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SWIM PLAN FOR Lake Apopka, Florida

Issued in compliance with the Surface Water Improvement and Management Act Chapter 87-97, *Laws of Florida*, and Rule 17-43.035, *Florida Administrative Code*

Prepared by

Victoria R. Hoge, Environmental Scientist Roxanne Conrow, Supervising Environmental Scientist David L. Stites, Ph.D., Supervising Environmental Scientist* Michael F. Coveney, Ph.D., Technical Program Manager Erich R. Marzolf, Ph.D., Supervising Environmental Scientist Edgar F. Lowe, Ph.D., Division Director Lawrence E. Battoe, Ph.D., Assistant Division Director

With contributions from

Walt Godwin, Elizabeth Mace, Rolland Fulton, Pam Bowen, Dawne Wilson,* Brian McGurk, Gianfranco Basili, Lois Bush,* Jeff Cole, Nancy Christman, and Janet Lowe*

*Previously with SJRWMD

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EXECUTIVE SUMMARY

The Surface Water Improvement and Management (SWIM) Act of 1987 identified Lake Apopka as a priority water body in need of restoration and preservation. Effective management of the Lake Apopka watershed is necessary to reverse the degradation of the system. In response to this mandate, the St. Johns River Water Management District (SJRWMD) has prepared a comprehensive management plan to restore and preserve the lake and its environment.

Lake Apopka was specifically identified for restoration efforts in 1985 by the Lake Apopka Restoration Act (Chapter 85, *Laws of Florida*). The Lake Apopka Restoration Council (LARC), SJRWMD, the Florida Department of Environmental Protection (FDEP) (formerly the Florida Department of Environmental Regulation), the Florida Fish and Wildlife Conservation Commission (formerly the Florida Game and Fresh Water Fish Commission), and Lake and Orange counties identified specific projects to be conducted in a scope of work. Projects planned and implemented under this mandate were incorporated into the Lake Apopka SWIM Plan.

SJRWMD has relied upon staff knowledge, agency and governmental reviews, public comment, and general goals developed by the LARC for guidance in developing the Lake Apopka SWIM Plan. These efforts have resulted in a coordinated, planned approach to develop economically feasible and environmentally sound strategies for the Lake Apopka restoration effort. Previous versions of the Lake Apopka SWIM Plan were published in 1989 and 1993.

The goals of the plan are to (1) restore the water in Lake Apopka to meet Class III water quality standards, (2) restore the functional capabilities of the lake's natural systems, (3) re-establish previous recreational and aesthetic values, and (4) implement a comprehensive basin management plan.

Seven priority issues were identified for action in the Lake Apopka restoration effort:

- Agricultural discharges
- Lack of fish and wildlife habitat
- Poor water quality and flocculent sediments
- Degradation of downstream lakes
- Low recreational and aesthetic values
- Nonpoint source pollution
- Future basin development

In the 18 years since the Lake Apopka Restoration Act, SJRWMD has implemented a comprehensive array of SWIM projects to address each of these issues. Through years of scientific study (diagnostic and feasibility programs), an implementation plan with six programs (restoration, planning, land acquisition, regulatory, technical support, and public information) and 16 projects was developed. Implementation has four main components:

- **Reduce phosphorus (P) loading** from external sources, primarily agricultural operations, through regulation and land acquisition.
- **Remove P and flocculent sediments** from the lake to accelerate recovery of the lake through wetland filtration (marsh flow-way) and removal of gizzard shad.
- **Improve food-web structure** to improve water quality and benefit production of game fish by removal of gizzard shad.
- **Restore lake habitat** through littoral zone planting and increased fluctuation in lake levels.

REDUCTION IN NUTRIENT LOADING

The first and foremost step towards the restoration of Lake Apopka is to reduce external nutrient loading, focusing primarily on P reductions. Regulatory, land acquisition, and restoration activities have been initiated that decrease external phosphorus loading to Lake Apopka.

A major regulatory action in support of the Lake Apopka restoration was to restrict external nutrient loading from muck farms on the northern shore of the lake. In June 1988, SJRWMD and A. Duda and Sons, Inc. (Duda), entered into a consent order designed to reduce discharges and help protect water quality according to a fixed time schedule through a major restructuring of the surface water control system on Lake Jem Farm.

In May 1989, SJRWMD and the Zellwood Drainage and Water Control District (ZDWCD) signed a similar consent order, although an administrative challenge delayed implementation of those consent order conditions until 1991.

The 1996 Lake Apopka legislation

- Set a phosphorus criterion for the lake of 55 parts per billion "in the event the district does not adopt a rule...by January 1997"
- Gave SJRWMD the legal authority to set a phosphorus discharge limitation

- Determined that it was in the public interest for SJRWMD to pursue buyout of the farms as the long-term solution to the problem
- Provided partial funding toward farm acquisition

SJRWMD established a phosphorus criterion of 55 parts per billion for Lake Apopka in August 1996. The criterion "will be used to establish discharge limitations for all regulated activities within the Lake Apopka drainage basin."

Phosphorus discharge limitations for Lake Apopka were approved by the Governing Board in December 2002. The rule amendments, which involve Chapters 40C-4, 40C-41, 40C-42, and 40C-44, *F.A.C.*, and related Applicant's Handbooks, became effective March 7, 2003.

With funding available from federal and state sources, a total of 13,846 acres (ac) east of the Apopka-Beauclair Canal was purchased by the end of 2000. Earlier, all muck farm areas (5,833 ac) west of the Apopka-Beauclair Canal were purchased for the Marsh Flow-Way Project, a restoration project using marshes to remove particulate phosphorus from lake water.

REMOVE P AND FLOCCULENT SEDIMENTS

Recirculation of lake water through the marsh flow-way, a 21 km² constructed treatment wetland located west of the Apopka-Beauclair Canal, will lead to the removal of particle-bound phosphorus. The Marsh Flow-Way Project included design, construction, and operation of a 530-ac, demonstration-scale wetland filter. This pilot project provided necessary experience and data for the design and construction of the 3,400-ac, full-scale flow-way. Construction of Phase I (650 ac) of the project was completed in 2001. Phase I will start operation when the currently record low lake levels increase sufficiently and when consultations with federal agencies are completed. The full project is expected to remove 30 metric tons of phosphorus annually from Lake Apopka.

IMPROVE FOOD-WEB STRUCTURE

The Trophic Structure Manipulation and Rough-Fish Harvesting projects tested and implemented rough fish (gizzard shad) harvest as an economical means of removing nutrients from the lake, increasing water clarity, and improving conditions for game fish. Lake Denham (a small hypereutrophic lake representative of Lake Apopka) served as the site for an initial pilot study. After removal of gizzard shad was followed by an improvement in water quality in Lake Denham, various harvesting techniques were tested in Lake Apopka to determine the most cost-effective method. From 1993 through 2002, the commercial rough-fish harvest funded by SJRWMD in Lake Apopka removed 3,729,945 kg (8.2 million pounds) of fish. In addition, removal of shad will benefit the lake by reducing internal phosphorus loading caused by fish stirring up the bottom sediments, by reducing predation of shad on zooplankton which feed on algae, and by reducing the phosphorus recycling that results from the shad's digestive processes.

Restore Lake Habitat

The Littoral Zone Restoration Project examined the potential for stabilization of nearshore sediments with inexpensive, moveable breakwaters and planting of desirable vegetation for improved habitat. The first barriers were installed in 1991, followed by on-going planting of native vegetation beginning in 1992. By 2001, 40 sites had been planted around the 40-mile perimeter of the lake.

In addition to providing valuable habitat, submersed macrophytes will hasten the recovery of the lake through several positive feedback mechanisms.

Planting "events," with volunteers of all ages participating, have been sponsored in cooperation with county and local governments and the Friends of Lake Apopka (FOLA) to restore littoral zone areas bordering public parks around the lake.

RESTORATION BENEFITS TO DATE

Beginning in 1993, consent orders with the farms resulted in modest reductions in phosphorus loading. Also, SJRWMD began removing gizzard shad from the lake. The combined effects of these efforts became evident in mid-1995, when the total phosphorus (TP) concentration began to fluctuate around a 30% lower value. This improvement has persisted to date. Chlorophyll, a measure of algal abundance, also declined in mid-1995 and has continued its downward trend. Secchi depth, a measure of water clarity, increased over the same period of time. Since 1995, native submersed aquatic vegetation, especially *Vallisneria americana* (eelgrass), has reappeared and has continued to recolonize Lake Apopka. In fall 2000, 83 patches of eelgrass were found with a combined area of more than 6 ac. These improvements are highly significant in that they indicate that Lake Apopka can and will recover from decades of pollution once the full restoration program has been implemented.

PESTICIDE RESIDUES IN FORMER AGRICULTURAL AREAS

Since the Legislature determined that it was in the public interest for SJRWMD to begin acquisition of the farms on the north shore of Lake Apopka in 1996, approximately 13,500 ac of farmland have been acquired east of the Apopka-Beauclair Canal by SJRWMD and the USDA National Resource and Conservation Service (NRCS). This area, the North Shore Restoration Area (NSRA), will ultimately be restored to wetland habitat, thereby reducing the nutrient-rich discharges to the lake.

During the fall of 1998 and winter of 1999, a significant bird mortality event occurred on a flooded portion of the NSRA. The U.S. Fish and Wildlife Service (USFWS) has linked this mortality to organochlorine pesticide toxicosis. The NSRA currently is being kept dry—by pumping excess water due to rainfall—to discourage its use by wetland birds.

In March 1999, SJRWMD and NRCS, with support from a 13-agency Technical Advisory Group, launched a \$1.5 million project to investigate the cause of the bird mortality and to determine safe levels for pesticide residues in organic soils. All data on soils and sediments, birds, and fish were provided to Exponent Inc., a consulting firm based in Bellevue, Washington. Their analysis of the data and draft report on the mortality event were completed for review in September 2000. A further draft, which incorporated comments from academic and agency reviewers, as well as new data from USFWS, was received in April 2003. The information provided by this study will be used to help guide interim management of the NSRA and other former muck farms targeted for restoration.

A primary uncertainty for evaluating risk from pesticide residues is the rate of bioaccumulation of pesticides from soils/sediments through the food chain to fish and then to birds. Soils with high organic matter contents, like those on the NSRA have not been studied, nor has environmental fate modeling for pesticides been evaluated under similar high organic conditions. Therefore, three additional phases of study were necessary: (1) laboratory microcosms, (2) field-scale mesocosms, and (3) bird feeding studies. SJRWMD initiated these studies during the spring of 2001.

In addition to the above studies, SJRWMD started cleanup during 2002 of a small, highly contaminated area. This site was discovered during the intensive soil sampling conducted in 1999. Also as a result of the intensive sampling and subsequent risk analysis, SJRWMD and NRCS have begun reflooding a 700-ac portion of the Duda farm.

PROJECT DESCRIPTIONS

Diagnostic projects further our understanding of the functioning of the lake and the causes of its degradation. Feasibility projects are directed toward the investigation and testing of potential restoration techniques. Of the 16 diagnostic and feasibility projects developed, 13 have been completed or no further action is planned. The scopes of the remaining three projects have been expanded and are near completion or are on-going. A number of restoration techniques originally proposed for Lake Apopka were found upon examination to be either ineffective or too costly. These include large-scale dredging and sediment recycling, phosphorus inactivation in the lake sediments, microbial decomposition, and ichthyofaunal reconstruction. The decision not to proceed with pilot-scale implementation of these techniques freed resources to support restoration methods that appear more promising.

In the Lake Apopka SWIM Plan, goals and specific strategies have been developed to address the seven priority issues. A total of eight programs implement the strategies of the plan. The programs are organized into 32 projects, some of which have been completed. The programs and projects included in the Lake Apopka SWIM Plan are outlined below.

- A. Diagnostic Program
 - 1. External Nutrient Budget—Quantified the exchange of water and nutrients between Lake Apopka and its watershed. COMPLETED
 - 2. Internal Nutrient Budget—Mapped the type, depth, and chemical characteristics of lake sediments. Quantified nutrients returning from the sediments to the water. Surveyed the levels and potential toxic effects of substances in the sediments. Studied accumulation rates of nutrients in sediments and changes in these rates over the past 100 years. COMPLETED
 - 3. Mathematical Modeling—Used data collected in the diagnostic and feasibility programs to project the effects of selected restoration techniques. COMPLETED
 - 4. Phytoplankton-Nutrient Interactions—Provided baseline information on algal biomass and productivity. Assessed the consequences of nutrient reduction on algal growth. COMPLETED
 - 5. Bathymetry—Provided a more recent and complete bathymetric survey of Lake Apopka. COMPLETED

- 6. Fishery—Obtain current information on the fishery in Lake Apopka by monitoring the game and rough fish populations. Determine changes in the fish community resulting from restoration efforts. Evaluate potential effects of existing organic toxins on alligator, turtle, and bird populations in Lake Apopka. ONGOING
- 7. Seismic Reflection Profiling—Examined subsurface geology across Lake Apopka and assessed the nature of the confining layers between the lake and the Floridan aquifer. COMPLETED
- 8. Hydrodynamic Survey—Modeled velocities and directions of water currents in selected portions of the lake. Evaluated the mixing dynamics of discharge from the marsh flow-way and evaluated possible "short circuiting" of filtered water back to the inlet. COMPLETED
- B. Feasibility Program
 - 1. Water Hyacinth Demonstration—Tested the ability of water hyacinths to remove nutrients from the lake. COMPLETED
 - 2. Phosphorus Inactivation/Precipitation—Evaluated the feasibility of using alum as a precipitant to trap nutrients in an insoluble matrix. COMPLETED
 - 3. Sediment Recycling—Evaluated dredging costs and potential markets for lake sediment to make dredging economically feasible. COMPLETED
 - 4. Microbial Decomposition—Evaluated ways of stimulating natural microbial processes to reduce the bulk of lake sediments and sequester nutrients. COMPLETED
 - 5. Ichthyofaunal Reconstruction (I, II)—Phase I: Compiled a literature review on biomanipulation to determine the applicability to problems in Lake Apopka. Phase II: Evaluated the potential for use of exotic fish species to aid in the restoration of Lake Apopka by consumption of excess production of algae. COMPLETED
 - 6. Trophic Structure Manipulation (I, II, III)—Phase I: Provided baseline data on the role of rough fish in plankton and nutrient dynamics. Phase II: Determined the effects of gizzard shad removal on lake trophic structure and nutrient recycling. Phase III: Tested standard harvesting gear for large-scale rough fish removal in Lake Apopka and tested feasibility of using harvested rough fish (primarily

gizzard shad) as marketable products to offset the cost of fish removal. COMPLETED

- 7. Drawdown and Lake Level Fluctuation—Evaluate the feasibility and ecological effects of temporarily lowering the water level in the lake or enhancing water level fluctuation. ONGOING
- 8. Socioeconomic Assessment and Methodology—Developed techniques for socioeconomic assessment of a lake basin. Assessed the present economic value of the recreational and commercial uses of Lake Apopka and predicted future economic growth concomitant with water quality improvement. Assessed the impact of muck farm buyout on the local economy. COMPLETED
- C. Restoration Program
 - 1. Marsh Flow-Way Restoration—Restores muck farmland to marsh land in order to filter nutrient-rich water from Lake Apopka. ONGOING; Phase I COMPLETED
 - 2. Rough Fish Harvesting—Harvests rough fish species to remove nutrients from Lake Apopka and improves water quality through food-web manipulation. ONGOING
 - 3. Wetland Restoration—Restores acquired properties to wetland habitat and examines restoration for effects upon water quality, vegetation, and wildlife. ONGOING
 - 4. Littoral Zone Restoration—Evaluates the feasibility of isolating and restoring small portions of Lake Apopka's shoreline to vegetated littoral zone and examines the potential macrophyte seed source from littoral zone sediments. Establishes an on-going planting and monitoring effort. ONGOING
- D. Regulatory Program
 - 1. Nonpoint Source Pollution Control—Identifies and controls sources of nonpoint pollution affecting Lake Apopka. ONGOING
 - 2. Nutrient Loading Limits Adoption—Developed and adopted more stringent permitting criteria to protect water resources in the Lake Apopka Basin from future development and establishes numerical nutrient loading limits. COMPLETED

St. Johns River Water Management District

- E. Planning Program
 - 1. District Water Management Plan—Provides a means to identify and address water resource issues by coordinating with various governmental agencies and other entities. ONGOING
 - 2. Local Government Comprehensive Plan Review—Reviews and comments on local government comprehensive plans. ONGOING
 - 3. Land Management Plan for the Lake Apopka Restoration Area—Develops a land management plan for the Lake Apopka Restoration Area. ONGOING
- F. Public Information Program
 - 1. Public Awareness—Uses multimedia communication techniques to inform and educate the public regarding the ongoing and future restoration efforts for Lake Apopka. ONGOING
 - 2. Local Government Information Project—Makes formal informational SWIM Program presentations to Planning Commissions, County Commission Boards, and other advisory and governing bodies. ONGOING
- G. Land Acquisition Program
 - 1. Marsh Flow-Way Land Acquisition—Acquired farmland west of the Apopka-Beauclair Canal in support of the Marsh Flow-Way Project. COMPLETED
 - 2. North Shore Land Acquisition—Acquired muck farms and adjacent conservation and preservation lands in the Lake Apopka Basin. COMPLETED (over 99%)
- H. Technical Support Program
 - 1. Implementation of Restoration and Management Techniques—Provides overall analysis and coordination of diagnostic, feasibility, regulatory, planning, and pilot restoration projects. ONGOING
 - 2. Restoration Monitoring and Analysis—Implements a restoration and postrestoration monitoring regime. ONGOING

3. Overall Program Management—Manages Lake Apopka SWIM Program. Provides annual and quarterly SWIM Plan updates. Provides interagency coordination and report preparation as necessary. ONGOING

The SWIM Plan also contains information on project timetables and budgets. A summary of the timetable has been included with the Executive Summary for reference.

Results of projects mandated and initiated under the 1985 Lake Apopka Restoration Act provided a basis for further efforts under SWIM to restore and preserve surface water resources in the Lake Apopka Basin. Continued implementation of this SWIM Plan will result in recovery of Lake Apopka with attendant economic and social benefits to the residents of central Florida. Since 1995, several critical and interrelated water quality measures have improved by over 30%. In addition, native submersed plants have reappeared and persisted in the lake for the first time in decades. These improvements demonstrate that Lake Apopka can and will improve in response to ongoing restoration efforts. These improvements in Lake Apopka also facilitate the SWIM-based restoration efforts in the Ocklawaha River Basin, which receives the improved downstream flow from Lake Apopka.

Eventual restoration of the most severely polluted large lake in Florida should provide the impetus and the technical knowledge for restoration of other severely degraded water bodies. Thus, the successful restoration of Lake Apopka represents not only a major test of the skills of water resource managers and policy makers, but also the commitment of Florida residents to reverse the trend of environmental degradation throughout the state.

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Prevention Drawdown and I ake Fluctuation				
USACE restudy	•			
Test atternative fluctuation schedules				
incorporate results into restudy				
Marsh Flow-Way Restoration				
Operation of Phase I				
Design and build inlet pump structure				
Pesticide evaluation				
Phase II design and construction				
Phase 8 operation				
Monitoring Program				
Rough Fish Harvesting				ľ
Harvesting				
Fisheries monitoring				
Gizzard shad stock estimate				
North Shore Restoration				I
Complete restoration plan				
Design, implement, evaluate monitoring program				
Bioaccumulation study and evaluation				
Remediation				
Aerial photography				
GIS interpretation				
GIS change analysis				
Soil amendment application				
Complete refloading of Duda				
Refloading of ZDWCD				
Littoral Zone Restoration				I
Vegetation planting				
Aerial photography				
Monitoring				
GPS mapping				
Analysis				

Figure ES1. Overall timetable for the Lake Apopka SWIM Program

	2003	2004	2005	2006
Task Name	Ctr 1 Ctr 2 Ctr 3 Ctr 4 Ctr 1	Otr 2 Otr 3 Otr 4 Otr 1	Otr 2 Otr 3 Otr 4 Otr 1	Ctr 2 Ctr 3 Ctr 4
Nonpoint Source Control		-		
Jones Avenue Stormwater Park				
Review local ordinances				
District Water Management Plan				
Publish annual progress report				
Update DWMP				
Local Govt. Comp. Plan Review				
Review regular amendments				
Review EAR-based amendments				
Land Management Plan				
Construction of public access and facilities				
Solid waste removal				
Maintenance of roads, levees, bridges, buildings				
Vegetation control				
Public Awareness				
Public awareness activities				
Outreach to Government Officials				
Tours, speaking engagements, etc.				
Coordinate with Basin Steering Committee				
North Shore Acquisition	ľ			
Appraisal, negotiation, Board approval				
Implementation of Techniques				
Provide technical support				
Restoration Monitoring and Analysis				
Fisheries sampling and analysis				
Fish and bird monitoring				
Water sampling and monitoring				
Annual nutrient budget calculations				
Contaminant monitoring and analysis				
Vegetation monitoring and analysis				
Overall Program Management				
Overall Program Management				

SWIM Plan for Lake Apopka

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ABBREVIATIONS

	acre
AOR	area of responsibility
ASTM	American Society for Testing and Materials
AWPB	Annual Work Plan and Budget
BMP	best management practice
CBC	Christmas bird count
cm	centimeter
DWMP	District Water Management Plan
EAR	environmental assessment report
ECFRPC	East Central Florida Regional Planning Council
EPA	U.S. Environmental Protection Agency
ERP	environmental resource permit
ESA	environmental site assessment
ET	evapotranspiration
F.A.C.	Florida Administrative Code
FDACS	Florida Department of Agriculture and Consumer Services
FDCA	Florida Department of Community Affairs
FDEP	Florida Department of Environmental Protection
FDER	Florida Department of Environmental Regulation
FDNR	Florida Department of Natural Resources
FDNR FDOT	Florida Department of Natural Resources Florida Department of Transportation
FDNR FDOT FEMA	Florida Department of Natural Resources Florida Department of Transportation Federal Emergency Management Agency
FDNR FDOT FEMA FOLA	Florida Department of Natural Resources Florida Department of Transportation Federal Emergency Management Agency Friends of Lake Apopka
FDNR FDOT FEMA FOLA FS	Florida Department of Natural Resources Florida Department of Transportation Federal Emergency Management Agency Friends of Lake Apopka <i>Florida Statutes</i>
FDNR FDOT FEMA FOLA FS FSA	Florida Department of Natural Resources Florida Department of Transportation Federal Emergency Management Agency Friends of Lake Apopka <i>Florida Statutes</i> Farm Service Agency
FDNR FDOT FEMA FOLA FS FSA ft	Florida Department of Natural Resources Florida Department of Transportation Federal Emergency Management Agency Friends of Lake Apopka <i>Florida Statutes</i> Farm Service Agency foot
FDNR FDOT FEMA FOLA FS FSA ft ft ³	Florida Department of Natural Resources Florida Department of Transportation Federal Emergency Management Agency Friends of Lake Apopka <i>Florida Statutes</i> Farm Service Agency foot cubic foot
FDNR FDOT FEMA FOLA FS FSA ft ft ³ ft ³ /s	Florida Department of Natural Resources Florida Department of Transportation Federal Emergency Management Agency Friends of Lake Apopka <i>Florida Statutes</i> Farm Service Agency foot cubic foot cubic feet per second
FDNR FDOT FEMA FOLA FS FSA ft ft ³ ft ³ /s FWC	Florida Department of Natural Resources Florida Department of Transportation Federal Emergency Management Agency Friends of Lake Apopka <i>Florida Statutes</i> Farm Service Agency foot cubic foot cubic foot Florida Fish and Wildlife Conservation Commission
FDNR FDOT FEMA FOLA FS FSA ft ft ³ ft ³ /s FWC GIS	Florida Department of Natural Resources Florida Department of Transportation Federal Emergency Management Agency Friends of Lake Apopka <i>Florida Statutes</i> Farm Service Agency foot cubic foot cubic foot cubic feet per second Florida Fish and Wildlife Conservation Commission geographic information system

SWIM Plan for Lake Apopka

ha	hectare
IFAS in.	Institute of Food and Agricultural Science inch
kg km	kilogram kilometer
LARC	Lake Apopka Restoration Council
m m ³ m ³ /s mgd mg/L MSSW	meter cubic meter cubic meters per second million gallons per day milligrams per liter management and storage of surface waters
N NGVD NOAA NPDES NRCS NSRA NWS OCP	nitrogen National Geodetic Vertical Datum National Oceanic and Atmospheric Administration National Pollution Discharge Elimination System National Resource and Conservation Service North Shore Restoration Area National Weather Service organochlorine pesticide
P P2000 PLRG ppb RPC	phosphorus Preservation 2000 pollutant load reduction goal parts per billion regional planning council
SCS SJRWMD SOR SRPP SWIM	Soil Conservation Service St. Johns River Water Management District Save Our Rivers strategic regional policy plan surface water improvement and management Tower Chemical Company
	rower Chemical Company

TMDL TP	total maximum daily load total phosphorus
UF USDA USACE USFWS USGS	University of Florida U.S. Department of Agriculture U.S. Army Corps of Engineers U.S. Fish and Wildlife Service U.S. Geological Survey
WRP	Wetlands Reserve Program
yd³	cubic yard
ZDWCD	Zellwood Drainage and Water Control District

INTRODUCTION

This section discusses the various legislative and administrative programs that augment the Lake Apopka Surface Water Improvement and Management (SWIM) Plan. The next section of this document provides a brief overview of Lake Apopka and its watershed, followed by a section outlining the local, regional, state, and federal governments that have jurisdiction over Lake Apopka and/or the area within one mile of its banks, as required in Chapter 87-97, *Laws of Florida* (Appendix A).

Seven priority issues have been identified for Lake Apopka. These issues represent the major problems that must be addressed in order to achieve restoration of the lake. The Planning section defines these issues and presents the goals, strategies, programs, and projects that address each issue. The status and progress of the Lake Apopka restoration are discussed in the next section. The Programs and Projects section is followed by the Details of Projects section, which contains details of program and project organization, describes project identification coding, and provides a brief description of the individual projects.

The Lake Apopka SWIM Plan is designed to be project-oriented. It is at the project level where the substance of the plan is implemented. Each project addresses a specific activity; active projects are detailed with timelines and itemized budgets in the Summary of Project Funding section.

SWIM programs are not intended to replace existing efforts or responsibilities, but rather to integrate efforts by local, regional, state, and federal agencies. Likewise, SWIM funds supplement programs and identify areas where monies need to be appropriated by other agencies.

THE SURFACE WATER IMPROVEMENT AND MANAGEMENT ACT

The SWIM Act (Chapter 87-97, *Laws of Florida*, and Section 373.451, *Florida Statutes* [*FS*], in Appendix A), was enacted in 1987 by the Florida Legislature to address one of the state's most pressing problems. That body found that the quality of many surface waters of the state had been or were in danger of becoming degraded. This degradation resulted from point and nonpoint source pollution and destruction of natural systems that purify surface waters and provide habitats for plants, fish, and wildlife. It was determined that surface water problems can be corrected and prevented through programs implemented by the regional water management districts with the cooperation of state agencies and local governments.

The intent of the legislation was to provide aesthetic and recreational pleasure for the people of the state; to provide habitat for native plants, fish, and wildlife, including endangered and threatened species; to provide safe drinking water to the growing population of the state; and to attract visitors and accrue other economic benefits. The SWIM legislation specifically designated Lake Apopka as a water body in need of restoration.

Each of the state's five water management districts, in cooperation with the Florida Department of Environmental Protection (FDEP), the Florida Department of Agriculture and Consumer Services (FDACS), the Florida Department of Community Affairs (FDCA), the Florida Fish and Wildlife Conservation Commission (FWC), and local governments, was mandated to prepare a list of prioritized water bodies of regional or statewide significance based upon criteria adopted by FDEP rule. In compliance with this mandate, the St. Johns River Water Management District (SJRWMD) staff prioritized water bodies within SJRWMD in 1988 (SJRWMD 1988). The water bodies were reprioritized in 1991 (Adamus 1992).

The legislation also charged the water management districts, in cooperation with state agencies and local governments, to develop and implement SWIM plans for surface water improvement and management of water bodies based upon the priority list approved by FDEP. The SWIM plans are required to be updated at least every three years. These updates provide continued opportunities for input and re-evaluation of the plans as the restoration and management programs develop.

FDEP established a uniform format for SWIM plans with the necessary flexibility to accommodate particular circumstances of the individual water bodies. The format designates the following six central concerns as the focus of the SWIM Act:

- 1. Point and nonpoint source pollution
- 2. Destruction of natural systems
- 3. Correction and prevention of surface water problems
- 4. Research for better management of surface waters and associated natural systems
- 5. Public awareness
- 6. Improved coordination and management

SWIM PLAN DEVELOPMENT

Chapter 85-148, *Laws of Florida*, created the Lake Apopka Restoration Act and established the Lake Apopka Restoration Council (LARC) in 1985 (Appendix A).

SJRWMD, in conjunction with FDEP, FWC, Lake and Orange counties, and the LARC, was mandated to determine environmentally sound and economically feasible restoration projects for Lake Apopka. As a result of that mandate, a scope of work for the restoration of Lake Apopka was developed by the LARC and adopted by the SJRWMD Governing Board. In 1986, the Governing Board directed the staff to begin restoration efforts for the lake. With the passage of the SWIM Act, SJRWMD incorporated projects from the scope of work into the SWIM planning process.

The SWIM Act specifically designated Lake Apopka, the lower St. Johns River, and the Indian River Lagoon as the first SWIM programs in SJRWMD (Adamus 1992).

The original Lake Apopka SWIM Plan expanded on previous restoration efforts (see the Planning section for a detailed description of the planning process), using several steps:

- Identification of problems and issues
- Definition of goals
- Program development
- Determination of program strategies
- Project development
- Definition of project objectives
- Determination of priorities for action

The original Lake Apopka SWIM Plan was accepted by the Governing Board in 1989 and approved by FDEP in the same year. With the development of this plan and the primary mission of the LARC complete, the Governor did not re-appoint the members of the restoration council for further service. In 1993, an update of the Lake Apopka SWIM Plan was completed.

RELATIONSHIP OF SWIM PLANNING TO OTHER PLANNING AND MANAGEMENT EFFORTS

District Water Management Plans

District water management plans (DWMPs), initially prepared by the five water management districts in 1994 and updated every five years, provide long-term guidance for water management district activities, identify performance measures for the districts and district programs, and serve as a source of technical information on water resources. The DWMPs are incorporated into the Florida Water Plan, initially prepared by FDEP in 1995 and also updated every five years. Requirements for the DWMPs are found in the Water Resource Implementation Rule (62-40.520, *Florida Administrative Code* [*F.A.C.*]) and in Section 373.036, *FS*. The format of the plans is developed jointly by the water management districts and FDEP. Additional guidance for preparation of the DWMPs comes from the policies, responsibilities, and authority relating to water management districts in various state statutes and rules.

The overall goal for the DWMPs and activities of all the water management districts is stated in the Water Resources element of the State Comprehensive Plan (Chapter 187, *FS*), as follows:

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

The state's goal is realized through individual district goals established for the four district areas of responsibility (AORs): water supply, flood protection and floodplain management, water quality, and natural systems.

SJRWMD's May 2000 DWMP identifies issues, objectives, strategies, and performance measures as well as a goal for each AOR, and issues, strategies, and program-specific performance measures for major watersheds. Issues were identified using resource assessments, information gathered from SJRWMD and other agency staff and various data sources, and input received from local government staff, elected officials, and the public at workshops conducted as part of the DWMP development process. Strategies to address the issues were developed by SJRWMD staff, taking into account input received at the DWMP workshops.

Issues, strategies, and performance measures relating to the Lake Apopka SWIM program are included in the chapter on watersheds. SJRWMD's schedule for developing pollutant load reduction goals (PLRGs) for SWIM and other water bodies and related strategies are included in the chapter on the water quality AOR. PLRGs for Lake Apopka are more fully discussed in the Progress section and in the description for Project LA-3-403-M (Nutrient Loading Limits Adoption) in the Detail of Projects section.

Watershed Management Program

Beginning in July 2000, FDEP began implementing a comprehensive approach to protect water quality involving basinwide assessments and the application of a full

range of regulatory and nonregulatory strategies to reduce pollution through the Watershed Management Program. This program is based on a five-phase cycle that rotates through Florida's basins every five years. The five phases include

- Initial basin assessment
- Strategic monitoring
- Data analysis and total maximum daily load (TMDL) development
- Watershed plan development
- Watershed plan implementation

Each cycle will lead to the development of a detailed watershed management plan that focuses on protecting healthy water bodies and reducing pollution in impaired surface waters, usually by developing a TMDL. The Ocklawaha River Basin, which contains Lake Apopka, is included in the first group of basins that is being evaluated.

TMDLs establish the maximum amount of a pollutant that a water body can assimilate without causing exceedances of water quality standards. Implementation of TMDLs refers to any combination of regulatory, nonregulatory, or incentive-based actions that attain the necessary reduction in pollutant loading. Section 303(d) of the federal Clean Water Act requires states to submit lists of surface waters that do not meet applicable water quality standards and establish TMDLs for these waters on a prioritized schedule. FDEP's authority for Florida's TMDL program was established with the 1999 Florida Watershed Restoration Act. TMDLs may be based on PLRGs. PLRGs are defined as estimated numeric reductions in pollutant loadings needed to preserve or restore designated uses of receiving bodies of water and maintain water quality consistent with applicable state water quality standards. PLRGs are developed by the water management districts.

Local Government Comprehensive Plans

Each local government is required to have a comprehensive plan to guide its future development and growth pursuant to the Local Government Comprehensive Planning and Land Development Regulation Act (Chapter 163, *FS*). The act specifies elements to be included and requires that they be internally consistent and that plans be economically feasible, sets out procedures for plan adoption and amendments, addresses plan implementation, and contains sanction and enforcement provisions. It also requires that local government comprehensive plans be consistent with the applicable strategic regional policy plan and the state comprehensive plan. Given the broad scope of a comprehensive plan and the strong consistency requirements, there may be no action a local government can take which has more impact on its constituents

SWIM Plan for Lake Apopka

and resources, including natural resources, than development. All private and public development and all local land development regulations must be consistent with the adopted comprehensive plan. Also, although a comprehensive plan can be amended, it sets the tone and direction for the municipality or county it covers for at least a 10-year period.

A number of the elements required in local government comprehensive plans provide a means to address many water resource issues in the Lake Apopka Basin. These include the Future Land Use Element; the Conservation Element; the Sanitary Sewer, Solid Waste, Stormwater Management, Potable Water and Natural Groundwater Aquifer Recharge Element; the Capital Improvements Element; and the Intergovernmental Coordination Element.

Local governments are also required to perform periodic assessments of their progress in implementing their comprehensive plans. These assessments, known as evaluation and appraisal reports (EARs), identify any needed actions or corrective measures. The next round of due dates for EARs for local governments in the Lake Apopka Basin ranges from July 2005 for Orange County to June 2009 for Montverde. The schedule for submittal of adopted EAR reports for the years 2002 through 2010 is included in Project LA-6-502-S in the Detail of Projects section.

SJRWMD intergovernmental coordinators work with local governments on land development regulations to promote improved implementation of comprehensive plan policies to protect water resources.

Stormwater Planning

Stormwater issues are addressed at the local, regional, state, and national levels. Historically, stormwater concerns centered on how to most expediently transport storm water from urban or agricultural areas. More recently, stormwater issues have been broadened to include water quality concerns, not just draining the land.

Stormwater management is most effective from a watershed perspective, with coordination among local governments in the watershed or subbasins within the watershed. Local government comprehensive plans, required by Chapter 163, *FS*, provide an excellent opportunity for local governments to review their existing stormwater management facilities and programs, adopt policies to address existing deficiencies and meet future needs, and coordinate with adjacent local governments. Stormwater master plans may be tied to local government comprehensive plans. Master plans are useful tools for performing inventories and evaluating drainage improvement and stormwater treatment needs within individual watersheds.

Regulatory Programs of Governmental Bodies

Regulation of water quality is delegated to the states under Section 401 of the federal Clean Water Act. The state originally regulated surface water quality through the wetland resource management (dredge and fill) and stormwater rules. The water management districts administered the management and storage of surface waters (MSSW) rule and the stormwater rule. In addition, under a formal operating agreement with FDEP, SJRWMD administered a portion of the Wetland Resource Management program. Under the 1993 Streamlining Act, the MSSW, Stormwater, and Wetland Resource Management regulatory programs were combined to create the environmental resource permit (ERP) program. First issued in 1995, the purpose of ERPs is to address impacts to wetlands and to ensure that construction takes into account flood protection and the protection of waterways from stormwater pollution.

County and municipal governments have several regulatory means to address stormwater issues. The most direct means of stormwater regulation is through a local "stormwater management ordinance." The effectiveness of such an ordinance depends on the permitting thresholds, the restrictiveness of the requirements, and the degree of inspection and enforcement established by the local government.

Regional Planning Councils

Pursuant to changes made to the Florida Regional Planning Council Act in 1993, regional planning councils (RPCs) prepared and adopted strategic regional policy plans (SRPPs) which contain regional goals and policies addressing natural resources of regional significance, affordable housing, economic development, emergency preparedness, regional transportation, and any other subjects relating to the particular needs and circumstances of a region. The SRPPs also identify and address significant regional resources and facilities. They replaced the comprehensive regional policy plans previously adopted by the RPCs but still are required to be consistent with the state comprehensive plan. The SRPPs provide the basis for regional reviews of local government comprehensive plans and plan amendments, developments of regional impact/Florida quality developments, and other regional comment functions.

The Lake Apopka Basin is contained within the East Central Florida Regional Planning Council jurisdiction. The east-central Florida SRPP consists of four documents: *At This Point in Time* (physical, economic, and social profile of the region), *What the Future Holds* (trends over the next 30 years), *Water, Plants and Concrete* (resources and facilities of regional significance), and *Taking the Next Step* (goals and policies/planning process/regional review functions/use of geographic information systems). *Taking the* *Next Step* contains general policies on water-related resources but also anticipates additional planning and policy development for sub-areas of the region. General planning objectives are being implemented under a coordinated regional planning effort, the Lake Apopka Basin Planning Initiative.

SJRWMD planning staff participated in the RPC processes used to develop the SRPPs applicable to counties in SJRWMD. That participation involved serving on technical advisory committees, evaluating policies, and providing technical data. Review of the east-central Florida SRPP in 2001 did not result in any amendments affecting Lake Apopka.

Land Acquisition Program

When the water management districts were established in 1972, the Florida Legislature provided the districts with the general authority to utilize land acquisition as one of the primary tools for carrying out the mission of "flood control, water storage, water management, and preservation of wetlands, streams, and lakes" (Section 373.139, *FS*). Subsequently, the Legislature established additional land acquisition programs with specific directives for the expenditure of funds.

The Save Our Rivers (SOR) legislation of 1981 created the Water Management Lands Trust Fund for acquiring a fee-simple or other interest in lands necessary for water management, water supply, and the conservation and protection of water resources. In 1986, Section 373.59, *FS* (Appendix A), was amended to allow for the use of up to 10% of the monies from the trust fund for management, maintenance, and capital improvements. This allocation was increased to 15% in 1992. In 1995, the statute was amended to allow up to a maximum of 25% of the Water Management Lands Trust Fund to be used for management purposes. In 1997, the limit on management use was removed altogether.

The Preservation 2000 (P2000) Act passed in 1990 provided additional funding for the water management districts for land acquisition, contingent on annual funding appropriated by the Legislature over a 10-year period. The program used bond proceeds supported by the general revenue portion of the documentary stamp tax. The P2000 Act recommended that governmental agencies work together to purchase lands jointly with a coordinated goal of protecting ecological systems. A major recipient of P2000 funding was the Conservation and Recreation Lands program. Established in 1979 by the Florida Legislature, the Conservation and Recreation Lands program received funding from bond proceeds, severance taxes on phosphate mining, and excise taxes on real estate and financial documents.
The Florida Forever Act (Section 259.105, *FS*) was passed in 1999 as the successor to the P2000 Act. It provides for the issuance of up to \$3 billion in bonds over a 10-year period to be used for land acquisition, water resource development, stormwater management, water body restoration, recreational facility construction, public access improvements, invasive plant control, and related projects. The annual appropriation of up to \$300 million is divided among programs administered by FDEP, the Florida Communities Trust, the Division of Forestry, FWC, and the five water management districts. Over the life of the program, at least 50% of the funds must be spent on land acquisition and the balance on capital improvement projects.

SJRWMD's Land Acquisition and Management Five Year Plan has been replaced by the Florida Forever Work Plan. The Florida Forever Work Plan, which covers a five-year period with updates in January of each year, presents projects eligible for funding under the Florida Forever Act and reports on project implementation.

OVERVIEW OF THE LAKE APOPKA BASIN

DESCRIPTION OF THE WATER BODY SYSTEM

Lake Apopka, the fourth largest lake in Florida, is the headwater lake for the Harris Chain of Lakes (Figure 1). The lake is located at latitude 28° 37' N and longitude 81° 38' W and is within Orange and Lake counties (Figure 2). The nearest major metropolitan area is Orlando, located to the southeast about 25 kilometers (km) (15 miles). The water surface of the lake is approximately 12,465 hectares (ha) (30,800 acres [ac]) at lake surface elevation 20.2 meters (m) (66.5 feet [ft]) National Geodetic Vertical Datum 1929 (NGVD 29). Average depth at this surface elevation is 1.6 m (5.4 ft).

The only surface water outflow from Lake Apopka is the Apopka-Beauclair Canal, which flows north into Lake Beauclair (Figure 3). Discharge from the canal is controlled at the Apopka-Beauclair Lock and Dam, which therefore influences lake stage.

HISTORY

Historically, Lake Apopka covered approximately 20,235 ha (50,000 ac) and had an average depth of 2.4–2.7 m (8–9 ft). The northern third of the lake was a shallow marsh system, which afforded habitat for abundant fish and wildlife populations. Prior to its decline, the lake provided superb sportfishing of national renown. During periods of high water, the lake likely drained to the northwest into Little Lake Harris, through an area known as Double Run Swamp.

Numerous activities in the nineteenth and twentieth centuries have contributed to the decline of the lake. Significant human impact affecting Lake Apopka probably began with the construction of the Apopka-Beauclair Canal, which altered the hydrology of the lake. In order to create a waterway for navigation and agricultural use, dredging of the Apopka-Beauclair Canal was originally begun by the Apopka Canal Company in 1880 (Schiffer 1994). In 1893, the Delta Canal Company successfully completed 32 miles of lateral ditches and 12 miles of canal from Lake Apopka through Lakes Beauclair, Dora, and Eustis to the Ocklawaha River. This action effectively lowered the water surface of Lake Apopka by about 4 ft, leaving approximately 8,100 ha (20,000 ac) of predominantly sawgrass land dry enough for farming (Shofner 1982). Crop production was mostly unsuccessful due to difficulty in water table management and a series of freezes in the mid and late 1890s. By 1910, the canal was filled with vegetation and the lake stage was similar to its original state (M.H. Connell and Associates 1954).



Figure 1. The St. Johns River Water Management District





In 1915, the Zellwood Produce Company continued improving the canal in order to plant potatoes. The lake level was again lowered, this time to 63 ft NGVD 29 despite the protest of agricultural producers on the southern shore of the lake who feared water supply shortages, decreased cold protection, and a threat to navigation. However, a destructive blow was struck by a hurricane in 1926, and the entire north shore farm area reverted to marshland "under six to eight feet of water" (Shofner 1982).

Due to improved technology, farming returned during World War II. In 1941, the Zellwood Drainage and Water Control District (ZDWCD) was created by a special act of the Legislature and charged with facilitating agricultural production activities. In 1941, the mean elevation of the lake was approximately 67 ft NGVD 29, the same elevation as the muck and peat land along the northern shore at that time. These lands were inundated when the lake rose above the mean elevation, and during lower lake stages, these lands drained into the lake or into the Apopka-Beauclair Canal. Under the management of ZDWCD, a levee was constructed on the north shore, effectively separating the marshes from the lake and allowing drainage of the farm fields (Shofner 1982). Aerial photography of the northern end of the lake taken in 1947 shows approximately 1,162 ha (2,870 ac) in row crops and an additional 1,974 ha (4,875 ac) being prepared for farming (Figure 4). A lake stabilization program was begun in 1952 (Schiffer 1994), and the Apopka-Beauclair Canal was deepened just two years later. Agricultural production peaked within the muck farms during the 1980s, with 7,290 ha (18,000 ac) of farmed land. With the final government purchase of the remaining muck farms on August 20, 1999, ZDWCD was dissolved in February 2000 by mandate of the 1999 Florida Legislature. A detailed chronology of Lake Apopka's degradation is provided in Appendix B.

