et al. 1995). Prey consists of invertebrates (insect larvae, crayfish), fish and amphibians which waders stalk in both open water and sparely vegetated regions of the littoral zone. Both shallow, open water areas and recently exposed lake bottom are used by ibis that forage on benthic fauna.

Impacts of Low and High Water

Impacts of Low Water

Extremely low lake levels provide access for terrestrial predators to wading bird nests or result in reduced nesting attempts. However, gradual reduction of lake levels during the breeding season has been shown to increase numbers of foraging wading birds at lakes with levees such as Lake Okeechobee (David 1994). Periodic low water levels also allow seed germination and thereby help maintain desirable habitat condition. The effects of water levels on wading bird nest productivity and foraging success may well vary from lake to lake depending on surrounding habitat types, location of colonies, lake bottom slopes, and other factors. Ongoing research such as the "Wading Bird Response to Water Patterns in the Northern and Central Everglades" project (http://www.sfwmd.gov/org/wrp/wrp_evg/projects/birds/bird_animation.html) may eventually provide a clearer picture of how best to manage water levels for waders.

Impacts of High Water

Prolonged, elevated water levels negatively affect wading birds in a variety of ways. First, their prey is dispersed, resulting in reduced prey density (Rodgers, pers. comm.). This can result in lower nest productivity if the parent birds cannot secure prey from other sources (if alternate sources are nearby, wading birds may not be affected). Second, high water levels can eventually weaken or kill aquatic woody vegetation, reducing or eliminating nest sites. Third, elevated water levels can reduce seed germination and over time alter foraging or nesting habitat. Alternatively, periodic high water events can flood new habitats, which can be very productive as foraging habitats.

Specific Recommendations

We recommend maintaining moderately high winter lake levels (>14.5m for Lake Kissimmee), followed by a moderate, steady, protracted (5-6 months) drawdown beginning in December or January. This schedule would be expected to maximize wading bird foraging habitat and nesting success.

Recommended future research

Additional research is needed to better determine optimal foraging habitat for wading birds in the KCOL. Specifically, what are optimal emergent vegetation stem densities for wading bird foraging? Can different lake levels in the KCOL be correlated to wading bird nesting success?

Where are preferred wading bird foraging areas in the KCOL, and how do they change in response to changes in water level? The distribution of preferred wading bird foraging habitat on the KCOL should be mapped and monitored for changes before and after lake restoration activities.

Literature Cited

Comiskey, J., J. Curnutt, L. Gross and M. Huston. 1998. Wading Bird Foraging Conditions Index: Basic Model Description. *ATLS website* (http://atlss.org/birdmod.html).

David, P. 1994. Wading bird use of Lake Okeechobee relative to fluctuating water levels. Wilson Bulletin 106:719-732.

Florida Fish and Wildlife Conservation Commission (FWC). 2003. Florida's breeding bird atlas: A collaborative study of Florida's birdlife. http://www.myfwc.com/bba/ (accessed 6/28/2005).

Florida Fish and Wildlife Conservation Commission (FWC). 2004. Florida's Endangered Species, Threatened Species, and Species of Special Concern. 6 pp.

Rodgers, J. A., Jr. 1987. On the antipredator advantages of coloniality: a word of caution. Wilson Bulletin 99:269-271.

Smith, J. P., J. R. Richardson, and M. W. Collopy. 1995. Foraging habitat selection among wading birds (Ciconiiformes) at Lake Okeechobee, Florida, in relation to hydrology and vegetative cover. Ecological studies on the littoral and pelagic systems of Lake Okeechobee, Florida, USA (N. G. Aumen and R. G. Wetzel, eds.) Advances in Limnology 45: 247-285.