CLIMATE AND HYDROLOGY

Rainfall

Due to the subtropical climate of the Lake Apopka area, annual rainfall averages about 127 centimeters (cm) (50 inches [in.]). Typical seasonal precipitation patterns include a dry season from November to May and a wet season from June to September. About 60% of the total annual rainfall occurs during the four-month summer season as convective thunderstorms. Frequency of precipitation during the remainder of the year is lower, with measurable amounts occurring on about 25% of the days. Precipitation during this period occurs primarily from frontal events and is usually moderate. Rainfall is the major source of water to the lake. Rainfall statistics for area monitoring stations at Lisbon, Ocala, and Clermont are summarized in Jenab et al. (1986), Rao (1988, 1991), and Rao et al. (1989, 1990a, and 1990b).



Evapotranspiration

Evapotranspiration (ET) is the combined water loss due to evaporation and transpiration. ET is a major component of the water budget in the basin. Affected by wind, temperature, solar radiation, relative humidity, and plant transpiration, the average annual potential ET value for the Lake Apopka Basin is approximately 109 cm (43 in.) (Fernald and Purdum 1998).

Drainage Basin

The area of the Lake Apopka drainage basin, including the surface of the lake, is approximately 48,471 ha (119,773 ac). Several subbasins contribute either direct stormwater runoff or runoff through small tributaries during rainfall events (Figure 5). However, many portions of the drainage basin contribute runoff infrequently. More than 60 small lakes are scattered throughout the basin, but they are generally landlocked except in periods of extreme runoff events (Appendix C).

Springs

The largest spring in the basin, Apopka Spring, also known as Gourd Neck Spring, discharges into Gourd Neck, a narrow water body located in the southwest corner of the lake. The spring opening is at a depth of approximately 11.2 m (37 ft) (Rao and Clapp 1996). Fed by the Floridan aquifer, the spring discharges from a single submerged oval-shaped opening 5–6 ft in diameter (LCWA 1985). The average discharge rate of Apopka Spring was approximately 0.85 cubic meters per second (m^3/s) (29.9 cubic feet per second $[ft^3/s]$) from 1988 through 1998 (range, 0.76–0.99 m³/s), depending on the lake stage level (Stites et al. 2001). Based on the Meinzer spring discharge scheme, Apopka Spring is classified as a magnitude 2 spring (Rosenau et al. 1977). McGurk and Presley (2002) projected that by the year 2020, a discharge reduction of up to 24% could be realized due to projected increases in groundwater withdrawals if alternative water sources are not utilized. This could reduce total discharges to downstream water bodies.

Three other named springs exist in the basin; however, discharge information is not available. Holt Lake Spring is located just south of Holt Lake. Bear Spring and Wolf's Head Spring are located just southwest of Clay Island.



Stage Discharge and Regulation

Lake Apopka has a moderate hydraulic detention time of approximately 2.5 years (1959–88 average). Water discharge from the lake occurred via the Apopka-Beauclair Canal at a mean annual rate of 6.81×10^7 m³/year (76.4 ft³/s) for the years 1959–99 (USGS 2002).

The water control structure in the canal has altered the natural periodic fluctuation of the lake stage and discharge. From 1956, when the present structure was installed, through July 2002, the lake level has ranged from a low of 19.0 m (62.5 ft) recorded in June 2002 to 20.8 m (68.4 ft).

The seasonal regulation schedule is nearly the opposite of natural seasonal fluctuations in water levels; the lake is held at its lowest levels during the summer wet season in order to provide flood storage capacity (Figure 6). During periods of low water, a minimum discharge is released downstream. This alteration in the natural hydrologic cycle may have contributed to declines in aquatic habitat, water quality, and fisheries in the basin (SJRWMD 2001b). The U.S. Army Corps of Engineers is initiating an Upper



Figure 6. Lake Apopka regulation schedule and average monthly discharge volume for the Apopka-Beauclair Canal, 1959–1988

Ocklawaha River Basin Restudy project, which will evaluate operational modifications that could be implemented to enhance environmental restoration benefits of the basin. During the study phase of this project, alternative lake regulation schedules may be tested.

Aquifer Systems

Two aquifer systems occur in the study area, the surficial aquifer and the underlying artesian Floridan aquifer (Jenab 1986). An aquifer system consists of two or more hydraulically connected aquifers (Fernald and Purdum 1998).

The surficial aquifer is the permeable hydrogeologic unit contiguous with the land surface. It holds the water table with water generally under unconfined conditions between a depth of 0-60 m (0-200 ft) (Jenab 1986). The water usually contains iron in sufficient quantities to give it a pronounced taste.

The Floridan aquifer is separated from the surficial aquifer throughout most of the region by the intermediate confining unit. This unit consists of poorly permeable Miocene age Hawthorn Group sediments and, locally, low permeability beds of early Pliocene age (Miller 1986; Murray and Halford 1996). Localized beds of permeable sand, shell, gravel, or limestone exist within and above the Hawthorn Group sediments. These beds can constitute a localized intermediate aquifer when permeable enough to produce significant quantities of water to a well, but they are not really extensive enough in western Orange County and eastern Lake County to be considered an aquifer system. The Hawthorn Group sediments are rich in phosphorus, which may contribute to the natural productivity of surface waters in the area.

The underlying Floridan aquifer is the regional water-yielding hydraulic unit. Water from the Floridan aquifer is generally good in quality and suitable for most domestic, small irrigation, and light industrial applications. The depth to the top of the Floridan aquifer varies throughout the basin and ranges from approximately 25 to 90 m (80–300 ft). Wells in the Floridan aquifer are usually cased from ground level to the top of the aquifer. The wells are then extended without casing into the aquifer to allow water to enter the open hole from the various layers (USGS 1988).

The height at which water stands in a tightly cased well penetrating an artesian aquifer is called the potentiometric surface (Miller 1986; Murray and Halford 1996) and reflects the hydraulic head in the artesian aquifer. The potentiometric surface in the Lake Apopka Basin generally decreases in a northeasterly direction toward the Atlantic Ocean. It ranges from approximately 23 to 26 m (75–85 ft) NGVD 29 at the southwestern shore to 16 to 20 m (55–65 ft) on the northeastern shore (Knowles et al. 1995; O'Reilly et

al. 1996). Since shallow aquifer or groundwater movement is a function of the permeability of deposits and the slope of the potentiometric surface, seepage enters the lake from the western and southern boundaries and exits the lake through the eastern and northern shores.

Physiography

Lake Apopka is located at the southern edge of the Central Valley region of Florida. The surrounding terrain is composed of mildly rolling to undulating hills dotted with numerous small lakes and depressions (Figure 7). Evidence suggests that uplift has occurred. Since the Florida peninsula is considered tectonically stable and is in a karst region, this uplift may be caused by the dissolution of large volumes of limestone (Meyer 1983). The basin is bordered on the east by the Mount Dora Ridge and on the west by the Lake Wales Ridge. Ridge elevations are from 23 to 94 m (75–308 ft), and elevation in the Central Valley is from 18 to 27 m (59–89 ft). It is generally accepted that these parallel ridges were developed as beach dune systems during the higher sea levels of the Neogene Period (Meyer 1983), approximately 23.7–1.6 million years ago (McClellan and Smith 1998).

The lake is underlain by clay, sandy clay, and sand of Miocene epoch (23.7–5.3 million years ago) and younger age. This layer retards water movement between the lake and the underlying aquifers (Anderson 1971). Generally, the organic soil in the basin is underlain by undifferentiated marl from the Upper Pleistocene epoch (1.6–0.01 million years ago) (Meyer 1983). This layer, which lies at approximately 5–15 m (15–50 ft) in depth, contains dark bluish gray to green clay with imbedded marine fossils. At approximately 15 m (50 ft), the Jackson Bluff Formation of the Lower Pliocene epoch (5.3–1.6 million years ago) contains unfossiliferous clayey quartz sand. Marine fossils are again present at about 20 m (65 ft) in a dark greenish-gray sand layer that contains gypsum. The Hawthorn Group lies below the 25 m (80 ft) depth. This layer, from the Middle Miocene epoch, contains sandy phosphatic dolomite to dolomitic phosphatic sand.

Soil types within the basin range from excessively drained sandy soils located on the ridges to very poorly drained organic soils bordering the northern edge of Lake Apopka (Furman et al. 1975). Generally, soils of the uplands and low ridges are moderately well drained to excessively drained soils that are sandy throughout. If a weak organic-stained subsoil is present, it is at a depth of greater than 1 m (40 in.) (Doolittle and Schellentrager 1989). Soils of the flatwoods, low ridges, and knolls are generally very poorly to moderately drained and have a sandy surface with an organic-stained or



loamy subsoil, sometimes at a depth of less than 0.76 m (30 in.). The swamps, sloughs, and floodplains in the basin are dominated by very poorly to poorly drained organic soils that are subject to ponding or flooding.

Hydrologic soil groups are used by the Natural Resources and Conservation Service (NRCS) to estimate runoff from precipitation (Doolittle and Schellentrager 1989). The groups are classified according to their intake of water, or infiltration, when the soils are thoroughly wet and receive precipitation for a long duration. The groups located in the Lake Apopka drainage basin are (Figure 8) as follows:

- Group A Even when thoroughly wet, these soils have a high infiltration rate.
- Group C When wet, these soils have a slow infiltration rate due to either a layer which impedes downward movement of water or a fine texture.
- Group D These soils have a very slow infiltration rate due to a high permanent water table, a shrink-swell potential, or an impervious layer near the surface of the soil when thoroughly wet.
- Group B/D These soils have a moderate infiltration rate when drained, but a very slow infiltration rate when undrained.

The buildup of marsh vegetation, predominately saw grass, over thousands of years is responsible for the accumulation of the highly productive organic soils (peats and mucks). The age of the soils is approximately between 2,000 to 6,000 years, according to radiocarbon dating (Meyer 1983). Agriculturalists generally describe peats as fibrous and undecomposed, while mucks become well decomposed after tillage. Organic soils reached a depth up to 20 ft thick at one time on the northeastern shore of the lake (Davis 1946). The marsh generally had shallower deposits to the northwest (6–8 ft) and the central portion of the marsh had deposits approximately 8–10 ft during the 1940s. However, subsidence has resulted in a loss of the organic layer thickness.

Subsidence is the shrinkage, consolidation, and biological oxidation of organic soils that are exposed to the atmosphere through drainage and aeration. During biological oxidation, microbial organisms begin to break down the organic material, and nutrients are released. Hortenstine and Forbes (1972) compared the nutrient content of the soil solution from an undisturbed, swampy area and an adjacent drained, newly cleared, unfertilized area of an Everglades mucky peat within the Lake Apopka Basin. The results showed that in the drained area, inorganic phosphorus was 10 times higher and nitrate-nitrogen was 8 times higher in the soil solution than in the undrained area. These nutrients are available for release when the soil is reflooded. Other factors that contribute to subsidence include wind erosion, water erosion, compaction, water table depth, character of the organic material, and the cropping system (Lucas 1982).





Figure 8.Soil hydrologic groups of the Lake Apopka BasinImage: Colspan="2">Group A-High infiltration rateImage: Colspan="2">Group C-Slow infiltration rateImage: Colspan="2">Group D-Very slow infiltration rateImage: Colspan="2">Group D-Very slow infiltration rateImage: Colspan="2">Group B/D-Moderate infiltration rate when drained

Very slow infiltration rate when undrained

WATER QUALITY

Lake Apopka is considered the most severely polluted large Florida lake (EPA 1979). The lake water is well buffered, alkaline, highly turbid, and pea-green in color. The Secchi transparency is approximately 30 cm (12 in.) or less. Lake Apopka has received heavy external loading of nutrients from muck farms previously situated within the northern floodplain. In addition, nutrients are recycled through decomposition in the sediments and subsequent wind-driven mixing (internal loading).

The Trophic State Index is a water quality index for lakes based on nitrogen and phosphorus concentrations, transparency, and chlorophyll *a* values. The index rating for Florida lakes ranges from 0 to 59 (good), 60 to 69 (fair), and 70 to 100 (poor) (Huber et al. 1982). Lake Apopka's average Trophic State Index has varied from 82 to 91 (poor/hypereutrophic condition) (Conrow et al. 1993). However, the 2000 Florida Water Quality Assessment reports an improving water quality trend (Hand et al. 2001).

In 1995, the total phosphorus (TP) concentration began to fluctuate around a new, lower level (Figure 9). Chlorophyll concentrations also declined in mid-1995 and have continued downward trajectory (Figure 10). In fact, the January 2000 value was the lowest monthly average measured in a decade of SJRWMD monitoring. Secchi depth, a measure of water clarity, increased during the same period, showing a significant improving trend (Figure 11). These changes occurred during a period when average wind speeds measured at Lake Apopka were constant. Whether chlorophyll and Secchi depth have reached equilibrium with the new, lower average TP concentration or if chlorophyll and Secchi depth will improve further without additional P loading reductions is unknown.

Chapter 62-302, *F.A.C.*, designates Lake Apopka as a Class III water body and sets water quality standards for such water bodies (Lowe et al. 1995). The rule does not set specific numerical criteria for nutrients, but refers to "natural" and "natural background" conditions. Particular attention is paid to waters which are presently high in nutrient concentrations. The criteria for surface water quality classification (62-302.530, *F.A.C.*) address transparency by stating that "the depth of the compensation point for photosynthetic activity shall not be reduced by more than 10% compared to the natural background value." The "compensation point" is defined as the "depth at which one percent of the light intensity at the surface remains unabsorbed" (62-302.200(6), *F.A.C.*).



Figure 9. Lake Apopka mean monthly total phosphorus, January 1987–March 2002



Figure 10. Lake Apopka mean monthly chlorophyll a (uncorrected), January 1987-March 2002



Figure 11. Lake Apopka mean monthly Secchi depth, January 1987–March 2002

Lowe et al. (1995) estimated the natural levels of these parameters and determined the target range for phosphorus which would allow the lake to achieve Class III conditions. Since the natural condition can be difficult to ascertain due to limited information, modern lake surveys and modeling techniques were used to determine background levels (Table 1). These levels are measures of annual central tendency, such as the median or mean, and are not meant to apply to individual measurements (Lowe et al. 1995).

Table 1. Most probable ranges for trophic state variables in pre-impacted and Class III (restored) states

Lake Condition	Total Phosphorus	Chlorophyll <i>a</i>	Secchi Depth
	(ppb)	(ppb)	(m)
Pre-impact	32 to 46	8 to 23	1.39 to 0.90
Class III	38 to 55	10 to 23	1.25 to 0.81

Note: m = meter

ppb = parts per billion

Source: Lowe et al. 1995

In 1996, the Florida Legislature created Section 373.461, *FS*, (Appendix A) which established a total phosphorus criterion of 55 parts per billion (ppb) for Lake Apopka if SJRWMD did not establish a rule by January 1997. SJRWMD responded with revisions to Chapter 40C-4, *F.A.C.*, and the *Applicant's Handbook: Management and Storage of Surface Waters* (Appendix A), effective August 1996. This rule established a phosphorus criterion of 55 ppb for Lake Apopka and discharge limitations for all activities within the Lake Apopka Basin permitted to discharge, directly or indirectly, into Lake Apopka, the Lake Level Canal, or the McDonald Canal. The phosphorus criterion specifies a numeric interpretation for phosphorus of the Class III narrative nutrient criterion.

Phosphorus discharge limitations for Lake Apopka were approved by the Governing Board in December 2002. The rule amendments, which involve Chapters 40C-4, 40C-41, 40C-42, and 40C-44, *F.A.C.*, and related Applicant's Handbooks, became effective March 7, 2003 (Appendix A).

SEDIMENTS

The sediments in Lake Apopka are composed of six different layers, including an unconsolidated floc, a consolidated floc, peat, sand, clay, and marl (Gale and Reddy 1994). The unconsolidated floc, which contains up to 97% water, covers 96% of the lake bottom to an average depth of 32 cm (1.0 ft) (Reddy and Graetz 1991). The high sedimentation rate is due to the abundance of nutrients being assimilated by algae. Upon their death, algal cells are deposited on the sediment surface, thus resulting in sediment buildup (Reddy et al. 1988).

Schelske (1997) concluded that phosphorus storage in the sediments has increased at least threefold in the last 50 years, based on comparisons by decade, and as much as fourfold if annual rates are compared. Sediment porewater nutrient levels are high and may provide the primary internal recycling of phosphorus for the lake through wind-induced mixing. Reddy and Graetz (1991) estimated the mass of total phosphorus stored in the unconsolidated floc was 1,371 metric tons. More than 5,200 tons was stored in the consolidated floc layer.

BIOTA

The biota of Lake Apopka reflect its chemical status. Blue-green algae dominate the water column throughout the year. The limited amount of emergent vegetation is predominantly cattails (*Typha* spp.), with some stands of bulrush (*Scirpus* spp.) and knot grass (*Paspalidium geminatum*) interspersed around the lake shoreline. In 1995, several small patches of eelgrass (*Vallisneria americana*) were observed near the north shore. By

January 2001, 83 patches of submergent vegetation, primarily eelgrass, totaling about 2.6 ha (6.5 ac) had been discovered around the lake, and small areas of musk-grass (*Chara* spp.) and southern naiad (*Najas guadalupensis*) were found and are being monitored for expansion.

The dominant zooplankton in the lake are smaller members of the water fleas (*Cladocera*) and rotifers (Crisman and Beaver 1988). Benthic invertebrate populations in the lake are low in diversity and density and are composed primarily of sludgeworms (tubificids) and midges (chironomids) (Brezonik et al. 1978). Most of the taxa in the lake are pollution-tolerant forms that can endure high levels of organic enrichment (Belanger 1979). The fish community is dominated by gizzard shad (*Dorosoma cepedianum*) and blue tilapia (*Tilapia aurea*) with remnant populations of sunfish (*Centrarchidae*). An active commercial fishery for catfish (*Ictaluridae*) existed in the lake until the early 1990s. That fishery has subsequently declined.

Several animal and plant species that occur or may occur in the Lake Apopka Basin have special protection status with federal and state agencies. These species are listed in Tables 2 and 3. All species listed may not be present within the immediate confines of the Lake Apopka Basin. The abundance of bird species that utilize the basin was apparent by a one-day visit in 1994 by Southeast Nature Tours to Zellwood Farms, where 70 different species of birds were sighted (Ganong 1994). Stenberg et al. (1998) reported 71 bird species during investigations in the demonstration marsh flow-way from 1990 through 1994. In 1998, the Zellwood/Mount Dora Christmas Bird Count recorded a likely North American inland record of 174 species (Cornell University 2002). Table 4 lists the birds observed at the Lake Apopka restoration site by SJRWMD personnel and volunteers.

LAND USE/LAND COVER

Land Use

Land use activity and development in a basin usually combine with regional geology to determine the quality of water in a receiving water body. In 1995, agriculture covered 21,626 ha (53,437 ac) of the 48,471 ha (119,773 ac) within the Lake Apopka drainage basin (Figure 12). Surface waters covered approximately 13,794 ha (34,084 ac). The remaining 19,353 ha (22,252 ac) was composed of wetland, forest, rangeland, urban development, and barren land. These land use/land cover categories are defined in Appendix D.

SWIM Plan for Lake Apopka

Table 2. Animal species that may occur in the Lake Apopka Basin and that have been granted special status by federal or state agencies

Common Name	Scientific Name	Category		
	Fish			
Lake Eustis pupfish*	Cyprinodon varigatus hubbsi	SSC		
Southern tesselated darter*	Etheostoma olmstedi maculaticeps	SSC		
Reptiles and Amphibians				
American alligator	Alligator mississippiensis	SSC		
Eastern indigo snake	Drymarchon corais couperi	FT, ST		
Bluetailed mole skink	Eumeces egregious lividus	FT, ST		
Gopher tortoise	Gopherus polyphemus	SSC		
Sand skink	Neoseps reynoldsi	FT, ST		
Florida pine snake	Pituophis melanoleucus mugitus	SSC		
Gopher frog	Rana capito	SSC		
Short tailed snake	Stilosoma exenuatum	ST		
	Mammals			
Florida panther	Felis concolor coryi	FE, SE		
Florida mouse	Podomys floridanus	SSC		
Sherman's fox squirrel	Sciurus niger shermani	SSC		
Florida black bear	Ursus americanus floridanus	ST		
	Birds			
Roseate spoonbill	Ajaia ajaja	SSC		
Florida scrub jay	Aphelocoma coerulescens	FT, ST		
Limpkin	Aramus guarauna	SSC		
Florida burrowing owl	Athene cunicularia floridana	SSC		
Little blue heron	Egretta caerulea	SSC		
Snowy egret	Egretta thula	SSC		
Tricolored heron	Egretta tricolor	SSC		
White ibis	Eudocimus albus	SSC		
Arctic peregrine falcon	Falco peregrinus tundrius	SE		
Southeastern American kestrel	Falco sparverius paulus	ST		
Whooping crane	Grus americana	SSC, FT (E/P)		
Florida sandhill crane	Grus canadensis pratensis	ST		
Southern bald eagle	Haliaeetus leucocephalus leucocephalus	FT, ST		
Wood stork	Mycteria americana	FE, SE		
Red-cockaded woodpecker	Picoides borealis	FE, ST		
Audubon's crested caracara	Polyborus plancus audubonii	FT, ST		
Snail kite	Rostrhamus sociabilus plumbeus	FE, SE		
Black skimmer	Rynchops niger	SSC		
Least tern	Sterna antillarum	ST		

*These fish species have not been found in Lake Apopka

Source: FWC 1997; Peterson 1997; USFWS 2001

Status code:

FE =	federal endangered	FT = federal threatene	d

- E/P = experimental population SSC = species of special concern SE = state endangered
 - ST = state threatened

Common Name	Scientific Name	Category
Curtiss' milkweed	Asclepias curtissii	SE
Florida bonamia	Bonamia grandiflora	FT, SE
Ashe's savorv	Calamintha ashei	ST
Pygmy fringe-tree	Chionanthus pygmaea	FE, SE
Pigeon wings (butterfly pea)	Clitoria fragrans	FT. SE
Short-leaved rosemary	Conradina breviflora	FE, SE
Large-flowered rosemary	Conradina grandiflora	SE
Beautiful pawpaw	Deeringothamnus pulchellus	FE, SE
Scrub mint	Diceranda frutescens	FE, SE
Water sundew	Drosera intermedia	ST
Scrub buckwheat	Eriogonum floridanum	FT, SE
Harper's beauty	Harperocallis flava	FE, SE
Florida hartwrightia	Hartwrightia floridana	ST
Florida hasteola	Hasteola rovertiorum	SE
Yellow star anise	Illicium parviflorum	SE
Cooley's water willow	Justica cooleyi	SE, FE
Nodding pinweed	Lechea cernua	ST
Catesby's lily	Lilium catesbaei	ST
Bog spicebush	Lindera subcoriacea	SE
Cardinal flower	Lobelia cardinalis	ST
Scrub lupine	Lupinus westianus var. aridorum	FE, SE
Florida milkweed	Matela floridana	SE
Pinesap	Monotropa hypopithys	SE
Slender naiad	Najas filifolia	ST
Fall flowering pleat-leaf	Nemastylis floridana	SE
Florida beargrass	Nolina atopocarpa	ST
Scrub beargrass (Britton's beargrass)	Nolina brittoniana	FE, SE
Hand adder's tongue fern	Ophioglossum palmatum	SE
Papery whitlow-wort	Paronychia chartacea	FT, SE
Pepper	Peperomia humilus	SE
Southern yellow fringeless orchid	Platenthera integra	SE
Lewton's polygala	Polygala lewtonii	SE, FE
Small's jointweed (sand lace)	Polygonella myriophylla	FE, SE
Scrub plum	Prunus geniculata	FE, SE
Wild coco	Pteroglossaspis ecristata	ST
Needle palm	Rhapidophyllum hystix	SSC
Florida willow	Salix floridana	SE
Hidden stylisma	Stylisma abdita	SE
Clasping warea (wide-leaf warea)	Warea amplexifolia	FE, SE
Carter's mustard	Warea carteri	FE, SE
East Coast coontie	Zamia umbrosa	С
Simpson's zephyr lily	Zephyranthes simpsonii	ST

Table 3. Plant species that may occur in the Lake Apopka Basin and that have been granted special status by federal or state agencies

Source: FWC 1997; Peterson 1997; USFWS 2001

Status code:

- FT = federal threatened SE = state endangered
- FE = federal endangered E/P = experimental population SSC = species of special concern
- ST = state threatened

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LOONS AND GREBES	DUCKS, GEESE, SWANS	RAILS, GALLINULES, COOTS, CRANES
Pied-billed grebe	Blue-winged teal	Limpkin
Horned grebe	Cinnamon teal	Sandhill crane
Eared grebe	Northern shoveler	Whooping crane
PELICANS AND ALLIES	Northern pintail	PLOVERS AND SANDPIPERS
American white pelican	Green-winged teal	Black-bellied plover
Brown pelican	Canvasback	American golden plover
Double-crested cormorant	Redhead	Semipalmated plover
Anhinga	Ring-necked duck	Killdeer
HERONS, IBISES, AND ALLIES	Greater scaup	Black-necked stilt
American bittern	Lesser scaup	American avocet
Least bittern	Bufflehead	Greater yellowlegs
Great blue heron	Hooded merganser	Lesser yellowlegs
Great white heron	Red-breasted merganser	Solitary sandpiper
Great egret	Ruddy duck	Willet
Snowy egret	HAWKS AND ALLIES	Spotted sandpiper
Little blue heron	Osprev	UPLAND SANDPIPER
Tricolored heron	Swallow-tailed kite	Whimbrel
Reddish earet	White-tailed kite	Long-billed curlew
Cattle egret	Snail kite	Marbled godwit
Green heron	Bald eagle	Ruddy turnstone
Black-crowned night-heron	Northern harrier	Red knot
Yellow-crowned night-heron	Sharp-shinned hawk	Sanderling
White ibis	Cooper's hawk	Semipalmated sandpiper
Scarlet ibis	Red-shouldered hawk	Western sandpiper
Glossy ibis	Broad-winged hawk	Least sandpiper
Roseate spoonbill	SHORT-TAILED HAWK	White-rumped sandpiper
STORKS AND VULTURES	Swainson's hawk	Baird's sandpiper
Wood stork	Red-tailed hawk	Pectoral sandpiper
Black vulture	Rough-legged hawk	Dunlin
Turkey vulture	Golden eagle	Curlew sandpiper
DUCKS, GEESE, SWANS	Crested caracara	Stilt sandpiper
Black-bellied whistling-duck	American kestrel	Buff-breasted sandpiper
Fulvous whistling-duck	Eurasian kestrel	Ruff
White-faced whistling-duck	Merlin	Short-billed dowitcher
Greater white-fronted goose	Peregrine falcon	Lona-billed dowitcher
Snow goose		Common snipe
Ross' doose	Wild turkev	American woodcock
Canada doose	Northern bobwhite	Wilson's phalarope
Muscovy duck	RAILS. GALLINULES, COOTS, CRANES	Red-necked phalarope
Wood duck	King rail	GULLS. TERNS, AND ALLIES
Gadwall	Virginia rail	Laughing gull
American wideon	Sora	Franklin's gull
American black duck	Purple gallinule	Bonaparte's gull
Mallard	Common moorhen	Ring-billed gull
Mottled duck	American coot	Herring gull

Table 4. Bird species observed at the Lake Apopka restoration site

Table 4—Continued

GULLS, TERNS, AND ALLIES	FLYCATCHERS	KINGLETS AND GNATCATCHERS
Lesser black-backed gull	Eastern wood-pewee	Golden-crowned kinglet
Gull-billed tern	Acadian flycatcher	Ruby-crowned kinglet
Caspian tern	Willow flycatcher	Blue-gray gnatcatcher
Royal tern	Least flycatcher	STARLINGS, PIPITS, WAXWINGS
Common tern	Eastern phoebe	European starling
Forster's tern	Vermillion flycatcher	American pipit
Least tern	Ash-throated flycatcher	Cedar waxwing
Black tern	Great-crested flycatcher	Wood Warblers and Allies
Black skimmer	Cassin's kingbird	Blue-winged warbler
PIGEONS AND DOVES	Western kingbird	Tennessee warbler
Rock dove	Eastern kingbird	Orange-crowned warbler
Eurasian-collared dove	Gray kingbird	Nashville warbler
White-winged dove	Scissor-tailed flycatcher	Northern parula
Mourning dove	Fork-tailed flycatcher	Yellow warbler
Common ground-dove	SHRIKES	Chestnut-sided warbler
CUCKOOS AND ANIS	Loggerhead shrike	Magnolia warbler
Black-billed cuckoo	VIREOS	Cape May warbler
Yellow-billed cuckoo	White-eyed vireo	Black-throated blue warbler
Groove-billed ani	Bell's vireo	Yellow-rumped warbler
OWLS AND GOATSUCKERS	Yellow-throated vireo	Black-throated green warbler
Barn owl	Blue-headed vireo	Blackburnian warbler
Eastern screech-owl	Philadelphia vireo	Yellow-throated warbler
Great horned owl	Red-eyed vireo	Pine warbler
Barred owl	JAYS AND CROWS	Prairie warbler
Short-eared owl	Blue jay	Palm warbler
Lesser nighthawk	Florida scrub jay	Bay-breasted warbler
Common nighthawk	American crow	Blackpoll warbler
Chuck-will's-widow	Fish crow	Cerulean warbler
Whip-poor-will	Swallows	Black-and-white warbler
SWIFTS, HUMMINGBIRDS,	Purple martin	American redstart
AND KINGFISHERS	Tree swallow	Prothonotary warbler
Chimney swift	Northern rough-winged swallow	Worm-eating warbler
Ruby-throated hummingbird	Bank swallow	Ovenbird
Black-chinned hummingbird	Cliff swallow	Northern waterthrush
Belted kingfisher	Barn swallow	Louisiana waterthrush
WOODPECKERS	CHICKADEES AND TITMICE	Kentucky warbler
Red-headed woodpecker	Carolina chickadee	Common yellowthroat
Red-bellied woodpecker	Tufted titmouse	Hooded warbler
Yellow-bellied sapsucker	WRENS AND BUBULS	Yellow-breasted chat
Downy woodpecker	Carolina wren	Wilson's warbler
Hairy woodpecker	Bewick's wren	Sparrows
Northern flicker	House wren	Eastern towhee
Pileated woodpecker	Sedge wren	Chipping sparrow
	Marsh wren	Clay-colored sparrow

Table 4—Continued

SPARROWS	Grosbeaks and Allies	Blackbirds and Allies
Field sparrow	Lapland longspur	Bobolink
Vesper sparrow	Northern cardinal	Red-winged blackbird
Lark sparrow	Rose-breasted grosbeak	Eastern meadowlark
Lark bunting (unverified)	Blue grosbeak	Yellow-headed blackbird
Savannah sparrow	Indigo bunting	Rusty blackbird
Grasshopper sparrow	Painted bunting	Common grackle
Henslow's sparrow	Dickcissel	Boat-tailed grackle
Le Conte's sparrow	THRUSHES AND ALLIES	Shiny cowbird
Fox sparrow	Veery	Bronzed cowbird
Song sparrow	Gray-cheeked thrush	Brown-headed cowbird
Lincoln's sparrow	Bicknell's thrush	Orchard oriole
Swamp sparrow	Swainson's thrush	Baltimore oriole
White-throated sparrow	Hermit thrush	Finches and Allies
White-crowned sparrow	Wood thrush	American goldfinch
Tanagers	American robin	OLD WORLD SPARROWS
Summer tanager	Gray catbird	House sparrow
Scarlet tanager	Northern mockingbird	
	Brown thrasher	

Source: Robinson 2000, 2001; SJRWMD staff reports (unpublished)

Due to multicropping, nearly 10,449 ha (25,800 ac) of total crops were harvested in 1996 within the muck farm area of 5,913 ha (14,600 ac), located on the lake's former floodplain. The estimated average economic value of the 1991–95 harvests totaled approximately \$62 million in direct annual sales (Apogee, Inc. 1996). A wide variety of vegetable crops were produced, including sweet corn, carrots, celery, cucumbers, cabbage, radishes, and other vegetables. During the early 1990s, Florida was the third highest state in the nation in fresh market carrot production and first in sweet corn production (Crnko et al. 1993). Statewide, approximately 90% of the carrots and 25% of the sweet corn were grown in the central Florida agricultural area around Zellwood (Crnko et al. 1993).

Due to soil subsidence, oxidation, and compaction, the former farm area lies approximately 1 m (3 ft) below the surface of the lake and is protected from flooding by a levee. The area was drained by a system of field ditches, canals, and large pumps. When water was required for irrigation or flooding of fields for pest control, water from the lake was used. During periods of excess rainfall, water was pumped back into the lake. The installation of detention ponds on several farms allowed recycling of water on the farm and greatly reduced pumping to Lake Apopka (Stites et al. 2001).



Citrus production on the eastern and western slopes of the lake peaked during the 1979–80 season, then declined quickly after killing freezes in December 1983 and January 1985. Trees on the south shore of Lake Apopka had minimum damage during the Christmas freeze of 1983 (Attaway 1997). However, the 1985 freeze produced temperatures below -5.6°C (22°F) for more than 6.5 hours in Groveland, just 15 miles west of Lake Apopka (Attaway 1997). The combined effects of the two severe freezes plus earlier freezes in 1981 and 1982 killed many acres of citrus trees.

Population growth is rapid within the basin (Table 5). For example, the population of Apopka grew approximately 96% from 1990 to 2000 (UF 2001). In 1996, Orange County

City	April 1, 1990 (census)	April 1, 2000 (census)	Total Change 1990–99	Percent Change 1990–99
Apopka	13,611	26,642	13,031	+96
Montverde	890	882	-8	-0.9
Oakland	700	936	236	+34
Winter Garden	9,863	14,351	4,488	+46

Table 5. Population by municipality within the Lake Apopka Basin

Source: UF 2001

was estimated to be the fourth fastest growing county in the state and was ranked as the sixth most populated county in Florida. By 2010, Orange County is projected to have a population of 1.1 million, based on a growth rate of 24% since 1990 (UF 2001). During the same time period, it is projected that the population of Lake County will grow by 26%, to 264,800.

Land Cover—Wetlands

Freshwater wetlands still cover approximately 8% of the land in the basin (Figure 13), and include swamps, bayheads, flatwoods depressions, deep marshes, and shallow marshes. Freshwater swamps are dominated by woody species such as cypress, red maple, sweetgum, and black tupelo. Freshwater depressions, marshes, sloughs, and artificial drainage ways are usually dominated by herbaceous and shrub species including grasses, sedges, rushes, ferns, buttonbush, Coastal Plain willow, primrose willow, cattail, saw grass, water lilies, submersed aquatics, and other water-tolerant plants.



Figure 13. 1995 land use/land cover composition

RECREATION AND PUBLIC USE

Lake Apopka supported a very popular sport and commercial fishery during the early portion of the twentieth century. In 1950, fish camps could accommodate over 300 overnight guests, and nearly 200 fishing boats were available for hire (Apogee, Inc. 1996). The estimated economic values of recreational and commercial fishing were estimated to be over \$1 million and \$250,000, respectively, in 1951 dollars. Largemouth bass, black crappie, and panfish were popular with sport fishermen, while the commercial interests targeted turtles and catfish. Between 1956 and 1965, the number of fish camps dwindled from 21 to 9 (Heaney et al. 1989).

Currently, the recreational facilities on Lake Apopka include Magnolia Park on the southwest shore, Winter Garden City Park and the Oakland Nature Park on the south shore, and a small public boat ramp in Montverde located on the southwest shore of the lake (see Figure 3). According to a 1996 economic analysis by Apogee, Inc., the Lake Apopka recreational sport fishery is well below usage levels of other nearby lakes. The

aesthetic quality of the lake discourages all water contact sports, such as swimming and skiing (Conrow et al. 1993). Recreational boating is well under-utilized, and there is limited opportunity for waterfowl hunting or bird watching (Apogee, Inc. 1996).

NUTRIENT POLLUTION SOURCES

Farms located in Lake and Orange counties on the northern shore of Lake Apopka (Figure 14) were historically the largest contributors of nutrient loading to the lake (Figure 15). SJRWMD estimates are that, until recently, farming operations discharged over 20 billion gallons of water annually for drainage, flood control, and pest control. The quality of this discharge water (one third of the lake's total volume) was poor due to high concentrations of nutrients. For example, the average mean volume-weighted TP concentration in farm discharges from 1989 to 1994 was 0.897 milligrams per liter (mg/L) (Stites et al. 2001). During that same time period, the farms contributed approximately 85% of the net phosphorus loading to Lake Apopka. During the late 1980s, SJRWMD entered into consent order agreements with the major farming interests, A. Duda and Sons and ZDWCD, which were designed to reduce discharges and improve water quality according to a fixed time schedule.

Ultimately, the farms were purchased following the passage of legislation in 1996, which determined that it was in the public interest for SJRWMD to pursue buyout of the farms to reduce phosphorus loading to the lake. The SJRWMD acquisition of the farms was completed in August 1999 using federal and state funds. The area will be restored to wetlands and, ultimately, reconnected to the lake.

The degree to which nonpoint pollution sources other than agriculture contribute to problems in the lake is presently small. An inventory of permitted nonpoint discharges (Chapter 373, Part IV, permits) is found in Appendix E. The relative contribution of pollutants from other nonpoint sources will increase as agricultural sources are successfully controlled.

Discharges to the lake from industrial or domestic point sources have been reduced over time. Since 1980, the City of Winter Garden Wastewater Treatment Facility has utilized a percolation/evaporation system for land application of its effluent, with no direct discharge to the lake. In 1996, the plant had an average daily flow of approximately 1.35 million gallons per day (mgd) and a capacity of 2.0 mgd. Currently, groundwater seepage moves through underdrains to an unnamed ditch and then flows through approximately one mile of wetlands and swamp to Lake Apopka. A proposed expansion to the plant would increase the total permitted capacity to 2.5 mgd, with a total design capacity of 4.0 mgd. Mining of peat deposits on approximately 170 ha





(425 ac) on Pine Island by the Scotts Hyponex Corporation consistently discharged approximately 1–1.5 billion gallons annually until the digging operation was closed in late 1997. This reduced annual phosphorus loading to the lake by approximately 350 kilograms (kg). Winter Garden Citrus Products constructed percolation ponds and spray fields in 1977, which limited the plant's surface water discharge to approximately 2.5 mgd.

All current point sources are listed in Appendix E.

TOXIC POLLUTANTS

The Zellwood groundwater contamination site, a 23-ha (57-ac) Superfund site, is located approximately one-half mile west of Zellwood (EPA 2001). Due to past waste disposal practices by four separate industries, groundwater, sediments, soil, and sludges at the site became contaminated with organic compounds including polycyclic aromatic hydrocarbons, pesticides, and heavy metals. Abandoned drums were removed and contaminated soil was excavated and solidified on-site. However, a plume of groundwater contamination containing metals and nutrients is present in the surficial aquifer and extends several hundred feet south of West Jones Avenue. A baseline risk assessment for human health indicated an unacceptable risk to human health would occur only if future residents/businesses were to use the shallow groundwater at and around the site for drinking water. The selected remedy is monitored natural attenuation with institutional controls.

From 1957 to 1981, Tower Chemical Company (TCC) manufactured, produced, and stored various pesticides (EPA 2002a). TCC discharged wastewater into a 0.5-ac unlined percolation/evaporation pond which was located over a relict sinkhole that created a conduit to the Floridan aquifer. Waste was burned and buried on a 1.5-ac plot. In 1980, following an overflow from a wastewater pond into Gourd Neck, TCC constructed a spray irrigation field for waste disposal that was not permitted by the state. TCC ceased operations following two court orders that prohibited the use of the sprayfield and of DDT. Following the spill, vegetation changes and a fish kill were reported within the Gourd Neck area of Lake Apopka (Rice and Percival 1996). The area was later designated a Superfund site by the U.S. Environmental Protection Agency (EPA) due to the presence of copper and pesticides, including DDT, in on-site surface and subsurface soils, groundwater (including the surficial aquifer and the deeper Floridan aquifer), and the on-site pond. Also, pesticides contaminated on- and off-site sediments and volatile organic compounds, including ethyl benzene, were present in on-site soils. To prevent contaminants from entering the Floridan aquifer, 1,720 cubic meters (m³) (2,275 cubic yards [yd³]) of contaminated soil, 1,170 m³ (1,545 yd³) of sediment, and 72 drums were

excavated and disposed of off-site in 1983 by EPA. In addition, over a million gallons of wastewater was pumped from the pond and treated, soil that was removed was replaced by clean fill, and a surface water runoff system was constructed to prevent migration of the contaminants off-site. The most recent groundwater data show that pesticides and other organic contaminants persist in the groundwater. Soil data from March 1997 show DDT and its metabolites are present to a depth of 8.5 m (28 ft) below ground surface (EPA 2002a). Monitoring of nearby potable wells was also initiated. An Interim Action Record of Decision, which provides an alternate water supply to the nearby residents, was signed in August 2000, but has not yet been funded (EPA 2002a). A baseline risk assessment was completed in 2001. EPA is currently analyzing tentatively identified and unknown compounds and determining their toxicity. The investigation is centering on improving the identification and quantification of dichlorobenzophene (DBP), a degradation product of DDT, which was used by TCC to formulate miticides for the citrus industry (EPA 2002b).

In 1981, a major decline was observed in juvenile alligator abundance in Lake Apopka (Woodward et al. 1993). An analysis of alligator eggs collected in 1985 showed that eggs from Lake Apopka had significantly elevated levels of DDD, DDT, and DDE (Rice and Percival 1996). These compounds and many other pesticides can act as hormones or as inhibitors of natural hormones in developing embryos (Guillette et al. 1994). U.S. Fish and Wildlife Service (USFWS), University of Florida (UF), and FWC researchers identified reproductive failure in alligator and turtle populations in the lake and found a possible link to DDE and other organic contaminants. Such compounds are found in low concentrations in Lake Apopka sediments. However, recent research by Gross et al. (1998) does not support the earlier hypothesis of a DDT or DDE link to clutch viability.

Two distinct alligator populations have been found in the lake (Gross et al. 1998). Clutches from the southern portion of Lake Apopka had higher nested egg numbers, hatched egg numbers, neonatal survivor numbers, viability rate, hatch rate, and production rate than clutches from the northern portion of Lake Apopka. According to Rice and Percival (1996), an increasing overall trend in the juvenile population and in clutch viability has occurred on Lake Apopka since 1989. They suggest two very different potential fates for alligators (and other vertebrate populations) in Lake Apopka. Either the system, damaged in the past by environmental contamination or other causes, is in recovery, or this apparent recovery phase may end, and juvenile animals present today might not reproduce or survive.

Overall, the studies of wildlife on Lake Apopka indicate altered reproductive function for alligators, turtles, and possibly largemouth bass. Research conducted by the UF has indicated that contaminant-induced endocrine disruption occurs in wildlife, specifically

fish and alligators, and several effective biomarkers have been identified to study these effects.

As a result of previous findings, FDEP (at that time, FDER) contracted with the UF in 1986 to conduct a survey of toxic organic chemical compounds in aquatic sediments and tissues of aquatic organisms throughout the state (Delfino et al. 1987). Sediments sampled in Lake Apopka contained low levels of DDT-related residues. Catfish tissue also showed low levels of DDT-related residues, although these low concentrations do not generally pose a threat to consumers of the fish. The findings were in general agreement with previous analyses.

During 1990 and 1991, a survey of levels and potential toxic effects of substances specifically in Lake Apopka sediments was conducted (Segal and Pollman 1991). Sediment cores from two depths at 10 locations were analyzed for the 152 elements and compounds on the EPA Toxic Compounds List. Thirteen elements occurred in sufficiently high concentrations to warrant a detailed examination; two—copper and lead—appear to pose the greatest threat of toxicity to the lake biota. Due to the complex interactions that occur in biological systems, the potential toxic effects of these elements were difficult to assess.

Prior to SJRWMD purchase of the muck farm properties on the north shore of Lake Apopka, all properties received an environmental site assessment (ESA) in accordance with the American Society for Testing and Materials Standard E1527. The ESA and subsequent remediation activities identified and removed highly contaminated soil from the farms in accordance with a site-specific cleanup plan.

In addition to the ESA, SJRWMD also conducted an environmental risk assessment to evaluate the potential for long-term (chronic) risk for wildlife from the average residual pesticide levels expected to remain in the farm soils after remediation was completed. The risk assessment and a subsequent follow up evaluation indicated no likelihood that background residual pesticide levels would present an acute toxicity risk to aquatic or wetland animals. Some concerns about long-term, sub-lethal effects on growth or reproduction were raised, and SJRWMD planned a monitoring program to assess these potential problems during restoration.

In late November 1998, unusually high bird mortality, especially among American white pelicans, was observed in one area of the former farmlands. Over a period of four months, 441 American white pelicans, 43 wood storks, 34 great egrets, 58 great blue herons, and smaller numbers of 20 other bird species died on-site. On February 17, 1999, USFWS issued a press release with a preliminary conclusion that the birds had died

from poisoning by organochlorine pesticides, including toxaphene, dieldrin, and DDT and its metabolites.

SJRWMD and NRCS launched an investigation of the bird mortality event in early 1999. To aid in the investigation of the mortality event, SJRWMD convened a team of experts from 13 federal, state, county, and private organizations to create a technical advisory group. Approximately 1,300 water, soil, and wildlife tissue samples were analyzed to help identify the chain of events that led to the bird mortality. More detailed information concerning this issue is available in the Progress of the Lake Apopka Restoration Program section.

In 1999, the Florida Department of Health evaluated human exposures from ingestion of fish from Lake Apopka. They evaluated the concentrations of 30 different pesticides and 30 different metals in the edible fillet portions of brown bullhead catfish, white catfish, largemouth bass, and blue tilapia. The risk assessment established the cancer risk for an individual who consumes fish from a source at 30 grams per day, 350 days per year, for 30 years. Based on their findings, they issued an advisory for brown bullhead catfish and recommended that consumption be limited to one 8-ounce fillet every two weeks.
GOVERNMENTAL JURISDICTION

Numerous governmental agencies have jurisdiction within the Lake Apopka Basin. Section 373.453(2)(b), *FS*, requires that the SWIM Plan contain an "identification of all governmental units that have jurisdiction over the water body and its drainage basin within the approved surface water improvement and management plan area, including local, regional, state, and federal units." A complete directory of addresses is found in Appendix F.

FEDERAL

U.S. Environmental Protection Agency

EPA was created under Reorganization Plan 3 of 1970 to consolidate the federal government's environmental regulatory activities under the jurisdiction of a single agency. The majority of environmental regulations are contained in *United States Code*, Title 40—Protection of the Environment. EPA administers several major programs based on specific legislation, including the Clean Water Act, the Safe Drinking Water Act, the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund), and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). EPA issues National Pollutant Discharge Elimination System (NPDES) permits and air quality permits. In Florida, FDEP assumed the administration of the NPDES stormwater program beginning in October 2000, except in Indian country lands. EPA also issues permits and reviews permits issued by FDEP for the treatment, disposal, and storage of hazardous wastes. EPA reviews USACE permit activities, sets minimum water quality standards, and sets guidelines for state environmental programs.

U.S. Department of Agriculture (USDA)

• The *Natural Resources and Conservation Service* (NRCS), formerly the Soil Conservation Service (SCS), was authorized by the Federal Crop Insurance Reform and Department of Agriculture Reorganization Act of 1994. NRCS works with private landowners on their lands to help them conserve natural resources. NRCS has responsibility for the three major areas covered by SCS: soil and water conservation, natural resource surveys, and community resource protection and management. In addition, NRCS administers the Wetlands Reserve Program (WRP) in consultation with the Farm Service Agency and other federal agencies. WRP is a voluntary program to restore and protect wetlands on private property. Landowners who choose to participate in WRP

may sell a conservation easement or enter into a cost-share restoration agreement with USDA to restore and protect wetlands.

• The *Consolidated Farm Service Agency* (FSA) is a new USDA agency formed in 1994 consisting of the Agricultural Stabilization and Conservation Service, Farmer's Home Administration, and NRCS. FSA provides administration of farm commodity programs, operating and emergency loans, conservation and environmental programs, emergency and disaster assistance, domestic and international food assistance, and international export credit programs. FSA provides support at a local level to help protect wetlands and solve water, woodland, and pollution problems on farms and ranches.

U.S. Department of the Interior

- The *U.S. Fish and Wildlife Service* (USFWS) is responsible for the protection and improvement of fish and wildlife and their habitats and has jurisdiction over federally listed threatened, endangered, and migratory species. USFWS reviews U.S. Army Corps of Engineers (USACE) permits for effects on fish and wildlife, conducts environmental research, manages migratory birds, and performs law enforcement.
- The U.S. Geological Survey (USGS) monitors surface and subsurface water resources, including lake levels, river and stream flow, water quality, and water use. USGS conducts and publishes results of hydrogeological research and maps related to topography, landforms, and hydrology. The Orlando subdistrict office of USGS is responsible for the collection of hydrologic data and interpretive studies of hydrology in central and northeast Florida. This work is conducted in cooperation with the St. Johns River, South Florida, and Southwest Florida water management districts, other federal agencies, counties, and other municipalities.

U.S. Army Corps of Engineers

USACE is responsible for construction, maintenance and planning of navigation, flood control, shore protection, recreation, and implementation of specific environmental restoration projects. USACE and FDEP regulate dredge and fill permits in Florida waters using a joint application, but under separate authorities and programs.

Federal Emergency Management Agency (FEMA)

FEMA advises on building codes and floodplain management; assists with local and state emergency preparedness; coordinates the federal response to disasters; trains

emergency managers; administers the national flood insurance program; and makes disaster assistance available to states, communities, businesses, and individuals.

U.S. Department of Commerce

The Department of Commerce promotes job creation, economic growth, sustainable development, and improved living standards by working in partnership with business, universities, communities, and workers.

- The mission of the *National Oceanic and Atmospheric Administration* (NOAA) is to describe and predict changes in the Earth's environment and wisely manage the nation's coastal and marine resources.
- The *National Weather Service* (NWS) is part of NOAA. NWS delivers climate, analysis, and forecast products and conducts research to improve the understanding and stewardship of the environment.

U.S. Department of Transportation

The *U.S. Coast Guard* assumed responsibility for bridges in 1967 when moved into the Department of Transportation from USACE. The Coast Guard is responsible for approval of the location and plans of bridges and causeways constructed across navigable waters of the United States.

STATE

Florida Department of Environmental Protection (FDEP)

In 1993, the Departments of Natural Resources (FDNR) and Environmental Regulation (FDER) were consolidated to form FDEP. The regulatory responsibilities of FDER relating to water resources were assumed by FDEP. FDEP's primary responsibility is to preserve the environmental integrity of Florida's air, water, and land resources. The department has permit jurisdiction over point and nonpoint source discharges, some MSSW, some dredge and fill, hazardous and solid wastes, drinking water systems, power plant siting, mines, and many construction activities in waters of the state. FDEP interacts closely with other state and federal agencies on water-related matters.

FDEP has also assumed the responsibilities of the former FDNR, including the administration of all state lands, including parks and aquatic preserves; land acquisition; enforcement for the Florida Endangered Species Act and the Oil Spill

Prevention and Pollution Control Act; coordination of aquatic plant research and control in the state; issuance of permits for transport of aquatic plants; and for herbicide spraying and other plant control methods in aquatic environments.

The Florida Wetland Information Center utilizes ecosystem management and ecological principles to develop a framework for a statewide ecological restoration program for wetlands and their associated uplands.

Florida Fish and Wildlife Conservation Commission (FWC)

The Florida Game and Fresh Water Fish Commission and the Marine Fisheries Commission were replaced with FWC July 1, 1999. FWC is responsible for conserving the state's freshwater aquatic life, marine life, and wild animal life. Its mission is to manage aquatic life and wild animal life and their habitats to perpetuate a diversity of species with densities and distributions that provide sustained ecological, recreational, scientific, educational, aesthetic, and economic benefits. The commission has a formal commenting role in the regulatory process relating to listed endangered species protection in wetland areas. The Division of Law Enforcement provides protection and enforces laws relating to all wild animal and aquatic resources and boating safety on the state's waters.

University of Florida / Institute of Food & Agricultural Science (UF/IFAS)

UF/IFAS is a statewide organization dedicated to teaching, research, and extension and serves the agricultural, human, and natural resource needs for the State of Florida. UF/IFAS is a partnership in food, agriculture, natural and renewable resource research, and education and is funded through federal, state, and local governments and industry. UF/IFAS has nearly 1,000 faculty located on the University of Florida campus and at extension offices in 67 counties, 21 research and education centers, and 4 demonstration units.

Florida Department of Community Affairs (FDCA)

FDCA has five service areas which include Community Planning, Emergency Management, Coastal Management, Housing and Community Development, and the Florida Communities Trust. The Bureau of Local Planning in the Division of Community Planning reviews local government comprehensive plans and plan amendments for compliance with state law and provides technical assistance to local governments. It also reviews developments of regional impact and Florida quality developments in coordination with regional planning councils and local governments. The Bureau of State Planning in the Division of Community Planning is responsible for coordination and development of FDCA's policy relating to Florida's growth management statutes and rules. The Division of Emergency Management directs the state's programs that plan for and respond to disasters, prepares a Comprehensive Emergency Management Plan and serves as the state's liaison with federal and local agencies.

Florida Department of Agriculture and Consumer Services (FDACS)

FDACS is responsible for safeguarding the public and supporting Florida's agricultural economy. FDACS performs all regulatory and inspection services relating to agriculture, with the exception of those functions which primarily protect the public health, and regulates the registration, labeling and inspection of pesticides, commercial fertilizer, gasolines and oils, and the licensing and regulation of pesticide applicators. The Office of Agricultural Water Policy provides support for the 63 soil and water conservation districts in the state. The Division of Forestry manages state forest lands and promotes the use of good silviculture practices on public and private lands. It is the lead fire control agency of the state and is responsible for authorizing prescribed burns as well as for suppressing wildfires.

Florida Department of Health

The Florida Department of Health responsibilities include permitting for public health functions of water supplies (primarily small to medium supplies), onsite sewage treatment and disposal, septic tank cleaning and waste disposal (in conjunction with FDEP), and solid waste control (secondary role).

Florida Department of Transportation (FDOT)

FDOT directs and coordinates roadway and bridge construction activities and related environmental studies, including corridor and impact mitigation planning.

Public Service Commission

The Public Service Commission is responsible for regulating the rates, services, and safety of several types of investor-owned utilities, including water and wastewater utilities.

REGIONAL

Water Management Districts

Florida is divided into five water management districts, which are dedicated to the preservation and management of Florida's water resources. Duties of the districts include issuing permits for various water use activities and/or activities that have the potential to adversely impact ground or surface water resources and adjacent lands; buying land to preserve or restore vital wetlands and water resources; conducting research about the quality and quantity of ground and surface water resources; mapping ground and surface water resources; and conducting outreach and public education programs.

SJRWMD is responsible for managing ground and surface water supplies in all or part of 19 counties in northeast and east-central Florida.

Regional Planning Councils (RPCs)

RPCs are multipurpose regional entities in a position to plan for and coordinate intergovernmental solutions to growth-related problems or greater-than-local issues, provide technical assistance to local governments, and meet other needs of the communities in their regions. RPCs review amendments to local government comprehensive plans for impacts to regionally significant resources and extrajurisdictional impacts and provide technical assistance and other services to local governments relating to comprehensive planning. RPCs serve as a coordination and review function for developments of regional impact/Florida quality developments.

The East Central Florida Regional Planning Council provides regional planning services to Brevard, Lake, Orange, Osceola, Seminole, and Volusia counties.

Soil and Water Conservation Districts

The 63 soil and water conservation districts located statewide are organized under Chapter 582, *FS*, as a governmental subdivision of the state. The appointed or elected volunteers serving on the governing boards coordinate public and private assistance to develop local solutions to natural resource concerns. The two local soil and water conservation districts located within the Lake Apopka Basin are those of Lake County and Orange County.

Water Authorities

The Lake County Water Authority, formerly known as the Ocklawaha Basin Recreation and Water Conservation and Control Authority, was created in 1953 by the Legislature to protect surface waters. It is actively involved in aquatic plant control, stormwater treatment, wetlands protection, providing recreational facilities, and land acquisition and management.

LOCAL

County Governments

- Lake County contains 14 municipalities, with Tavares as the county seat. Board of County Commissioners
 - Environmental Management Division Mosquito Control and Aquatic Plant Management Department of Growth Management Health Department Department of Community Services Department of Economic Development and Tourism Department of Public Safety Department of Public Works
- Orange County contains 13 municipalities, with Orlando as the county seat. Board of County Commissioners

Department of Community and Environmental Services Department of Growth Management Department of Health and Family Services Director of Public Safety Public Works Department Utilities Department

Municipal Governments

- Lake County
 Town of Montverde
- Orange County City of Apopka City of Oakland City of Winter Garden

PLANNING: ISSUES, GOALS, STRATEGIES, PROGRAMS, AND PROJECTS

DISTRICT PLANNING

SJRWMD has an integrated planning, budgeting and reporting system under which long-term plans guide short-term plans, budgets are linked to plans, progress is tracked using statewide water management and program-specific performance measures, and progress is reported on a regular basis. The District Water Management Plan (DWMP), SJRWMD's comprehensive long-term plan, and other long-term plans, such as SWIM plans, provide direction for the Annual Work Plan and Budget (AWPB), fiscal plans, and other District planning efforts. The AWPB connects tasks listed for each District program with program budgets.

The DWMP contains strategies for identified water resource issues to be implemented over the five-year period between DWMP updates. The strategies for the Lake Apopka SWIM program in the May 2000 DWMP, as updated for the June 2001 Florida Forever Work Plan, are as follows:

- Adopt and achieve full implementation of a PLRG-based rule for reducing and allocating phosphorus loads in the Lake Apopka Basin.
- Operate Phase I of the marsh flow-way and achieve removal efficiencies of at least 30% of total phosphorus, 30% of total nitrogen, and 80% of total suspended solids.
- Construct Phase II of the Lake Apopka Marsh Flow-Way.
- Continue to harvest gizzard shad up to 900,000 pounds a year or until the annual stock is depleted.
- Treat remaining former farm areas to bind sediment phosphorus.
- Complete all necessary pesticide studies and remediation activities.
- Continue lake littoral zone planting and management to encourage native and discourage exotic vegetation.
- Complete and begin implementation of a restoration plan for the NSRA as approved by partners and stakeholders.
- Complete infrastructure development as set out in the NSRA restoration plan.
- Shallowly flood appropriate areas in the NSRA as soon as the necessary infrastructure is completed and oversight agency approval is received.
- Restore 13,000 acres of wetlands in the NSRA, pending approval of the USDA-NRCS.
- Attain a healthy diversity of wetland plant and animal communities.
- Complete revisions to the SWIM Plan for Lake Apopka.

- Evaluate progress made in the lake ecosystem restoration.
- Provide technical assistance and cost-share funding for implementation of the Lake Apopka Basin Planning Initiative Work Program, to be completed by fiscal year 2000–2001.
- Provide technical assistance to and coordinate SJRWMD restoration activities with local governments in the Lake Apopka Basin, developing and implementing small-area plans to guide their future development.

Tasks for the Lake Apopka SWIM program in the AWPB contribute to the implementation of these strategies, as well as the strategies identified in the SWIM Plan. Performance measures for the Lake Apopka SWIM program in the May 2000 DWMP and AWPB follow, along with baseline data and standards for the measures.

Measure:	Designated use determinations in the FDEP 305(b) report for Lake Apopka watersheds
Baseline:	Lake Apopka watershed not meeting and Apopka (Gourd Neck) Spring watershed partially meeting its designated use in 1998
Standard:	Both watersheds fully meeting their designated use
Measure:	Mean total phosphorus concentration in Lake Apopka
Baseline:	0.218 mg/L from 1987 to 1995
Standard:	0.055 mg/L

LAKE APOPKA SWIM PLAN

A planning process for the restoration of Lake Apopka was initiated in 1985 under the Lake Apopka Restoration Act. The Lake Apopka Restoration Council (LARC) recommended specific goals for restoration of the lake, as follows:

- Rooted native vegetation at 50% lake bottom coverage
- Fish biomass in the littoral zone of 37 kg/ha (200 lbs/ac)
- Sportfish biomass at 70% of total
- Largemouth bass greater than 25 cm (9.8 in.) total length in littoral zone at six fish/ha (15 fish/ac)
- Fishing success rate of .25 largemouth bass/hour of effort and 1.25 panfish/hour of effort
- Macroinvertebrate Shannon-Weaver Diversity Index of 1.9
- Total phosphorus and total nitrogen at specified concentrations (to be set)
- Chlorophyll *a* at specified levels (to be set)
- Specified Secchi disk depth (to be set)

The technical advisory committee to the LARC recommended the following values for the latter four specific goals: total phosphorus, 0.02 mg/L (20 ppb); total nitrogen, 0.50 mg/L (50 ppb); chlorophyll *a*, 6.0 grams per liter (g/L) (6.0 ppb); Secchi disc depth, 1.3 m (4.2 ft). To achieve these goals, the LARC recommended the following strategies as some of the most logical alternatives to pursue:

- Conversion of muck farms to wetland systems
- Lake level drawdown/increased water level fluctuation
- Sediment recycling or dredging
- Sediment phosphorus inactivation
- Lake drawdown combined with dredging
- Lake drawdown combined with phosphorus inactivation in non-drawdown areas
- Microbial decomposition with sediment aeration
- Microbial decomposition without sediment aeration
- Lake drawdown combined with microbial decomposition of non-drawdown areas
- Introduction of exotic fish and management of the food web
- Littoral zone restoration
- Growth and harvesting of water hyacinths
- Alteration of the density of plankton-feeding fishes in the lake
- No action taken after nutrient diversion

Based on the LARC 1986 and 1987 reports and the Interim SWIM Plan (Battoe et al. 1988), the 1989 SWIM Plan (Conrow et al. 1989) developed seven priority issues for Lake Apopka (Figure 16). These issues, which must be addressed in order to achieve the restoration of the lake and to help in protection of downstream water bodies, are as follows:

- Agricultural discharges
- Lack of fish and wildlife habitat
- Poor water quality and flocculent sediments
- Degradation of downstream lakes
- Low recreational and aesthetic values
- Nonpoint pollution sources
- Future basin development

The SWIM Plan establishes water body goals which reflect the broader goals of the SWIM Act as follows:

ISSUES

- A. Agricultural discharges
- B. Lack of fish and wildlife habitat
- C. Poor water quality and flocculent sediments
- D. Degradation of downstream lakes
- E. Low recreational and aesthetic values
- F. Nonpoint pollution sources
- G. Future basin development

PROGRAMS and PROJECTS

Diagnostic

External Nutrient Budget Internal Nutrient Budget Mathematical Modeling Phytoplankton-Nutrient Interactions Bathymetry Fishery Seismic Reflection Profiling Hydrodynamic Survey

Planning

District Water Management Plan Local Govt. Comp. Plan Review Land Management Plans

Land Acquisition Marsh Flow-Way Lands Acquisition North Shore Land Acquisition

Technical Support

Implementation of Restoration and Management Techniques Restoration Monitoring and Analysis Overall Program Management

Figure 16. Overall Lake Apopka SWIM Plan

Feasibility

Water Hyacinth Demonstration Phosphorus Inactivation/Precipitation Sediment Recycling Microbial Decomposition Ichthyofaunal Reconstruction (I, II) Trophic Structure Manipulation (I, II, III) Drawdown and Lake Level Fluctuation Socioeconomic Assessment and Methodology

Restoration

Marsh Flow-Way Restoration Rough Fish Harvesting Wetland Restoration Littoral Zone Restoration

Regulatory

Nonpoint Source Pollution Control Nutrient Loading Limits Adoption

Public Information

Public Awareness Local Government Information Project Lake water restored to meet Class III water quality standards

- Natural systems restored
- Recreational and aesthetic values restored
- A comprehensive management plan developed for maintenance of the water body and its environment

The following sections present details on the seven priority issues for the restoration of Lake Apopka. The goals associated with each priority issue, the strategies that will be employed to attain the goal(s), and the programs and projects considered necessary for implementing the strategies are listed under each issue. Progress made towards achieving the goals is summarized for each priority issue, and detailed status summaries are available for each project (Detail of Projects section).

An identification numbering system has been developed to facilitate tracking of individual projects. These codes are described in the Programs and Projects section , along with detailed explanations of Lake Apopka SWIM programs and projects.

The restoration goals recommended by the LARC and the technical advisory committee are maintained as desirable results of the restoration program developed in the Lake Apopka SWIM Plan. The feasibility of attaining these specific goals cannot yet be determined. LARC goals dealing with habitat and sport fishery will be considered in the Littoral Zone Restoration Project (LA-2-304-M). Technical advisory committee goals dealing with nutrients, chlorophyll *a*, and Secchi depth will be considered in the setting of PLRGs (Nutrient Loading Limits Adoption, LA-3-403-M). Many of the studies recommended by the LARC were completed as SWIM projects. A bibliography and abstracts of many of these studies are included in Appendices G and H, respectively.

A. Agricultural Discharges

<u>Issue Description</u>. Agricultural discharges (Figure 17) have been the major source of external nutrient loading to Lake Apopka. Prior to implementation of consent orders, SJRWMD estimated that over one-third of the lake's water volume was discharged annually to Lake Apopka and the Apopka-Beauclair Canal from the adjacent agricultural operations. These discharge waters were nutrient-laden and contributed approximately 85% of the phosphorus loading to Lake Apopka from 1989 to 1994. The discharge waters did not comply with water quality standards as in Chapter 62-302, *F.A.C.*, and negatively affected the natural systems of the lake.

Goal. Decrease agricultural nutrient loading to meet or exceed established PLRGs.





<u>Strategies</u>

- Measure nutrient loading from agricultural discharges.
- Evaluate the impact of agricultural nutrient loading.
- Develop and adopt nutrient loading limits for the lake.
- Pursue regulatory enforcement and consent order compliance.
- Monitor agricultural discharges to assure compliance.
- Reduce number of acres in agricultural production by acquiring land.
- Investigate potential for matching grant program for agricultural waste treatment facility construction.

<u>Programs and Projects</u>. The following programs and projects are considered necessary to implement designated strategies:

- 1. Diagnostic Program Project LA-1-101-D (External Nutrient Budget Study) Project LA-4-103-D (Mathematical Modeling)
- 2. Regulatory Program Project LA-3-403-M (Nutrient Loading Limits Adoption)
- Public Information Program Project LA-5-602-S (Public Awareness) Project LA-5-603-S (Local Government Information Project)
- 4. Land Acquisition Program Project LA-3-701-S (Marsh Flow-Way Land Acquisition) Project LA-3-704-S (North Shore Land Acquisition)
- B. Lack of Fish and Wildlife Habitat

<u>Issue Description</u>. There has been a substantial loss of fish and wildlife habitat in Lake Apopka (Figure 18). The once-prolific beds of submerged vegetation that provided food and cover for game fish have disappeared due to increased turbidity from algal blooms and resuspended flocculent sediments. Wildlife habitat provided by the original palustrine wetlands of the lake has been destroyed by encroachment of muck farms, and flocculent organic sediments have buried the original, firmer lake bottom. Cultural eutrophication of the water body has resulted in a shift of primary productivity from large plants to algae. This loss of habitat has resulted in a drastic decline in the recreational fishery of Lake Apopka.



Figure 18. Lack of fish and wildlife habitat

<u>Goals</u>

- Protect remaining fisheries/wildlife habitat
- Restore marshes adjacent to the lake
- Restore and expand lake littoral zone and emergent vegetation along the shore
- Improve lake bottom habitat and restore submerged rooted vegetation

<u>Strategies</u>

- Purchase available lands appropriate for habitat restoration.
- Investigate and test methods to improve fisheries habitat by increasing water clarity and consolidating sediments.
- Identify and map existing fisheries/wildlife habitat and investigate restoration and expansion of littoral zone.
- Develop and adopt special nutrient loading limits for the lake.
- Assist in the development and implementation of stronger local ordinances.

<u>Programs and Projects</u>. The following programs and projects are considered necessary for strategy implementation:

- Diagnostic Program Project LA-4-107-D (Fishery) Project LA-4-109-D (Hydrodynamic Survey)
- Feasibility Program
 Project LA-4-206-F (Ichthyofaunal Reconstruction I, II)
 Project LA-4-207-F (Trophic Structure Manipulation I, II, III)
 Project LA-4-208-F (Drawdown and Lake Level Fluctuation)
- Restoration Program
 Project LA-3-301-M (Marsh Flow-Way Restoration)
 Project LA-3-302-M (Rough Fish Harvesting)
 Project LA-2-304-M (Littoral Zone Restoration)
 Project LA-3-303-M (Wetland Restoration)
- 4. Regulatory Program Project LA-3-403-M (Nutrient Loading Limits Adoption)
- Planning Program
 Project LA-6-501-M (District Water Management Plan)
 Project LA-6-502-S (Local Government Comprehensive Plan Review)

SWIM Plan for Lake Apopka

Project LA-6-503-M (Land Management Plans)

- Public Information Program Project LA-5-602-S (Public Awareness) Project LA-5-603-S (Local Government Information Project)
- Land Acquisition Program Project LA-3-701-S (Marsh Flow-Way Land Acquisition) Project LA-3-704-S (North Shore Land Acquisition)

C. Poor Water Quality and Flocculent Sediments

<u>Issue Description</u>. Lake Apopka was once crystal clear with a firm bottom. Water quality in the lake has become severely degraded, and the bottom is now covered with flocculent organic sediments several feet thick (Schelske 1997). High nutrient loading, primarily from agricultural sources, has resulted in high nitrogen and phosphorus levels, excessive algal production, and reduced water clarity in the lake. The lack of sufficient light reaching the lake's bottom limits submerged aquatic vegetation growth. The excessive algal production has caused accelerated accretion of flocculent sediments over most of the lake bottom (Figure 19).

<u>Goals</u>

- Develop and implement a cost-effective and scientifically sound restoration program to improve water quality and consolidate sediments.
- Restore and manage wetlands for improvement and maintenance of water quality.
- Undertake appropriate basin management to promote improved water quality and long-term management to prevent water quality degradation.

Strategies

- Develop a clear understanding of water quality problems and associated ecological impacts.
- Determine external and internal nutrient inputs.
- Continue diagnostic studies to fill critical data deficiencies.
- Continue feasibility studies to evaluate potential restoration techniques.
- Plan and implement nutrient loading limits for the watershed.
- Establish a long-range comprehensive management plan for the basin.
- Participate in local and regional planning efforts.
- Implement cost-effective restoration projects.





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<u>Programs and Projects</u>. The following programs and projects are considered necessary to implement the primary strategies:

1. Diagnostic Program

Project LA-1-101-D (External Nutrient Budget)
Project LA-1-102-D (Internal Nutrient Budget)
Project LA-4-103-D (Mathematical Modeling)
Project LA-4-104-D (Phytoplankton-Nutrient Interactions)
Project LA-4-106-D (Bathymetry)
Project LA-1-108-D (Seismic Reflection Profiling)

2. Feasibility Program

Project LA-4-201-F (Water Hyacinth Demonstration)
Project LA-4-202-F (Phosphorus Inactivation/Precipitation)
Project LA-4-204-F (Sediment Recycling)
Project LA-4-205-F (Microbial Decomposition)
Project LA-4-206-F (Ichthyofaunal Reconstruction I, II)
Project LA-4-207-F (Trophic Structure Manipulation I, II, III)
Project LA-4-208-F (Drawdown and Lake Level Fluctuation)

3. Restoration Program

Project LA-3-301-M (Marsh Flow-Way Restoration)
Project LA-3-302-M (Rough Fish Harvesting)
Project LA-3-303-M (Wetland Restoration)
Project LA-3-304-M (Littoral Zone Restoration)

4. Regulatory Program Project LA-3-403-M (Nutrient Loading Limits Adoption)

- Planning Program Project LA-6-501-M (District Water Management Plan) Project LA-6-502-S (Local Government Comprehensive Plan Review) Project LA-6-503-M (Land Management Plans)
- 6. Public Information Program Project LA-5-602-S (Public Awareness) Project LA-5-603-S (Local Government Information Project)
- Land Acquisition Program Project LA-3-701-S (Marsh Flow-Way Land Acquisition) Project LA-3-704-S (North Shore Land Acquisition)

D. Degradation of Downstream Lakes

<u>Issue Description</u>. Lake Apopka is the headwater lake and primary source of surface water for the Harris Chain of Lakes (Lakes Beauclair, Dora, Eustis, Harris, Griffin, and Yale) and the Upper Ocklawaha River. Nutrient-laden water from Lake Apopka contributes significantly to the eutrophication of the remaining lakes in the chain.

<u>Goal</u>. Reduce or eliminate the degradation of downstream lakes from Lake Apopka discharge water (Figure 20).

<u>Strategies</u>. Reduction in nutrient and sediment transport from the Lake Apopka Basin requires (1) a reduction in external nutrient loading, especially from farms along the Apopka-Beauclair Canal, (2) improvement in water quality in Lake Apopka, and (3) discharge of water from Lake Apopka through the marsh flow-way instead of directly from the lake.

- Purchase available agricultural lands.
- Enforce existing water quality regulations and consent order compliance.
- Confine downstream discharges to waters filtered through the marsh flow-way system.
- Monitor downstream discharge at the Apopka-Beauclair Canal.
- Develop and adopt nutrient loading limits for the watershed.
- Evaluate potential for matching grants for agricultural wastewater treatment facilities construction.

<u>Programs and Projects</u>. The following programs and projects are necessary to reduce downstream discharge of degraded water:

- Diagnostic Program Project LA-1-101-D (External Nutrient Budget) Project LA-4-103-D (Mathematical Modeling)
- 2. Restoration Program Project LA-3-301-M (Marsh Flow-Way Restoration)
- 3. Regulatory Program Project LA-3-403-M (Nutrient Loading Limits Adoption)



Figure 20. Degradation of downstream lakes

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- 4. Public Information Program Project LA-5-602-S (Public Awareness) Project LA-5-603-S (Local Government Information Project)
- 5. Land Acquisition Program Project LA-3-701-S (Marsh Flow-Way Land Acquisition) Project LA-3-704-S (North Shore Land Acquisition)
- E. Low Recreational and Aesthetic Value

<u>Issue Description</u>. Lake Apopka was once a lake with clear waters, a stable habitat for fish propagation, and a productive sports fishery. The lake environment also provided excellent potential for water contact recreation and wildlife observation. Due to water quality degradation and loss of habitat, the lake environment is now one of unsightly blue-green algal blooms, soft bottom sediments, and very limited wetland habitat. These changes have resulted in lost recreational opportunities in and around Lake Apopka (Figure 21).

<u>Goals</u>

- Attain water quality suitable for water contact recreation.
- Improve multi-use recreational opportunities.
- Restore abundant and diverse populations of native plants, wildlife, and fish to the basin.

Strategies

- Acquire available agricultural lands.
- Test feasibility of littoral zone restoration and expansion.
- Investigate methods of water quality restoration and sediment consolidation.
- Establish marsh flow-way.
- Develop and adopt additional regulatory criteria for the lake basin.
- Establish a long-range comprehensive management plan for the basin.
- Develop land management plans for acquired properties.
- Implement rough fish harvest.
- Participate in local government comprehensive planning.

<u>Programs and Projects</u>. The following programs and projects are considered necessary for strategy implementation:



Figure 21. Low recreational and aesthetic value

- 1. Feasibility Program Project LA-4-208-F (Drawdown and Lake Level Fluctuation) Project LA-4-209-F (Socioeconomic Assessment and Methodology)
 - Restoration Program
 Project LA-3-301-M (Marsh Flow-Way Restoration)
 Project LA-3-302-M (Rough Fish Harvesting)
 Project LA-3-303-M (Wetland Restoration)
 Project LA-2-304-M (Littoral Zone Restoration)
 - 3. Regulatory Program Project LA-3-403-M (Nutrient Loading Limits Adoption)
 - Planning Program Project LA-6-501-M (District Water Management Plan) Project LA-6-502-S (Local Government Comprehensive Plan Review) Project LA-6-503-M (Land Management Plans)
 - 5. Public Information Program Project LA-5-602-S (Public Awareness) Project LA-5-603-S (Local Government Information Project)
 - 6. Land Acquisition Program Project LA-3-701-S (Marsh Flow-Way Land Acquisition) Project LA-3-704-S (North Shore Land Acquisition)
- F. Nonpoint Pollution Sources

<u>Issue Description</u>. The degree to which nonpoint sources other than agriculture contribute to problems in Lake Apopka was unclear during the formulation of the SWIM Plan. High nitrogen and phosphorus levels, excessive algal production, and reduced water clarity in the lake necessitated an evaluation of the relative importance of all nonpoint sources of pollution (Figure 22).

<u>Goal</u>. Evaluate and eliminate significant nonpoint sources of pollution to Lake Apopka.

Strategies

- Assess external sources of nutrients and internal recycling.
- Assess the extent of urban runoff around the lake.



Figure 22. Nonpoint pollution sources

- Determine the extent of failed septic systems around the lake.
- Participate in local government comprehensive planning and assist in the development and implementation of stronger local ordinances.
- Assess potential for enforcement contracts with Lake and Orange counties.
- Adopt nutrient loading limits.

<u>Programs and Projects</u>. The following programs and projects are considered necessary to implement designated strategies:

- Diagnostic Program
 Project LA-1-101-D (External Nutrient Budget)
 Project LA-1-102-D (Internal Nutrient Budget)
 Project LA-4-103-D (Mathematical Modeling)
- Regulatory Program Project LA-3-402-M (Nonpoint Source Pollution Control) Project LA-3-403-M (Nutrient Loading Limits Adoption)
- Planning Program Project LA-6-501-M (District Water Management Plan) Project LA-6-502-S (Local Government Comprehensive Plan Review)
- 4. Public Information Program Project LA-5-602-S (Public Awareness) Project LA-5-603-S (Local Government Information Project)
- G. Future Basin Development

<u>Issue Description</u>. Simultaneously with the completion of the projects that have addressed the preceding six issues, it will be necessary to support comprehensive basin planning to ensure maintenance of restored conditions in Lake Apopka. Proper protection and restoration of the lake's resources require coordination among the federal, state, regional, and local agencies that have planning, regulatory, or management authority in the basin. The SWIM Act partially fulfills this requirement by directing SJRWMD, with the participation of other governmental agencies, to develop and implement an interagency management plan (Figure 23).



Figure 23. Future basin development

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<u>Goals</u>

- Develop plan consistent with environmental protection of the lake.
- Enforce effective rules and permit compliance.
- Standardize resource management among regulatory agencies.

<u>Strategies</u>

- Establish nutrient loading limits for the water body.
- Evaluate the implementation of the District Water Management Plan annually.
- Participate in local government comprehensive planning and assist in the development and implementation of stronger local ordinances.
- Establish a long-range comprehensive management plan for the basin.

<u>Programs and Projects</u>. The following programs and projects are considered necessary to implement designated strategies:

- Regulatory Program Project LA-3-403-M (Nutrient Loading Limits Adoption) Project LA-3-402-M (Nonpoint Source Pollution Control)
- Planning Program Project LA-6-501-M (District Water Management Plan) Project LA-6-502-S (Local Government Comprehensive Plan Review)

PROGRESS OF THE LAKE APOPKA RESTORATION PROGRAM

OVERVIEW

The Lake Apopka restoration effort is a holistic water resources, economic, and recreational restoration approach designed to return the water body to a condition that meets Class III water quality standards. In the years since the 1985 Lake Apopka Restoration Act, SJRWMD has implemented a comprehensive array of SWIM projects to address the seven priority issues described in the previous section. Following thorough scientific study, a four-part restoration program was developed:

- **Reduce phosphorus loading** from external sources, primarily resulting from agricultural operations, through regulation and land acquisition.
- **Remove phosphorus and flocculent sediments** to accelerate recovery of the lake by wetland filtration (marsh flow-way) and by mass removal of rough fish.
- **Improve food-web structure** by removal of gizzard shad to benefit production of game fish and improve water quality.
- **Restore lake habitat** through littoral zone planting and increased fluctuation in lake levels.

REDUCTION IN NUTRIENT LOADING

Actions are under way that will decrease phosphorus loading to the lake through regulatory, land acquisition, and nutrient reduction activities.

Regulatory

A major regulatory action in support of the Lake Apopka restoration was to restrict phosphorus loading from the muck farms formerly located on the northern edge of the lake. Two major farming entities operated on the former marshes: A. Duda and Sons (Duda), with approximately 2,633 ha (6,500 ac) of muck farm fields on both sides of the Apopka-Beauclair Canal, and the Zellwood Drainage and Water Control District (ZDWCD), controlling discharges from about one dozen farms on 3,524 ha (8,700 ac) east of the Duda Jem Farm holdings. ZDWCD contained two large farming areas, Unit I to the north of the McDonald Canal and Unit II to the south of the McDonald Canal.

On June 1, 1988, SJRWMD began regulating agricultural discharges under authority transferred by FDEP. That same month, SJRWMD and Duda entered into a consent order designed to reduce discharges and protect water quality according to a fixed time

schedule (Appendix I). The consent order required Duda to construct a reservoir for Jem Farm and acknowledged that the farms west of the Apopka-Beauclair Canal would be sold to SJRWMD. In May 1989, SJRWMD and ZDWCD signed a consent order (Appendix I). In the case of ZDWCD, a challenge brought by a local resident delayed implementation of the consent order until 1991. Later modifications of the consent order between ZDWCD and SJRWMD outlined a provision for construction of an alum injection system to reduce orthophosphate loads from ZDWCD, beginning in 1995.

In 1994, SJRWMD published a proposed Works of the District rule for Lake Apopka as the means of meeting the PLRG set for the lake. ZDWCD challenged the rule in a State of Florida Administrative Hearing. In August 1995, the Final Order of the Hearing Officer stated that SJRWMD did not have the regulatory authority to implement narrative water quality standards through nutrient limitations for the lake, and found that certain components of the technical basis of the rule were flawed.

The 1996 Legislature gave SJRWMD the legal authority to set a phosphorus discharge limitation for Lake Apopka (Appendix A). The legislation provided for the development of a cost-shared detention pond system in the event that the buyout program was not successful. It also set a phosphorus criterion for the lake of 55 ppb in the event that SJRWMD did not adopt a rule by January 1997.

SJRWMD responded with revisions to Chapter 40C-4, *F.A.C.*, and the *Applicant's Handbook: Management and Storage of Surface Waters* (Appendix I) effective August 1996. This rule "establishes a phosphorus criterion for Lake Apopka." It will be used to establish discharge limitations for all regulated activities within the Lake Apopka drainage basin that are permitted to discharge, directly or indirectly, into Lake Apopka, the Lake Level Canal, and the McDonald Canal.

PLRGs will be a primary tool to control the level of nutrient inputs to Lake Apopka from all sources. These goals will serve as the basis for the EPA-mandated TMDL process, required for all impaired water bodies and administered through FDEP. Public workshops to discuss phosphorus discharge limits were conducted during 1997, 2000, 2001, and 2002. A notice of development of proposed rules was published in the *Florida Administrative Weekly* on December 29, 2000 (FAW 2001). Based on further discussions and a consultant's review of the existing stormwater treatment criteria, SJRWMD staff incorporated several revisions to the proposed rule. The proposed rule was approved by the Governing Board in 2002 and was published in the *Florida Administrative Weekly* on April 19, 2002. Following concern by the public over the implementation cost of the rule, SJRWMD considered less costly alternatives that would still meet the statutory objectives of the proposed rule. The final rule adoption hearing was held in December 2002. The rule became effective in March 2003. For activities SJRWMD regulates, the rule will limit the loading of phosphorus, which must not increase over predevelopment rates. SJRWMD and FDEP will share implementation responsibilities.

Land Acquisition

Nutrient loading to Lake Apopka was decreased by SJRWMD's purchase of all muck farms west of the Apopka-Beauclair Canal (2,362 ha or 5,833 acres). A portion of this land is being converted to the Marsh Flow-Way Project, which will remove particulate phosphorus from lake water. Lease-back agreements (which provided for orderly termination of farming activities) ended in August 1993 for Hooper Farms and Duda/Whittle. Similar agreements with Wilkinson-Cooper and C.C. Ranch ended in May 1994. Agricultural discharges from this area were primarily to the Apopka-Beauclair Canal and contributed to downstream loading.

The 1996 Legislature determined that it was in the public interest for SJRWMD to pursue buyout of the farms east of the Apopka-Beauclair Canal as the long-term solution to the nutrient loading problem and provided \$20 million toward farm acquisition. In addition, SJRWMD received \$26 million from the USDA WRP. With the federal and state funding available, SJRWMD purchased the 1,285 ha (3,173 ac) Duda Lake Jem farm in April 1997. A technical restoration plan is being developed with the assistance of NRCS, which oversees the reserve program.

During the 1997 legislative year, the state appropriated an additional \$45 million for purchasing additional agricultural lands within the NSRA (Appendix A). Under Chapter 99-226, *Laws of Florida*, the Legislature authorized Specific Appropriation 1205 to release \$11 million for purchase of farmlands from the Water Management Lands Trust Fund during the 1999–2000 fiscal year.

In August 1999, the final farmlands were purchased within ZDWCD. Through the end of 2000, a total of 7,972 ha (19,684 ac) had been approved by the Governing Board for purchase. Bringing the land into public ownership completes SJRWMD's acquisition of Lake Apopka muck farms, with acquisition of small non-farming areas still pending (Figure 24). ZDWCD was dissolved in February 2000 as directed by 1999 state legislation. Water management responsibilities within ZDWCD were transferred to SJRWMD.

All of the SJRWMD-acquired muck lands within the NSRA will eventually be restored to wetland and aquatic habitat. Restoration work will include modifications to the extensive network of drainage, pump, and levee systems; planting; and monitoring the progress of habitat development. Partial funding for initial restoration work is being provided by NRCS.



Nutrient Reduction Activities

In 1991, the Lake Apopka Hydrologic Unit Area Project was initiated jointly by the IFAS/Florida Cooperative Extension Service, NRCS, and the Consolidated Farm Service Agency. SJRWMD cooperated with this program, which provided technical and financial assistance to the 19 vegetable and sod growers to implement best management practices (BMPs), which reduced discharges into Lake Apopka and limited nutrient loading. For example, approximately 124,000 kg (273,000 pounds) of phosphorus fertilizer were applied to vegetables in the Lake Apopka Basin in 1991 (Crnko et al. 1993). After emphasizing the use of calibrated soil testing for nutrient management through field trials, the amount of phosphorus fertilizer applied to farms in the Lake Apopka Basin was reduced 55% by 1993 (Crnko et al. 1993). During the same period, 14 internal pumps, 164 water control structures, and 3 floating staff gauges were installed to promote water recycling and reduce discharges (Neal et al. 1994).

Following purchase of the farms, SJRWMD developed a plan to further reduce phosphorus loading to meet discharge targets. Because the initial phosphorus release from reflooding the purchased farms on the north shore of Lake Apopka could be substantial, a soil amendment is being added to the soil surface to bind phosphorus with a single application. Soil treatment will reduce the time until the farms can be reconnected to the lake or until other final restoration steps are taken. Approximately 800 ha (1,968 ac) of Jem Farms was treated in spring 1999, and Phase I of the marsh flow-way was treated as part of final construction. ZDWCD will be treated when studies of pesticide residues are completed.

The soil amendment selected for use within the NSRA and the marsh flow-way is alum residual, a by-product of the drinking water treatment process. Surface water, in this case from Lake Washington in Brevard County, contains suspended materials such as sand, microscopic organisms, clay, and organic particles that cause color, taste, odor, and turbidity. Aluminum sulfate, or alum, is used to coagulate these particles so that they may be separated out. Other ingredients that are added during the process include granulated activated carbon and quick lime. Polymers are used to dewater the material. The residual was thoroughly tested for safety and effectiveness. Nationally, this material is becoming popular as a phosphorus pollution abatement tool and also is used worldwide as a soil additive (Hoge 2001).