Life History Requirements of Two Candidate Waterfowl Indicators for the Kissimmee Chain of Lakes (KCOL)

Life History Requirements of Candidate Indicators

The two waterfowl indicators examined are the Florida mottled duck (*Anas fulvigula fulvigula*) and ring-necked duck (*Aythya collaris*). The mottled duck was chosen because it is commonly found on the KCOL and its habitat requirements are similar to those of many of the dabbling duck species that migrate through and winter on the KCOL each year. By providing quality littoral zone habitat for the non-migratory mottled duck throughout its annual cycle, the habitat requirements for other dabbling duck species during migration and winter would also largely be met. The ring-necked duck, which commonly occurs during fall and winter on the KCOL, was chosen as an indicator to represent the group of ducks known as diving ducks. Florida supports a large proportion (upwards of 22%; Bellrose 1980) of North America's ring-necked ducks during winter. Thus, having adequate wintering habitat for this species in the state is important to the well being of the continental ring-necked duck population. The ring-necked duck is the most numerous species in Florida's waterfowl sport harvest and the most abundant and widespread diving duck species using freshwater wetlands in the state. This document describes life history requirements for both mottled ducks and ring-necked ducks and critical linkages between particular life history stages and freshwater aquatic habitat characteristics (vegetation type, substrate type, areal coverage, etc.).

Mottled Duck

Florida's mottled ducks are nonmigratory and inhabit inland emergent wetlands in peninsular Florida, including those within the KCOL wetland complex. In this area, FWC biologists (during aerial surveys, leg-banding efforts, and radio telemetry monitoring) have observed mottled ducks using the littoral zones of lakes during all periods of the birds' annual cycle. Florida mottled ducks breed and nest predominantly from March through June (Gray 1993, Bielefeld and Cox[b]), but copulations have been observed as early as the beginning of December. Females nest mainly in upland grass areas or other dense vegetative cover within 1 km of wetlands and have been observed with broods at night and during the day in lake littoral zones (Gray 1993, Bielefeld and Cox[b]). During the flightless, wing-molt period, mottled ducks commonly congregate on large wetlands, including littoral zones of lakes. Wing-molt in males may occur as early as June, but females undergo wing-molt after their reproductive effort is complete, usually in late July through mid-September (Moorman and Gray 1994). During winter, mottled ducks use littoral areas for diurnal activities such as foraging and loafing (Bielefeld and Cox[b]).

Mottled ducks favor shallow, emergent wetlands because they provide a combination of food and cover. Mottled ducks feed primarily by tipping-up; therefore, they require relatively shallow water (15-30 cm) to forage effectively (Chamberlain 1960). However, water can be deeper if submersed aquatic plants occur within 30 cm of the surface. The ratio of open water to emergent vegetation should range from 30:70 to 70:30. It is desirable to have the open-water portion support submersed or floating-leaved aquatic plants. At least 30% of the coverage of the emergent vegetation should consist of annual seed-producing plants (e.g., grasses, sedges, and smartweeds [*Polygonum spp.*]; Beckwith and Hosford 1955, 1957). Valuable species of submersed and floating-leaved aquatics include *Nymphaea odorata, Brasenia schreberi, Najas marina, Potamogeton* spp.*,* and *Vallisneria americana* (Beckwith and Hosford 1955, 1957; Stieglitz 1972; O'Meara et al. 1982). Emergent vegetation should be interspersed among open water areas forming a mosaic of patches varying in size and shape. These conditions often provide abundant invertebrates, which can be an important food source. Good interspersion of vegetation also provides visual barriers for mottled duck pairs during the breeding season, a time when pairs defend territories.

Ring-necked Duck

Ring-necked ducks generally arrive in significant numbers in Florida sometime in November and remain until early March (Montalbano and Johnson 1986). During winter, ring-necked ducks require habitats that can provide adequate food and protective cover. The foraging habitat objective for ring-necked ducks should have water depths of 30-180 cm (Chamberlain 1960). Fifty percent of the area should be no deeper than 120 cm. Ring-necked duck foraging habitat should contain at least 70% coverage of submersed aquatic or floating-leaved vegetation. Food plants valuable to this species include *Nymphaea odorata, Brasenia schreberi, Najas marina, Potamogeton* spp.*, Vallisneria americana,* and *Hydrilla verticillata* (Montalbano et al. 1978, Johnson and Montalbano 1984). Submersed aquatics should reach the water surface for highest value to ring-necked ducks. These plants provide food directly and indirectly as substrate for invertebrates. Large areas of hydrilla matted on the surface provide valuable habitat for ring-necked ducks, which eat all parts of this plant.