Reductions in Discharge and Nutrient Loading

An additional methodology implemented to reduce phosphorus loadings to Lake Apopka is to treat pumped discharges from ZDWCD Unit I and Unit II. When SJRWMD acquired the ZDWCD properties, ZDWCD had already implemented a liquid

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alum treatment system in Unit II, but discharges from Unit I were untreated. In September 2001 it became necessary to discharge water from Unit I, so SJRWMD implemented a second liquid alum treatment system. To improve water treatment and water control efficiency, SJRWMD has contracted with a consultant to redesign both alum injection systems. The redesign is expected to be completed and implemented by mid-2003.

Since 1989, there has been a significant decrease in the average annual muck farm total phosphorus (TP) loading to the lake (Figure 25) (Stites et al. 2001). Farm phosphorus discharges decreased due to altered water management practices, purchase of farm properties east of the Apopka-Beauclair Canal, and low rainfall in 1993 (Figure 26).



Figure 25. Lake Apopka Basin muck farm discharge of total phosphorus, 1989–96

Water Quality Improvements

In 1995, the TP concentration began to fluctuate around a new, lower level (Figure 27). Chlorophyll concentrations also declined in mid-1995 and have continued on a downward trajectory (Figure 28). In fact, the January 2000 value was the lowest monthly average measured in a decade of SJRWMD monitoring. Secchi depth, a measure of water clarity, increased by approximately 30% over the same period of time, with a significant increasing trend (Figure 29). These changes occurred during a period when average wind speeds measured at Lake Apopka were constant. Whether chlorophyll and Secchi depth have reached equilibrium with the new, lower average TP


Figure 26. Lake Apopka Basin muck farm volumetric discharge, 1989–98



Figure 27. Lake Apopka mean monthly total phosphorus, January 1987–March 2002



Figure 28. Lake Apopka mean monthly chlorophyll a, October 1998–March 2002



Figure 29. Lake Apopka mean monthly Secchi depth, January 1987–March 2002

concentration or if chlorophyll and Secchi depth will improve further without additional P loading reductions is unknown. With the first phase of the Lake Apopka Marsh Flow-Way scheduled to begin filtering the lake in the near future and the restoration of the acquired farmlands under way, even more dramatic improvements in water quality and clarity are anticipated within Lake Apopka in the coming years.

REMOVAL OF PHOSPHORUS AND FLOCCULENT SEDIMENTS

Due to the sedimentary store of available phosphorus and the moderate hydraulic detention time in Lake Apopka (2.5 years), decreased nutrient loading to the lake will need to be augmented by aggressive phosphorus removal techniques to hasten the recovery of the lake.

Marsh Flow-Way Project

The Lake Apopka Marsh Flow-Way, a created wetland located west of the Apopka-Beauclair Canal, will remove phosphorus from lake water and permanently bury it in marsh sediments. Algae, resuspended sediments, and particle-bound nutrients will be removed from lake water as it flows through 13 independent marsh cells and returns to the lake (Figure 30). A portion of the treated water will also entirely replace the poorquality water now flowing through the Apopka-Beauclair Canal to the downstream lakes, thus improving their quality as well. Over the long term, about 10% of flow through the wetland will be discharged downstream and 90% will re-circulate to Lake Apopka. The full project is expected, given current water quality conditions, to remove 30 metric tons of phosphorus annually from Lake Apopka (Lowe et al. 1989). The three long-term goals for the full-scale Marsh Flow-Way Project are to

- Establish and maintain a hydrologic regime and vegetation that will maximize phosphorus removal in terms of both power (mass P removed/unit time) and capacity (mass P removed over project life)
- Create a broad and persistent biological connection with the lake
- Establish and maintain a diversity of habitats to support aquatic and wetland wildlife (Lowe et al. 1992)

Until water quality conditions in the lake are sufficiently improved to warrant a change of focus, the marsh flow-way will be operated to meet the first of the three goals.

The first step of the Marsh Flow-Way Project was the design, construction, and operation of a 223-ha (550-ac) demonstration-scale constructed wetland. This pilot project provided necessary experience and data for the design and construction of



Phase I. Physical design, flow regimes, management tools, and operational costs for this type of wetland treatment system were evaluated in the seven-year effort. Experimental planting of emergent wetland plant species in three 2-ha (5-ac) plots were used to assess possible benefits of planting the system compared to the natural revegetation process allowed in the rest of the wetland.

Lessons learned included the following (Coveney 1995):

- Hydraulic functioning is key to effective nutrient control.
- Multiple parallel cells are preferable to a single large treatment area.
- Large-scale channelization must be avoided to maximize the hydraulic time distribution.
- Drawdown was a necessary and effective technique to consolidate newly deposited sediment.

The demonstration wetland was capable of removal of total suspended solids and total phosphorus at or above target efficiencies of 85% and 30%, respectively (Coveney, Lowe, and Battoe 2001). Several design features, such as multiple inlet and outlet locations and the creation of regularly spaced ditches perpendicular to flow, were applied in the design of Phase I to minimize channelization.

Construction of Phase I of the full project began in December 1997. Funding for Phase I included

- \$1.5 million in SWIM funds allocated by the Legislature in 1996
- 25% of invoices up to \$4 million from Lake County and the Lake County Water Authority
- \$1 million from the EPA Clean Water Act fund

Phase I construction was completed in 2001 for approximately \$4.32 million. SJRWMD will start operation of the project when the currently low lake levels increase sufficiently and when discussions with federal agencies regarding pesticide residues in the soils are completed. The first phase of construction developed 4 of 13 treatment cells in the flow-way. The design allows future construction phases to proceed while Phase I is fully operational. Phases II and III will be constructed as funding becomes available.

IMPROVE FOOD-WEB STRUCTURE

Gizzard Shad Harvest

The purpose of the Trophic Structure Manipulation and Rough Fish Harvesting Projects is to remove "rough fish," primarily gizzard shad (Dorosoma cepedianum). Shad harvest is a cost-effective means of removing phosphorus stored in the lake and helping change water quality and the trophic structure (animal community) of the lake toward conditions conducive to a diverse fish community with abundant game fish. The gizzard shad, presently the dominant fish in Lake Apopka, is a filter-feeding species that thrives in the current turbid, algal-dominated water of the lake. Its dominance reflects current poor quality conditions in the lake. The fish helps to maintain those conditions by increasing the rate at which the phosphorus in the water is made available for algal growth, by stirring up loose bottom sediments, and by removing the larger zooplankton grazers that more efficiently feed on blue-green algae. Removal of the gizzard shad population from Lake Denham, a 120-ha (300-ac) lake connected to downstream Lake Harris, between 1990 and 1992 provided a successful demonstration of the potential benefits of this restoration technique. Haul seine removal of gizzard shad from Lake Denham resulted in significantly improved water quality, including reductions in total phosphorus, nitrogen, suspended solids, turbidity, and chlorophyll a concentrations and increased water clarity measured by Secchi disk. Recreational fishing improved dramatically as well.

From 1993 through 2002, commercial fishermen harvested 3,729,945 kg (8.2 million pounds) of gizzard shad from Lake Apopka. A winter/spring harvest, supported by SJRWMD funding, is augmented by the availability of year-round permits for commercial fishermen that have yielded as much as 250,000 pounds annually without cost to SJRWMD. Low lake levels prevented large-scale harvest of gizzard shad in 2001 and the spring of 2002. To improve lake access for commercial fishing, a new dock facility was constructed in 2002 on McDonald Canal on the former A. Duda and Sons Jem Farm property.

IMPROVE LAKE HABITAT

Littoral Zone Replanting

Historically, the northern third of Lake Apopka was a vast floodplain wetland dominated by saw grass. A healthy littoral zone surrounded the rest of the lake, including a shallow-water habitat for fish population development. However, the 7,290 ha (18,000 ac) of northern wetlands were eliminated and the remaining littoral zone is degraded, with loose sediments unsuitable for game fish nesting sites. Dense stands of cattail, which provide a poor habitat for fish (Johnson and Crumpton 1998), make up approximately 48% of the areal coverage of the existing near-shore vegetation (SJRWMD, unpublished data).

In the Littoral Zone Restoration Project, desirable native vegetation is planted behind inexpensive, moveable breakwaters to reintroduce emergent wetland species lost to littoral zone areas and to begin to stabilize the loose surficial sediments. It is expected that in addition to providing the protection from wave action necessary for newly planted vegetation to establish and thrive, these breakwaters will help reduce sediment resuspension, clear the water column, and promote development of submerged vegetation. A contract effort to transplant six native aquatic plant species behind protective barriers and at unprotected control sites began in July 1992 and was completed in December 1993. Additional aquatic vegetation planting was begun by SJRWMD staff in June 1992, primarily on the northern shore of the lake. This is an ongoing effort, and over one noncontiguous mile of shoreline, comprising over 40 sites, has been planted (Figure 31). Planting "events" have been sponsored by SJRWMD with county and local governments and the Friends of Lake Apopka (FOLA) to restore littoral zone areas fronting public parks along the lake. Volunteers of all ages have participated in these events. Also, the existing shoreline vegetation around the 40-mile perimeter of the lake has been mapped using global positioning and geographic information systems (Conrow and Peterson 2000). This effort will establish a baseline for quantifying changes in future vegetative coverage.

New Vegetation Development

Since 1995, *Vallisneria americana* (eelgrass) has increased markedly in the lake after being nearly absent from the lake bottom in recent decades. By January 2001, more than 83 patches with a combined area over 2.6 ha (6.5 ac) were documented. This spontaneous return of submersed macrophytes may be a response to improved underwater light conditions. In addition to providing valuable habitat, submersed macrophytes will hasten the recovery of the lake through several positive feedback mechanisms.



OTHER EFFORTS

Wetland Restoration Area Pesticide Residue Effort

As discussed in the Overview section, two different evaluations were performed as steps in the land acquisition process at Lake Apopka: (1) an environmental site assessment (ESA) and (2) an environmental risk assessment (ERA).

The ESA and subsequent remediation activities identified and removed highly contaminated soil from former storage areas, with mix/load sites, solid waste sites, etc. The ERA evaluated the potential for acute or long-term (chronic) problems to occur with wildlife as a result of the average pesticide residue concentrations in the purchased areas that resulted from normal farming operations.

All properties considered for acquisition received a Phase I ESA in accordance with American Society for Testing and Materials (ASTM) Standard E1527. Eleven properties were audited, although not all of these properties are part of the currently active 9,000-acre restoration area.

Final remediation included removal of over 18,600 tons of soil that were contaminated by petroleum, metals, and pesticides. SJRWMD also conducted an ERA of the residual pesticide levels expected to remain in the farm soils after remediation was completed. Approximately 400 soil samples were analyzed for pesticide residues in the ERA process. The risk assessment and subsequent follow up evaluation indicated no likelihood that background residual pesticide levels would present an acute toxicity risk to aquatic or wetland animals. Some concerns about long-term, sub-lethal effects on growth or reproduction were raised, and SJRWMD planned a monitoring program to assess these potential problems during restoration.

The promotion of lush emergent vegetation through shallow flooding was identified as the best management strategy to remediate the background levels of pesticides. This approach combined the beneficial effects of (1) a halt to further application of pesticides, (2) accelerated microbial breakdown of pesticides in a nutrient-rich, anaerobic soil environment, and (3) burial and dilution of the pesticide residues with new organic matter.

Flooding the Farm Fields and Bird Mortality

Remediation activities at the farms were completed during the summer of 1998, and the farms were shallowly flooded. Shallow flooding of the farm fields was the farmers' historical practice to control crop pests and reduce erosion during the summer fallow

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period. Shallow flooding was extended into the fall in order to expedite restoration efforts, specifically to

- Limit weed growth to facilitate soil amendment application
- Minimize pumping of drainage water to Lake Apopka
- Provide habitat for migrating shorebirds

As autumn progressed, an enormous number and variety of birds came to the site. SJRWMD began draining the site in early November to prepare for treatment of the area with a soil amendment to trap excess phosphorus left by the farming process. The range of water depths created in the NSRA as fields began to dry resulted in an extraordinary response by bird populations. The 1998 Zellwood/Mount Dora Christmas Bird Count recorded a likely North American inland record of 174 species (Cornell University 2002).

However, in late fall 1998, a significant mortality event affecting primarily white pelicans occurred on the site. Birds were also found sick or dead in other parts of Florida. The deaths of about 1,000 white pelicans and other fish-eating birds statewide have been attributed to the mortality event on the north shore of Lake Apopka. The number of dead pelicans represented a significant fraction of the white pelican population wintering in Florida.

In order to discourage fish-eating birds from coming to the area, SJRWMD accelerated draining of the farmland in January 1999. The fields were completely drained by February. By March, the pelican population had migrated from the sites and mortalities of all bird species were infrequent.

Investigating the Causes of the Bird Mortality

USFWS, the federal agency responsible for migratory birds and federally listed species, began an investigation of the bird mortality shortly after the deaths began. On February 17, 1999, USFWS issued a press release with a preliminary conclusion that the birds had died from poisoning by organochlorine pesticides. Among the pesticides that were implicated are toxaphene, dieldrin, and DDT and its metabolites.

SJRWMD and NRCS, with the concurrence of other Florida government agencies, determined that further investigation was necessary. A total of \$1.5 million for Phase 1 of the study was pledged from SJRWMD and NRCS, and other organizations pledged in-kind support. In March 1999, a team of experts from 13 federal, state, county, and private organizations convened as the technical advisory group to the investigation.

Using the USFWS conclusions as a working hypothesis, the technical advisory group investigation was designed to evaluate two potential hypotheses. The first hypothesis was that typical pesticide concentrations in the fields were sufficiently high to cause acute toxicity. The second hypothesis was that a highly contaminated site was not found during the ESAs conducted for each farm.

All data on soils and sediments, birds, and fish were provided to Exponent Inc., a consulting firm based in Bellevue, Washington. Their analysis of the data and a draft report on the mortality event were completed for review in September 2000. The draft Exponent report generated significant debate among the technical advisory group and others as to the cause of the bird mortality. In April 2001, USFWS released a significant amount of data that it had obtained through necropsies conducted by USFWS on birds that were sequestered by USFWS after the bird mortality. These data, along with technical review comments, were then made available to Exponent for preparation of the final report. A further draft was received in April 2003.

A primary uncertainty for evaluating risk from pesticide residues is the rate of bioaccumulation of pesticides from soils/sediments through the food chain to fish and then to birds. Soils with high organic matter contents, like those on the NSRA have not been studied, nor has environmental fate modeling for pesticides been evaluated under similar high organic conditions. Therefore, three additional phases of study are necessary initial components of restoration efforts for the NSRA: (1) laboratory microcosms, (2) field-scale mesocosms, and (3) bird feeding studies. SJRWMD initiated these studies during the spring of 2001.

In addition to the above studies, SJRWMD started cleanup of a small, highly contaminated area during 2002. Through January 2003, a total of 9,203 tons of contaminated soil had been excavated. This site was discovered during the intensive soil sampling conducted in 1999. Also as a result of the intensive sampling and subsequent risk analysis, SJRWMD developed and submitted to NRCS a plan for reflooding a portion of the Duda farm. This 700-acre area had the lowest pesticide concentrations found on the NSRA, with soil concentrations below all thresholds suggested by Exponent (2000). Reflooding was initiated in June, 2002 and will be accompanied by intensive monitoring of water chemistry, hydrology, bird use, and pesticide residues in fish, sediments, and water. Finally, additional soil sampling for pesticides has been completed on portions of the NSRA not involved in the mortality event.

After any necessary remediation is complete, SJRWMD will flood the site to begin shallow marsh development. The present long-term restoration plan includes several potential management areas such as shallow marsh, deep marsh connected to the lake, and shorebird management areas. As final restoration activities are developed, SJRWMD may consider and implement other appropriate management alternatives as well.

Further information on the bird mortality, pesticide study objectives, and possible remediation methods is found in the Detail of Projects section under Project LA-3-303-M: Wetland Restoration.

Future Basin Management Alternatives

The restoration projects outlined above will continue beyond the time horizon covered by this plan. Because these restoration efforts represent a large investment of time and resources, important consideration will be given to protecting the quality of the water body during and after restoration.

One important effort toward that end is the Lake Apopka Basin Planning Initiative, initiated by FOLA, a coordinated regional planning effort involving local elected officials, the East Central Florida Regional Planning Council (ECFRPC), SJRWMD, and other interested parties. In 2000, a steering committee consisting of local elected officials from the two counties and six municipalities in the basin examined needs and opportunities relating to five areas considered to be key pieces for achieving an ecologically and economically sustainable future for the basin. Those five areas are shoreline protection, greenways and trails, viewsheds, public access, and natural setting.

One major opportunity identified through the initiative is development of a recreational trail around Lake Apopka. Using a concept plan prepared by ECFRPC, FOLA is promoting a detailed study of ways such a trail could link all the municipalities in the basin and SJRWMD lands within a 50+ mile loop. Also, a resident's group in Lake County is attempting to have County Road 455 on the west side of the lake designated as a Florida Scenic Highway in an effort to feature and protect environmental and cultural resources in the western portion of the basin. A similar group is organizing around old Highway 50 in Oakland.

Using a grant from Orange County, FOLA hired professional planners to develop the Lake Apopka Development Design Guidelines. Each of the eight local jurisdictions will be asked by FOLA to adopt and apply the shoreline protective measures as they approve future developments. Lake County has written a new ordinance based on the guidelines and several new proposed developments have incorporated the guidelines.

The Jones Avenue Regional Stormwater Management Project will provide a regional wet detention pond system to improve the water quality in the northern portion of the

basin. The 16-ha (40-ac) project will be located on SJRWMD property within the NSRA and will be funded by a cost-share agreement between SJRWMD and Orange County.

PROGRAMS AND PROJECTS

This section contains an overview of programs and projects to be implemented in the Lake Apopka SWIM Plan. All of the projects are categorized under the following eight programs:

- 1. Diagnostic Program—studies to collect necessary information on Lake Apopka. This includes studies designed to further understand the functioning of the lake and the causes of its degradation.
- 2. Feasibility Program—investigation and testing of potential restoration techniques.
- 3. Restoration Program—demonstration and full project restoration efforts. This will include implementation of techniques developed as pilot studies under the Feasibility Program.
- 4. Regulatory Program—compliance enforcement actions regarding point and nonpoint source pollution. An assessment and development of regulatory needs and a compilation of a database necessary to promulgate additional regulatory criteria will be completed.
- 5. Planning Program—planning and coordination of efforts with state agencies and local governments. Efforts will be closely coordinated with the Regulatory Program.
- 6. Public Information Program—public information and awareness efforts.
- 7. Land Acquisition Program—acquisition planning and acquisition.
- 8. Technical Support Program—support activity such as budget preparation, project planning, integration of diagnostic and feasibility projects, data management, and SWIM Plan revisions

PROJECT CODING

Each project has been assigned a code. The code has (1) a two-letter prefix to identify the water body (e.g., LA = Lake Apopka), (2) a single-digit number which relates the project to the most applicable central concern of the SWIM Act (e.g., LA-1 = LakeApopka, point and nonpoint source pollution central concern), (3) a three-digit number, the first to identify the appropriate program and the remaining digits to identify each project (e.g., LA-1-105 = Lake Apopka, point and nonpoint source pollution central concern, diagnostic program, project number five), and (4) a single-letter suffix (D, F, M, or S) for a budget code (e.g., LA-1-105-D = Lake Apopka, point and nonpoint source pollution central concern, diagnostic program, project number five, diagnostic fiscal budget code). The code segments for the Lake Apopka SWIM Program follow.

Prefix: LA—Lake Apopka

Central concerns of the SWIM Act:

- Point and nonpoint source pollution
- Destruction of natural systems
- Correction and prevention of surface water problems
- Research for better management of surface waters and associated natural systems
- Public awareness
- Improved coordination and management

Programs:

100 series	Diagnostic Program
200 series	Feasibility Program
300 series	Restoration Program
400 series	Regulatory Program
500 series	Planning Program
600 series	Public Information Program
700 series	Land Acquisition Program
800 series	Technical Support Program

Suffix:

- D Diagnostic
- F Feasibility/Applied Research
- M Management/Restoration
- S Technical Support

PROGRAM AND PROJECT DESCRIPTIONS

The following are brief descriptions of complete, ongoing, and proposed projects for Lake Apopka. Each project is described in detail in the following section.

A. Diagnostic Program

- External Nutrient Budget LA-1-101-D Quantifies the exchange of water and nutrients between Lake Apopka and its watershed.
- Internal Nutrient Budget LA-1-102-D Maps the type, depth, and chemical characteristics of lake sediments. Quantifies nutrients returning from the sediments to the water and examines sediment deposition rates in the Lake Apopka Basin.
- 3. Mathematical Modeling
 - LA-4-103-D

Uses data collected in the diagnostic and feasibility programs to project the effects of selected restoration techniques.

- Phytoplankton-Nutrient Interactions LA-4-104-D Provides baseline information on algal biomass and productivity. Assesses the consequences of nutrient reduction on algal growth.
- 5. Bathymetry
 - LA-4-106-D

Provides a bathymetric survey of the bottom contours of Lake Apopka.

- 6. Fishery
 - LA-4-107-D

Obtains current information on the fishery in Lake Apopka for modeling purposes. Monitors the game and rough fish populations.

 Seismic Reflection Profiling LA-1-108-D

Examines subsurface geology across Lake Apopka and assesses the nature of the confining layers between the lake and the Floridan aquifer.

- 8. Hydrodynamic Survey
 - LA-4-109-D

Characterizes the dominant seasonal meteorological conditions and models velocities and directions of water currents in selected portions of the lake.

B. Feasibility Program

- Water Hyacinth Demonstration LA-4-201-F Tests the ability of water hyacinths to remove nutrients from the lake.
- Phosphorus Inactivation/Precipitation LA-4-202-F Evaluates the feasibility of using alum as a precipitant to trap nutrients in an insoluble matrix.
- 3. Sediment Recycling
 - LA-4-204-F

Evaluates dredging costs and potential markets for lake sediment to make dredging economically feasible.

- Microbial Decomposition LA-4-205-F Evaluates ways of stimulating natural microbial processes which reduce the bulk of lake sediments and sequester nutrients.
- 5. Ichthyofaunal Reconstruction (I, II) LA-4-206-F

Phase I—Compiles a literature review on biomanipulation to determine applicability to problems in Lake Apopka. Phase II—Evaluates the potential for use of exotic fish species to aid in the restoration of Lake Apopka by consumption of excess production of algae.

6. Trophic Structure Manipulation (I, II, III) LA-4-207-F

EA-4-207-F Phase I—Provides baseline data on the role of rough fish in plankton and nutrient dynamics. Phase II—Determines the effects of gizzard shad removal on lake trophic structure and nutrient recycling. Phase III—Tests standard harvesting gear for largescale rough fish removal in Lake Apopka and tests feasibility of using harvested rough fish as marketable products to offset the cost of fish removal.

7. Drawdown and Lake Level Fluctuation (I, II, III) LA-4-208-F

Phase I—Evaluates the feasibility and ecological effects of temporary lowering the water level in the lake or enhancing water level fluctuation. Phase II—Examines the effects of a partial drawdown of a similar nearby lake. Phase III—Formulates

alternative enhanced lake fluctuation schedules, assesses socioeconomic consequences, and recommends new regulation schedules.

8. Socioeconomic Assessment and Methodology LA-4-209-F

Develops techniques for socioeconomic assessment of the Lake Apopka Basin. Assesses the present economic value of the recreational and commercial uses of Lake Apopka and predicts economic growth with water quality improvement. Assesses the impact of a total farm buyout on the local economy.

C. Restoration Program

- 1. Marsh Flow-Way Restoration
 - LA-3-301-M

Restores muck farmland to a treatment marsh in order to filter nutrient-rich water from Lake Apopka.

2. Rough Fish Harvesting LA-3-302-M

Harvests rough-fish species to remove nutrients from Lake Apopka and improves water quality through food-web manipulation.

- 3. Wetland Restoration
 - LA-3-303-M

Restores acquired properties to wetland habitat and examines restoration for effects upon water quality, vegetation, and wildlife.

- 4. Littoral Zone Restoration
 - LA-2-304-M

Evaluates the feasibility of isolating and restoring small portions of Lake Apopka's shoreline to vegetated littoral zone and examines the potential macrophyte seed source from littoral zone sediments.

D. Regulatory Program

- Nonpoint Source Pollution Control LA-3-402-M Identifies and controls sources of nonpoint pollution affecting Lake Apopka.
- 2. Nutrient Loading Limits Adoption LA-3-403-M

Develops and adopts more-stringent permitting criteria, as necessary, to protect water resources in the Lake Apopka Basin from future development and establishes numerical nutrient loading limits.

E. Planning Program

- District Water Management Plan LA-6-501-M Provides a means to identify and address water resource issues.
- Local Government Comprehensive Plan Review LA-6-502-S Reviews and comments on local government comprehensive plans.
- Land Management Plan for the Lake Apopka Restoration Area LA-6-503-M Develops land management plan for the entire Lake Apopka restoration effort.

F. Public Information Program

1. Public Awareness

LA-5-602-S Uses media communication techniques to inform and educate the public regarding ongoing and future restoration efforts for Lake Apopka.

 Local Government Information Project LA-5-603-S Makes formal informational SWIM program presentations to Planning Commissions, County Commission Boards, and other municipal advisory and governing bodies.

G. Land Acquisition Program

- Marsh Flow-Way Land Acquisition LA-3-701-S Acquires 2,360 ha (5,833 ac) of farmland in support of the Marsh Flow-Way Project.
- 2. North Shore Land Acquisition LA-3-704-S

Evaluates potential acquisitions of muck farms and adjacent conservation and preservation lands in the Lake Apopka Basin, prioritizes purchases, and acquires lands.

H. Technical Support Program

- Implementation of Restoration and Management Techniques LA-6-802-S Provides overall analysis and coordination of diagnostic, feasibility, regulatory, planning, and pilot restoration projects.
- Restoration Monitoring and Analysis LA-6-803-S Implements a post-restoration monitoring regime.
- Overall Program Management LA-6-804-S Manages Lake Apopka SWIM Program. Provides inter-agency coordination and

report preparation, as necessary.

DETAIL OF PROJECTS

Diagnostic projects further our understanding of the functioning of the lake and the causes of its degradation. Feasibility projects are directed toward investigation and testing of potential restoration techniques. Of the 16 diagnostic and feasibility projects discussed within this section, no further action is planned for 13. The remaining three projects are ongoing, some with expanded scopes of work. Successful completion of these studies represents a major milestone. A number of restoration techniques originally proposed for Lake Apopka were found upon examination to be inefficient or ineffective. These techniques include large-scale sediment recycling, phosphorus inactivation in the lake sediments, microbial decomposition, and ichthyofaunal reconstruction. The decision not to proceed with pilot-scale implementation of these techniques has freed resources to support the restoration methods that have been shown to be effective for this lake.

The following individual project presentations contain a priority code assigned to the project, an issue category which refers to the seven priority issues, an objective, a scope of work, and a status report. Each project is related to the central concerns of the SWIM Act by applicable intent and focus. Schedules through fiscal year 2005–2006 are included for projects that are incomplete or ongoing. Timelines for Lake Apopka projects over the planning period of this document are illustrated in Figure 32.

PROJECT (LA-1-101-D): EXTERNAL NUTRIENT BUDGET

PROGRAM: Diagnostic

PRIORITY: Completed

<u>ISSUE CATEGORIES</u>: Agricultural discharges; poor water quality and flocculent sediments

<u>PROJECT OBJECTIVE</u>: To quantify all interchanges of water and nutrients between Lake Apopka and its environment by monitoring surface and subsurface flow, rainfall and dry deposition, evaporation, and pump discharges from farms and restoration areas



Figure 32. Overall timetable for the Lake Apopka SWIM Program

SWIM Plan for Lake Apopka

	2003	2004	2005
Task Name	Otr 1 Otr 2 Otr 3 Otr 4 Otr 1	Otr 2 Otr 3 Otr 4 Otr 1	Catr 2 Catr 3 Catr 4 Catr 1 Catr 2 Catr 3 Catr 4
Nonpoint Source Control			
Jones Avenue Stormwater Park			
Review local ordinances			
District Water Management Plan			F. (1)
Publish annual progress report			
Update DWMP			
Local Govt. Comp. Plan Review			
Review regular amendments			
Review EAR-based amendments			
Land Management Plan			
Construction of public access and facilities			
Solid waste removal			
Maintenance of roads, levees, bridges, buildings			
Vegetation control			
Public Awareness			
Public awareness activities			
Outreach to Government Officials	60 × 101		64 4 6 6 1
Tours, speaking engagements, etc.			
Coordinate with Basin Steering Committee			
North Shore Acquisition			
Appraisal, negotiation, Board approval			
Implementation of Techniques			
Provide technical support			
Restoration Monitoring and Analysis			
Fisheries sampling and analysis			
Fish and bird monitoring			
Water sampling and monitoring			
Annual nutrient budget calculations			
Contaminant monitoring and analysis			
Vegetation monitoring and analysis			
Overall Program Management			
Overall Program Management			

<u>SCOPE OF WORK</u>: Conduct full-scale monitoring during calendar years 1989 and 1990. Continue nutrient monitoring after 1990 as part of ongoing project. External sources of nutrients and water include the following: precipitation, tributaries, muck farms (new SJRWMD restoration areas), Apopka Spring, direct overland runoff, groundwater seepage, and industrial and municipal point sources. Losses of nutrients and water occur through the Apopka-Beauclair Canal, muck farm (restoration area) withdrawals, removal by fish harvesting, seepage, and evaporation. During the full monitoring period, implement a telemetry network to provide meteorological data: temperature, solar radiation, wind speed, precipitation, barometric pressure, evaporation, and relative humidity. Monitor permanent tributaries with the radio telemetry system and seasonal tributaries manually, once a month. Sample monthly water quality at all flowing tributaries, at Apopka Spring, at stations located in the lake, and at the Apopka-Beauclair Canal. Monitor agricultural discharge by event at nine point discharges from the Lake Apopka muck farms. Quantify domestic and industrial discharges provided through monthly operating reports to FDEP. Characterize groundwater quality with monthly samples of shallow aquifer wells located around the lake. Measure subsurface seepage with a network of piezometers located along the dikes and around the lake. Monitor flow continuously at the Apopka-Beauclair and Lake Level canals. Develop an FDEP-approved Quality Assurance Plan.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: This project provides the necessary data to calculate a water budget for the lake and to quantify external nutrient loads to the lake. Such information has been used in enforcement compliance, regulation planning, and planning a restoration program for the lake. Information on response of the lake to past development will help in evaluation of the effects of present and future land use. External nutrient loading data will also provide a basis to evaluate recent and future effects of nutrient reductions and of other restoration measures in the lake.

<u>SUMMARY AND STATUS</u>: Nutrient loading to the lake is calculated by combining the results of a water budget analysis with water quality measurements. This is a difficult process, which requires a large amount of accurate data to account for the inherent variability in field data from a complex system. The quality assurance plan was approved by FDEP (then, FDER) in January 1989.

Monitoring of hydrologic variables with the full telemetry sensor net and water quality sampling proceeded during calendar years 1989 and 1990. From 1991 to 1998, SJRWMD efforts focused on monitoring of atmospheric deposition, ambient water quality, and discharges from the Apopka-Beauclair Canal. Other data on phosphorus loading to the lake and losses from the lake were compiled from farmers' consent order reports and from industrial and domestic wastewater discharge permit compliance reports. A draft

technical memorandum describing a six-year (1989–94) phosphorus budget for Lake Apopka was completed (see Appendix H). After acquisition of most of the agricultural area in 1998, SJRWMD again began monitoring nutrient discharges from that area.

One source of water to Lake Apopka is Apopka Spring (Gourd Neck Spring). The orifice of the spring is covered by natural and man-made debris and is irregular in shape, which creates difficulty in obtaining accurate measurements. Therefore, a substantial discharge variability (31.4 to 70.4 cubic feet per second) was evident in the six spring discharge measurements made by USGS in Apopka Spring from 1988 to 1992.

In order to more precisely predict Apopka Spring's contribution to the water quality and quantity of Lake Apopka, 15 additional discharge measurements were taken by Karst Environmental Services between May 1997 and June 1999 inside the spring vent. These measurements were used to refine the relationship between Floridan aquifer and Lake Apopka elevations and spring flow so that spring discharges could be estimated.

A 1996 assessment of muck farm development using aerial photography from 1941 to 1990 provided a clearer picture of the historical loading changes that Lake Apopka has undergone (see Figure 4). Monitoring and analysis of nutrient loading and water quality for Lake Apopka during the implementation of the restoration program are accomplished under Project LA-6-803-S: Restoration Monitoring and Analysis.

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PROJECT (LA-1-102-D): INTERNAL NUTRIENT BUDGET

PROGRAM: Diagnostic

PRIORITY: Completed

ISSUE CATEGORY: Poor water quality and flocculent sediments

<u>PROJECT OBJECTIVE</u>: To map the type, depth, distribution, and quality of lake sediments, and to quantify internal nutrient dynamics in the lake; to examine the dynamics of nutrient conversion and exchange with the atmosphere due to processes such as gaseous nitrogen fixation, denitrification, carbon fixation, and respiration

<u>SCOPE OF WORK</u>: Take intact sediment cores at 100 sampling stations that approximate the locations sampled in 1968 by Schneider and Little (1969). Compare data between the two studies to provide an indication of changes in sediment characteristics over the intervening 19-year period. Process the cores to determine rates of accumulation of organic carbon, aerobic and anaerobic decomposition zones, spatial variation in organic sediment depth, and concentrations of different forms of carbon, nitrogen, and phosphorus. Determine the net flux of dissolved nutrients from the sediments to the overlying water column, the importance of biological and physicochemical transformation of sedimentary nutrients, and the rates of transformation. Analyze sediments for metals, volatile and semi-volatile organic compounds, and pesticides. Utilize diatom analysis and ²¹⁰Pb dating techniques to evaluate sediment characteristics of the sediment layers and accumulation rates.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: This project will provide the data necessary to evaluate internal nutrient loading and recycling in Lake Apopka and provide a basis for simulation models to predict how internal loading can be reduced. <u>SUMMARY AND STATUS</u>: The original contractual projects were completed and the final report was prepared in two parts. Phase I was accepted by the Governing Board in March 1991. Phase II was accepted by the Governing Board in May 1991 and revised in December 1992. Additional research based on the results of the administrative hearing on the Lake Apopka Nutrient Limitation Rule, which became Phase III, was completed and approved by the Governing Board in 1997.

Phase I—The *Internal nutrient budget for Lake Apopka*, completed by a University of Florida research team, provides a compendium of basic data from chemical and physical analyses on sediment samples from a 90-station grid over the bottom of Lake Apopka (Reddy and Graetz 1991). These data have been used in the report to map sediment type and thickness. SJRWMD staff have used the data to estimate available nutrient stores in the sediments and to provide a measure of permanent burial of phosphorus. The basic information in this report is central to our understanding of the role that the sediments in Lake Apopka play during the restoration process. The report also provides measurements of various exchange rates between the sediments and lake water for the nutrients carbon, nitrogen, and phosphorus. Design and evaluation of restoration projects and establishment of loading limits for Lake Apopka have relied and will continue to rely heavily on data provided in this report.

Phase II—Assessment of potential sediment contamination for the restoration of Lake Apopka presented a survey of levels and potential toxic effects of substances in Lake Apopka sediments (Segal and Pollman 1991). Sediment cores from two depths at 10 locations were analyzed by KBN Engineering and Applied Sciences for the 152 elements and compounds on the EPA Toxic Compounds List. Thirteen elements occurred in sufficiently high concentrations to warrant detailed examination; two (copper and lead) appear to pose the greatest threat of toxicity to the lake biota. Because of the complexity of interactions that occur in biological systems, the potential toxic effects of these elements are difficult to assess. SJRWMD staff have enlisted the support of other state agencies in determining the need for further studies, such as fish tissue analyses.

Phase III—Research on internal nutrient dynamics stemming from the results of the administrative hearing on the Lake Apopka Nutrient Limitation Rule focused on evaluating sediment characteristics of the sediment layers and accumulation rates using methods independent of previous research in this area. In 1996, a research group at UF under the direction of Dr. Claire Schelske was awarded a contract to further research the development and characteristics of the lake sediments using diatom analysis and ²¹⁰Pb dating techniques (Appendix H). The final report was approved by the Governing Board in December 1997. Diatom analysis indicates two distinct sediment layers, the upper layer from a phytoplankton-based system and the lower layer from a

macrophyte-dominated system (Schelske 1997). This comparison indicates that calculated storage of organic matter closely approximates storage evaluated independently. The whole-basin inventory of total phosphorus in flocculent sediments was estimated at 2,250 metric tons.

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PROJECT (LA-4-103-D): MATHEMATICAL MODELING

PROGRAM: Diagnostic

<u>PRIORITY</u>: Completed

<u>ISSUE CATEGORIES</u>: Agricultural discharges; poor water quality and flocculent sediments; degradation of downstream lakes

<u>PROJECT OBJECTIVE</u>: To develop simulation models with data collected in the diagnostic and feasibility projects to project the effects of selected restoration techniques

<u>SCOPE OF WORK</u>: Develop conceptual and mathematical models to help understand the present condition of the lake, how that condition is maintained, and what effects different restoration treatments will have. Build models that will simulate conditions in the lake by mathematically defining and linking processes that describe lake system functions. Simulate management alternatives and their effects by changing the rates and levels at which the different processes occur and defining new processes that describe restoration methods.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: This project will provide a predictive capability to determine the allowable phosphorus loading consistent with the restoration of Lake Apopka. The project also will predict effects of proposed restoration techniques on lake water quality.

<u>STATUS</u>: Model formulation and testing proceeded concomitant with data collection. Input-output models were developed to predict the effect of removal of phosphorus in the marsh flow-way on phosphorus levels in the lake. Models also were used to determine the allowable phosphorus loading (from all sources) consistent with restoration goals.

<u>Report</u>

Coveney, M.F. 2000 (draft). Sedimentary phosphorus stores, accumulation rates, and sedimentation coefficients in Lake Apopka. Prediction of the allowable phosphorus loading rate. Technical memorandum. St. Johns River Water Management District, Palatka, Fla.

PROJECT (LA-4-104-D): PHYTOPLANKTON-NUTRIENT INTERACTIONS

PROGRAM: Diagnostic

PRIORITY: Completed

ISSUE CATEGORY: Poor water quality and flocculent sediments

<u>PROJECT OBJECTIVE</u>: To provide baseline information on algal biomass and productivity. Nutrient and light limitation will be assessed to enable prediction of the effects of restoration measures on algal growth.

<u>SCOPE OF WORK</u>: Evaluate the methodology and the utility of physiological indicators of phytoplankton nutrient status in Lake Apopka, including assays for N and P limitation in the lake water. Develop procedures to measure daily phytoplankton primary production in vertical profiles using light-dark bottle methodology. Sample the center lake station twice per month; conduct assays for N and P limitation and phytoplankton primary production, and measure water column light extinction concurrently. Determine photosynthesis as a function of light intensity for lake phytoplankton.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: This project will establish baseline levels of algal biomass and production, which are primary symptoms of eutrophication. Data on nutrient limitation conditions for algae are critical for evaluating the potential effects on algal growth of nutrient reduction through restoration activities.

<u>SUMMARY</u>: In May 1989, SJRWMD entered a contract with UF, Department of Fisheries and Aquaculture, to conduct field measurements and experiments to monitor the growth and nutrient status of algae (phytoplankton) in Lake Apopka. The report provides important data on which management decisions can be based and from which the results of management decisions can be assessed. The last historical data were from 1977 and 1978. Phytoplankton biomass is high in Lake Apopka and is controlled partly by wind-driven resuspension of settled algae. Phytoplankton are responsible for approximately half of the light absorption of Lake Apopka water. Phytoplankton production is high and without distinct seasonality. Production levels were similar to those measured in 1977 and 1978.

Monthly experiments showed a primary nitrogen limitation to growth 96% of the time, with secondary phosphorus limitation about 25% of the time. Phytoplankton are nitrogen-limited because of cellular storage of phosphorus from excessive loading to the lake. Phosphorus loading must be reduced to reduce algal levels. Experiments provided evidence that, as algal levels are reduced through filtration of lake water through the marsh flow-way, remaining algae will be enriched in phosphorus. These processes should improve efficiency of phosphorus removal in the flow-way.

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Shumate, B.C., C.L. Schelske, T.L. Crisman, and W.F. Kenney. 2002. Response of the cladoceran community to trophic state change in Lake Apopka, Florida. *Journal of Paleolimnology* 27:71-77.

PROJECT (LA-4-106-D): BATHYMETRY

PROGRAM: Diagnostic

PRIORITY: Completed

ISSUE CATEGORY: Poor water quality and flocculent sediments

PROJECT OBJECTIVE: To conduct a new bathymetric survey of Lake Apopka

<u>SCOPE OF WORK</u>: Map the bottom contours of Lake Apopka using a recording fathometer on a 600-m (2000-ft) or smaller grid pattern. From the bathymetric data obtained, draw publication quality bathymetric and water depth maps of the lake (in metric and foot scales) with isopleth intervals of 0.25 m and 1.0 ft. Calculate stage-area and stage-volume relationships. Make quantitative analyses of errors and provide 95% confidence limits for the several relationships developed.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: This project will provide an up-to-date bottom contour profile of Lake Apopka. Accurate bathymetric data are essential for the engineering of restoration projects and to evaluate future changes in bottom contours resulting from restoration efforts.

<u>SUMMARY</u>: The field survey was completed in June 1989. The Governing Board accepted a final report in January 1990. The results have been used to estimate the lake volume and provide relationships between lake stage, volume, and surface area. The lake was shown to be relatively flat, with some evidence of scouring channels, particularly in the southwest. Bathymetric survey data are being used in analysis of water circulation patterns in the lake for siting of marsh flow-way intake structures and for design of littoral zone restoration plantings. The mean lake depth at 20 m (66 ft) (msl) is 1.46 m (4.81 ft).

Report

Danek, L.J., and M.S. Tomlinson. 1989. *Bathymetric analysis of Lake Apopka*. Special Publication SJ89-SP6. Palatka, Fla.: St. Johns River Water Management District.

PROJECT (LA-4-107-D): FISHERY

PROGRAM: Diagnostic

PRIORITY: Completed

<u>ISSUE CATEGORIES</u>: Lack of fish and wildlife habitat; low recreational and aesthetic values

<u>PROJECT OBJECTIVE</u>: To obtain information on game and rough-fish populations in Lake Apopka

<u>SCOPE OF WORK</u>: Phase I—To collect data from electrofishing and blocknet studies prior to restoration efforts in the lake. Phase II—To determine any changes in the fish community resulting from ongoing restoration efforts; to collect data in the same manner and locations to allow comparisons with the Phase I project; to add new sampling sites in recently planted littoral zone areas; and to include electrofishing, blocknets, gill nets, and otter trawl sampling methods on adult and subadult game fish.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: This project will provide ongoing information on the effects of efforts to improve fisheries and fisheries habitat in Lake Apopka.

SUMMARY AND STATUS: Phase I—This cooperative (non-contract) effort with FWC (formerly the Florida Game and Fresh Water Fish Commission) to monitor fish stocks began in 1988 and was implemented on a cooperative and no-cost basis. The project terminated at the end of the 1990-91 fiscal year. FWC has provided SJRWMD with a final report on the three-year effort. Littoral blocknet sample results show a 22% relative abundance for the four primary Centrarchid gamefish species in the 1973–76 period, and a 39% relative abundance for these species in the 1989-91 period. Average littoralzone biomass of these species increased from 125 kg/ha for the 1973-76 period to 240 kg/ha for the 1988–91 period. Black crappie was the only gamefish species to make a substantial contribution to the pelagic fish population of Lake Apopka; however, there was no significant difference in the percent relative abundance of this species between the two time periods. Although the total littoral zone gamefish biomass of Lake Apopka has apparently increased since 1976, the biomass of the most important recreational species, largemouth bass, remains low when compared to other eutrophic lakes in the region (17.5 kg/ha for Lake Apopka, 25.7 kg/ha for nearby Lake Griffin for the 1989–91 period). The cause for the apparent gamefish population increase in Lake Apopka is

unknown; however, water quality improvement and germination of emergent littoral vegetation during the 1981 low-water period are suspected causes.

Phase II—This contractual project with FWC is designed to determine any changes in the gamefish community resulting from ongoing restoration efforts. Beginning in November 1996 and continuing through November 1997, adult and subadult samples were collected from the Lake Apopka shoreline zone. When compared with blocknet samples taken from 1989 to 1991, average total biomass and numbers of harvestablesize sport fish were lower or unchanged in 1997 samples.

Beginning in 1981, a major decline was observed in juvenile alligators on Lake Apopka. USFWS, UF, and FWC researchers identified reproductive failure in alligator and turtle populations in the lake and found a possible link to DDE and other organic contaminants. Such compounds are found in low concentrations in Lake Apopka sediments. However, recent work by Gross et al. (1998) does not support the hypothesis that DDT or DDE are linked to alligator clutch viability. Also, two distinct populations of alligators have been detected. Clutches from south Lake Apopka had higher nested egg numbers, hatched egg numbers, neonatal survivor numbers, viability rate, hatch rate, and production rate than clutches from north Lake Apopka. According to Rice and Percival (1996), an increasing trend in the juvenile population and in clutch viability has occurred on Lake Apopka since 1989. They suggest that the system may be recovering or that the juvenile animals, though currently surviving, might not reproduce or survive in the future.

A National Institute of Environmental Health Sciences grant, based upon EPA Superfund resources, was awarded to a group of researchers centered at UF to study environmental effects of organic toxins in Lake Apopka and elsewhere. This research has indicated that contaminant-induced endocrine disruption occurs in wildlife, specifically fish and alligators, and several effective biomarkers have been identified to study these effects.

Crain et al. (1999) found that embryonic exposure to 2,4-D or atrazine did not cause significant alterations in gonadal structure or hepatic steroidogenic enzyme activity of hatchling American alligators. The results indicate that these herbicides alone are not responsible for the gonadal abnormalities previously reported for juvenile alligators from Lake Apopka. Since structural assessment (i.e., histological analysis) alone may be insufficient to detect subtle endocrine alterations, the function (i.e., steroidogenic enzyme activity) should also be analyzed. Also, they suggested examining the effects of other endocrine-disrupting contaminants that are present in Lake Apopka.
Further assessments and analyses of the fish community or of other wildlife populations in Lake Apopka during the implementation of the restoration program are accomplished under Project LA-6-803-S: Restoration Monitoring and Analysis.

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PROJECT (LA-1-108-D): SEISMIC REFLECTION PROFILING

PROGRAM: Diagnostic

<u>PRIORITY</u>: Completed

ISSUE CATEGORY: Poor water quality and flocculent sediments

<u>PROJECT OBJECTIVE</u>: To examine subsurface geology across Lake Apopka and assess the nature of the confining layers between the lake and the Floridan aquifer

<u>SCOPE OF WORK</u>: Construct approximately 70 km (44 miles) of continuous seismic reflection profiles. Use existing well data to interpret the profiles.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: This project provides data to quantify potential subsurface water exchange which would affect the water budget for Lake Apopka.

<u>SUMMARY AND STATUS</u>: A final report was submitted to SJRWMD in August 1988 by the University of South Florida. The report concludes that significant water exchange between Lake Apopka and the underlying Floridan aquifer is unlikely. No further work is planned for this project at present.

<u>Report</u>

Locker, S.D., G.R. Brooks, and L.J. Doyle. 1988. *Results of a seismic reflection investigation and hydrogeologic implications for Lake Apopka, Florida*. Special Publication SJ88-SP5. Palatka, Fla.: St. Johns River Water Management District.

PROJECT (LA-4-109-D): HYDRODYNAMIC SURVEY

PROGRAM: Diagnostic

PRIORITY: Completed

ISSUE CATEGORY: Lack of fish and wildlife habitat

<u>PROJECT OBJECTIVE</u>: To characterize dominant seasonal meteorological conditions at Lake Apopka; to model water current velocities and directions in Lake Apopka and describe how water movements vary with meteorological conditions; to estimate mixing dynamics of discharge waters from a fully implemented marsh flow-way; and to evaluate potential solutions to "short circuiting" of filtered water from the marsh discharge point to the intake point

<u>SCOPE OF WORK</u>: Evaluate the historical record of wind speed and direction in Lake Apopka and quantify the dominant seasonal characteristics. Model the velocities and directions of water currents in Lake Apopka to determine the potential for "short circuiting" of discharge water from the full-scale marsh flow-way and to select suitable areas for littoral zone restoration. Evaluate various flow-way designs and operational levels to quantify the degree of short-circuiting.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: This project provides information necessary to design the full-scale marsh and to determine areas of Lake Apopka suitable for littoral zone restoration. These projects provide water quality improvements and restoration of natural systems.

<u>SUMMARY</u>: The project was initiated in May 1992. SJRWMD provided summarized historical wind velocity data and current meteorological data. The contractor, UF, produced wind velocity information from SJRWMD data and compared this information to regional information to evaluate data quality. Meteorological and hydrodynamic measurements were made over a five-week period for initial calibration of the hydrodynamic model. A draft model was completed and installed on SJRWMD computers. A draft software documentation report was received with the model. The first phase of the work was extended in an effort to perform a dye study under wind conditions that had not occurred in the first part of the winter. The dye study, designed to assess the extent of mixing of marsh discharge water from the Apopka-Beauclair Canal with lake water, was completed. Results from fluorometer readings, aerial photographs, and analysis of dye samples all revealed consistent dispersion patterns of the discharge water: an initial southward movement and a subsequent eastward movement of the discharge plume.

Phase II was initiated in May 1993. Analysis of Phase I work indicated a potential for "short circuiting" of the marsh outflow to the inflow and the need for additional bathymetry work in the northwest area of the lake. The necessary contract amendments and other changes to specific tasks made as a result of Phase I findings were approved in the fourth quarter of 1993. The contract termination date was extended to December 1994. The final report in five volumes was accepted after revision and the contract was terminated.

Reports

- Sheng, P., and S. Schofield. 1994. Assessment of hydrodynamic conditions in Lake Apopka. Vol. II, Bathymetric surveys of the northwest section of Lake Apopka, and Vol. III, Lake Apopka 1992 field data report. Final reports prepared for St. Johns River Water Management District, Palatka, Fla. University of Florida, Gainesville.
- Sheng, P., X. Meng, and S. Schofield. 1994. Assessment of hydrodynamic conditions in Lake Apopka. Vol. I, Analysis of wind data from Lake Apopka and Orlando airport. Final report prepared for St. Johns River Water Management District, Palatka, Fla. University of Florida, Gainesville.
- Sheng, P., S. Schofield, X. Meng, and K. Ellins. 1994. Assessment of hydrodynamic conditions in Lake Apopka. Vol. IV, Dispersion of discharge water from the Apopka-Beauclair Canal into Lake Apopka, and Vol. V, A three-dimensional hydrodynamic numerical model of wind-driven circulation in Lake Apopka (LAHM3D): Theory, Model documentation, user's manual and model simulation. Final reports prepared for St. Johns River Water Management District, Palatka, Fla. University of Florida, Gainesville.

PROJECT (LA-4-201-F): WATER HYACINTH DEMONSTRATION

PROGRAM: Feasibility

PRIORITY: Completed

ISSUE CATEGORY: Poor water quality and flocculent sediments

<u>PROJECT OBJECTIVE</u>: To test the feasibility of using water hyacinths to remove nutrients from Lake Apopka

<u>SCOPE OF WORK</u>: Utilize a series of small enclosures in Lake Apopka to determine the rate of growth and growth-affecting factors for water hyacinths cultured in Lake Apopka. Stock enclosures with hyacinths at specific densities and monitor until maximum density is reached or for a 90-day period, whichever occurs first. At the end of the test period, harvest hyacinths and record fresh weight biomass. Obtain water quality samples adjacent to the enclosures and analyze for nutrients. Analyze plant tissue from these samples for N and P levels. Utilize larger enclosures in a small, hypereutrophic lake to test hyacinth growth rates and the depletion of N, P, and organic carbon in the water column and sediments. Establish a small hyacinth farming operation in the experimental lake and determine the cost/unit weight of water column and sediment nutrient removal from the results of the farming operation.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: This project will evaluate hyacinth culture as a potential method of reducing nutrient levels in Lake Apopka as directed by the 1985 Lake Apopka Restoration Act (Appendix A).

<u>SUMMARY</u>: The Round Lake water hyacinth demonstration farm was to operate for 24 months from May 1989. However, serious drought conditions resulted in water levels so low that farming operations had to be terminated in September 1990, after approximately 17 months. During operation of the hyacinth farm, water, sediment, pesticide, and plant samples were collected and analyzed. The water hyacinth enclosures in Lake Apopka were stocked with water hyacinths in April 1989. Water, sediment, pesticide, and plant samples were collected and analyzed as scheduled for a 24-month period.

The project was restructured in February 1991 to reflect the reductions in scope and budget necessitated by prematurely terminating Round Lake operations. The project was amended in September 1991 to add a two-month experiment. In this experiment, nutrient diffusion rates from the sediments and the nutrient and detritus sedimentation rates were measured in three isolated enclosures stocked with varying concentrations of water hyacinths and in two controls without hyacinths. One control enclosure was covered with five layers of shade cloth to simulate light conditions underneath a dense water hyacinth mat.

Three semi-annual progress reports and a draft final report were received describing the Round Lake hyacinth farm and studies in the Lake Apopka enclosures. The contract was amended to an October 31, 1993, termination date and a June 30, 1993, draft report deadline. After a review of the draft reports, the contract was extended to August 1994. A final agreement with the contractor terminated the work and further revision of the final products.

PROJECT (LA-4-202-F): PHOSPHORUS INACTIVATION/PRECIPITATION

PROGRAM: Feasibility Program

PRIORITY: Completed

ISSUE CATEGORY: Poor water quality and flocculent sediments

<u>PROJECT OBJECTIVE</u>: To evaluate the feasibility of using alum as a precipitant to trap nutrients in an insoluble form

<u>SCOPE OF WORK</u>: Perform a literature survey to determine the strengths and weaknesses of chemical treatment methods and likelihood of their successful application to Lake Apopka. Conduct laboratory tests of alum and other precipitants using Lake Apopka water and sediments. Determine the economic costs of treating different size areas of the lake.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: This project was formulated to evaluate alum as a potential chemical treatment method to reduce nutrient levels in Lake Apopka.

<u>SUMMARY AND STATUS</u>: Phase I was completed and a final report submitted to SJRWMD in September 1987. The report discourages alum use as the sole restoration technique in Lake Apopka.

<u>Report</u>

Baird, R.A., and J.M. Bateman. 1987. A preliminary assessment of phosphorus precipitationinactivation as a restoration technique in Lake Apopka. Special Publication SJ87-SP5. Palatka, Fla.: St. Johns River Water Management District.

PROJECT (LA-4-204-F): SEDIMENT RECYCLING

PROGRAM: Feasibility

<u>PRIORITY</u>: Completed

<u>ISSUE CATEGORY</u>: Poor water quality and flocculent sediments

<u>PROJECT OBJECTIVE</u>: To determine feasibility of sediment removal and reuse for the restoration of Lake Apopka

<u>SCOPE OF WORK</u>: Investigate the existing scientific literature for case studies of other systems restored by sediment removal. Use those case studies in conjunction with extant data for Lake Apopka to assess the effects of sediment removal on surface chemistry of the lake. Evaluate the market potential for recovered sediment and develop a cost/benefit analysis for using sediment removal to restore Lake Apopka.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: Flocculent organic sediments represent a significant problem in Lake Apopka. Internal nutrient loading and altered bottom conditions associated with these sediments may require their removal or consolidation in restoration of the lake. This project was formulated to determine the feasibility of dredging for sediment removal.

<u>SUMMARY</u>: A final report was prepared by KBN Engineering and Applied Sciences in November 1988 for Governing Board acceptance in January 1989. Dredging was found to have potential as a restoration technique, although questions regarding redistribution of flocculent sediments during the long dredging period and nutrient release from exposed peat layers would need to be addressed. Removal of four feet of sediments would require five 24-in. dredges operating continuously for six years at an estimated cost of \$868,800,000. This cost estimate includes shore facilities for dewatering dredged sediment and for treatment of runoff water, but does not include the cost of land for these facilities. Sediment reuse offers only limited ability to recover these costs; an absolute upper limit for savings is \$97,400,000. Dredging is presently not considered cost-effective for a full-scale restoration.

<u>Report</u>

Pollman, C.D., D.A. Graetz, F.V. Ramsey, K.R. Reddy, and T.J. Sullivan. 1988. Feasibility of sediment removal and reuse for the restoration of Lake Apopka. Special Publication SJ88-SP10. Palatka, Fla.: St. Johns River Water Management District.

PROJECT (LA-4-205-F): MICROBIAL DECOMPOSITION

PROGRAM: Feasibility

PRIORITY: Completed

<u>ISSUE CATEGORY</u>: Poor water quality and flocculent sediments

<u>PROJECT OBJECTIVE</u>: To evaluate ways of stimulating natural processes which reduce the bulk of lake sediments

<u>SCOPE OF WORK</u>: Compile and evaluate available information regarding *in situ* sediment decomposition, provide a preliminary assessment of the feasibility of the technology, and present recommendations on further research and assessment activities. Investigate the following four techniques for sediment decomposition: microbial inoculation, nitrate application, hydrogen peroxide addition, and ozonation.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: This project provides an evaluation of a potential methodology to reduce the bulk of flocculent organic sediments in Lake Apopka.

<u>SUMMARY AND STATUS</u>: Phase I was completed and a final report prepared in December 1988 for Governing Board acceptance in February 1989. The four specific techniques evaluated were microbial inoculation, nitrate addition to stimulate denitrification, hydrogen peroxide application, and ozonation. The theoretical framework for microbial inoculation is highly controversial and is not supported by experimental data. Chemical techniques (hydrogen peroxide, ozonation) are effective in oxidizing sediments but create severe water quality problems in overlying waters. Nitrate application has a demonstrated ability to oxidize organic sediments and reduce phosphorus recycling, but estimated costs for treatment of Lake Apopka are high (\$790 million). Therefore, this technique is not presently considered cost-effective.

<u>Report</u>

Gremillion, P.T., and C.E. Mericas. 1988. *A literature review and feasibility analysis assessing microbial decomposition as a technique for restoring Lake Apopka*. Special Publication SJ88-SP11. Palatka, Fla.: St. Johns River Water Management District.

PROJECT (LA-4-206-F): ICHTHYOFAUNAL RECONSTRUCTION (I, II)

PROGRAM: Feasibility

PRIORITY: Completed

<u>ISSUE CATEGORIES</u>: Lack of fish and wildlife habitat; poor water quality and flocculent sediments

<u>PROJECT OBJECTIVE</u>: Phase I—To compile a literature review and annotated bibliography on biomanipulation as a lake restoration technique. Phase II—To evaluate the potential for use of exotic fish species to aid in the restoration of Lake Apopka by consumption of excess production of algae

<u>SCOPE OF WORK</u>: Phase I—Prepare literature review with annotated bibliography on the subject of biomanipulation as a potential restoration technique, including information on the use of exotic species for algal biomass control. Identify candidate fish species for introduction. Design pilot studies to determine the applicability of the proposed introductions to manipulation of the algal biomass of Lake Apopka. Phase II—Use bighead carp (*Hypophthalmichthys nobilis*) in replicated pond studies to determine if this exotic fish is able to cause a reduction in nutrients and/or changes in the algal community. Use four ponds as experimental treatments and two ponds as controls. Use two stocking rates in the experimental ponds. Collect data on fish length, weight, and food habits. Sample water column to determine water quality and phytoplankton species composition. This project will test the use of bighead carp to consume algal biomass directly or to cause a positive change in the algal structure of the lake.

<u>SUMMARY</u>: Phase I—The literature review report was prepared in November 1988 for Governing Board acceptance in January 1989. No clear judgment could be made concerning the past success of this methodology or the expected effects of fish biomanipulation in Lake Apopka.

Phase II—This pilot project used experimental ponds adjacent to Lake Apopka which were either not stocked with fish or stocked with bighead carp to low density or high density to measure effects of fish on water quality and phytoplankton density and community structure. Ponds were stocked with fish in the spring of 1990, and the experiment proceeded with data collection until September 1990. A final report on this work was completed in January 1992. Results show that there were no significant differences in water quality parameters between control ponds (not stocked) and ponds stocked with fish. Algal density or community composition did not change significantly in the ponds stocked with fish; however, there was some measurable change in the blue-green/green algal ratio in those ponds stocked with fish. The fish biomass level projected as necessary to cause significant changes in the algal community and in water quality was not achieved in the experimental ponds due to slow growth and high mortality of the stocked fish.

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- Shireman, J.V., and K.K. Opuszynski. 1992. *Ichthyofaunal reconstruction for the management of phytoplankton*. Special Publication SJ92-SP4. Palatka, Fla.: St. Johns River Water Management District.

PROJECT (LA-4-207-F): TROPHIC STRUCTURE MANIPULATION (I, II, III)

PROGRAM: Feasibility

PRIORITY: Completed

<u>ISSUE CATEGORIES</u>: Lack of fish and wildlife habitat; poor water quality and flocculent sediments

<u>PROJECT OBJECTIVE</u>: Phase I—To provide baseline data on the role of rough fish in plankton and nutrient dynamics in enclosures. Phase II—To determine whether harvest of rough fish (primarily gizzard shad) can improve water quality through effects on the food web or through export of in-lake nutrients. Phase III—To test standard harvesting gear for large-scale rough-fish removal in Lake Apopka and to determine the feasibility of using harvested rough fish (primarily gizzard shad) as marketable products to offset the cost of fish removal

<u>SCOPE OF WORK</u>: Phase I—Perform short-term enclosure studies in Lake Apopka. Place rough fish in experimental enclosures and determine whether nutrients and plankton dynamics over short time periods are different from control enclosures with no fish.

Phase II—Select a small hypereutrophic lake representative of Lake Apopka as the site for this pilot study. Collect baseline data for up to one year from this lake on plankton community structure, biomass, and production; nutrient dynamics and water quality; sediment dynamics; and fish community dynamics. During the second segment of the study, remove rough fish (gizzard shad) from the lake by haul seine. Monitor the lake system during the third segment of the project to detect changes in lake trophic structure or nutrient recycling following rough-fish removal efforts. Phase III—Test standard harvesting gear in Lake Apopka: haul seine, gill net, and pound net. Record catches to the species level and collect biological statistics. Investigate potential markets for harvested rough fish in a contracted marketing study. Attempt to develop marketable products from the harvested fish.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: Rough fish constitute the majority of fish biomass in hypereutrophic lakes such as Lake Apopka. Experimental evidence suggests that these fish may be directly linked to blue-green algal dominance and rapid nutrient recycling. This project will assess the effects of removal of gizzard shad on lake trophic structure and nutrient recycling.

<u>SUMMARY</u>: Phase I—The principal investigator was Dr. Tom Crisman, UF. A final report was delivered to SJRWMD in April 1988. The experiment provided evidence that the effects of shad and tilapia on plankton community metabolism differed greatly. Compared to tilapia, the presence of shad caused wider fluctuations in daily dissolved oxygen concentrations, which may stress or kill desirable game fish. There are also indications that the grazing activities of shad promote mineralization and accelerate phosphorus recycling.

Phase II—This pilot experiment contrasted water quality, zooplankton, phytoplankton, and fish in an experimental lake subject to rough-fish removal (Lake Denham) with conditions in control lakes Beauclair and Apopka. Sampling to document initial conditions in Lakes Denham, Beauclair, and Apopka was initiated in 1989. Rough fish were removed from Lake Denham by haul seine from January to April 1990, in May 1991, and again in June 1992. The adult gizzard shad biomass was reduced by about 85% by the haul-seine efforts.

Monitoring of post-manipulation conditions is ongoing (see Project LA-6-803-S, Restoration Monitoring and Analysis). Data indicate some of the classical "trophic cascade" effects in Lake Denham following fish removal. In experimental gill net sets taken quarterly, medium-to-large gizzard shad make up the majority of the catch. Young-of-the-year shad are still in low numbers. Water quality parameters, phytoplankton abundance and composition, and zooplankton abundance and composition showed large changes in the experimental lake. Some changes were observed in the control lakes as well, which emphasizes the need for rigorous statistical tests of the final data set. Following removal of a fish barrier at the downstream end of the lake, gizzard shad re-entered Lake Denham. A decline in water quality followed the re-establishment of shad in the lake; however, lake conditions remain better than for the period prior to fish removal. Phase III—Trial haul-seining operations were conducted in Lake Apopka in April and May 1990. The large size, shallow water depth, and extensive flocculent sediments of the lake were detrimental to the seining operation, and this technique was not an efficient or cost-effective method for fish removal in Lake Apopka. SJRWMD was unable to contract to test pound nets; it appears that this fishing technique is no longer used in Florida. Modified purse gill nets and trawls were not successful for harvesting gizzard shad in Lake Apopka; however, standard gill nets were found to be an efficient and cost-effective harvest method for large-scale rough-fish removal (see Project LA-3-302-M, Rough Fish Harvesting).

A product development and marketing survey project for gizzard shad was contracted with FDEP in January 1990, and a final report on this work was accepted in February 1991. Current market demand for gizzard shad from Lake Apopka is low, and attempts to develop new markets for products from the fish have not been successful. Because of the weak market position, the harvesting of gizzard shad from the lake is not yet selfsustaining.

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PROJECT (LA-4-208-F): DRAWDOWN AND LAKE LEVEL FLUCTUATION

PROGRAM: Feasibility

PRIORITY: 1

<u>ISSUE CATEGORIES</u>: Low recreational and aesthetic values; lack of fish and wildlife habitat; poor water quality and flocculent sediments

<u>PROJECT OBJECTIVE</u>: To evaluate the feasibility of using drawdown or greater fluctuation in water levels to consolidate littoral sediments and stimulate aquatic vegetation to improve fish and wildlife habitat

<u>SCOPE OF WORK</u>: Phase I—Evaluate the experience base and the scientific literature to determine documented ecological effects of lake drawdowns or enhanced fluctuation.

Phase II—Examine the effects of partial drawdown of Newnans Lake with regard to (1) flushing of organic matter, nitrogen, and phosphorus in discharge from the lake, (2) effects of exposing littoral sediment to air, and (3) net change of organics, nitrogen, and phosphorus in profundal and littoral sediments.

Phase III—Produce a basin hydrologic model that permits long-term simulation of lake stages under various water regulation scenarios and climate patterns. Collect data on wetland plant communities along elevational transects. Determine elevations of manmade structures. Examine existing and proposed water regulation schedules for environmental effects and socioeconomic consequences. Recommend new regulation schedules for rule changes.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: Stabilized water levels have been cited as a factor in the degradation of Lake Apopka. This project will determine the potential for improvement in environmental conditions through modification of lake regulation schedules.

<u>SUMMARY AND STATUS</u>: Phase I—Dames and Moore was contracted in October 1989 to provide a comprehensive study of the ecological effects of drawdown, and their final report was completed in December 1990. Generally, drawdowns improve shoreline vegetation and the associated macroinvertebrate populations, increase population sizes of some species of fish, and may consolidate lake sediments in exposed areas. However, these benefits last only 2–7 years; drawdowns must be repeated on a recurring basis. Drawdowns do not improve water quality, and they can lead to significant sediment and nutrient loading to downstream waters which receive the discharge. In Lake Apopka, a drawdown of 1 m (3 ft) would expose only 8.6% (1,070 ha or 2,640 ac) of lake bottom. However, due to the wicking action of the sediments, only about 240 ha (600 ac) (1.9%) would probably be consolidated. A 1-m drawdown on Lake Apopka would require discharging about 70% of the lake volume to the downstream chain of lakes.

This discharge water would have high concentrations of sediments and nutrients and would therefore be detrimental to downstream lakes. Drawdown as a restoration technique for Lake Apopka also was evaluated by Fulton (1998).

Phase II—A contractual study with UF was initiated in March 1989 to measure the water quality and sediment effects of a three-month drawdown of hypereutrophic Newnans Lake. The final report in two parts was approved in September 1992 and is pertinent to lakes where drawdowns are considered for the removal of organic matter and nutrients and for sediment consolidation and oxidation. Net oxidation of exposed lake bottom sediments was not demonstrated to result from drawdown. Consolidation of exposed lake bottom sediments was an observed benefit, however. This study demonstrated the importance of sediment redistribution during drawdowns and that flocculent sediments were eroded from the littoral zone toward deeper areas of the lake. Moderate removal of organic matter and nutrients from the lake by flushing during drawdown also was documented. The timing of drawdowns to coincide with periods of high winds to enhance resuspension and subsequent removal of flocculent lake sediments was an important recommendation made in this study.

Phase III—In-house work to formulate and evaluate alternative enhanced lake level fluctuation schedules continues. The long-term goal of this project is to develop a schedule that allows lake level fluctuations that more closely follow seasonal and longterm rainfall patterns without impacting flood control efforts. Vegetative analyses along surveyed transects in Lake Apopka and the other upper Ocklawaha River lakes to determine elevation gradients of existing wetlands have been completed. Engineering components-including surveys of elevations of docks, canals, and bulkheads to permit a full economic-impact analysis of proposed schedules and work to refine the basin hydrology model—are ongoing. Preliminary recommendations for enhanced lake-level fluctuation were prepared and discussed in several meetings of the Ocklawaha River Basin Technical Advisory Group and in public workshops. More recently, original proposals made several years ago have been re-evaluated to better understand the potential problems that would be caused by lower low-water levels and higher highwater levels in Lake Apopka and the Harris Chain. Efforts to change the way lake levels are managed reached a turning point in 2001 with the determination that new schedules should not increase the frequency of high water levels.

Consideration of regulation schedules will continue, in part, through a new project conducted by the U.S. Army Corps of Engineers and SJRWMD. The reconnaissance phase of the Upper Ocklawaha River Basin Restudy project began in 2002. If this reconnaissance study leads to the next (feasibility) phase, one of the goals will be to find and evaluate operational modifications that could enhance environmental restoration benefits in the basin. A major component may be further consideration of a new regulation schedule for Lake Apopka that would follow rainfall more closely and restore higher periodic water levels in Lake Apopka and its associated wetlands.

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Drawdown and Lake Level Fluctuation

Time Schedule Activity	FY 02-03	FY 03-04	FY 04-05	FY 05-06
U.S. Army Corps of Engineers restudy	x x x x	x x x x	x x x x	x x x x

PROJECT (LA-4-209-F): SOCIOECONOMIC ASSESSMENT AND METHODOLOGY

PROGRAM: Feasibility

<u>PRIORITY</u>: Completed

ISSUE CATEGORY: Lack of fish and wildlife habitat

<u>PROJECT OBJECTIVE</u>: To develop methodology to assess the economic value of recreational and commercial uses of Lake Apopka, predict the economic benefit of lake restoration, and assess the impact of a total muck farm buyout on the local economy

<u>SCOPE OF WORK</u>: Develop an evaluation procedure for performing a socioeconomic assessment of the Lake Apopka Basin. Incorporate the procedure into computer

software to be used by SJRWMD. Perform a socioeconomic assessment of the basin, including the potential economic losses and benefits of the purchase of 5,670 ha (14,000 ac) of muck farms in Lake and Orange counties, plus possible mitigation measures to offset employment losses.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: The degradation of Lake Apopka has resulted in greatly reduced recreational and aesthetic values of the water body. This project will provide factual information on the present values of the lake and the potential values of the lake in a restored condition.

<u>STATUS</u>: A report was submitted in July 1989 by UF which developed methodology and predicted the economic benefit of lake restoration (Heaney et al. 1989). The estimated net revenue from the muck farms was compared to losses from decreased recreational values, lowered environmental quality to the general public, and decline in property values to the riparian owners.

The 1996 Legislature determined that it was in the public interest to pursue the purchase and marsh restoration of all the muck farms in the Lake Apopka Basin. One consequence of such an action would be the loss of the farm business income and jobs. An economic impact analysis of the cessation of muck farming in the Lake Apopka Basin was performed by Apogee Research. A final report was provided to SJRWMD in December 1996. The report identified \$110 million of annual economic losses incurred through such an action, roughly divided into direct sales losses and loss of income. A preliminary partial analysis of restoration benefits was estimated at \$30 million annually. Additional research would be necessary to identify and quantify all benefits resulting from a farm buyout, such as increased land values and increased recreation in downstream lakes.

Reports

- Apogee Research, Inc. 1996. Lake Apopka economic analysis. Final report for Contract 96G307. Submitted to St. Johns River Water Management District, Palatka, Fla. Bethesda, Md.
- Heaney, J.P., T.D. Feather, and M. Shafer. 1989. *Development of a socio-economic assessment methodology with applications to the Lake Apopka Basin*. Special Publication SJ89-SP5. Palatka, Fla.: St. Johns River Water Management District.

PROJECT (LA-3-301-M): MARSH FLOW-WAY RESTORATION

PROGRAM: Restoration

PRIORITY: 1

<u>ISSUE CATEGORIES</u>: Lack of fish and wildlife habitat; poor water quality and flocculent sediments; degradation of downstream lakes; low recreational and aesthetic values

<u>PROJECT OBJECTIVE</u>: To restore muck farm land to wetland in order to filter nutrientrich water from Lake Apopka and re-establish fish and wildlife habitat. Nutrients will be removed from Lake Apopka as water is circulated through the marsh, and downstream lakes will receive a higher quality discharge.

<u>SCOPE OF WORK</u>: Demonstration project—Design and construct pump stations, spillways, levees, culverts, weir, ponds, and inlet and outlet structures to build a demonstration project on 750 ha (1,850 ac) of muck farm land. Restore approximately 365 ha (900 ac) to wetland, of which 225 ha (550 ac) is the monitored flow-way. Plant three 2-ha (5-ac) test plots with diverse native wetland plant species to determine success of different species and planting techniques. Flow water from Lake Apopka through the project to determine the nutrient removal efficiency of the wetland at various water depths and flow rates. Monitor hydrology, hydraulics, soil and water chemistry, vegetative development, and wildlife.

Full Marsh Phase I—Design and construct the full 1,380-ha (3,400-ac) marsh flow-way in three phases, based on monitoring information from the demonstration project. Develop and test techniques to minimize initial flushing of nutrients from flooded muck soils. Plan and implement monitoring programs for hydrology, hydraulics, soil and water nutrient chemistry, vegetation, pesticides, and wildlife.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: Completion of the project will result in water quality improvements occurring more rapidly in response to the nutrient load reduction efforts in the lake, reduced nutrient levels in the lake water, improved water quality of downstream discharges, entrapment of flocculent sediments, burial and bioattenuation of farmed soils with residual pesticides, and establishment of fish and wildlife habitat.

<u>STATUS</u>: Demonstration project—Design criteria were developed for the demonstration phase of the marsh flow-way restoration. The Center for Wetlands at UF and Post Buckley Schuh and Jernigan reviewed the design, and the design was further reviewed by FWC and FDEP. Negotiations with FDEP regarding a permit for the project started in April 1989 and were concluded in November. Two major construction contracts included Couch Pumps for repair and modification of existing pumps and for installation of pump controls and fuel system, and Phillips & Jordan for construction. Construction started in December 1989 and was substantially completed by December 1990.

A "shakedown" period of operation, November 1990 through mid-February 1992, involved sheetflow establishment through the southern wetland cell. In mid-February, the marsh was drawn down to permit experimental planting of 6 ha (15 ac) with wetland vegetation. Experimental planting and final scheduled construction, including the automatic pump control system, the fuel system, and walkways and platforms for monitoring equipment, were completed by August 1991. Both the southern and northern cells were flooded in September 1991. Starting in May 1992, pumps were used at the inlet to replace low-gravity flows as necessary.

Because of different past land uses, the southern and northern wetland cells of the demonstration project showed different nutrient retention behaviors. The south cell had been farmed less intensively and then had been left fallow several years, resulting in appreciable wetland vegetation at the time of flooding. This cell provides our best model for the future flow-way system.

Retention of suspended solids (algae, resuspended sediments) was high (>90%) in the south cell. Therefore, the water reaching the north cell was already highly treated, leaving little potential for additional improvement in the north cell. Between 30% and 50% of total nitrogen was removed in the south cell, with little potential for additional improvement. Phosphorus leached from soils in the south cell for approximately six months after start of operation. After that period, removal efficiency for TP varied between 30% and 50%. A similar but longer period of leaching from soils in the north cell occurred. The high removal of suspended matter in the demonstration flow-way resulted in significantly increased transparency of water discharged downstream.

In late 1992, hydrologic experimentation on the south cell of the marsh included a collector ditch reaching out from the south cell weir basin in an attempt to improve flow through the system. Filtration efficiency in the cell declined after that time, which was caused by unanticipated hydraulic short circuiting. Nutrient and solids retention in the south cell did not return to pre-collector ditch levels, and the ditch was plugged in the third quarter of 1993.

The south cell of the demonstration marsh was drawn down between March and July 1994 to consolidate sediments that had accumulated since November 1990 and to experiment with vegetation management and alteration of flow paths. The consolidation was successful; vegetation management was only partially successful. However, short-circuiting was not disrupted by the drawdown, which was judged to be of too short a duration to allow plant growth sufficient to alter flows. Other hydraulic

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modifications were made to reduce hydraulic short-circuiting, and by the end of the year, the system was again in operation. The system operated at low to moderate flows until flow was stopped in 1997 to prepare for construction of the first phase of the full-scale flow-way.

Nutrient removal performance of the Marsh Flow-Way Demonstration Project was analyzed in a series of publications (Coveney 1995; Coveney, Lowe, and Battoe 2001; Coveney, Stites et al. 2001).

The Nutrient Storage and Movement Project, conducted by UF, was designed to measure the major nutrient constituents in the marsh soil and vegetation; to determine the rate of transformation of nutrients to and from the soil, the water column, and vegetation; and to estimate the nutrient retention capacity of the system as affected by drawdown, drying, re-flooding, and burning. Drawdown successfully compacted the solids that had settled in the marsh, but it also allowed soil oxidation sufficient to release significant amounts of soluble phosphorus.

To address the issue of soluble phosphorus release from soils and to follow up laboratory batch incubation experiments, a six-month field plot experiment testing several soil amendments' ability to reduce the phosphorus concentration in the water column was completed in December 1996. This research was a cooperative effort involving SJRWMD and UF. Results indicated that calcium hydroxide and an alum residual (aluminum hydroxide floc: a by-product from the use of alum $[Al_2(SO_4)_3 \text{ or}]$ aluminum sulfate] as a clarifying agent for drinking water) were both effective in trapping phosphorus soil flux when applied on the soil surface. Two larger field-size experiments, one within the marsh flow-way property, were conducted in 1998. Alum residual was extremely effective in reducing phosphorus soil flux compared to calcium hydroxide and gypsum (calcium sulfate). The application of alum residual will be one management tool for the full-scale marsh flow-way. During the summer of 2000, approximately 650 ac in Phase I of the flow-way were treated with alum residual obtained from the city of Melbourne water treatment plant.

Contracted field work for vegetation monitoring by UF ended in August 1994. The Governing Board accepted the final report in January 1998. Over the course of the study, a total of 104 plant species were identified in the naturally re-vegetating portions of the flow-way project. In addition, this study monitored vegetation growth in three 2-ha (5-ac) sites that had been planted with 11 species of wetland plants in 1991.

Above- and belowground live biomass from the August 1991 samples ranged from 268 to 928 grams per square meter (dry weight). By March 1994, values ranged form 485 to 1,414 grams per square meter (dry weight). The study documented the development of

extensive floating mats in the south marsh. The percentage of sample plots with floating mats went from 0% in 1990 to 41% in 1993. The data on plant biomass and on nutrient (P and N) content of plants from this study were used by SJRWMD in analyses of the nutrient-removal function of the flow-way project.

In December 1998, GEONEX completed contractual services to interpret vegetation communities in the Demonstration Marsh Flow-Way from aerial photography for the years 1990–97. The dominant species for the communities and the acreage changes for succeeding years were determined. Between 1990 and 1997, the marsh became predominantly mixed herbaceous, dominated by cattail (*Typha* spp.) and *Ludwigia* spp.

Evaluation of the experimental planting sites revealed that spikerush, pickerel weed, arrowhead, giant bulrush, and giant flag tended to establish quickly and resist invasion by cattail. A mixed-species planting strategy may provide the best opportunity to generate a diverse, invasion-resistant plant community.

The high removal of suspended matter in the demonstration flow-way resulted in significantly increased transparency of water discharged downstream. Monitoring data on hydrology, hydraulics, soil and water chemistry, vegetative development, wildlife, and nutrient uptake at various water depths and flow rates were essential to the design process for Phase I of the full-scale project.

LESSONS LEARNED FROM THE DEMONSTRATION PROJECT

- Hydraulic loading values in the range 35–45 m yr⁻¹ (10–12 cm d⁻¹) gave maximum flows through the densely vegetated first cell and avoided excessively high water elevations at the inlet end. The resistance to flow observed in the demonstration project was one reason that up to 13 cells in parallel will be constructed in the full-scale project rather than a single large treatment wetland. Inlet pumps will be used to maintain flows during seasonal periods of low lake stage.
- The wetland filter was capable of removing suspended solids and TP from Lake Apopka water at or above target efficiencies of 85% and 30%, respectively (Coveney, Lowe, and Battoe 2001; Coveney, Stites et al. 2001). These results confirmed earlier projections of P removal efficiency (Lowe et al. 1989, 1992). Nutrient removal occurred at the expense of particulate N and P fractions in most periods; dissolved fractions usually were either unaffected or augmented in the wetland. Minimal channelization and maximal distribution of residence times were required to meet or exceed target removal efficiencies for suspended solids and phosphorus.

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- Cumulative leaching of soluble phosphorus after the initial flooding was about 3 g P m⁻². Methods proposed to deal with the leaching of soluble phosphorus in the full-scale project include soil amendments to bind P, recycling of floodwaters through adjacent cells, and minimizing the frequency and duration of drawdowns.
- De-watering through drawdown was a necessary and effective technique to consolidate new sediment in the wetland.

Full Marsh Phase I—In 1997, the design for Phase I of the marsh flow-way was completed. The construction of Phase I was completed for approximately \$4.32 million. Funds for the construction of the system were partially provided by the following:

- SWIM Fund (\$1.5 million provided in 1996 legislation)
- Lake County (\$750,000)
- Lake County Water Authority (\$250,000)
- EPA Clean Water Act Fund (\$1 million)

The pump station will discharge water from the four wetland treatment cells back into Lake Apopka and down the Apopka-Beauclair Canal.

In 2002, consultations were initiated with EPA and USFWS to begin operation of the flow-way. A plan of operation (EPA 2002), which includes monitoring and management of potential soil pesticide exposure, has been submitted for regulatory consultation. Operation will begin after completion of those consultations and after Lake Apopka water elevations increase above the record lows of 2001–2002, which have been insufficient to allow operation.

The system will receive a hydraulic loading rate of about 10 cm day⁻¹. At this rate, Phase I will remove between 8 and 10 metric tons of phosphorus per year, depending on lake water quality and actual flow rates. When all phases are operational, the marsh flow-way will treat approximately two lake volumes per year and remove, for long-term average water quality conditions, about 30 metric tons of phosphorus annually. Furthermore, all water discharged from Lake Apopka downstream to the Harris Chain will pass through the marsh flow-way.

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Time Schedule Activity	FY 02–03	FY 03-04	FY 04-05	FY 05-06
Begin operation of Phase I	X			
Inlet pump design and construction		X X		
Pesticide evaluation	XXXX			
Phase II design		XXXX		
Phase II construction				XXXX

Marsh Flow-Way Restoration

PROJECT (LA-3-302-M): ROUGH FISH HARVESTING

PROGRAM: Restoration

PRIORITY: 1

<u>ISSUE CATEGORIES</u>: Lack of fish and wildlife habitat; poor water quality and flocculent sediments

<u>PROJECT OBJECTIVE</u>: To manipulate the food-web structure and/or export nutrients from Lake Apopka by harvesting rough fish (primarily gizzard shad)

<u>SCOPE OF WORK</u>: Remove rough fish (primarily gizzard shad) in Lake Apopka under permit from FWC. Catches will be monitored for tonnage and biological data.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: This project may provide a low-cost or no-cost effective method of nutrient removal from Lake Apopka. Other beneficial effects of biomanipulation through rough-fish removal could improve surface water quality.

<u>STATUS</u>: Data from Phase II of the Trophic Structure Manipulation Project indicate positive food-web changes and improved water quality resulting from rough-fish removal in Lake Denham. Phase III of the Trophic Structure Manipulation Project tested various harvesting techniques for rough-fish removal in Lake Apopka and found that gill nets could provide an efficient and cost-effective method to accomplish large-scale rough-fish removal for nutrient depletion and food-web alterations in the lake.

From 1993 through 2002, commercial fishermen harvested a total of 3,729,945 kg (8.2 million pounds) of gizzard shad from Lake Apopka. Harvesting removed and exported 24.62 metric tons (54,253 pounds) of phosphorus and 73.75 metric tons (162,539 pounds) of nitrogen from the lake. Low lake levels prevented large-scale harvest of gizzard shad in 2001 and the spring of 2002. To improve lake access for commercial fishing, a new dock facility was constructed in 2002 on McDonald Canal on the former A. Duda and Sons Jem Farm property. Both the large-scale winter commercial harvest and the small-scale year-round harvest will continue in Lake Apopka.

Successful management of the fish removal process requires accurate estimates of the adult gizzard shad stock for the lake. A stock assessment completed in 1995 indicated the most probable population of harvestable gizzard shad prior to the 1995 harvest to be 3,877,582 fish or about 127 fish/acre. Stock estimates for 1996 ranged from 726,288 to 2,073,744 fish. The estimated harvest for 1997 was 1,186,364 shad or about 39 fish/acre. Even allowing for production and growth of young shad, commercial fishermen had apparently harvested a significant portion of the standing stock of adult gizzard shad in the lake. Downward shifts in length/frequency and declines in catch-per-unit-of-effort, lengths and weights were recorded in 1997 through 1999 (Crumpton 2000). Trends from the year 2000 experimental gill net samples indicated that the gizzard shad population may be recovering. This recovery may be attributed to reduction in fishing pressure by commercial fishermen due to low lake levels.

FWC (Benton et al. 1995) refined a procedure to assign ages to gizzard shad through the use of a bony structure (sagittal otolith). An evaluation of 290 fish collected in the spring of 1994 showed that commercial gill nets (>4.0-in. mesh) caught fish of two years of age or more. Females grew faster than males and survived longer; few males survived beyond two years. Estimates of mortality for ages 0 to 3 from blocknet samples gave a range of total annual mortality of 57–85%.

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Rough Fish Harvesting

Time Schedule Activity	FY 02-03	FY 03-04	FY 04-05	FY 05-06
Rough fish harvest Fisheries monitoring	X X X X X	X X X	X X X	X X X
Gizzard shad stock estimate		X X		

PROJECT (LA-3-303-M): WETLAND RESTORATION

PROGRAM: Restoration

PRIORITY: 1

<u>ISSUE CATEGORIES</u>: Lack of fish and wildlife habitat; poor water quality and flocculent sediments; low recreational and aesthetic values

<u>PROJECT OBJECTIVE</u>: To restore muck farm land east of the Apopka-Beauclair Canal and examine restoration for effects upon water quality, vegetation, and wildlife. Various methods for wetland restoration will be examined. As restoration progresses, effects upon wildlife will be monitored.

<u>SCOPE OF WORK</u>: Examine various methods for wetland restoration. Monitor effects upon wildlife as restoration progresses.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: This project will result in reduced nutrient loading to Lake Apopka and reduced downstream discharges and provide additional habitat for fish and wildlife.