Some ring-necked ducks use emergent wetlands for roosting. Consequently, habitats with characteristics like those favored by mottled ducks should provide ring-necked ducks with suitable roosting areas.

General relationships between candidate indicators and required habitat

Mottled Duck

During wing-molt and brood rearing, mottled ducks frequent shallow water areas with exposed mudflats or hummocks for loafing (LaHart and Cornwell 1970, Gray 1993, Bielefeld and Cox[b]). These areas also are characterized by an abundance of emergent vegetation that provides protective cover during the day and an abundant invertebrate food source. During the breeding season, mottled ducks use shallow water habitats with discrete areas of open water and abundant emergent vegetation (bulrush, cattails, sedges, rushes, grasses) located near upland areas with dense vegetation (Lotter and Cornwell 1969, Johnson et al. 1991, Bielefeld and Cox[b]). Shallow water provides foraging areas, while discrete open-water areas within emergent vegetation provide habitat that can be defended from other breeding pairs. During the post-breeding and winter periods, mottled ducks use a variety of wetland habitats with the aforementioned water depths and characterized by emergent vegetation interspersed with areas of open water and submersed aquatic plants (Johnson and Montalbano 1984, Bielefeld and Cox[b]).

Ring-necked Duck

During November through March, ring-necked ducks use open-emergent to open-aquatic-bed wetlands with water depths in the aforementioned range for foraging and loafing habitat (Johnson and Montalbano 1984). For roosting, ring-necked ducks often use emergent wetlands with shallower water, similar to those favored by mottled ducks.

Linkages between candidate indicators and water level fluctuations

Mottled Duck

A study of mottled duck ecology in the Upper St. Johns River Basin indicated that recruitment and survival were lower in drought years (Bielefeld and Cox[a]). During this study, mottled ducks experienced high mortality when surface waters receded during the wing-molt period.

After wing-molt, when mottled ducks regained flight capability, they responded to wetland drying by moving to areas with adequate water. Birds moved from rural areas to urban/suburban areas presumably because man-made/altered wetlands in these areas held water through the drought. Such movements into urban/suburban habitats can pose a risk to mottled ducks because they more frequently come into contact with feral mallards. This close contact likely increases the probability of interbreeding and hybridization between the two species.

High water also can cause mottled ducks to move out of an area if water becomes too deep to allow effective foraging or if some other habitat requirement (e.g., lack of dry loafing or nesting areas) is negatively affected. However, if high water results in greater wetland surface area, productive habitats maybe be inundated and made available. No negative effects on mottled duck survival or recruitment have been linked to over-abundant surface water.

Rapid and dramatic changes in water levels retard the growth of annual seed-bearing and submersed aquatic plants and can flood or dewater other important areas such as loafing, nesting, and brood-rearing sites. Consequently, large, rapid fluctuations in water level can have negative effects on mottled ducks irrespective of when the changes occur during the annual cycle. This is not to say that water levels should be stabilized within a system for long periods of time, as such conditions promote low wetland productivity. In general, the historic hydrology for the area should be emulated whenever possible to promote diversity and productivity over the long-term.

Ring-necked Duck

During winter, low water levels may reduce overall available habitat for ring-necked ducks, especially loafing sites. However, if low water levels result in an abundance of hydrilla or other desirable submersed aquatic plant foods on or near the surface, then an increase in foraging habitat will result, likely benefiting these birds. Conversely, high water levels likely increase the overall availability of habitat for ring-necked ducks, but foraging habitats may be limited if water depths in the areas with desirable plant foods surpass the aforementioned maximums. If water levels increase or decrease rapidly to levels that preclude effective foraging or eliminate loafing sites, ring-necked ducks likely will move to better habitat.