<u>SUMMARY AND STATUS</u>: The 1996 Legislature determined that it was in the public interest to pursue a total farm buyout, and the state appropriated \$20 million toward that goal (Appendix A). SJRWMD signed an agreement with the USDA WRP to receive up to \$26 million in matching land acquisition funds for the NSRA. In 1997, the Florida Legislature appropriated an additional \$45 million for purchasing additional agricultural lands within the basin. The land acquisition phase of the restoration effort has been completed, with the exception of a few non-crop growing properties. A total of 5,554 ha (13,713 ac) are now under public ownership, and further application of pesticides and fertilizers has been halted.

SJRWMD will develop restoration plans with the concurrence of NRCS, USFWS, and FDEP and in coordination with FWC, FOLA, and other interested parties. All of the SJRWMD-acquired muck lands on the North Shore will eventually be restored to wetlands and other aquatic habitat.

Restoration work will include treatment of soils with alum residual to bind the initial flux of phosphorus from the soils; plugging of abandoned irrigation wells; modifications to the extensive network of drainage, pump, and levee systems; planting; and monitoring the progress of habitat development. Other capital improvement projects include fence construction, bridge replacement and repair, and other access improvement projects that will protect SJRWMD property from damage or theft or provide safe access for public uses. Partial funding for initial restoration work is being provided by NRCS.

Initial restoration activities are already in progress on the 3,645 ha (9,000 ac) enrolled in the WRP (Duda and ZDWCD Unit 2). The application of a soil amendment on the former Duda farm has been completed. This amendment, a by-product of potable water treatment containing reacted alum and activated carbon, will absorb much of the excess phosphorus left in the soil by the farming activity. Repairs to levees necessary to manage water for the initial restoration period are completed. In addition, most of the remaining buildings and debris have been cleared from the NSRA.

An additional methodology implemented to reduce phosphorus loadings to Lake Apopka is to treat pumped discharges from ZDWCD Unit I and Unit II. When SJRWMD acquired the ZDWCD properties, ZDWCD had already implemented a liquid alum treatment system in Unit II, but discharges from Unit I were untreated. In September 2001, it became necessary to discharge water from Unit I, so SJRWMD implemented a second liquid alum treatment system. To improve water treatment and water control efficiency, SJRWMD has contracted with a consultant to redesign both alum injection systems. The redesign is expected to be completed and implemented by mid-2003.

As part of the acquisition process, all properties received an ESA in accordance with ASTM Standard E1527. An ESA usually consists of four phases. The first phase is an indepth review of the documents available concerning how the land was used, what the land was used for, and what potential contamination issues might be present. The second phase implements sampling based upon the recommendations made in the first phase. The third phase involves the delineation and development of a remediation plan for any contamination found. The fourth phase is remediation, additional sampling to confirm the adequacy of the remediation, and a final report. At the purchased properties, on-site remediation included removal and disposal of over 18,600 tons of soil.

To evaluate the possibility that a significant contamination source might have been missed during the ESA process, SJRWMD contracted an independent audit of the ESA investigations. The audit found that the ESAs were conducted within the ASTM guidelines and that there were no substantial deficiencies. The audit included some recommendations for additional work, which have been addressed.

SJRWMD also contracted for an environmental risk assessment (ATRA 1997) and a second followup report (ATRA 1998) to examine the risk to wildlife posed by restoration of the former agricultural areas. The results of the environmental risk assessment indicated that soil pesticide residues did not present an acute toxicity risk to wetland fish and wildlife (ATRA 1997, 1998). However, there was concern for potential long-term, sub-lethal effects of DDT residuals on growth or reproduction of top-level,

predatory birds. The reports recommended, and SJRWMD concurred, that long-term monitoring of the site was necessary when the restoration flooding commenced.

By August 1998, SJRWMD, in partnership with WRP, had purchased most of the farms east of the Apopka-Beauclair Canal: Duda Farm, Zellwin Sand Farm, and ZDWCD Units 1 and 2. The farmers in Unit 2 were asked to leave their fields shallowly flooded following their final crop harvest in the summer of 1998. Shallow flooding for 4–6 weeks was standard farming practice at the end of each year's growing season, in order to minimize soil subsidence and erosion and to control nematodes. SJRWMD made this request in order to minimize discharge of P-rich water to the lake and to inhibit growth of terrestrial vegetation. Rainfall during the fall of 1998 caused these fields to remain flooded. The fields were to be drained during the winter and treated with a soil amendment (alum residual) to prevent P release when restoration flooding commenced.

Over the past 50 years, migratory birds have used Florida's flooded farm fields during July, August, and September (Stevenson 1972; Sykes and Hunter 1978; Kale et al. 1990). The late-summer conditions of 1998 were similar to previous years. However, as water levels in the farm fields began to rise with seepage and rainfall, and as more birds and more species of birds arrived, the situation became unique and unprecedented. By the annual Audubon Christmas Bird Count (CBC), there was a large diversity of waterfowl, shorebirds, marsh birds, and thicket species. The total count was 174 species, likely a record for inland sites in North America (1998–99 CBC issue of American Birds; also, http://birdsource.tc.cornell.edu/cbcdata/). Although small flocks of 20–30 American white pelicans were seen on the lake during winter months in previous years, the 1998–99 CBC recorded 400 American white pelicans. The total Christmas count of American white pelicans in Florida that year totaled 6,298, with all inland sites accounting for 1,173 birds.

In December 1998, the population of American white pelicans on the NSRA rose to over 3,500 in one day's count. Also that month, the first mortalities were recorded (several dead pelicans were initially observed in November, but these deaths were not recorded). Over the next four months, 441 American white pelicans, 43 wood storks, 34 great egrets, 58 great blue herons, and smaller numbers of 20 other bird species died onsite. In February 1999, USFWS attributed the deaths to organochlorine pesticide (OCP) poisoning. SJRWMD had begun draining the site in November 1998. Pumping was accelerated in January 1999. By mid-February 1999, the entire NSRA farm field area had been drained. Since then, the fields have been kept dry and have become vegetated with prairie and upland shrub communities.

In March 1999, a team of experts from 13 federal, state, county, and private organizations convened as the technical advisory group to the investigation. The team

included representatives from SJRWMD, USFWS, NRCS, FDEP, EPA, FDACS, the Florida Department of Health, FWC, the Florida Audubon Society, UF, FOLA, Lake County, the Lake County Water Authority, Orange County, and ATRA, Inc., a toxicological consultant to SJRWMD.

SJRWMD and NRCS are providing the leadership and the majority of the funding for the pesticide study. The other team members are providing staff time and specific resources and review of work products.

A massive \$1.5 million investigation was undertaken in an effort to determine the cause of the bird mortality and to reassess the potential risks of OCPs to wildlife. During 1999, a total of 920 soil samples were taken from 709 locations and analyzed at a laboratory chosen for its extensive experience with OCPs, especially toxaphene. In addition to the soil samples, 158 tissues from 34 birds and 36 whole fish (six species) were analyzed for pesticide levels by the same laboratory. All data on soils, sediments, and tissues (bird and fish) were provided to Exponent, a consulting firm based in Bellevue, Washington. Their analysis of the data and the draft report on the mortality event were completed for review in September 2000. A further draft, which incorporated comments from academic and agency reviewers, as well as new data from USFWS, was received in April 2003.

The investigation has shown that soil pesticide levels are not uniform in the various units of the NSRA. Because of its lower levels of OCPs, the Duda property, especially the eastern portion, presents the lowest risk to wildlife and has been proposed for interim flooding. A Biological Assessment and interim restoration plan for a portion of the Duda property was submitted by NRCS to USFWS in June 2001 (USDA 2001). A Biological Opinion with an incidental take statement was received from USFWS in April 2002 (USFWS 2002). The 700-ac site known as Duda sub-east has now been reflooded, and the site will be intensively monitored for at least one year. After a year, the collected data will be reviewed by SJRWMD, NRCS, and USFWS, and a final level of monitoring will be proposed. This information will also assist in the development of future management strategies for other portions of the NSRA.

One of the recommendations of Exponent and the academic and agency reviewers was for additional studies to more precisely quantify bioaccumulation of OCPs in wildlife. In addition to the proposed interim management plan for the east Duda property, SJRWMD has contracted with the USGS Florida Caribbean Science Center and UF for a four-part investigation to provide essential insights into the movement of pesticides from the soils to biota on the NSRA. Bioaccumulation models can then be more accurately calibrated for the development of restoration plans for the various parts of the NSRA. The investigation's components include the following:

- Experiments to address the potential for pesticides to quickly flush from the highly organic NSRA soils when first inundated
- Experiments in microcosms using a matrix of pesticide and soil carbon levels to investigate the bioaccumulation of pesticides into fish and crayfish as a function of both soil pesticide and carbon levels
- Experiments in replicated 0.25-ac fenced and screened ponds built on the NSRA at three sites with distinct pesticide concentrations. These ponds will be stocked with a variety of typical organisms and the bioaccumulation of pesticides will be evaluated under natural conditions
- The bioaccumulation and distribution of pesticides within caged great egrets fed fish grown in fenced and screened ponds on the NSRA. This investigation will track the movement of the actual pesticide mixtures on the NSRA from fish into the various tissues of a common top-level predator common on the NSRA.

The study is expected to be complete by the end of 2004.

Additional sampling of soils in the NSRA has identified at least one area of high OCP contamination; this area is adjacent to a former airplane landing strip. By January 2003, 9,203 tons of contaminated soils from this area had been excavated and removed for disposal at an approved landfill. Remediation methods for other potential "hot spot" sites, as well as for the overall field sites, are being considered and include the following:

- 1. <u>Localized contamination</u>: The likely remediation approach will be excavation and disposal of waste at an approved landfill.
- 2. <u>Widespread contamination from normal farming operations</u>: Remediation may include natural attenuation and biological treatment in place. Methods to encourage microbial breakdown of pesticide residues and creation of new sediments should result in surface sediment contaminant concentrations that decline to safe levels. These goals can be attained by
 - Shallow flooding that will shift sediment chemistry to conditions appropriate for the chemical breakdown of many pesticide residues
 - The colonization of wetland plants that will rapidly provide material for new sediments through decomposition

- The accumulation of these new sediments that will dilute and bury the old sediments.
- 3. <u>Application of innovative treatments for large areas</u>: New treatments may be examined but would likely need to be adapted to work in the NSRA.

A pilot remediation project to evaluate the effectiveness of using lake sediments to cap and isolate impacted surface soils on the former farmlands was initiated with Foster Wheeler Environmental Corporation. Suitable materials dredged from Lake Apopka would be placed over OCP-contaminated areas, thereby eliminating the pathway for exposure to human and/or ecological receptors. The efficiency of this potential remediation technique will be evaluated as a complete remediation procedure is developed.

After remediation is complete, SJRWMD will, in the short term, flood the NSRA to begin shallow-marsh development. The present long-term restoration plan considers several potential management areas such as shallow marsh, deep marsh connected to the lake, and shorebird management areas. As final restoration activities are developed, SJRWMD may consider and implement other appropriate management alternatives as well.

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- ———. 2000. Phases I and II environmental site assessment of the Strickland property, Lake Apopka, Florida. Tampa, Fla.
- ———. 2000. Phases I and II environmental site assessments of the Bates property, Lake Apopka, Florida. Tampa, Fla.
- ———. 2000. Soil removal activities at areas D & E, Lake Apopka, Florida. Tampa, Fla.
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- ———. 2001. Phase I environmental site assessment of the Holt property, Lake Apopka, Florida. Tampa, Fla.
- ———. 2001. Phase I environmental site assessment of the Shaffer property, Lake Apopka, Florida. Tampa, Fla.
- ———. 2001. Phase I environmental site assessment of the Shortz property, Lake Apopka, Florida. Tampa, Fla.
- ———. 2001. Phase IV remediation action report for Progressive Growers, Lake Apopka, Florida. Tampa, Fla.
- ———. 2001. Tank closure assessment report for pump house 3 and pump house 4, Lake Level Canal, Lake Apopka, Florida. Tampa, Fla.
- [USDA] U.S. Department of Agriculture. 2001. Lake Apopka North Shore Restoration Area biological assessment and interim restoration plan for Duda property. Natural Resources Conservation Service. Gainesville, Fla.
- [USFWS] U.S. Fish and Wildlife Service. 2002. Biological opinion for the interim restoration plan for the Duda sub-east property located at the North Shore Restoration Area of Lake Apopka, Orange County, Florida. Jacksonville, Fla.

SWIM Plan for Lake Apopka

Time Schedule Activity]	FY O)2–0	3]	FY 0	3-04	4]	FY 0	4-0	5	I	FY 0	5-0	6
Complete restoration plan	X	X	X	X	X	X	X	X		-	-	-	-	-	_	-
Build infrastructure	Х	Х	Х	Х	Х	X	X	Х	Х	X						
Soil amendment application										X	X	Х	X	Х	X	X
Design, establish, and implement	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
monitoring program					~				~							~
Restoration flooding																
Duda sub-east flooding	X	Χ														
Rest of Duda flooding					X	X	X	X								
ZDWCD flooding											X	X	X	X		
Pesticide study Bioaccumulation study Field-scale mesocosms Bird feeding studies Remediation	X X	X	X X	X X	X X	X	X	X								
Airstrip cleanup	Х	Х	Х	Х												
Treatment methodology					X	X	X	X								
Implementation									Χ	X						
Vegetation assessment																
Aerial photography	X				X				X				X			
GIS interpretation and change analysis	X				X				X	X	X	X				

Wetland Restoration

PROJECT (LA-2-304-M): LITTORAL ZONE RESTORATION

PROGRAM: Restoration

PRIORITY: 1

<u>ISSUE CATEGORIES</u>: Lack of fish and wildlife habitat; poor water quality and flocculent sediments; low recreational and aesthetic values

<u>PROJECT OBJECTIVE</u>: Phase I—To conduct a study of the feasibility of restoring littoral zone vegetation behind earthen dikes and to assess the effects of the restored littoral zone on gamefish populations. Phase II—To test the feasibility of re-establishing native aquatic plant communities in the littoral zone of the lake using man-made and natural vegetation barriers for protection of plantings. To examine the potential

macrophyte seed source from sediments of the various water depth contours of the lake. Phase III—To establish test plots of planted wetland species in the lake to determine viability under ambient lake conditions and to maintain an ongoing planting and monitoring effort

<u>SCOPE OF WORK</u>: Phase I—Develop a demonstration project to evaluate the feasibility of littoral zone restoration by the creation and management of permanent subbasins within Lake Apopka. Identify a suitable site for the study in Lake Apopka and conduct an economic analysis of the costs of land acquisition, design, construction, drawdown, re-vegetation, and management.

Phase II—Deploy protective barriers along the littoral zone of the lake to protect natural and planted aquatic vegetation. Determine the feasibility of sculpturing existing stands of cattails to provide protection for more desirable planted aquatic vegetation. Monitor effects of barriers on plant growth and water quality. Interpret existing aerial photography for wetland vegetation and map. Take sediment cores from transects perpendicular to the shoreline and incubate under greenhouse conditions to determine the natural seed bank.

Phase III—Plant and monitor littoral zone sites. Map vegetation in the existing littoral zone area around the lake perimeter using a global positioning system (GPS). Compare these results with the geographic information system (GIS) maps from earlier aerial photography.

<u>RELATIONSHIP TO FOCUS AND INTENT OF THE SWIM ACT</u>: This project evaluates the feasibility of littoral zone restoration by the creation and management of permanent subbasins within Lake Apopka or by re-establishing a diverse native aquatic plant community behind protective barriers in the littoral zone of the lake. The sediment seed bank study will provide data on the macrophyte seed base and possible germination in potential expanded littoral zone areas of the lake. The re-establishment of a diverse vegetated littoral zone for the lake will result in the partial restoration of habitat once present in Lake Apopka. The growth and expansion of submerged aquatic vegetation within the lake is a key goal of the restoration plan. Submerged aquatic vegetation provides critical and currently missing habitat and will reduce internal nutrient loading by reducing the ability of wind-driven currents to resuspend sediments.

<u>STATUS</u>: The Phase I study was completed and indicated that littoral zone restoration by construction of permanent subbasins was not economically feasible.

Phase II—Field surveys were conducted to determine potential littoral zone sites for vegetation restoration efforts. A considerable portion of the shallow shelf zone of Lake

Apopka is suitable for some form of aquatic vegetation restoration. Construction and testing of light-weight portable floating barriers has been completed. About 5,000 linear feet of barrier has been deployed at designated aquatic vegetation planting sites and around some stands of existing vegetation. A contract effort to transplant six native aquatic plant species behind protective barriers and at unprotected control sites began in July 1992 and was completed in December 1993. The six species planted were giant bulrush (*Scirpus californicus*), knot grass (*Paspalidium geminatum*), spatterdock (*Nuphar luteum*), eelgrass (*Vallisneria americana*), Illinois pondweed (*Potamogeton illinoensis*), and southern naiad (*Najas guadalupensis*).

Phase III—Additional aquatic vegetation planting was begun by SJRWMD staff, primarily near the northern shore of the lake, in June 1992. By 2001, 40 sites had been planted around the 40-mile perimeter of the lake. Planting "events" have been sponsored by SJRWMD with county and local governments and FOLA, a citizen advocacy group, to restore littoral zone areas fronting public parks along the lake. Both wild and purchased native plants are used. As the plants become established, the artificial barriers are moved to new sites. One problem that has been noted is the grazing of the plants by fish and/or turtles. This has slowed the expansion of the planting zones in several cases.

GPS mapping of vegetation in the littoral zone has been completed and will serve as a baseline for future analysis (Conrow and Peterson 2000). Since 1995, *Vallisneria americana* (eelgrass) has increased markedly in the lake. In June 1997, 63 patches of eelgrass totaling about 1.16 ha (2.87 ac) had been discovered around the lake, and other small areas of musk-grass and southern naiad were found and are being monitored for expansion. In January 2001, more than 83 patches with a combined area over 2.6 ha (6.5 ac) were documented. This spontaneous return of submersed macrophytes may be a response to improved underwater light conditions. In addition to providing valuable habitat, submersed macrophytes will hasten the recovery of the lake through several positive feedback mechanisms.

<u>Report</u>

Conrow, R., and J. Peterson. 2000. A panel atlas of the major aquatic plants of Lake Apopka, Florida, using global positioning and geographic information systems. St. Johns River Water Management District, Palatka, Fla.

Time Schedule Activity	I	FY O)2-0	3	J	FY O)3–0	4]	FY O	4–0	5	I	FY 0	5–06	6
Vegetation planting	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Vegetation monitoring (planted sites)			Χ	X			X	X			X	Χ			X	X
Aerial photography	Х				Х				Х				Х			
GPS mapping and analysis		x	x	x		x	x	x		x	x	x		x	x	x
(lakewide)		~	~	~		~	~	~		~	~	~		~	~	~

Littoral Zone Restoration

PROJECT (LA-3-402-M): NONPOINT SOURCE POLLUTION CONTROL

PROGRAM: Regulatory

PRIORITY: 2

ISSUE CATEGORY: Nonpoint pollution sources

<u>PROJECT OBJECTIVE</u>: To identify and control nonpoint sources of pollution affecting Lake Apopka

<u>SCOPE OF WORK</u>: Support master stormwater planning efforts. Identify stormwater conveyance systems and determine potential impact to the lake. Map stormwater conveyance systems and compile compliance history. Determine the extent of inadequate septic systems around the lake. Assist in the development and implementation of stronger local ordinances. Continue SJRWMD compliance and enforcement efforts. Assess potential for future enforcement contracts with Lake and Orange counties to provide the needed enforcement personnel.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: Improved regulation of nonpoint source pollution into Lake Apopka will become important as agricultural and point source pollution problems are resolved. This project will address the nonpoint source issue.

<u>STATUS</u>: Using a grant from Orange County, FOLA hired professional planners to develop the Lake Apopka Development Design Guidelines. Each of the eight local jurisdictions will be asked by FOLA to adopt and apply the shoreline protective measures as they approve future developments. Lake County has written a new ordinance based on the guidelines, and several new proposed developments have incorporated the guidelines.

The Jones Avenue Regional Stormwater Management Project will provide a regional wet detention pond system to improve the water quality in the northern portion of the basin. The 16.2-ha (40-ac) project will be located on SJRWMD property within the NSRA and will be funded by a cost-share agreement between SJRWMD and Orange County.

Time Schedule Activity	I	F	Y 0	3–0 4	ļ		FY 0	4-0	5]	FY 0	5-06	3			
Review local ordinances Design, permitting, and	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
construction of Jones Avenue Stormwater Park	X	X	X	X	X	X	X									

Nonpoint Source Pollution Control

PROJECT (LA-3-403-M): NUTRIENT LOADING LIMITS ADOPTION

PROGRAM: Regulatory

PRIORITY: Completed

<u>ISSUE CATEGORIES</u>: Agricultural discharges; lack of fish and wildlife habitat; poor water quality and flocculent sediments; degradation of downstream lakes; nonpoint pollution sources; future basin development

<u>PROJECT OBJECTIVE</u>: To develop and adopt a phosphorus loading limit rule and more-stringent permitting criteria, if necessary, to protect water resources in the Lake Apopka Basin

<u>SCOPE OF WORK</u>: Incorporate information from other projects, including external and internal nutrient budgets, phytoplankton-nutrient interactions, and mathematical modeling to recommend final PLRGs and performance criteria for Lake Apopka. Draft special basin criteria for Lake Apopka for incorporation under appropriate SJRWMD rules. These special basin criteria will comply with mandates of 62-40.420, *F.A.C.* Evaluate a number of more-stringent review criteria, such as smaller size threshold for projects requiring permits, treatment of larger volumes of stormwater to protect receiving water quality, identification and protection of natural habitats, and establishment of a buffer for the lake from future development pressures. Hold rule workshops to promote public input before final rule adoption by the Governing Board.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: This project will result in decreased nutrient loading to the Lake Apopka Basin.

<u>STATUS</u>: Regulatory and land acquisition actions that will decrease phosphorus loading to the basin have already been initiated. A proposed Works of the District Rule to regulate phosphorus loading to Lake Apopka was approved by the Governing Board in October 1994 and published in November 1994. Challenges to the rule were filed in December, and an administrative hearing on the challenges was held in late January 1995. The hearing officer found in favor of the petitioner, ruling that SJRWMD did not have authority to promulgate the rule. In addition, he found against SJRWMD on some points of fact concerning the sediment accumulation rate. Subsequent contracted research with UF provided additional data that SJRWMD used to verify the original measurements.

SJRWMD and FDEP staff cooperated with the legislative delegation and FOLA for passage of 1996 legislation, which included authority for SJRWMD to develop a nutrient limitation rule for the lake and to set a phosphorus criterion for Lake Apopka of 55 ppb if SJRWMD chose not to act.

The phosphorus criterion is a numeric interpretation for phosphorus of the Class III narrative nutrient criterion. SJRWMD responded with revisions to Chapter 40C-4, *F.A.C.*, and *Applicant's Handbook: Management and Storage of Surface Waters* (Appendix I), effective August 1996. This rule established a phosphorus criterion of 55 ppb for Lake Apopka pursuant to the mandate of the Lake Apopka Restoration Act. It has been used to establish discharge limitations for all regulated activities within the Lake Apopka drainage basin that are permitted to discharge, directly or indirectly, into Lake Apopka, the Lake Level Canal, or the McDonald Canal.

A revised draft technical memorandum that derived a PLRG for phosphorus in Lake Apopka was completed in 2000. The recommended allowable phosphorus loading to Lake Apopka from all sources is 15.9 metric tons per year. This loading is compatible with restoration goals.

SJRWMD staff worked to further improve the technical basis of the nutrient limitation rule and began the rule promulgation process again in 1999. A Notice of Proposed Rule Development was published in the *Florida Administrative Weekly* on December 29, 2000 (Appendix A). On January 31, 2001, a public workshop was held in Orlando to discuss the proposed rule amendments. Environmental Research and Design (ERD) was contracted to review SJRWMD's existing stormwater treatment criteria to determine if they were adequate to limit postdevelopment phosphorous loading. ERD submitted a draft report to SJRWMD in July 2001. Based on the consultant's report and further discussions, SJRWMD staff incorporated several revisions to the proposed rule. The proposed rule was approved by the Governing Board in April 2002 and was published

in the *Florida Administrative Weekly* on April 19, 2002. Following concern by the public over the implementation cost of the rule, SJRWMD considered less costly alternatives that would still meet the statutory objectives of the proposed rule. The final rule adoption hearing was held in December 2002. The rule became effective in March 2003.

Reports

- Coveney, M.F. 2000 (draft). Sedimentary phosphorus stores, accumulation rates, and sedimentation coefficients in Lake Apopka. Prediction of the allowable phosphorus loading rate. Technical memorandum. St. Johns River Water Management District, Palatka, Fla.
- Environmental Research and Design, Inc. 2001 (draft). Evaluation of water quality stormwater regulations for the Lake Apopka Basin. Final report submitted to St. Johns River Water Management District, Palatka, Fla.
- [SJRWMD] St. Johns River Water Management District. 1994. Public hearing, Chapters 40C-1 and 40C-61, *F.A.C.* Pollutant load reduction goals for Lake Apopka. F.O.R. 94-1496. Palatka, Fla.

——. 1994. Economic impact statement for the proposed amendments to Chapter 40C-61,
F.A.C. Works of the District Basins. (Lake Apopka Works of the District). SJEIS 94-02.
Palatka, Fla.

PROJECT (LA-6-501-M): DISTRICT WATER MANAGEMENT PLAN

PROGRAM: Planning

PRIORITY: 1

ISSUE CATEGORY: Future basin development

<u>PROJECT OBJECTIVE</u>: To regularly evaluate progress being made in implementing the DWMP and to update the DWMP every five years

<u>SCOPE OF WORK</u>: Prepare annual progress reports on the DWMP. For each DWMP update, identify the state of water resources in SJRWMD and water resource issues by water management district area of responsibility and major watershed, using resource assessments and other tools; develop strategies to address identified issues with a focus on what can be accomplished within the next five-year period; modify goals, objectives, policies and performance measures for SJRWMD or SJRWMD programs, as needed.

<u>RELATIONSHIP TO FOCUS AND INTENT OF THE SWIM ACT</u>: During the DWMP update process, SJRWMD works closely with state agencies, local governments, and others to identify water resource issues and develop strategies to address them. The DWMP includes a chapter on watersheds that identifies and addresses issues specific to the Lake Apopka Basin.

<u>STATUS</u>: The original DWMP was completed in spring 1995, and the first update of the DWMP was completed in spring 2000. The second update will be due to FDEP for review in November 2004. Lake Apopka SWIM program staff provide input concerning Lake Apopka for annual progress reports and participate in other reporting efforts as requested. They also are involved in the development of SJRWMD's Annual Work Plan and Budget, for which the DWMP sets direction. In addition, given the role the DWMP plays as SJRWMD's primary long-term planning tool, they assist in the preparation of periodic updates of the DWMP.

The original DWMP included a chapter organized by county to assist regional planning councils and local governments in addressing water resource issues. The Local Government Partnership Project followed and resulted in SJRWMD's publication of county water resource atlases in 1996 that contain strategies developed jointly by SJRWMD and local governments in each county, along with lists of critical water resource issues, current initiatives and maps created for the DWMP and other efforts. These atlases have served as a useful tool for linking land and water planning efforts. A watersheds chapter replaced the county chapter in the May 2000 DWMP. New county water resource atlases that will provide county- and watershed-oriented water resource information from the DWMP and other sources was published in 2002. The atlas will be updated every five years in order to assure that the best available information is in the hands of local government decision makers.

Reports

[SJRWMD] St. Johns River Water Management District. 2000. District water management plan (DWMP) and DWMP executive summary. Palatka, Fla.

———. 2003. Water resource atlas. St. Johns River Water Management District, Palatka, Fla.

District Water Management Plan

Time Schedule Activity	F	FY 0	2–03	3	F	Y 0	3–04	ł	FY 04-0	05	F	FY 05-06
Publish annual progress report Update DWMP (including resource assessments)	X	X	X	X X	X X	X	X	X X	X	X	X	X

PROJECT (LA-6-502-S): LOCAL GOVERNMENT COMPREHENSIVE PLAN Review

PROGRAM: Planning

PRIORITY: 1

<u>ISSUE CATEGORIES</u>: Low recreational and aesthetic values; poor water quality and flocculent sediments; lack of fish and wildlife habitat; nonpoint pollution sources; future basin development

<u>PROJECT OBJECTIVE</u>: To review and comment on local government comprehensive plan amendments, plan updates, and evaluation and appraisal reports (EARs)

<u>SCOPE OF WORK</u>: Furnish local governments with data and policy-related information for their planning process. Review comprehensive plans and plan amendments in relation to statutory water management district responsibilities and Chapter 163, *FS*, and its implementing regulations (Rule Chapter 9J-5, *F.A.C.*). Provide assistance to local governments in the preparation of EARs on their comprehensive plans and review EARs as requested and as staff time permits.

<u>RELATIONSHIP TO FOCUS AND INTENT OF THE SWIM ACT</u>: This project will provide a vehicle for improved coordination between the Lake Apopka restoration effort and local government planning. Inclusion of priority issues associated with restoration into the local planning process is necessary to address and prevent future problems in the basin.

<u>STATUS</u>: Adopted EARs for Lake County and its largest cities were due on May 1, 1998. They were due for Orange County and its largest cities, including Apopka, Ocoee, and Winter Garden, on July 1, 1998. The next step in the process, following or during an EAR sufficiency review process conducted by FDCA, is the submission of EAR-based comprehensive plan amendments which are reviewed by SJRWMD. The schedule for submittal of adopted EAR reports for the years 2002 through 2010 pursuant to Section 163.3191(9), *FS*, is listed in Table 6.

SJRWMD also continues to review regular (not EAR-based) comprehensive plan amendments as submitted.

County/Municipality	Due Date	County/Municipality	Due Date
Lake	August 2007	Orange	July 2005
Montverde	June 2009	Apopka	August 2006
		Oakland	August 2007
		Winter Garden	November 2007

Table 6. Evaluation and appraisal report schedule, 2002-2010

(DCA 2001a)

Local Government Comprehensive Plan Review

Time Schedule Activity	I	FY 02–03				FY O	3-0	4	FY	04-0)5	J	FY 0	5-0	6
Review regular comprehensive plan amendments	X	X	X	X	X	X	X	X	x x	X	X	X	X	X	X
Review EAR-based amendments															X

PROJECT (LA-6-503-M): LAND MANAGEMENT PLAN FOR THE LAKE APOPKA Restoration Area

PROGRAM: Planning

PRIORITY: 1

<u>ISSUE CATEGORIES</u>: Agricultural discharges; lack of fish and wildlife habitat; low recreational and aesthetic values

<u>PROJECT OBJECTIVE</u>: To develop and implement a land management plan for the Lake Apopka Restoration Area, which includes the marsh flow-way and the NSRA

<u>SCOPE OF WORK</u>: Develop and revise the land management plan for the restoration area to include newly acquired properties, and define restoration activities. Update the land management plan every five years. Initiate implementation of the plan in cooperation with other agencies and the public.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: The Lake Apopka management unit is designated as a restoration area. Thus, primary management emphasis will reflect the goals and objectives of the SWIM program (lake restoration), with secondary emphasis on maintaining or restoring the uplands in good ecological health and providing compatible public use.

<u>STATUS</u>: Legislative directives (Chapters 373 and 375, *FS*) guide the land management process from acquisition evaluations to the development of land management plans. These plans identify resource needs and compatible uses. The process provides both the mechanism and the opportunity for SJRWMD staff, other agencies, and the public to participate in the process.

The Ocklawaha River Basin Conceptual Management Plan, which contains the Lake Apopka Restoration Area, was completed in January 1992 and adopted by the SJRWMD Governing Board in March 1992. Development of a land management plan for acquired properties is required within one year of purchase, and the plans are revised about every five years.

Land maintenance activities at the Lake Apopka Restoration Area consist largely of maintaining the roads, canals, and levees, as well as various mowing efforts. Exotic weed control and prescribed burning activities are conducted as needed. Additional land maintenance includes maintenance of various facilities, solid waste removal, and replacement of bridges, including the bridge over the Apopka-Beauclair Canal.

Many of the land management activities planned for the Lake Apopka Restoration Area have been delayed pending the resolution of restoration plans for the area. It is anticipated, however, that once the remediation has taken place and the restoration efforts are resumed, various land management activities will resume.

SJRWMD land management staff have been cooperating with local residents on a regional planning effort for the Lake Apopka Basin. FOLA has led the effort—working with the region's local governments, non-profit groups and residents—to develop a Lake Apopka Basin Master Plan. This plan encompasses long-term goals for greenways, trails, recreation, and ecotourism within the basin. Despite the uncertainty surrounding the restoration plans, SJRWMD has been cooperating with the regional planning effort to explore the possibility of trail connections and other recreational opportunities on the SJRWMD-owned property. Possible public use and recreational activities planned for the property include construction of observation towers, establishment of parking areas, and installation of entrance signs and interpretive kiosks.

Reports

Donelin, L.N., and R.E. Turnbull. 1992. Draft conceptual management plans for District-owned lands: Ocklawaha River Basin. St. Johns River Water Management District, Palatka, Fla.

[SJRWMD] St. Johns River Water Management District. 2000. Land acquisition and management: 2000 five-year plan. Palatka, Fla.

———. 2001. Recreation guide to District lands. Palatka, Fla.

Time Schedule Activity	I	FY 0	2–03	}]	FY ()3–0	4	I	FY 0	4-0	5]	FY 0	5-06	6
Revise land management plan to include acquired properties	X	X	X	X	X											
Road, levee, and canal maintenance	Х	X	X	X	X	X	X	Χ	X	X	X	X	X	X	X	X
Vegetation maintenance	Х	X	X	X	X	X	X	Χ	X	X	Х	X	X	X	X	X
Prescribed burning	Х	X			X	X			X	X			X	X		
Exotic plant control	Χ	X	X	X	X	X	X	Χ	X	X	Х	X	X	X	X	X
Structure maintenance and repair	Х	X	X	X	X	X	X	Χ	X	X	X	X	X	X	X	X
New construction	Х	Х	X	Х	Х	Х	Х	Χ	Χ	X	X	Х	X	X	Х	X
Solid waste removal	X	X	X	X												

PROJECT (LA-5-602-S): PUBLIC AWARENESS

PROGRAM: Public Information Program

PRIORITY: 1

<u>ISSUE CATEGORIES</u>: Agricultural discharges; nonpoint pollution sources; lack of fish and wildlife habitat; poor water quality and flocculent sediments; degradation of downstream lakes; low recreational and aesthetic values

<u>PROJECT OBJECTIVE</u>: To increase public awareness of the degradation of Lake Apopka, the challenges of restoration, restoration successes, and the future restoration plans through communication with the public and news media

<u>SCOPE OF WORK</u>: Continue to increase public awareness of Lake Apopka restoration issues. Communicate with the public and news media about the issues relating to the restoration of Lake Apopka.

The Office of Communications and Governmental Affairs will continue the following activities:

• Inform the public and news media about the progression and initiation of projects

SWIM Plan for Lake Apopka

- Initiate and coordinate tours of Lake Apopka with the news media, elected officials, and stakeholders
- Prepare and distribute news releases about project milestones, and follow up with the news media on coverage
- Speak to community groups about projects
- Develop public information materials as needed
- Enhance SJRWMD's Internet site with updated information
- Publish stories in *StreamLines* on the status of projects
- Coordinate public events to mark significant project milestones
- Communicate issues to FOLA and other special interest groups

The Education section of the Office of Communications and Governmental Affairs will continue to

- Support Florida Yards, Neighborhoods and Ponds activities
- Conduct stormwater pond education
- Provide Environmental Landscaping Distance Learning classes to community colleges
- Conduct Green Building seminars and CEU programs for contractors, builders, and home buyers
- Implement the Watershed Action Volunteer program
- Coordinate Community Water Festival with interested organizations
- Implement the Legacy program
- Provide teacher and facilitator training programs
- Support Orange County Envirothon efforts
- Expand intensive school programs
- Provide presentations and training for staff of after school, extended day, park and recreation, and summer or camp programs

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: This project will use communications with the public and news media to increase awareness and support for Lake Apopka restoration efforts. Information about the restoration projects will be communicated to the public and news media for the purpose of maintaining support for the Lake Apopka SWIM effort.

<u>STATUS</u>: News media interviews, presentations to community groups, development of public information materials, coordination of public events, and tours of Lake Apopka restoration sites are an ongoing component of the restoration project. Tours are regularly provided to members of the news media, the public, dignitaries, and scientific

delegations from around the United States and foreign countries interested in the restoration techniques being applied at Lake Apopka. Extensive public awareness efforts are also conducted through presentations to civic groups in Lake and Orange counties. Cooperative efforts with a residents' group, FOLA, have resulted in volunteer shoreline plantings, school presentations, and media coverage. During 2001, students at eight Seminole County schools collected 16,000 socks to assist littoral zone planting efforts over the next two years. The sand-filled socks are tied to the base of plants, which are placed in the water. They anchor the plants in place long enough for their roots to become established. Eventually, the socks decompose and the sand falls to the bottom of the lake. SJRWMD provided a grant to FOLA in partial support of an educational video they developed. FOLA has formed a boat patrol to help SJRWMD monitor and track the development of submersed and other aquatic vegetation in the lake. The public outreach effort is an important method for SJRWMD to educate, inform, and address public issues.

Reference materials available:

- Lake Apopka fact sheet (2001)
- Lake Apopka Marsh Flow-Way fact sheet (2001)
- Littoral zone/sock drive overview (2001)
- Lake Apopka tri-fold display (2000)
- District recreation guide (2000)

Public Awareness

Time Schedule Activity	FY 02-03]	FY O)3–0	4	F	FY O	94–0	5	J	FY 0	5–0	6
Tours, interviews, speaking engagements, etc.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Development of education materials	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

PROJECT (LA-5-603-S) LOCAL GOVERNMENT INFORMATION PROJECT

PROGRAM: Public Information Program

PRIORITY: 1

<u>ISSUE CATEGORIES</u>: Agricultural discharges; lack of fish and wildlife habitat; poor water quality and flocculent sediments; degradation of downstream lakes; low recreational and aesthetic values; nonpoint pollution sources

<u>PROJECT OBJECTIVE</u>: To increase awareness among local, state, and federal elected officials and staff of the degradation of Lake Apopka, the challenges of restoration, restoration successes, and the future restoration plans

<u>SCOPE OF WORK</u>: Continue a systematic approach to communicate the value of the Lake Apopka SWIM Plan to local, state, and federal government officials and encourage their participation as the lake restoration continues. Conduct on-site tours of the Lake Apopka restoration projects to demonstrate program successes.

<u>RELATIONSHIP TO FOCUS AND INTENT OF THE SWIM ACT</u>: This project will result in improved coordination with government officials to increase their awareness and support for Lake Apopka restoration efforts and the SWIM program.

<u>STATUS</u>: Elected officials and staff at all levels of government are kept aware of project status.

Activities by other agencies/interest groups:

- FOLA initiated the formation of the Lake Apopka Basin Planning Initiative, a coordinated regional planning effort involving local elected officials, ECFRPC, SJRWMD, and other interested parties.
- In February 2000, the Lake Apopka Basin Steering Committee was established to prioritize regional initiatives. The Initiative will serve to unite the six cities and two counties in addressing growth and development issues within the basin. Five areas were targeted to achieve an ecological and economical sustainable future (ECFRPC 2000):
 - Shoreline protection
 - Greenways and trails
 - Viewsheds
 - Public Access
 - Natural setting
- FOLA has begun an initiative to study and recommend a coordinated recreation planning report which focuses on a regional trails network. An intergovernmental management agreement was finalized during 2000 with the town of Oakland and the Oakland Nature Preserve for the disbursement of mitigation funds for the management of the Oakland Nature Preserve.

Reference materials available:

- Lake Apopka: A basinwide planning initiative (ECFRPC, 2000)
- Lake Apopka fact sheet (2001)
- Lake Apopka Marsh Flow-Way fact sheet (2001)
- Littoral zone/sock drive overview (2001)
- Lake Apopka tri-fold display (2000)
- District recreation guide (2003)

Local Government Information Project

Time Schedule Activity	F	FY 0	2–03	}]	FY O	3-0-	4	I	FY 0	94–0	5]	FY O	5-0	6
Tours, speaking engagements, etc. Coordinate with the Lake Apopka	X X															
Basin Steering Committee SWIM plan public hearing																X

PROJECT (LA-3-701-S): MARSH FLOW-WAY LAND ACQUISITION

PROGRAM: Land Acquisition

PRIORITY: Completed

<u>ISSUE CATEGORIES</u>: Agricultural discharges; lack of fish and wildlife habitat; poor water quality and flocculent sediments; degradation of downstream lakes; low recreational and aesthetic values

<u>PROJECT OBJECTIVE</u>: To acquire necessary muck farm lands and other agricultural lands in support of the marsh flow-way

<u>SCOPE OF WORK</u>: Attain and review three appraisals. Negotiate with land owners. Prepare inventory and environmental site assessment of the property. Prepare closing documents. Acquire property.

<u>RELATIONSHIP TO FOCUS AND INTENT OF THE SWIM ACT</u>: This project resulted in acquisition of agricultural lands, upon which the demonstration marsh and Phase I of the marsh flow-way have been constructed. Future cells D through H are kept in a flooded condition to create wetland habitat, eliminate fertilizer and pesticide application, and reduce pumping of water to the Apopka-Beauclair Canal. <u>SUMMARY</u>: A total of 2,164 ha (5,343 ac) of former agricultural lands west of the Apopka-Beauclair Canal were acquired from 1988 to 1992 to support the Marsh Flow-Way Project. Parcels purchased include Hooper Farms, Duda (Clay Island), Brady/RICO, Howard (Clay Island), Duda/Whittle, Wilkinson-Cooper Farm, and CC Ranch. An additional 198 ha (490 ac) west of the canal (Keen, Blunt, and Boyd-Davis properties) were obtained from 1990 through 1995 to support the restoration project. Five million dollars was appropriated in both 1988 and 1989 through the State Infrastructure Trust Fund and in 1990 by Preservation 2000 for land acquisition by SJRWMD to facilitate the Lake Apopka restoration efforts.

PROJECT (LA-3-704-S): NORTH SHORE LAND ACQUISITION

PROGRAM: Land Acquisition

PRIORITY: Priority 1

<u>ISSUE CATEGORIES</u>: Agricultural discharges; lack of fish and wildlife habitat; poor water quality and flocculent sediments; degradation of downstream lakes; low recreational and aesthetic values

<u>PROJECT OBJECTIVE</u>: To plan, evaluate, prioritize, and acquire properties within the former Lake Apopka floodplain wetlands to provide conservation and preservation lands

<u>SCOPE OF WORK</u>: Evaluate, prioritize, and acquire critical habitats in the NSRA as additions to the wetlands restoration effort or as preservation projects. Annually assess acquisition needs comprehensively within resource-based planning areas and watershed subbasins for the update to the Florida Forever work plan. Actual acquisitions will be dependent upon availability of funding.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: This project will provide a basis for additional land acquisitions critical to the restoration of the lake and the preservation efforts in the basin. Budget and time schedules will be developed as necessary.

<u>STATUS</u>: Legislation in 1996 provided the direction to pursue a total farm buyout and \$20 million toward that goal. The Governing Board approved purchase of the 1,285-ha (3,173-ac) Jem Farm, owned by A. Duda and Sons, Inc., in December 1996. The closing date was April 18, 1997. SJRWMD signed an agreement with USDA to receive up to \$26 million in matching land acquisition funds through the WRP for the NSRA. This money

comprised part of the funding for Jem Farm in conjunction with Save Our Rivers and Conservation and Recreation Lands funding.

During the 1997 legislative year, an additional \$45 million was appropriated for purchasing additional agricultural lands. Through the end of 1997, the Governing Board had approved Zellwin Farms' 2,128 ha (5,254 ac) and a total of 1,818 ha (4,488 ac) within ZDWCD for purchase. The properties include Lust Farms, Lust and Long Precooler, Stroup Farms, Clonts Farm, Crakes and Sons, Grower's Precooler, Beall Farms, and Long Farms. The closing dates were August through October 1998. The final farmlands (381 ha, or 940 ac) within the ZDWCD were purchased in August 1999. Bringing the land into public ownership completes SJRWMD acquisition of the Lake Apopka muck farms. As a result of state legislation in 1996, 1997, and 1998, SJRWMD and WRP have brought approximately 5,636 ha (13,900 ac) into public ownership within the NSRA.

Reports

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———. 2001. Florida Forever work plan. Palatka, Fla.

North Shore Acquisition

Time Schedule Activity	FY 02–03	FY 03–04	FY 04–05	FY 05–06
Parcel evaluation and appraisal of adjoining properties Purchase negotiation Coverning Board purchase approval	X X X X X X X X X			

PROJECT (LA-6-802-S): IMPLEMENTATION OF RESTORATION AND MANAGEMENT TECHNIQUES

PROGRAM: Technical Support

PRIORITY: 1

ISSUE CATEGORY: All issues

SWIM Plan for Lake Apopka

<u>PROJECT OBJECTIVE</u>: To provide overall analysis and coordination of diagnostic, feasibility, regulatory, planning, land acquisition, public information, and restoration projects

<u>SCOPE OF WORK</u>: Review, analyze, and integrate results of diagnostic, feasibility, and pilot restoration studies. Coordinate technical studies with regulatory, planning, public information, and land acquisition projects. Recommend ecologically sound and cost-effective restoration and management techniques as these are evaluated. Identify goals and strategies for regulatory activity concurrent with restoration.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: This project represents the integration of the Lake Apopka SWIM Program to implement restoration, management, and regulatory strategies.

<u>STATUS</u>: Thirteen of the 16 diagnostic and feasibility studies have been completed. These initial projects were vital in shaping the direction of the Lake Apopka Restoration Plan. Presently, the major effort is focused on the restoration program. Phase I of the marsh flow-way is now constructed, and management plans are being developed for the restoration of acquired farmland. In addition, rough-fish harvesting and littoral zone restoration continues. The integration of these diverse programs will be vital to the attainment of the Lake Apopka restoration goals.

Reports

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Implementation of Restoration and Management Techniques

Time Schedule Activity	I	FY 02	2–03	3]	FY 0	3-04	4	F	FY 0	4–0	5	J	FY 0	5-0	3
Provide technical support	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

PROJECT (LA-6-803-S): RESTORATION MONITORING AND ANALYSIS

PROGRAM: Technical Support

PRIORITY: 1

ISSUE CATEGORY: All issues

<u>PROJECT OBJECTIVE</u>: To implement a monitoring program during restoration activities and in the post-restoration period, and to assess restoration progress, facilitate adaptive management, and track performance measures

<u>SCOPE OF WORK</u>: Monitor physical, chemical, and biological conditions in Lake Apopka and the NSRA. Depending on monitoring site, include meteorological conditions, water quality, phytoplankton and zooplankton composition, invertebrate community structure, fish and wildlife species composition and abundance, and vegetation development in the littoral zone and in restored wetlands. Design and execute restoration monitoring to quantify the effects of restoration techniques and to collect data on performance measures for the project. Develop and implement a monitoring program for agricultural chemical residues remaining in the soils of the NSRA. Incorporate these data into districtwide relational databases and spatial databases.

<u>RELATIONSHIP TO FOCUS AND INTENT OF SWIM ACT</u>: During and following the implementation of restoration efforts in Lake Apopka, a monitoring program is necessary to measure the performance of restoration projects and to indicate any need to modify restoration techniques through time (adaptive management).

<u>STATUS</u>: SJRWMD monitoring of water quality and nutrient loading continues at several sites in Lake Apopka, the Apopka-Beauclair Canal, and newly acquired farmlands. Monitoring is required to measure the effectiveness of efforts to reduce nutrient loading to the lake and to improve lake water quality. Since mid-1995, there has been a significant decline in phosphorus and chlorophyll in the lake. At the same time, the resulting increased transparency (light availability) likely is responsible for the reappearance of submersed aquatic plants within the lake, a key indicator for restoration progress. Analysis of phytoplankton samples collected over the past several years was started to assess changes in the algal community related to the changes in water quality. Monitoring and analysis of fish populations are required as part of SJRWMD's permit to harvest rough fish and provide important information on success of the harvest and on changes in ecologically and economically important fish stocks.

SJRWMD staff and volunteers from FOLA have begun a project to monitor vegetation development around the lake. Resident volunteers patrol the lake, noting the location and types of submersed vegetation that they find. This information is provided to SJRWMD staff, who accurately locate and quantify the vegetation patches and monitor changes in those patches. The data are then mapped, which provides a history of vegetation development in a spatial database as the restoration continues. The work also provides information on the location of invasive exotic vegetation, particularly hydrilla. Early detection of hydrilla is essential if SJRWMD is to continue to be successful in controlling it at very low levels.

As part of the investigation into the cause of the bird deaths on the Lake Apopka NSRA in 1998 and 1999, SJRWMD has sampled the soils of the entire NSRA and various animal tissues. This work led to the development of several databases to manage and analyze contaminant data from soil, sediment, and tissue samples and necropsy data from a variety of sources including SJRWMD, UF, FDEP, EPA, USFWS, and various contractors.

Reports

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Time Schedule Activity	I	FY 0	2–03	}]	FY O	3-04	4]	FY 0	4–0	5	I	FY 0	5–0	6
Water quality sampling and nutrient budgets	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Vegetation monitoring and analysis	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Contaminant monitoring and analysis	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Fishmonitoring						X	X			X	Х			Х	X	
Bird monitoring	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Restoration Monitoring and Analysis

PROJECT (LA-6-804-S): OVERALL PROGRAM MANAGEMENT

<u>PROGRAM</u>: Technical Support

PRIORITY: 1

ISSUE CATEGORY: All issues

<u>PROJECT OBJECTIVE</u>: To provide overall management of the Lake Apopka SWIM program

<u>SCOPE OF WORK</u>: Provide managerial and secretarial support and interagency coordination. Develop quarterly and annual reports on the Lake Apopka SWIM Project. Prepare, review, and submit revisions of the Lake Apopka SWIM Plan for approval in accordance with statutory requirements. Prepare reports to FDEP and other agencies as needed. Participate in SJRWMD planning, budgeting, and progress evaluation and reporting activities.

<u>RELATIONSHIP TO FOCUS AND INTENT OF THE SWIM ACT</u>: This project will result in successful coordination and management of the Lake Apopka restoration effort.

<u>STATUS</u>: Managerial and secretarial support and interagency coordination was provided for the Lake Apopka SWIM effort. Reports to FDEP and other agencies were prepared as required. The Lake Apopka SWIM Plan was extensively revised in 1989 with review by FDEP, FWC, other state agencies, and local governments. Update of schedules and progress shown in the SWIM Plan was accomplished through quarterly and annual reporting. A draft triennial revision of the Lake Apopka SWIM Plan was completed in October 1992 for agency review, and the SJRWMD Governing Board gave its final approval to the plan in January 1993.

SJRWMD has recently implemented a project delivery system and project control system to improve the implementation of projects. The benefits of these systems include improved budgeting, scheduling, tracking, and quality.

<u>Reports</u>

- Battoe, L.E., D. Walker, and J. Modica. 1988. Interim SWIM Plan for Lake Apopka. St. Johns River Water Management District, Palatka, Fla.
- Conrow, R., W. Godwin, M.F. Coveney, and L.E. Battoe. 1993. SWIM plan for Lake Apopka. St. Johns River Water Management District, Palatka, Fla.
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Overall Program Management

Time Schedule Activity	F	Y 0	2–03	3]	FY O	3-0-	4	F	FY 0	4–0	5	J	FY 0	5-00	3
Report compilation and review	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
overall program management coordination	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

SUMMARY OF PROJECT FUNDING

INTRODUCTION

Enactment of the Lake Apopka Restoration Act in 1985 created the impetus to accelerate the development of an "environmentally sound, economically feasible method for restoring Lake Apopka to a Class III water body" (Appendix A). The legislative directive also provided \$2,265,000 for FY 1985–86 to initiate comprehensive monitoring and research efforts. The SWIM Act of 1987 further spurred the planning and implementation of the restoration. During the early years of the program, much of the funding was directed to diagnostic projects conducted to evaluate the status of the water body and to reach a clearer understanding of the causes of existing problems. As the diagnostic and feasibility projects were completed, the emphasis of the program was refocused on restoration, regulatory, and land acquisition projects.

A detailed list of the project budgets by fiscal year is in Table 7. Staff salaries are included except within projects in the public information, planning, and land acquisition program areas. The salaries for these programs are contained within budgets outside of this document. Table 8 details land acquisition costs.

FUNDING SOURCES

The restoration of a water body the magnitude of Lake Apopka requires a financial participation by many local, state, regional, and federal agencies. A partial listing of agencies participating in the restoration of Lake Apopka follows.

Federal Participation

EPA—EPA contributed \$1 million in 1997 toward construction of the marsh flow-way.

USDA—In 1997, SJRWMD received a commitment of \$26 million from the NRCS WRP for the purchase of farm properties (Table 8). Approximately \$18.5 million of the WRP funds has been spent for acquisition of the farm properties in the NSRA.

SWIM Plan for Lake Apopka

Table 7. Estimated capital and operating funding required for Lake Apopka SWIM projects, FY 2002–2006

Title	FY 02-03	FY 03-04	FY 04-05	FY 05-06
Diagnostic Program				
External Nutrient Budget	\$60,815	\$27,704	\$14,199	\$14,553
Fishery	0	66,926	0	0
Program total	60,815	94,630	14,199	14,553
Feasibility Program	I		1	1
Drawdown and Lake Level Fluctuation	20,272	20,778	21,298	14,553
Program total	20,272	20,778	21,298	14,553
Restoration Program				
Marsh Flow-Way Restoration	483 930	540 857	3 298 474	380 132
Rough Fish Harvesting	213 514	356 926	282 009	207 277
Wetland Restoration	4 347 062	1 863 970	4 013 970	3 785 623
Littoral Zone Restoration	40 543	51 557	45 496	46,384
Program total	4.418.184	2.761.753	7.640.039	4.419.416
	,,,	, ,	1,010,000	.,,
Regulatory Program				
Non Point Source Pollution Control	13,514	6,926	7,099	7,277
Program total	13,514	6,926	7,099	7,277
Planning Program		-		
District water Management Plan				
Local Government Comp. Plan Review				
Land Management Plan and	1 506 666	247 546	190,206	225.266
Program total	1,506,666	347,516	189,390	223,200
Frogram total	1,500,000	347,510	109,390	225,200
Public Information Program				
Public Awareness Program*				
Local Government Information Project*				
Program total				
Land Acquisition Program	I		-	-
North Shore Land Acquisition*	250,000	0	0	0
Program total	250,000	0	0	0
Technical Support Program				
Restoration and Management Techniques	40 543	41 557	42 596	43 660
Restoration Monitoring and Analysis	214 130	224 670	237 787	250 981
Program total	254.673	266,227	280,383	294.641
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Overall Program Management				
Overall Program Management	108,115	110,818	106,489	101,874
Program total	108,115	110,818	106,489	101,874
Overall totals	6,682,239	3,608,648	8,258,903	5,077,580

*The salaries for these projects are contained within budgets outside of the program.

Property Acquired	operty Acquired Funding Mechanism		Date Acquired	Cost (\$)
	Marsh Flow-Way and Adjoining Pro	operties		
Duda/Clay Island	Legislative appropriation	1,859.9	11/30/88	4,500,000
Brady/RICO	Legislative appropriation	198	1/2/90	83,197
Hooper Farms	Legislative appropriation	1,363.1	3/28/90	4,800,000
Hooper Farms	Legislative appropriation	200	10/27/88	200,000
Howard	Legislative appropriation	5	8/6/90	70,000
Duda/Whitle	Legislative appropriation	1,100	8/30/90	2,950,000
Wilkinson-Cooper Farm	P2000	365	5/15/92	1,279,145
C.C. Ranch	P2000	255	5/15/92	669,296
Boyd-Davis	P2000	181.44	8/30/95	474,128
Wilkinson	Ad valorem	5.35	1/26/01	18,725
Subtotal		5,532.79		15,044,491
Nor	th Shore Restoration Area and Adjoin	ing Propertie	S	40.4.00.4
Keen Ranch	P2000	256	12/9/93	434,384
Blunt	P2000	53	5/29/95	106,000
Duda/Jem Farm	SOR, CARL, and WRP	3,172.89	4/18/97	20,032,495
Zellwin Farms	SOR, WRP, P2000, and leg. app.	5,168.69	8/21/98	32,968,815
Long Farms, Inc.	SOR, WRP, P2000, and CARL	1,016.58	10/6/98	8,926,160
Clarence Beall	P2000 and WRP	310.49	9/14/98	1,316,111
Clonts Farm	P2000 and WRP	642.74	9/14/98	4,200,000
Lust Farms, Inc.	P2000, WRP, and leg. ap.	1,507.51	9/14/98	9,211,900
Stroup Farms, Inc.	P2000 and WRP	414.43	9/14/98	1,935,377
Lust and Long Precooler	P2000	13.37	9/25/98	1,274,465
Growers Precooler, Inc.	P2000	17.23	10/14/98	3,377,175
Crakes and Sons, Inc.	P2000 and WRP	508.84	10/6/98	2,639,814
Grinnell, Hensel and Rogers,			0/00/00	0 000 550
B. Potter and K. Rice, M. Rice	Legislative appropriation	829	8/20/99	9,333,550
Hickerson	Leg. ap., SOR, and ad valorem	119.8	8/20/99	3,305,075
Baumgardt	Lake Apopka lease revenues	0.2	9/9/99	20,000
Freeman	Lake Apopka lease revenues	11.4	9/9/99	30,000
Wallace Carrot, Inc.	Lake Apopka lease revenues		4/21/99	155,000
Teddy Smith	Lake Apopka lease revenues	35.66	3/22/00	108,550
M.E. Marsell	Lake Apopka lease revenues	1.99	6/29/00	7,960
J. and F.M. Marsell	Lake Apopka lease revenues	11.07	6/29/00	44,280
S. Marsell	Lake Apopka lease revenues	19.98	6/29/00	52,947
Bates	Lake Apopka lease revenues	8.49	7/21/00	213,000
NAPA	Lake Apopka lease revenues	34.86	8/30/00	258,222
Davison	Lake Apopka lease revenues	9.13	3/30/01	36,148
Schaffer	Lake Apopka lease revenues	12.86	5/17/01	38,580
	Property exchange for Grinnell	0.00	44/00/04	(70,400)
World Foliage Resources	Precooler	8.00	11/26/01	(79,193)
Grinnell Precooler	Property for World Foliage Resources	-5.6	11/26/01	Exchange
Strickland	Ad valorem	19.09	2/1/02	55,173
VVOIIG FOIlage Resources	Beitway mitigation	60.32	9/27/02	328,000
Keen Kanch addition	P2000	49.6	12/19/02	1/1,312
	Beitway mitigation	58	12/20/02	141,370
Suptotal		14,366.55		100,642,670
Total		19,895.90		115,687,161

Table 8A. St. Johns River Water Management District land acquisition in the Lake Apopka Basin as of December 20, 2002

Note: — = purchased infrastructure only, no property

SWIM Plan for Lake Apopka

Funding Mechanism	Acres	Estimated Closing Date	Total Cost (\$)
Beltway mitigation	52.1	Unknown	515,000
Land swap	9.4	Unknown	0
	61.5		515,000
	Funding Mechanism Beltway mitigation Land swap	Funding MechanismAcresBeltway mitigation52.1Land swap9.461.5	Funding MechanismAcresEstimated Closing DateBeltway mitigation52.1UnknownLand swap9.4Unknown61.561.561.5

Table 8B. Properties under contract (not closed) as of December 20, 2002

State Participation

State Infrastructure Trust Fund—Five million dollars was appropriated in both 1988 and 1989 for land acquisition in the Lake Apopka Basin.

Preservation 2000 (P2000)—Five million dollars was appropriated to SJRWMD for land acquisition in 1990 for Lake Apopka restoration. The General Appropriations Act for FY 1997–98 appropriated \$45 million to SJRWMD for purchase of farmlands within the basin with \$20 million of that total routed through the P2000 program and \$25 million from FDEP general revenues.

Conservation and Recreation Lands (CARL) Trust Fund—The General Appropriations Act for FY 1996–97 appropriated \$12 million to SJRWMD from CARL (Appendix A). SJRWMD was directed to use \$8 million from its share of funds from the Water Management Lands Trust Fund (WMLTF) or from funds derived from revenue bonds as a revenue source for the purchase of farm lands.

SWIM trust funds—Created by the enactment of the 1987 SWIM Act, SWIM funds are limited to the costs of detailed planning for and implementation of programs prepared for priority surface waters. They are intended to enhance existing funding and to produce improved environmental results, not to replace existing programs. SWIM trust funds required at least a 20% match from the water management districts for FY 1990–91 and a 40% match for FY 1992–97 from ad valorem revenues, operations funds, cash grants, future state funding, eligible sources of district matching funds, and annual allocation of funds to the districts.

WMLTF—Created through the Save Our River legislation (Section 373.59, *FS*), the fund is to be used for the purposes of land acquisition, management, and maintenance, and capital improvements. Through Specific Appropriation 1205 in Chapter 99-226, *Laws of Florida*, the state Legislature provided \$11 million for the purchase of farms from the WMLTF.

Florida Forever—The initial five-year SJRWMD Florida Forever Work Plan (January 2002) allocates \$7.5 million for works in the NSRA (FY 2003–2004).

Central Florida Beltway—In September 1998, mitigation for the environmental impacts of the Western Beltway SR-429 Part A provided \$2 million for the construction of the Lake Apopka Marsh Flow-Way. In September 2001, mitigation for an additional segment of the Beltway, SR-429 Part C Phase I, provided \$2,077,980 for Lake Apopka land acquisition, restoration, and water quality enhancements.

Local Participation

Ad valorem taxes—SJRWMD was given the authority under Section 353.503, *FS*, to levy taxes up to a 0.6 millage rate, commencing in 1977.

Local government—Lake County and the Lake County Water Authority committed up to \$1 million in matching funds toward the construction of the marsh flow-way, Phase I, during 1998–99.

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APPENDIX A—LEGISLATION AND RULES

The following documents were reproduced from scanned images using optical character recognition technology. Every effort was made to ensure that these are accurate reproductions of the original documents, but in some cases, the documents may appear different from the original forms. In addition, some non-pertaining sections were removed to conserve resources. The laws are now incorporated into Sections 373.451-373.459, SWIM legislation, and Section 373.461, Lake Apopka improvement and management of the *Florida Statutes (FS* 2000).

1.	Lake Apopka Restoration Act Chapter 85-148, Laws of Florida19	98
2.	1987 SWIM Legislation Chapter 87-97, Laws of Florida20	01
3.	1996 Lake Apopka Legislation Chapter 96-207, Laws of Florida2	13
4.	1997 Lake Apopka Legislation Chapter 97-81, Laws of Florida2	17
5.	Rule No. 40C-4.091, <i>F.A.C.</i> (establishing phosphorus criterion for Lake Apopka) pursuant to the mandate of Chapter 96-207, <i>Laws of Florida</i> 22	23
6.	Proposed Rule Revisions to Sections 40C-4, 40C-41, 40C-42, and 40C-44, <i>F.A.C.</i> , and Related Applicant Handbooks: Management and Storage of Surface Waters Drainage Basins and Phosphorus Limitations (<i>FAW</i> 2002)	l 29
7.	Notices of Change to the proposed rule	45

CHAPTER 85-148

Committee Substitute for House Bill No. 251

An act relating to the preservation of Florida's lakes; amending s. 403.0615, F.S.; renaming the "Water Resources Restoration and Preservation Act" as the "Lake Restoration Act"; establishing a program to assist in the restoration and protection of certain state lakes; providing criteria for allocation of restoration funds; providing for a trust fund; providing priority for Lake Apopka and requiring submission of a restoration and management plan therefore; providing an appropriation; providing an effective date.

Be It Enacted by the Legislature of the State of Florida:

- Section 1. The Legislature hereby directs the St. Johns River Water Management District, in conjunction with the Department of Environmental Regulation, Game and Fresh Water Fish Commission, Lake and Orange Counties, and the Lake Apopka Restoration Council to initiate a pilot project for Lake Apopka. The purpose of the project is to identify an environmentally sound, economically feasible method for restoring Lake Apopka to a Class III water body.
- Section 2. (1) There is created within the St. Johns River Water Management District the Lake Apopka Restoration Council. The council shall consist of eleven members as follows: a scientific representative from the St. Johns River Water Management District, a scientific representative from the Game and Fresh Water Fish Commission, a scientific representative from the Department of Environmental Regulation, and a scientific representative from Orange County, each to be appointed by their respective agencies; a nonagricultural lake front property owner; two representatives from the lake front agricultural community, each representative of the sportsfishing industry, a representative of a municipality abutting Lake Apopka from Orange County and a representative of a municipality abutting Lake Apopka from Lake County, each to be appointed by the Governor. The council shall be advisory to the St. Johns River Water Management District governing board.
 - (2) Immediately after their appointment, the members of the council shall meet and organize by electing a chairman, a vice chairman, and a secretary, whose terms shall be for 3 years each. Council officers may not serve consecutive terms. Council members representing state agencies shall not have voting powers; however, at the discretion of the council they may serve in the capacity of chairman.
 - (3) The council shall meet at the call of its chairman, at the request of a majority of its members, or at the request of the St. Johns River Water Management District governing board chairman.

Section 3. The Lake Apopka Restoration Council shall have the powers and duties to:

- (1) Review studies and data specifically related to lake restoration techniques and advise the district governing board of approaches to be considered for restoration of Lake Apopka.
- (2) Make a recommendation to the district governing board for a Lake Apopka restoration program.

- (3) Report directly to the Legislature before November 25 of each year with a Lake Apopka restoration progress report and any recommendations for the forthcoming fiscal year.
- Section 4. Members of the Lake Apopka Restoration Council shall receive no compensation for their services but are entitled to be reimbursed for per them and travel expenses as provided in s.112.061, Florida Statutes.
- Section 5. The St. Johns River Water Management District governing board shall specify tasks which are to be undertaken by the district, the Department of Environmental Regulation, pertinent local governments, and the Game and Fresh Water Fish Commission in order to initiate the pilot project for Lake Apopka. The governing board shall:
 - (1) Conduct extensive water sampling of the lake and its associated tributaries to determine the existing water quality and to determine the long term effects of nutrient loading from agricultural activities.
 - (2) Evaluate the restoration of a portion of floodplain marsh between Lake Apopka and the Apopka-Beauclair Lock by allowing sheetflow of waters prior to their entrance to the Apopka-Beauclair Canal.
 - (3) Develop a nutrient budget for the lake to ensure that appropriate regulatory efforts are instituted with respect to nutrient loading.
 - (4) Examine techniques which may be used to modify the existing physical and biological characteristics of the lake.
 - (5) Conduct a feasibility study to determine the effects of diking-off and restoring the littoral zone of the lake to enhance sportfish production.
 - (6) Implement and evaluate a program to demonstrate the feasibility of utilizing water hyacinths to extract excessive nitrogen and phosphorus from the sediment and water columns of the lake.
 - (7) Implement and evaluate a program to demonstrate the feasibility of recreating a marsh along the lake-shoreline using muck dredged from the lake bottom, and
 - (8) From funds appropriated by this act, expend up to \$100,000 to contract for a feasibility study on the recycling of muck from Lake Apopka.

The St. Johns River Water Management District shall provide the staff for the Lake Apopka Restoration Council while engaged in carrying out the provisions of this act.

- Section 6. There is hereby appropriated to the Department of Environmental Regulation for the St. Johns River Water Management District the following sums of money for fiscal year 1985-1986 to carry out the provisions of this act:
 - (1) The sum of \$765,000 for fiscal year 1985-1986 from the water Resources Restoration and Preservation Trust Fund within the Department of Environmental Regulation to implement the provisions outlined in subsections (1) through (5) of section 5.

- (2) The sum of \$1.5 million for fiscal year 1985-1986 from the Aquatic Plant Control Trust Fund within the Department of Natural Resources to implement the provisions outlined in subsection (6) of section 5.
- Section 7. It is the intent of the Legislature that the St. Johns River Water Management District shall, through competitive bid, award contracts to implement the provisions of this act.

Section 8. This act shall take effect July 1, 1985 or upon becoming a law, whichever occurs later.

Approved by the Governor June 17, 1985.

Filed in Office Secretary of State June 17, 1985.

CHAPTER 87-97

Committee Substitute for House Bill No. 1350

An act relating to natural resources; creating the "Surface Water Improvement and Management Act"; providing legislative findings and intent; providing for the developing of lists of prioritized water bodies of regional or statewide significance and for the design and implementation of surface water improvement and management plans and programs by the state's five regional water management districts; providing for participation by state agencies, local governments, and advisory committees; providing for the review of surface water improvement and management plans by certain state agencies and for the review of agency rules; providing for the implementation of surface water improvement and management plans and programs and making funds available; providing for the creation within the Department of Environmental Regulation of the Surface Water Improvement and Management Trust Fund and providing procedures for the administration of the Trust Fund; providing for a program to protect the water quality of Lake Okeechobee: creating the Lake Okeechobee Technical Advisory Council; Providing for limitations on the diversion of specified waters; establishing a program for the improvement and management of the Lower St. Johns River; creating the Duval County Water Quality Council; establishing areas of jurisdiction and creating an approval process; amending section 5 of chapter 85-148. Laws of Florida: providing tasks for the pilot project for Lake Apopka; amending section 7 of chapter 85-148, Laws of Florida; providing for competition among contractors for projects; directing the Department of Environmental Regulation to conduct a study to evaluate the existing classification systems for waters of the state; amending s. 373.503, F.S.; removing certain restrictions on the use of millage levied by the St. Johns Water Management District; changing the distribution of certain taxes for district and basin purposes; amending ss. 161.021, 161.041, 161.053, 161.054, 161.091, 161.101, 161.141, 161.161, 373.026, F.S.; providing definitions; prohibiting the Department of Natural Resources from issuing permits for certain construction or excavation except in specified circumstances; establishing criteria for local coastal construction zoning and building codes; providing for permits when liens are imposed on the property; establishing property rights of the state; renaming the Erosion.Control Trust Fund; authorizing the department to use funds from the Beach Management Trust Fund to pay certain costs of specified beach management projects; providing procedures for approval of projects; providing for powers and duties of the Department of Environmental Regulation; providing for a report on public access to sandy beaches; making funds available from the State Infrastructure Trust Fund; providing an effective date.

Be It Enacted by the Legislature of the State of Florida:

Section 1. Short title; legislative findings and intent.—

- (1) Sections 1 through 6 of this act may be cited as the "Surface Water Improvement and Management Act."
- (2) Legislative intent.—The Legislature finds that the water quality of many of the surface waters of the state has been degraded, or is in danger of becoming degraded, and that the natural systems associated with many surface waters have been altered so that these surface waters no longer perform the important functions that they once performed. These functions include:

- (a) Providing aesthetic and recreational pleasure for the people of the state;
- (b) Providing habitat for native plants, fish, and wildlife, including endangered and threatened species;
- (c) Providing safe drinking water to the growing population of the state; and
- (d) Attracting visitors and accruing other economic benefits.
- (3) The Legislature finds that the declining quality of the state's surface waters has been detrimental to the public's right to enjoy these surface waters and that it is the duty of the state, through the state's agencies and subdivisions, to enhance the environmental and scenic value of surface waters.
- (4) The Legislature finds that factors contributing to the decline in the ecological, aesthetic, recreational, and economic value of the state's surface waters include:
 - (a) Point and nonpoint source pollution; and
 - (b) Destruction of the natural systems which purify surface waters and provide habitats.
- (5) The Legislature finds that surface water problems can be corrected and prevented through plans and programs for surface water improvement and management that are designed and implemented by the regional water management districts, with the participation and cooperation of the state's agencies and local governments.
- (6) It is therefore the intent of the Legislature that each water management district design and implement plans and programs for the improvement and management of surface waters.
- (7) It is also the intent of the Legislature that statewide research be conducted to provide a better scientific understanding of the causes and effects of surface water pollution and of the destruction of natural systems in order to improve and manage surface waters and associated natural systems.

Section 2. Surface water improvement and management plans and programs.

(1) Each water management district, in cooperation with the Department of Environmental Regulation, the Game and Fresh Water Fish Commission, and the Department of Natural Resources, shall prepare a list, by March 1, 1988, which shall prioritize water bodies of regional or statewide significance within each water management district. The list shall be based on criteria adopted by rule of the Department of Environmental Regulation and shall assign priorities to the water bodies based their need for protection and restoration. Criteria developed by the Department of Environmental Regulation shall include, but need not be limited to, consideration of violations of water quality standards occurring in the water body, the amounts of nutrients entering the water body and the water body's trophic state, the existence of or need for a continuous aquatic weed control program in the water body, the biological condition of the lake, reduced fish and wildlife values, and threats to agricultural and urban water supplies and recreational opportunities. The sum of \$500,000 shall be available from the Surface Water Improvement and Management Trust Fund to the Department of Environmental Regulation for fiscal year 1987-1988 to be used cooperatively by the department and the water management districts to identify and prioritize water bodies within the district that are of regional and statewide significance and in need of restoration. In developing their respective priority lists, water management districts shall give consideration to the following priority areas:

- (a) The South Florida Water Management District shall give priority to the restoration needs of Lake Okeechobee, Biscayne Bay, and the Indian River Lagoon system and their tributaries.
- (b) The Southwest Florida Water Management District shall give priority to the restoration needs of Tampa Bay and its tributaries.
- (c) The St. Johns River Water Management District shall give priority to the restoration needs of Lake Apopka, the Lower St. Johns River, and the Indian River Lagoon system and their tributaries.
- (2) Once the priority lists are established, the water management districts, in cooperation with the Department of Environmental Regulation, the Game and Fresh Water Fish Commission, the Department of Natural Resources, and local governments, shall develop surface water improvement and management plans for the water bodies based on the priority lists approved by the Department of Environmental Regulation. Each plan shall include a schedule established by the water management district and agreed to by the Department of Environmental Regulation for restoring water bodies on the priority list. These plans shall also enumerate preventive measures which need to be taken to augment surface water improvement and management efforts. The Department of Environmental Regulation shall establish a uniform format for such plans. The plans shall be reviewed and, if necessary revised annually by the water management districts. These plans shall include, but not be limited to:
 - (a) A description of the water body system, its historical and current uses, its hydrology, and a history of the conditions which have led to the need for restoration;
 - (b) An identification of all governmental units that have jurisdiction over the water body and the land within a 1-mile perimeter of the water body, including local, regional, state, and federal units;
 - (c) A description of adjacent land uses and those of important tributaries, point and nonpoint sources of pollution, and permitted discharge activities;
 - (d) A list of the owners of point and nonpoint sources of water pollution that are discharged into each water body and tributary thereto and that adversely affect the public interest, including separate lists of those sources that are:
 - 1. Operating without a permit;
 - 2. Operating with a temporary operating permit; and
 - 3. Presently violating effluent limits or water quality standards.

The plan shall also include a timetable for bringing all sources into compliance with state standards when not contrary to the public interest. This paragraph does not authorize any existing or future violation of any applicable statute or regulation and does not diminish the authority of the Department of Environmental Regulation;

- (e) A description of strategies and potential strategies for restoring the water body to Class III or better;
- (f) A listing of studies that are being or have been prepared for the surface water body;
- (g) A description of the research and feasibility studies which will be performed to determine the particular strategy or strategies to restore the water body;
- (h) A description of the measures needed to manage and maintain the water body once it has been restored and to prevent future degradation; and
- (i) An estimate of the funding needed to carry out the restoration strategies.
- (3) Each water management district shall be responsible for planning, implementing, and coordinating restoration strategies for the priority water bodies within the district which have been approved by the Department of Environmental Regulation as water bodies of regional and statewide significance in need of restoration. The governing board of the appropriate water management district shall hold at least one public hearing and public workshops in the vicinity of the water body under consideration as may be necessary for obtaining public input prior to finalizing the surface water improvement and management plans for the water bodies on the priority list. The water management district shall then forward a copy of the plans to the Department of Environmental Regulation and to appropriate local governmental units. By September of 1988 and each September thereafter, the water management districts, in cooperation with the Department of Environmental Regulation, shall develop a funding proposal for the next fiscal year's water restoration activities for priority water bodies which specifies the activities that need funding and the amounts of funding and. fully describes the specific restoration activities proposed.
- (4) The governing board of each water management district is encouraged to appoint advisory committees as necessary to assist in formulating and evaluating strategies for water body protection and restoration activities and to increase public awareness and intergovernmental cooperation. Such committees should include representatives of the Game and Fresh Water Fish Commission, the Department of Natural Resources, the Department of Agriculture and Consumer Services, appropriate local governments, federal agencies, existing advisory councils for the subject water body, and representatives of the public who use the water body.
- (5) The water management districts may contract with appropriate state, local, and regional agencies to perform various tasks associated with implementation of the surface water improvement and management plans.

Section 3. Review of surface water improvement and management plans.

(1) At least 30 days prior to any public hearing on its surface water improvement and management plan, a water management district shall transmit its proposed plan to the Department of Environmental Regulation, the Game and Fresh Water Fish Commission, the Department of Agriculture and Consumer Services, and the Department of Natural Resources and shall transmit a summary of the proposed plan to affected counties and municipalities. A copy of the proposed plan shall be provided to any affected county or municipality upon request.

- (2) The Department of Environmental Regulation shall review each proposed surface water improvement and management plan for the purpose of determining:
 - (a) Whether the costs described in the plan, as projected by the water management districts, are reasonable estimates of the actual costs of the programs in the plan;
 - (b) The likelihood of the programs in the plan resulting in significant improvements in water quality in the priority surface waters designated in the plan; and
 - (c) The combination of programs which can be funded based on available revenues within the Surface Water Improvement and management Trust Fund. If the department determines that a plan or program does not meet these requirements, that the projected costs are not reasonable estimates of the actual costs of the programs in the plan, or that a program in the plan is not likely to result in significant water improvements in the priority surface water, the department shall recommend modifications of or additions to the plan, or a program thereof, to the district at the district's public hearing on the proposed plan.
- (3) The Game and Fresh Water Fish Commission shall review each proposed surface water improvement and management plan for the purpose of determining the effects of the plan on wild animal life and freshwater aquatic life and their habitats. If the commission determines that the plan, or a program thereof, has adverse effects on these resources, and that such adverse effects exceed the beneficial effects on these resources, the commission shall recommend modifications of or additions to the plan, or a program thereof, to the district at the district's public hearing on the proposed plan. The commission shall also recommend to the district at the district's public hearing on the proposed plan any modification or addition to the plan, or a program thereof, which would result in additional beneficial effects on wild animal life or freshwater aquatic life or their habitats.
- (4) The Department of Natural Resources shall review each proposed surface water improvement and management plan for the purpose of determining the effects of the plan on state-owned lands and on marine and estuarine aquatic life and their habitats. If the department determines that the plan, or a program thereof, has adverse effects on these resources, and that such adverse effects exceed the beneficial effects on these resources, the department shall recommend modifications of or additions to the plan, or a program thereof, to the district at the district's public hearing on the proposed plan. The department shall also recommend modifications of or additions to the plan, or a program thereof, to the district at the district of or additions to the plan, or a program thereof, to the district at the district of or additions to the plan, or a program thereof, to the district at the district of or additions to the plan.
- (5) The Department of Agriculture and Consumer Services shall review each proposed surface water improvement and management plan for the purpose of determining the effects of the plan on the agricultural resources of the area and the state. If the department determines that the plan, or a program thereof, has adverse effects on these resources, and that such adverse effects exceed the beneficial effects on these resources, the department shall recommend modifications of or additions to the plan, or a program thereof, to the district at the district's public hearing on the proposed plan. The department shall also recommend modifications of or additions to the plan, or a program thereof, to the district is public hearing on the proposed plan.

(6) The water management districts, the Department of Environmental Regulation, the Department of Transportation, the Department of Natural Resources, and the Department of Health and Rehabilitative Services shall review their rules as they pertain to pollution of surface waters to determine where such rules could be strengthened to protect surface waters. The agencies shall also review their- enforcement programs for weaknesses in pursuing violations which result in surface water pollution. By March 1, 1988, the agencies shall report to the Governor, the Speaker of the House of Representatives, the President of the Senate, and the minority leaders of the House of Representatives and the Senate, and their findings and recommendations for remedies.

Section 4. Implementation of surface water improvement and management plans and programs.

- (1) The funds in the Surface Water Improvement and Management Trust Fund shall be available to the water management districts for detailed planning for and implementation of surface water improvement and management plans. However, sections 1-6 of this act do not prohibit a water management district from requesting and receiving funds from the Surface Water Improvement and Management Trust Fund prior to March 1, 1988, for surface water improvement and management activities.
- (2) In developing implementing programs for their surface water improvement and management plans, the water management districts shall consider the following program recommendations for the use of funds for fiscal year 1987-1988 in the priority areas identified in Section 2 of this act:
 - (a) The sum of \$4,800,000 shall be available for the South Florida Water Management District for Lake Okeechobee.
 - (b) The sum of \$2,000,000 shall be available for the South Florida Water Management District for Biscayne Bay, of which up to \$500000 is recommended to clean up the Miami River. The remainder of the funds available are recommended for retrofitting the 55 stormwater outfalls already identified by the Environmental Resources Management Department of Metro-Dade County as posing the greatest threat to the Biscayne Bay area or for other projects or activities that will contribute to the restoration of Biscayne Bay.
 - (c) The sum of \$1,500,000 shall be available for the Indian River Lagoon System, of which up to \$178,000 is recommended for the Marine Resource Council. For the funds made available for this area and recommended to be used, 70 percent shall be available for programs of the St. Johns River Water Management District and 30 percent shall be available for programs of the South Florida Water Management District. The secretary of the Department of Environmental Regulation shall settle any dispute between the two districts relating to funding allocations.
 - (d) The sum of \$2,000,000 shall be available for the Southwest Florida Water Management District for Tampa Bay and its estuaries, of which up to \$850,000 is recommended for a water quality assessment and scientific information compilation.
 - (e) The sum of \$2,200,000 shall be available for the St. Johns River Water Management District for Lake Apopka.

(f) The sum of \$2,500,000 shall be available for the St. Johns River Water Management District for the Lower St. Johns River, of which up to \$1,000,000 is recommended for stormwater cleanup based on Duval County's providing equal matching funds.

The amounts set forth in this subsection for the priority areas that are unencumbered at the end of fiscal year 1987-1988 shall remain in the Surface Water Improvement and Management Trust Fund and be available for the water bodies previously assigned.

- (3) Each water management district shall prepare detailed plans for and shall implement the programs in its surface water improvement and management plan upon the release of funds by the Department of Environmental Regulation.
- (4) Each water management district shall update annually, as necessary, its approved surface water improvement and management plan. If a district determines that modifications of or additions to its plan are necessary, such modifications or additions shall be subject to the review process established in section 3 of this act.

Section 5. Surface Water Improvement and Management Trust Fund.

- (1) There is created, within the Department of Environmental Regulation, the Surface Water Improvement and Management Trust Fund to be used as a nonlapsing fund for the deposit of funds appropriated by the Legislature for the purposes of sections 1-6 of this act. The department shall administer all funds appropriated to or received for the Surface Water Improvement and Management Trust Fund. The moneys in the Surface Water Improvement and Management Trust Fund are continually appropriated for the purposes of sections 1-6 of this act. Expenditure of the moneys shall be limited to the costs of detailed planning for and implementation of programs prepared for priority surface waters. Moneys from the fund shall not be expended for planning for, or construction or expansion of, treatment facilities for domestic or industrial waste disposal.
- (2) The secretary of the Department of Environmental Regulation shall authorize the release of money from the Surface Water Improvement and Management Trust Fund within 30 days after receipt of a resolution adopted by the governing board of a water management district certifying that the money is needed for detailed planning for or implementation of programs approved pursuant to section 2 of this act. Beginning with the state fiscal year 1988-1989 and annually thereafter, a water management district may not receive more than 30 percent of the moneys in the Surface Water Improvement and Management Trust Fund in any fiscal year unless otherwise provided by law.
- (3) The amount of money that may be released to a water management district from the Surface Water Improvement and Management Trust Fund for approved programs, or continuations of approved programs, to improve and manage the surface waters described in sections 1-6 of this act is limited to not more than 80 percent of the amount of money necessary for the approved programs. The district shall provide at least 20 percent of the amount of money necessary for the programs.
- (4) Moneys in the trust fund, which are not needed to meet current obligations incurred under this section shall be transferred to the State Board of Administration, to the credit of the trust fund,

to be invested in the manner provided by law. Interest received on such investments shall be credited to the trust fund.

Section 6. Lake Okeechobee improvement and management.

- (1) LAKE OKEECHOBEE PROGRAM.—The South Florida Water Management District shall immediately design and implement a program to protect the water quality of Lake Okeechobee. Such program shall be based upon the recommendations of the Lake Okeechobee Technical Advisory Committee report entitled "Final Report: Lake Okeechobee Technical Committee" and dated August 1986, including the recommendations relating to the diversion of Taylor Creek-Nubbins Slough, but such program may include other projects. In addition, the program design shall be completed by December 1, 1988, and shall be designed to result, by July 1, 1992, in reductions of phosphorous loadings to the lake by the amount specified as excess in the South Florida Water Management District's Technical Publication 81-2.
- (2) DIVERSIONS; LAKE OKEECHOBEE TECHNICAL ADVISORY COUNCIL.-
 - (a) The Legislature finds that efforts to reduce nutrient levels in Lake Okeechobee have resulted in diversions of nutrient-laden waters to other environmentally sensitive areas, which diversions have resulted in adverse environmental effects. The Legislature also finds that both the agriculture industry and the environmental community are committed to protecting Lake Okeechobee and these environmentally sensitive areas from further harm and that this crisis must be addressed immediately. Therefore:
 - 1. The South Florida Water Management District shall not divert waters to the Indian Riverestuary, the Caloosahatchee River or its estuary, or the Everglades National Park, in such a way that the state water quality standards are violated, that the nutrients in such diverted waters adversely affect indigenous vegetation communities or wildlife, or that fresh waters diverted to the Caloosahatchee or Indian River estuaries adversely affect the estuarine vegetation or wildlife, unless the receiving waters will biologically benefit by the diversion. However, diversion is permitted when an emergency is declared by the water management district, if the secretary of the Department of Environmental Regulation concurs.
 - 2. The South Florida Water Management district may divert waters to other areas, including Lake Hicpochee, unless otherwise provided by law. However, the district shall monitor the effects of such diversions to determine the extent of adverse or positive environmental effects on indigenous vegetation and wildlife. The results of the monitoring shall be reported to the Lake Okeechobee Technical Advisory Council. If the monitoring of such diversions reveals continuing adverse environmental effects, the district shall make recommendations to the Legislature by July 1, 1988, on how to cease the diversions.
 - (b) l. There is hereby created a Lake Okeechobee Technical Advisory Council. Council members shall be experts in the fields of botany, wildlife biology, aquatic biology, water quality chemistry, or hydrology and shall consist of:
 - a. Three members appointed by the Governor;

- b. Three members appointed by the Speaker of the House of Representatives;
- c. Three members appointed by the President of the Senate;
- d. One member from the Institute of Food and Agricultural Sciences, University of Florida, appointed by the President of the University of Florida; and
- e. One member from the College of Natural Sciences, University of South Florida, appointed by the President of the University of South Florida.

Members shall be appointed not later than July 15, 1987.

- 2. The purpose of the council shall be to investigate the adverse effects of past diversions of water and potential effects of future diversions on indigenous wildlife and vegetation and to report to the Legislature, no later than March 1, 1988, with findings and recommendations proposing permanent solutions to eliminate such adverse effects.
- 3. The South Florida Water Management District shall provide staff and assistance to the council. The Department of Environmental Regulation, the Game and Fresh Water Fish Commission, and the district shall cooperate with the council.
- 4. The council shall meet not less than once every 2 months at the call of the chairman, or at the call of four other members of the council. The council shall elect from its members a chairman and vice chairman and such other officers. as the council deems necessary. The council may establish other procedures for the conduct of its business.
- 5. The members of the council are not entitled to compensation but are eligible for per diem and travel expenses pursuant to s. 112.061, Florida Statutes.