Specific Recommendations

Mottled ducks

- During February-September, littoral zones of lakes should provide emergent and submersed aquatic plant habitats, with water depths of 15-30 cm, and have a ratio of open water to emergent vegetation between 30:70 and 70:30. Fluctuations in water level should be minimal during this period, but a slow dry-down during February-May, emulating the normal dry season, would be optimal to promote productivity of these habitats. A rapid dry-down during July, August, and September, which would concentrate both flightless mottled ducks and predators, should be avoided to minimize mottled duck mortality.
- During October-January, similar habitats should be available as managed for during February-September. A slow dry-down starting in November and emulating the historic decease in water levels associated with the onset of drier winter weather would be desirable.
- At least 30% of the coverage of emergent vegetation should consist of annual seed-producing plants (e.g., grasses, sedges, and smartweeds [*Polygonum spp*.]). Valuable

species of submersed and floating-leaved aquatics include *Nymphaea odorata, Brasenia schreberi, Hydrilla verticillata, Najas marina, Potamogeton* spp., and *Vallisneria americana*.

- Emergent vegetation should be interspersed among open water areas forming a mosaic of patches varying in size and shape.

Ring-necked Ducks

- During November-February, portions of the littoral zones of lakes should be flooded from 30-180 cm in depth and support dense (70% coverage) submerged aquatic plants. Drastic fluctuations in water level that preclude the establishment and vigorous growth of and access to submerged aquatic plants by ring-necked ducks should be avoided. A slow dry-down during this period that results in new submerged aquatic plants becoming accessible to ring-necked ducks would be optimal.
- Plants valuable to this species include *Nymphaea odorata, Brasenia schreberi, Najas marina, Potamogeton* spp., *Vallisneria americana,* and *Hydrilla verticillata;* and they are most valuable when they reach the surface of the water.

Literature Cited

Beckwith, S. L. and H. J. Hosford. 1955. The Florida duck in the vicinity of Lake Okeechobee, Glades County, Florida. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 9:188-201.

Beckwith, S. L. and H. J. Hosford. 1957. Report on seasonal food habits and life history notes of the Florida duck in the vicinity of Lake Okeechobee, Glades County, Florida. American Midland Naturalist 57:461-473.

Bellrose, F. C. 1980. Ducks, geese, and swans of North America. Stackpole, Harrisburg, Pennsylvania.

[a]Bielefeld, R. R., and R. R. Cox. In Press. Survival and cause-specific mortality of adult female mottled ducks in east-central Florida. Wildlife Society Bulletin.

[b]Bielefeld, R. R., and R. R. Cox. In Prep. Habitat use and movements of adult female mottled ducks in east-central Florida. Wildlife Society Bulletin.

Chamberlain, E. B., Jr. 1960. Florida waterfowl populations, habitats and management. Game and Fresh Water Fish Commission. Technical Bulletin 7, Tallahassee, Florida, USA. 62 pp.

Gray, P. N. 1993. The biology of a southern mallard: Florida's mottled duck. Dissertation, University of Florida, Gainesville, Florida, USA.

Johnson, F. A., F. Montalbano, J. D. Truitt, and D. R. Eggeman. 1991. Distribution, abundance, and habitat use by mottled ducks in Florida. Journal of Wildlife Management 55:476-482.

Johnson, F. A. and F. Montalbano III. 1984. Selection of plant communities by wintering waterfowl on Lake Okeechobee, Florida. Journal of Wildlife Management. 48:174-178.

LaHart, D. E., and G. W. Cornwell. 1970. Habitat preference and survival of Florida duck broods. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 24:117-121.

Lotter, C. F., and G. W. Cornwell. 1969. Comparison of airplane, air-boat and helicopter for censusing Florida ducks, *Anas platyrhynchos fulvigula*. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 23:97-101.

Montalbano, F., H. Hardin, W. M. Hetrick. 1979. Utilization of hydrilla by ducks and coots in central Florida. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies. 33: 36-42.

Montalbano, F. III, and F. A. Johnson. 1986. Implications of migration chronology upon waterfowl harvest opportunities in Florida. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies. 40:470-475.

Moorman, T. E. and P. N. Gray. 1994. Mottled Duck (*Anas fulvigula*). In The Birds of North America, No. 81 (A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.

O'Meara, T. E., W. R. Marion, O. B. Meyers, and W. M. Hetrick. 1982. Food habits of three bird species on phosphate-mine settling ponds and natural wetlands. Proceeding of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies. 36: 515-526.

Stieglitz, W. O., 1972. Food habits of the Florida duck. Journal of Wildlife Management. 36: 422-428.