Section 7. Section 5 of chapter 85-148, Laws of Florida, is amended to read:

- Section 5. The St. Johns River Water Management District governing board shall specify tasks which are to be undertaken by the district, the Department of Environmental Regulation, pertinent local governments, and the Game and Fresh Water Fish Commission in order to initiate the pilot project for Lake Apopka. The governing board shall:
 - (1) Conduct extensive water sampling of the lake and its associated tributaries to determine the existing water quality and to determine the long term effects of nutrient loading from agricultural activities.
 - (2) Evaluate the restoration of a portion of floodplain marsh between Lake Apopka and the Apopka-Beauclair Lock by allowing sheet-flow of waters prior to their entrance to the Apopka-Beauclair Canal.
 - (3) Develop a nutrient budget for the lake to ensure that appropriate regulatory efforts are instituted with respect to nutrient loading.
 - (4) Examine techniques which may be used to modify the existing physical and biological characteristics of the lake.

- (5) Conduct a feasibility study to determine the effects of diking-off and restoring the littoral zone of the lake to enhance sportfish production.
- (6) Implement and evaluate a program to demonstrate the feasibility of utilizing water hyacinths to extract excessive nitrogen and phosphorous phosphorus from the sediment and water columns of the lake.
- (7) Implement and evaluate a program to demonstrate the feasibility of recreating a marsh along the lake shoreline using muck dredged from the lake bottom.
- (8) From funds appropriated by this act, expend up to \$100,000 to contract for a feasibility study on the recycling of muck from Lake Apopka.
- (9) Conduct a study to determine the feasibility of using ichthyofauna reconstruction as a lake restoration method.

These tasks and other related pilot studies may be conducted in water bodies other than Lake Apopka if the St. Johns River Water Management District determines it would be scientifically and technically acceptable and economically advantageous. The St. Johns River Water Management District shall assign a staff person to act as the executive director of the Lake Apopka Restoration Council and provide reasonable staff support for the provide the staff for the Lake Apopka Restoration Council while engaged in carrying out the provisions of this act.

Section 8. Section 7 of chapter 85-148, Laws of Florida, is amended to read:

- Section 7. It is the intent of the Legislature that the St. Johns River Water Management District shall <u>encourage competition among contractors for projects</u>, through competitive bid, award contracts to implement the provisions of this act. <u>Accordingly</u>, the district shall be governed by its laws and <u>policies for selecting contractors for scientific and technical research projects</u>.
- Section 9. The Department of Environmental Regulation shall conduct a study and make a report evaluating the current surface water classification system. The report shall include a review of the relationship of this classification system to the classification system used for shellfish harvesting waters and specifically consider whether the classifications applied to artificially created or significantly altered water bodies are appropriate; provided, however, that consideration shall also be given to the impacts of artificially created or significantly altered water bodies on other water bodies that have fish and wildlife values. However, artificially created or significantly altered water bodies to be considered for reclassification in the report shall not include those water bodies that are:
 - (1) Determined to have viable or high potential for viable fish and wildlife populations;
 - (2) Located in high groundwater recharge areas; or
 - (3) Determined to have high recreational usage.

Prior to initiating the study, the department shall publish notice and invite participation from local governments, affected interest groups, and other state and federal agencies. The report shall be submitted

to the Governor, the Speaker of the House of Representatives, and the President of the Senate no later than March 1, 1989. In addition, the department shall notify the Governor, the Speaker of the House of Representatives, and the President of the Senate by January 15, 1988, of the data needed to adopt and implement rules establishing limits for discharges of nitrogen and phosphorous into the waters of the state and the costs of obtaining the data.

Section 10. Subsection (3) of section 373.503, Florida Statutes, is amended to read: 373.503 Manner of taxation.

- (3)(a) The districts may levy ad valorem taxes on property within the district solely for the purposes of this chapter and of chapter 25270, Laws of Florida, 1949, as amended, and chapter 61-691, Laws of Florida, as amended. The authority to levy ad valorem taxes as provided in this act shall commence with the year 1977. However, the taxes levied for 1977 by the governing boards pursuant to this section shall be prorated to ensure that no such taxes will be levied for the first 4 days of the tax year, which days will fall prior to the effective date of the amendment to s. 9(b), Art. VII of the Constitution of the State of Florida, which was approved March 9, 1976. When appropriate, taxes levied by each governing board may be separated by the governing board into a millage necessary for the purposes of the district and a millage necessary for financing basin functions specified in s. 373.0695. Beginning with the taxing year 1977, and not withstanding the provisions of any other general or special law to the contrary, the maximum total millage rate for district and basin purposes shall be:
 - 1. Northwest Florida Water Management District: 0.05 mill.
 - 2. Suwannee River Water Management District: 0.75 mill.
 - 3. St. Johns River Water Management District: 0.6 0.375 mill, plus an additional .225 mill which may be used only for land acquisition and capital projects associated with such acquisition.
 - 4. Southwest Florida Water Management District: 1.0 mill.
 - 5. South Florida Water Management District: 0.80 mill.
 - (b) The maximum millage assessed for district purposes shall not exceed 25 percent of the total authorized millage when there are one or more basins in a district, and the maximum millage assessed for basin purposes shall not exceed 75 percent of the total authorized millage, except that:
 - 1. The apportionment in the South Florida Water Management District St. Johns River Water Management District shall be a maximum of 40 15 percent for district purposes and a maximum of 60 85 percent for basin purposes, respectively.
 - 2. Within the Southwest Florida Water Management District, the maximum millage assessed for district purposes shall not exceed 40 percent of the total authorized millage when there are one or-more basins in the district, and the maximum millage assessed for basin purposes shall not exceed 60 70 percent of the total authorized millage.

Continued...

- Section 23. Beginning in fiscal year 1988-1989 and annually thereafter at least \$35 million shall be available from the State Infrastructure Trust Fund for the purposes provided in s. 161.091(l), Florida Statutes.
- Section 24. This act shall take effect July 1, 1987, or upon becoming a law, whichever occurs later.

Approved by the Governor June 29, 1987.

Filed in Office Secretary of State June 29, 1987.

CHAPTER 96-207

Committee Substitute for Senate Bill No. 2954

An act relating to Lake Apopka restoration; creating s. 373.461, F.S.; providing findings and legislative intent: providing that it is the intent of the Legislature to enhance and accelerate the restoration process begun by previous acts of the Legislature relating to the restoration of the Lake Apopka basin; providing that acquisition of agricultural lands impacting Lake Apopka would serve the public interest; providing intent regarding the development of a process to limit the discharge of phosphorus into the lake and the cost-sharing of such a process; providing definitions; providing for the construction of stormwater-management facilities; providing for cost-sharing by the state, the St. Johns River Water Management District, and the Zellwood Drainage and Water Control District; providing for the responsibilities of the St. Johns River Water Management District and the Zellwood Drainage and Water Control District; granting the St. Johns River Water Management District the power of eminent domain over certain specified lands; providing for the purchase of certain lands under certain conditions; providing that certain existing consent or settlement agreements are not affected and will remain in effect; providing that existing water-quality standards are not altered; providing an appropriation; providing an effective date.

Be It Enacted by the Legislature of the State of Florida:

Section 1. Section 373.461, Florida Statutes, is created to read:

373.461 Lake Apopka Improvement and Management.

- (1) FINDINGS AND INTENT.—
 - (a) The Legislature has expressed its intent that economically and technically feasible methods be developed to restore the Lake Apopka basin through the Lake Apopka Restoration Act and the Surface Water Improvement and Management Act. It is the Legislature's intent to enhance and accelerate the restoration process begun by those previous acts of the Legislature.
 - (b) Technical studies have determined that substantial reductions in or elimination of phosphorus in farm discharges to Lake Apopka will be necessary in order to improve water quality and restore the lake to Class III standards.
 - (c) Acquisition of the lands in agricultural production which discharge phosphorus to Lake Apopka, and their related facilities, would serve the public interest by eliminating the impacts of introduction of phosphorus from these sources into the lake. It is the Legislature's intent that a fair and equitable program of acquisition of the lands necessary to achieve the purposes of this section be implemented.
 - (d) The Legislature finds that time is of the essence and that a complete purchase of properties described in this section should be accomplished in an accelerated and economical manner.

- (e) If funds cannot be identified for acquisition of these agricultural lands, it is the Legislature's intent to provide a process for development of phosphorus-discharge limitations that will bring such discharges into compliance with state water-quality standards and to provide for interim phosphorus abatement measures designed to further reduce phosphorus discharges from the Zellwood Drainage and Water Control District, which is the largest agricultural entity within the Lake Apopka Basin. The Legislature finds that it is in the public interest to jointly share in the cost of implementing such interim phosphorus reduction measures with Zellwood.
- (f) A. Duda and Sons, Inc., has implemented phosphorus treatment and has worked cooperatively with the district to meet applicable water-quality standards. An existing settlement agreement outlines treatment measures that should satisfy all discharge limitations and criteria.
- (2) DEFINITIONS.-As used in this section:
 - (a) "District" means the St. Johns River Water Management District.
 - (b) "Phosphorus criterion" means a numeric interpretation for phosphorus of the Class III narrative nutrient criterion.
 - (c) "Stormwater management system" has the meaning set forth in s. 373.403(10).
 - (d) "Zellwood" means the Zellwood Drainage and Water Control District as it is described in chapter 20715, Laws of Florida.
- (3) PHOSPHORUS CRITERION AND DISCHARGE LIMITATIONS FOR LAKE APOPKA.
 - (a) The district shall, no later than September 30, 1996, file a notice of rulemaking in the Florida Administrative Weekly to establish a phosphorus criterion for Lake Apopka.
 - (b) In the event the district does not adopt a rule establishing a phosphorus criterion for Lake Apopka by January 1997, the phosphorus criterion for the lake shall be 55 parts per billion (ppb).
 - (c) The district shall adopt by rule discharge limitations for all permits issued by the district for discharges into Lake Apopka, the Lake Level Canal, and the McDonald Canal.
- (4) CONSTRUCTION OF STORMWATER-MANAGEMENT SYSTEMS.
 - (a) It is the intent of the Legislature that in the event no funding mechanisms to purchase all the lands within Zellwood are in place by July 1, 1997, construction of stormwater-management facilities to store, treat, and recycle Zellwood's agricultural stormwater runoff will be necessary during the interim period while discharge limitations are being established for Lake Apopka. The Legislature finds that it is in the public interest for state, regional, and local revenue sources to be used along with Zellwood's revenue sources to finance the costs of acquiring land and constructing such facilities. One-third of the cost of the facilities shall be contributed by Zellwood, one-third by the state, and one-third by the district.

- (b) Consistent with the funding formula outlined in paragraph (a), the state will provide up to \$2 million, with the same amount being committed by both Zellwood and the district, for a total of \$6 million. These funds shall be used for the purpose of acquiring the necessary land for and constructing a stormwater-management facility, not to exceed 600 acres in total size, for Zellwood's farm runoff, together with the necessary pumps and other infrastructure associated with such facilities, provided that Zellwood's contribution shall be used for project purposes other than acquiring land.
- (c) The district shall be responsible for design of the facilities and for acquiring any necessary interest in land for the facilities. Zellwood will be responsible for construction of the facilities in accordance with the district's design. The district will administer the funds provided for under this section. No later than September 30, 1997, the district and Zellwood will develop an agreement regarding dispersal of funds for construction of the facilities which shall take into account the financing mechanisms available to the parties. Zellwood shall not be required to assess more than \$25 per acre per year in financing its share of the stormwater management facility. However, it must provide its one-third share of the funding within the timeframes outlined for construction of the stormwater construction facility outlined in this section.
- (d) Construction of the stormwater retention and treatment facilities provided for in this section shall begin within 90 days after acquisition of interests in land necessary for the facilities and completed, within 1 year thereafter. After completion of the facilities, Zellwood shall be responsible for operation and maintenance so long as the facilities are used by Zellwood.
- (e) The district may, as appropriate, alter or modify the design of the facility to reduce the cost of the acquisition and construction of the facility if lands presently in production within Zellwood are acquired pursuant to subsection (5) before construction of the facility. The district shall have the flexibility to adjust these dates due to any unforseen circumstances such as, and not limited to, acts of God, delays due to litigation by outside parties, or unnecessary or unforseen permitting or construction delays.
- (f) The district and Zellwood hall give preferential consideration to the hiring of agricultural workers displaced as a result of the Lake Apopka Restoration Act, consistent with their qualifications and abilities, for the construction and operation of the stormwater facility.

(5) PURCHASE OF AGRICULTURAL LANDS.

- (a) The Legislature finds that it is in the public interest of the state to acquire lands in agricultural production, along with their related facilities, which contribute, directly or indirectly, to phosphorus discharges to Lake Apopka, for the purpose of improving water quality in Lake Apopka. These lands consist of those farming entities on Lake Apopka having consent and settlement agreements with the district and those sand land farms discharging indirectly to Lake Apopka through Lake Level Canal, Apopka-Beauclair Canal, or McDonald Canal. The district is granted the power of eminent domain on those properties.
- (b) In determining the fair market value of lands to be purchased from willing sellers, all appraisals of such lands may consider income from the use of the property for farming and, for this purpose, such income shall be deemed. attributable to the real estate.

- (c) The district shall explore the availability of funding from all sources, including any federal, state, regional, and local land acquisition funding programs, to purchase the agricultural lands described in paragraph (a). It is the Legislature's intent that, if such funding sources can be identified, acquisition of the lands described in paragraph (a) may be undertaken by the district to purchase these properties from willing sellers.
- (d) In connection with successful acquisition of any of the lands described in this section which are not needed for stormwater-management facilities, the district shall give the seller the option to lease the land for a period not to exceed 5 years, at a fair market lease value for similar agricultural lands. Proceeds derived from such leases shall be used to offset the cost of acquiring the land.
- (e) If the lands within Zellwood are purchased in accordance with this section prior to expiration of the consent agreement between Zellwood and the district, Zellwood shall be reimbursed for any costs described in subsection (4).
- (6) EXISTING CONSENT OR SETTLEMENT AGREEMENTS PRESERVED.-Except to the extent specifically modified in this section, the district's existing consent or settlement agreements with A. Duda and Sons, Inc., and Zellwood, including requirements regarding compliance with any discharge limitations established for Lake Apopka, shall remain in effect.
- (7) APPLICABILITY OF LAWS AND WATER-QUALITY STANDARDS; AUTHORITY OF DISTRICT AND DEPARTMENT.
 - (a) Except as otherwise provided in this section, nothing in this section shall be construed:
 - 1. As altering any applicable state water-quality standards, laws, or district or department rules; or
 - 2. To restrict the authority otherwise granted the department and the district pursuant to this chapter or chapter 403. The provisions of this section shall be deemed supplemental to the authority granted pursuant to this chapter and chapter 403.
- Section 2. As provided in the General Appropriations Act for fiscal year 1996-1997, only, there is appropriated from funds deposited in the Conservation and Recreation Lands Trust Fund the sum of \$12 million to the St. Johns River Water Management District, to be used for the purpose of purchasing lands described in section 373.461(6)(a), Florida Statutes. In addition, the St. Johns River Water Management District is directed to use \$8 million from its share of funds from the Water Management Lands Trust Fund or from funds derived from revenue bonds using Water Management Lands Trust Fund revenues as the revenue source for the purpose of purchasing lands described in section 373.461(5)(a), Florida Statutes.

Section 3. This act shall take effect July 1, 1996.

Approved by the Governor May 24, 1996.

Filed in Office Secretary of State May 24, 1996.

St. Johns River Water Management District 216

CHAPTER 97-81

Committee Substitute for Senate Bill No. 1486

An act relating to community redevelopment; authorizing the Office of Tourism, Trade, and Economic Development to amend the boundaries of certain enterprise zones: providing restrictions; providing for repeal; amending s. 373.461, F.S., relating to Lake Apopka improvement and management; providing legislative intent that interim phosphorus abatement measures be provided and stormwater management facilities be constructed unless specified time requirements for land purchase are met; revising provisions relating to commencement of construction of stormwater facilities; providing a maximum purchase price for certain agricultural lands; providing for sale of certain tangible personal property and for use of the proceeds of such sale; authorizing the Office of Tourism, Trade, and Economic Development to expend such funds; providing for use of an appropriation made by ch. 96-207, Laws of Florida; creating s. 290.0067, F.S.; authorizing Orange County and Apopka to apply for designation of an enterprise zone in areas suffering adverse impacts due to governmental acquisition of Lake Apopka farmlands; authorizing the Office of Tourism, Trade, and Economic Development to designate such zone and providing a termination date; authorizing the Office of Tourism, Trade, and Economic Development to amend the boundaries of certain areas; providing for severability; providing an effective date.

Be It Enacted by the Legislature of the State of Florida:

- Section 1. Notwithstanding any other provision of law, prior to June 30, 1998, the Office of Tourism, Trade, and Economic Development may amend the boundaries of an area designated as an enterprise zone in a community having a Population of 7,500 persons or more but less than 20,000, so long as the area does not increase the overall size of the zone. The amendment must also be consistent with the limitations imposed by section 290.0055, Florida Statutes, upon establishment of the enterprise zone.
- Section 2. (1) The Office of Tourism, Trade, and Economic development may, no later than June 30, 1998, modify the boundaries of any enterprise zone that is located within an inland county having a population greater than 500,000, to allow for the expansion of one noncontiguous area, as long as the area added does not exceed 5 square miles and is consistent with the categories, criteria, and limitations imposed by this section and section 290.0055, Florida Statutes, upon the establishment of such an enterprise zone.

(2) This section is repealed July 1, 1998.

Section 3. Paragraph (e) of subsection (1), paragraphs (a) and (d) of subsection (4), and paragraphs (c) and (e) of subsection (5) of section 373.461, Florida Statutes, 1996 Supplement, are amended, and paragraphs (f) and (g) are added to subsection (5) of said section, to read:

373.461 Lake Apopka improvement and management.-

(1) FINDINGS AND INTENT.

- (e) If funds cannot be identified for acquisition of these agricultural lands, It is the Legislature's intent to provide a process for development of phosphorus discharge limitations that will bring such discharges into compliance with state water quality standards and to provide for interim phosphorus abatement measures designed to further reduce phosphorus discharges from the Zellwood Drainage and Water Control District, which is the largest agricultural entity within the Lake Apopka Basin, unless both of the timeframes specified in paragraph (4)(a) regarding purchase agreements and completion of purchases are met. The Legislature finds that it is in the public interest to jointly share in the cost of implementing such interim phosphorus reduction measures with Zellwood.
- (4) CONSTRUCTION OF STORMWATER MANAGEMENT SYSTEMS.
 - (a) It is the intent of the Legislature that in the event no funding mechanisms to purchase all the lands within Zellwood are in place by July 1, 1997, construction of stormwater management facilities to store, treat, and recycle Zellwood's agricultural stormwater runoff will be necessary during the interim period while discharge limitations are being established for Lake Apopka, unless both of the following conditions are met:
 - 1. Agreements to purchase all the lands within Zellwood are executed by September 30, 1997, or a later execution deadline established by the United States for such agreements before reallocation of Commodity Credit Corporation funds made available to acquire wetland reserve program conservation easements within the Lake Apopka Partnership Project area; and
 - 2. All such purchases are completed pursuant to the terms of such agreements.

The Legislature finds that it is in the public interest for state, regional, and local revenue sources to be used along with Zellwood's revenue sources to finance the costs of acquiring land and constructing such facilities. One third of the cost of the facilities shall be contributed by Zellwood, one-third by the state, and one-third by the district.

- (d) Construction of the stormwater retention and treatment facilities provided for in this section shall begin within 90 days after acquisition of interests in land necessary for the facilities and the district's delivery of the design of the facilities to Zellwood, and shall be completed within 1 year thereafter. After completion of the facilities, Zellwood shall be responsible for operation and maintenance so long as the facilities are used by Zellwood.
- (5) PURCHASE OF AGRICULTURAL LANDS.-
 - (c) The district shall explore the availability of funding from all sources, including any federal, state, regional, and local land acquisition funding programs, to purchase the agricultural lands described in paragraph (a). It is the Legislature's intent that, if such funding sources can be identified, acquisition of the lands described in paragraph (a) may be undertaken by the district to purchase these properties from willing sellers. However, the purchase price paid for acquisition of such lands that were in active cultivation during 1996 shall not exceed the highest appraisal obtained by the district for these lands from a state-certified general appraiser following the Uniform Standards of Professional Appraisal Practice. This maximum purchase price limitation shall not include, nor be applicable to, that portion of

the purchase price attributable to consideration of income described in Paragraph (b), or that portion attributable to related facilities, or closing costs.

- (e) If all the lands within Zellwood are purchased in accordance with this section prior to expiration of the consent agreement between Zellwood and the district, Zellwood shall be reimbursed for any costs described in subsection (4).
- (f) 1. Tangible personal property acquired by the district as part of related facilities pursuant to this section, and classified as surplus by the district, shall be sold by the Department of Management Services. The Department of Management Services shall deposit the proceeds of such sale in the Economic Development Trust Fund in the Executive Office of the Governor. The proceeds shall be used for the purpose of providing economic and infrastructure development in portions of northwestern Orange County and east central Lake County which will be adversely affected economically due to the acquisition of lands pursuant to this subsection.
 - 2. The Office of Tourism, Trade, and Economic Development shall, upon presentation of the appropriate documentation justifying expenditure of the funds deposited pursuant to this paragraph, pay any obligation for which it has sufficient funds from the proceeds of the sale of tangible personal property and which meets the limitations specified in paragraph (h). The authority of the Office of Tourism, Trade, and Economic Development to expend such funds shall expire 5 years from the effective date of this paragraph. Such expenditures may occur without future appropriation from the Legislature.
 - 3. Funds deposited under this paragraph may not be used for any purpose other than those enumerated in paragraph (h).
- (g)1. The proceeds of sale of tangible personal property authorized by Paragraph (f) shall be distributed as follows: 60 percent to Orange County; 25 percent to the City of Apopka: and 15 percent to Lake County.
 - 2. Such proceeds shall be used to implement the redevelopment plans adopted by the Orange County Board of County Commissioners, Apopka City Commission, and Lake County Board of County Commissioners.
 - 3. Of the total proceeds, the Orange County Board of County Commissioners, Apopka City Commission, and Lake County Board of County Commissioners, may not expend more than:
 - a. Twenty percent for labor force training related to the redevelopment plan
 - b. Thirty-three percent for financial or economic incentives for business location or expansion in the redevelopment area, and
 - c. Four percent for administration, planning, and marketing the redevelopment plan.

- 4. The Orange County Board of County Commissioners, Apopka City Commission, and Lake County Board of County Commissioners must spend those revenues not expended under subparagraph 3. for infrastructure needs necessary for the redevelopment plan.
- Section 4. The \$20 million appropriation in fiscal year 1996-1997 pursuant to chapter 96-207, Laws of Florida, shall be used for the purpose of purchasing lands described in section 373.461(5)(a), Florida Statutes, and their related facilities.

Section 5. Section 290.0067, Florida Statutes, is created to read:

290.0067 Enterprise zone designation for communities impacted by Lake Apopka land acquisition.-Orange County and the municipality of Apopka may Jointly apply to the Office of Tourism, Trade, and Economic Development for designation of one enterprise zone encompassing areas suffering adverse economic impacts due to governmental acquisition of Lake Apopka farmlands pursuant to s. 373.461. The application must be submitted by December 31, 1998, and must comply with the requirements of s. 290.0055, excepts. 290.0055(3). Notwithstanding the provisions of s. 290.0065 limiting the total number of enterprise zones designated and the number of enterprise zones within a population category, the Office of Tourism, Trade, and Economic Development may designate one enterprise zone under this section The Office of Tourism, Trade, and Economic Development shall establish the initial effective date of the enterprise zone designated pursuant to this section based upon when unemployment will occur due to the cessation of farming on lands acquired pursuant to s. 373.461. The zone shall terminate 5 years following the established effective date.

- Section 6. Notwithstanding any other provisions of law, the Office of Tourism, Trade, and Economic Development may mend the boundaries of an area designated as an enterprise zone in a community having a population of 235,000 persons but less than 245,000, so long as the area does not increase the overall size of the zone by greater than 25 acres and the increased area is contiguous to the existing enterprise zone. The amendment must also be consistent with the limitations imposed by section 290.0055, Florida Statutes, upon establishment of the enterprise zone.
- Section 7. If any provision of this act or the application thereof to any person or circumstance is held invalid, the invalidity shall not affect other provisions or applications of the act which can be given effect without the invalid provision or application, and to this end the provisions of this act are declared severable.

Section 8. This act shall take effect upon becoming a law.

Approved by the Governor May 23, 1997.

Filed in Office Secretary of State May 23, 1997.

SJR WATER MANAGEMENT DISTRICT July 30, 1996

Ms. Liz Cloud, Chief Bureau of Administrative Code The Elliott Building Tallahassee, Florida 32399-0250 F.O.R. 96-1679

Dear Liz:

Pursuant to 120.54(11)(b), F.S., please find enclosed for filing with the Department of State, an original and two copies of the following documents regarding revisions to chapter 40C-4, F.A.C, and Applicant's Handbook: Management and Storage of Surface Waters.

1. The certification of the above-referenced rule chapter, with text of the rule section and history notes attached.

3. Summary of the rule, summary of the hearing held on the rule, statement of the facts and circumstances justifying the rule.

We appreciate your assistance in this matter. If you have any questions, please do not hesitate to contact us.

Sincerely,

NORMA K. MESSER, Rules Coordinator Office of General Counsel

/nkm

Enclosures

cc: Thomas M. Swihart, DEP Bonnie Fowler, RegFiles

CERTIFICATION OF ST. JOHNS RIVER WATER MANAGEMENT DISTRICT ADMINISTRATIVE RULES FILED WITH THE DEPARTMENT OF STATE

I do hereby certify:

- [X] (1) The time limitations prescribed by paragraph 120.54(11)(a), F.S., have been complied with; and
- [X] (2) There is no administrative determination under subsection 120-54(4), F.S., pending on any rule covered by this certification; and
- [X] (3) All rules covered by this certification are filed within the prescribed time limitations of paragraph 120.54(11)(b), F.S. They are filed not less than 28 days after notice required by subsection 120.54(l), F.S., and;
- [X] (a) Are filed not more than 90 days after the notice; or
- [] (b) Are filed not more than 90 days after the notice, not including days an administrative determination was pending; or
- [] (c) Are filed within 21 days after the adjournment of the final public hearing on the rule, or
- [] (d) Are filed within 21 days after the date of receipt of all material authorized to be submitted at the hearing, or
- [] (e) Are filed within 21 days after the date the transcript was received by this agency.

Attached are the original and two copies of each rule covered by this certification. The rules are hereby adopted by the undersigned agency by and upon their filing with the Department of State.

Rule No.	Specific Rule-Making Authority	Law Being Implemented or Made Specific
40C-4. 091	120.54(8), 373.044, 373.046(4), 373.113, 373.171, 373.415, 373.421(2), 373.461(3) FS	120.54(8), 373.O46, 373.413, 373.4135, 373.415, 373:416, 373.421(2)-(6), 373.426, 373.461(3) FS

Under the provision of paragraph 120.54(12)(a), F.S., the rules take effect 20 days from the date filed with the Department of date as set out below.

Effective:

(month) (day) (year)

WILLIAM M. SEGAL <u>SJRWMD Governing Board Chairman</u> Title TWO Number of Pages Certified

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT ENVIRONMENTAL RESOURCE PERMITS: SURFACE WATER MANAGEMENT SYSTEMS

RULE CHAPTER TITLE:	RULE CHAPTER NO.:
Environmental Resource Permits: Surface Water Management Systems	40C-4, F.A.C.
RULE TITLE:	RULE NO.:
Publications Incorporated by Reference	40C-4.091, F.A.C.

40C-4.091 Publications Incorporated by Reference:

(1) The Governing Board hereby adopts by reference:

(a) Part I "Policy and Procedures," Part II "Criteria for Evaluation," subsections 18.0, 18.1, 18.2, and 18.3 of Part III and Appendix K "Legal Description Upper St. Johns River Hydrologic Basin," "Legal Description Ocklawaha River Hydrologic Basin", "Legal Description of the Wekiva River Hydrologic Basin," "Legal Description of the Econlockhatchee River Hydrologic Basin," "Legal Description of the Sensitive Karst Areas Basin. Alachua County," and "Legal Description of the Lake Apopka Drainage Basin" of the document entitled "Applicant's Handbook: Management and Storage of Surface Waters," effective ______ 10-3-95.

- (b) No change
- (2) No change

Specific Authority 120-54(8), 373.044, 373.046(4), 373.113, 373.171, 373.415, 373.421(2),<u>373.461(3)</u> FS. Law Implemented 120.54(8), 373.046, 373.413, 373.4135, 373.415, 373.416, 373.421(2)-(6), 373.426, <u>373.461(3)</u> FS. History—New 12-7-83, Amended 10-14-84, Formerly 40C- 4.09 1, Amended 5-17-87, Formerly 40C-4.009 1, Amended 8-20-87, 10-1-87, 10-11-87, 11-26-87, 8-30-88, 1-1-89, 8-1-89, 10-19-89, 4-3-91, 8-11-91, 9-25-91, 11-12-91, 3-1-92, 7-14-92, 9-8-92, 9-16-92, 11-12-92, 11-30-92, 1-6-93, 1-23-94, 2-27-94, 11-22-94, 10-3-95,____.

CERTIFICATION OF ST. JOHNS RIVER WATER MANAGEMENT DISTRICT PUBLICATIONS INCORPORATED BY REFERENCE FILED WITH THE DEPARTMENT OF STATE

I do hereby certify that the attached are correct and complete copies of amendments made to Part II and Appendix K of the document entitled "Applicant's Handbook: Management and Storage of Service Waters," incorporated by reference in section 40C-4.091, F.A.C., effective _____.

(Date)

WILLIAM M. SEGAL <u>SJRWMD Governing Board Chair</u> Title SEVEN Number of Pages Certified
ST. JOHNS RIVER WATER MANAGEMENT DISTRICT APPLICANT'S HANDBOOK: MANAGEMENT AND STORAGE OF SURFACE WATERS

11.0 Basin Criteria

Chapter 40C-41, F.A.C., <u>and this section</u> establishes additional criteria which are to be used in reviewing applications for permits in certain hydrologic basins. These basins are: (a) through (e) No change

(f) Lake Apopka Hydrologic Basin

See Figure 11.0-1 for a description of the areas contains within the St. Johns River Hydrologic Basin, the Ocklawaha River Hydrologic Basin, the Wekiva River Hydrologic Basin, and the Econlockhatchee Hydrologic Basin. See Figures 11.0-2, 11.0-3, and 11.0-4 for a description of the areas contained within the Sensitive Karst Areas Basin. <u>See Figure 11.0-5 for a description of the areas contained with the Lake Apopka Hydrologic Basin</u>. A description of the Hydrologic Basin boundaries is available Appendix K.

11. 1 through 11.5 No change

11.6 Lake Apopka Drainage Basin

Pursuant to section 373.461(3)(a), F.S., the phosphorus criterion for Lake Apopka is 55 parts per billion. This phosphorus criterion shall be used to establish phosphorus discharge limitations for all permits within the Lake Apopka Drainage Basin authorizing discharges, directly or indirectly, into Lake Apopka, the Lake Level Canal, and the McDonald Canal.

APPENDIX K

LEGAL DESCRIPTION OF THE LAKE APOPKA DRAINAGE BASIN

Begin at the Northeast corner of Section 29, Township 22 South, Range 28 East; thence South along the Section lines to the Southeast corner of the Northeast quarter of Section 32 Township 22 South, Range 28 East, thence west along the quarter section line to the Southeast corner of the Northwest quarter of Section 31, Township 22 South, Range 28 East; thence South along, the quarter section line to the Southeast corner of the Southwest quarter of Section 31, Township 22 South, Range 28 East; thence West along the Section lines to the Southwest corner of the Southeast quarter of Section 36, Township 22 South, Range 27 East; thence South along the quarter section line to the Southeast corner of the Southwest quarter of Section 1, Township 23 South, Range 27 East; thence West along the Section line to the Southeast corner of Section 2, Township 23 South, Range 27 East; thence West along the Section line to the Southeast corner of the Northeast quarter of Section 11 Township 23 South, Range 27 East; thence west along the quarter section line to the Southeast corner of the Northwest quarter of Section 11, Township 23 South, Range 27 East; thence south along the Section lines to the Southeast corner of the Northeast quarter of Section 11 Township 23 South, Range 27 East; thence west along the quarter section line to the Southeast corner of the Northwest quarter of Section 11, Township 23 South, Range 27 East; thence south along the quarter section line to the Southeast corner of the Southwest quarter of Section 11. Township 23 South, Range 27 East; thence west along the guarter section line to the Southeast corner of the Northwest quarter of Section 11, Township 23 South, Range 27 East; thence south along the quarter section line to the Southeast corner of the Southwest quarter of Section 11. Township 23 South, Range 27 East: thence West along the Section lines to the Southeast corner of the Southwest quarter of Section 7, Township 23 South, Range 27 East; thence South along the quarter section line to the Southeast corner of the Northwest guarter of Section 18, Township 23 South, Range 27 East: thence West along the quarter section line to the Southwest corner of the Northwest quarter of Section 18, Township 23 South, Range 27 East: thence North along the Section line to the Southwest corner of Section 7, Township 23 South, Range 27 East; thence West along the Section line to the Southwest corner of the Southeast quarter of Section 12, Township 23 South, Range 26 East; thence North along the quarter section line to the Southeast corner of the Southwest quarter of Section 1, Township 23 South, Range 26 East; thence west, along the Section lines to the Southwest corner of the Southeast quarter of Section 6, Township 23 South, Range 26 East; thence North alone the guarter section line to the Northwest corner of the Northeast guarter of Section 6. Township 23 South, Range 26 East; thence East along, the Section line to the Southwest corner of Section 32, Township 22 South, Range 26 East; thence North along the Section line to the Northwest corner of Section 32, Township 22 South, Range 26 East; thence East along the Section line to the Southwest corner of Section 28, Township 22 South, Range 26 East; thence North along the Section line to the Southwest corner of Section 4, Township 22 South, Range 26 East: thence West along the Section line to the Southwest corner of Section 5, Township 22 South, Range 26 East: thence North along the Section lines to the Northwest corner of Section 32, Township 21 South, Range 26 East; thence East along the Section line to the Northeast corner of the Northwest quarter of. Section 32, Township 21 South, Range 26 East; thence North along the quarter section lines to the Northwest corner of the Northeast quarter of Section 20. Township 21 South, Range 26 East; thence East along the Section line to the Southwest corner of Section 16, Township 21 South, Range 26 East; thence North along the Section line to the Northwest comer of Section 16. Township 21 South, Range 26 East: thence East along the Section line to the Southwest corner of the Southeast quarter of Section 9 Township 21 South, Range 26 East; thence North along the quarter section line to the Northwest corner of the Southeast quarter of Section 4, Township 21 South. Range 26 East; thence West along the quarter section line to the Southwest corner of the Northwest quarter of Section 4, Township 21 South Range 26 East, thence North along the Section lines to the Northwest corner of Section 28, Township 20 South, Range 20 East, thence East along the Section lines to the Southwest corner of the Southeast quarter of Section 24, Township 20 South, Range 26 East; thence North along the quarter section line to the Northwest corner of the Southeast quarter of Section 24, Township 20 South, Range 26 East; thence East along the quarter section line to the Northeast corner of the Southeast quarter of Section 24. Township 20 South, Range 26 East; thence North along the Section line to the Northwest corner of Section 19. Township 20 South, Range 27 East; thence East along the Section lines to the Northwest corner of Section 21, Township 20 South, Range 27 East; thence North along the Section line to the Northwest corner of the Southeast quarter of Section 16, Township 20 South, Range 27 East; thence East along the quarter section line to the Northeast corner of the Southeast quarter of Section 16, Township 20 South, Range 27 East; thence North along the Section line to the Northwest corner of Section 15, Township 20 South, Range 27 East; thence East along the Section line to the Northeast Corner of Section 14, Township 20 South, Range 27 East; thence South along the Section lines to the Southeast corner of Section 23, Township 20 South, Range 27 East; thence West along the Section line to the Southwest corner of the Southeast quarter of Section 23, Township 20 South, Range 27 East; thence South along the quarter section line to the Northwest corner of the Northeast quarter of Section 35,

Township 20 South, Range 27 East; thence East along the Section line to the Northeast corner of Section 35, Township 20 South, Range 27 East; thence South along the Section line to the Southeast corner of Section 35, Township 20 South, Range 27 East; thence East along the Section line to the Southwest corner of the Southeast quarter of Section 36, Township 20 South, Range 28 East, thence North along the quarter section line to the Northwest corner of the Southeast quarter of Section 36, Township 20 South, Range 27 East; thence East along the quarter section line to the Northeast corner of the Southeast quarter of Section 36, Township 20 South, Range 27 East; thence North along the Section line to the Northwest corner of Section 31. Township 20 South, Range 28 East; thence East along the Section lines to the Northeast corner of the Northwest guarter of Section 33. Township 20 South, Range 28 East: thence South along the quarter section lines to the Southeast corner of the Southwest quarter of Section 9, Township 21 South, Range 28 East, thence East along the Section line to the Northeast corner of Section 16, Township 21 South, Range 28 East; thence South along the Section line to the Southeast corner of Section 16, Township 2 South, Range 28 East thence West along the Section line to the Southwest corner of the Southeast guarter of Section 16. Township 21 South. Range 28 East: thence South along the quarter section line to the Southeast corner of the Southwest quarter of Section 21, Township 21 South, Range 28 East; thence West along the Section line to the Southeast corner of Section 20, Township 21 South, Range 28 East; thence South along, the Section line to the Southeast corner of Section 32 Township 21 South, Range 28 East; thence West along, the Section line to the Southwest comer of the Southeast quarter of Section 32, Township 21 South, Range 28 East; thence South along the quarter section line to the Southwest corner of the Northeast quarter of Section 8, Township 22 South, Range 28 East; thence East along the quarter section line to the Southeast corner of the Northeast quarter of Section 8, Township 22 South, Range 28 East; thence South along the Section line to the Southeast corner of Section 8, Township 22 South, Range 28 East; thence West along the Section line to the Southeast corner of Section 7, Township 22 South, Range 28 East; thence South along the Section line to the Southeast corner of the Northeast quarter of Section 18, Township 22 South. Range 28 East; thence West along the quarter section line to the Northeast corner of the Southeast quarter of Section 13, Township 22 South, Range 27 East; thence South along the Section line to the Southeast corner of Section 13, Township 22 South, Range 27 East; thence West along the Section line to the Southwest corner of the Southeast guarter of Section 13, Township 22 South, Range 27 East; thence South along the quarter section line to the Northwest quarter of the Northeast corner of Section 25, Township 22 South, Range 27 East; thence East along the Section lines to the Northeast corner of Section 29, Township 22 South, Range 28 East which is also the Point of Beginning.

address. A copy of <u>the letter</u> Form DC3-247 will be maintained in the offender file as documentation that the victim was notified of this condition. Form DC3-247 is hereby incorporated by reference. A copy of this form may be obtained from the Forms Control Administrator, Office of the General Counsel, 2601 Blair Stone Road, Tallahassee, Florida 32399-2500. The effective date of this form is December 18, 2001.

(2) Prohibition of Living Within 1000 Feet of Place Where Children Regularly Congregate – If the court or releasing authority imposes this condition of supervision, the supervisor shall ensure:

(a) The officer has researched the offender's residence location for known places where children regularly congregate to ensure compliance with the order of supervision and paragraphs 948.03(5)(a) and (b), Florida Statutes; and

(b) The officer documents research conducted and measurements obtained in the electronic case notes.

(3) Submission of Blood or Biological Specimens for DNA Analysis – If the court or releasing authority imposes a this condition for submission of blood specimens or other biological specimens, or if the offender's offense meets statutory criteria of pursuant to s. <u>943.325</u> 948.03(5)(a) and (b), F.S., the officer shall verify that the offender's specimens have been collected and received by the Florida Department of Law Enforcement:

(a) The circuit administrator shall ensure agreements are formulated and upheld with DNA collection sites within the circuit; and,

(b) The officer will ensure documentation is received from the collection site verifying the DNA blood specimens were drawn.

(4) through (5) No change.

(6) HIV Testing – If the court or releasing authority imposes this condition of supervision the circuit administrator shall <u>identify and advise staff of ensure arrangements are made</u> to set up a testing locations in each circuit for sex offenders required to submit to HIV testing.

(7) Pornographic Material – If the court or releasing authority imposes a prohibition on viewing, owning, or possessing any obscene, pornographic, or sexually stimulating visual or auditory material, including telephone, electronic media, computer programs or computer services that are relevant to the offender's deviant behavior pattern, the officer shall ensure compliance by conducting walk-through searches during the initial <u>visit</u> and, at a minimum, once quarterly <u>during</u> subsequent visits to the offender's residence, which can lead to warrantless planned searches if pornographic material is observed.

(8) Computer or Internet Restrictions – If the court or releasing authority imposes a condition of supervision that limits or prohibits use of computers or the internet, the officer shall monitor compliance by:

(a) Conducting walk through searches during the initial <u>visit</u> and, <u>at a minimum</u>, <u>once quarterly during</u> subsequent visits to the offender's residence to ensure the offender is in compliance with the condition of supervision;

(b) If the officer verifies or suspects that the offender has access to the internet, and this is prohibited as a condition of supervision, the officer shall contact <u>a correctional probation</u> officer or supervisor certified to conduct computer searches FDLE or <u>a</u> local law enforcement <u>officer certified to conduct</u> <u>computer searches</u> computer experts to investigate further. Under no circumstances will an officer who has not been certified in conducting computer searches be authorized to to touch the offender's computer in an The officer will not attempt to view icons for internet access or other graphic file formats created by the Joint Photographic Experts Group, unless the officer has successfully completed the Basic Computer Data Recovery Class and has been authorized, in writing, by the circuit administrator to conduct computer searches.

Specific Authority 944.09 FS. Law Implemented 944.09, 947.1405, 948.03 FS. History–New 12-18-01<u>, Amended</u>.

NAME OF PERSON ORIGINATING PROPOSED RULE: Tina Hayes

NAME OF SUPERVISOR OR PERSON WHO APPROVED THE PROPOSED RULE: Michael W. Moore

DATE PROPOSED RULE APPROVED BY AGENCY HEAD: April 2, 2002

DATE NOTICE OF PROPOSED RULE DEVELOPMENT PUBLISHED IN FAW: March 22, 2002

WATER MANAGEMENT DISTRICTS

St. Johns River Water Management RULE TITLE:

RULE NO .:

Publications Incorporated by Reference 40C-4.091 PURPOSE AND EFFECT: The purpose and effect of this proposed rule amendment is to amend section 11.7, Applicant's Handbook: Management and Storage of Surface Waters, entitled "Lake Apopka Hydrologic Basin," to establish discharge limitations for total phosphorus for: (1) surface water management systems (systems) located within the Lake Apopka Hydrologic Basin, which discharge into Lake Apopka or its tributaries; and (2) systems that cause an interbasin diversion of water from another hydrologic basin to the Lake Apopka Hydrologic Basin and discharge water to Lake Apopka or its tributaries. The proposed rule amendments will also establish water quantity limitations on diversions of water to Lake Apopka or its tributaries from an area that does not currently discharge water to Lake Apopka or its tributaries. The proposed rule amendments revise Figure 11.0-5 in the Applicant's Handbook: Management and Storage of Surface Waters to more accurately reflect the hydrologic boundaries of the Lake Apopka Hydrologic Basin and to depict the Lake Apopka Hydrologic Basin in relation to nearby cities and public roads. Additionally, the proposed rule amendments will establish requirements for monitoring the post-development total phosphorus load discharged from the project area, methodologies to determine the pre-development total phosphorus load discharged from the project area, and an annual inspection requirement.

SUMMARY: The proposed rule amendment would establish post-development total phosphorus discharge limitations for discharges to Lake Apopka or its tributaries, pursuant to Section 373.461, F.S., create water quantity limitations on diversions of water to Lake Apopka or its tributaries, revise one figure and create a new figure depicting the Lake Apopka Hydrologic Basin, create related monitoring requirements, create methodologies for determining pre-development total phosphorus load discharged from the project area, and establish an annual inspection requirement.

SUMMARY OF STATEMENT OF ESTIMATED REGULATORY COST: No statement of estimated regulatory cost has been prepared.

Any person who wishes to provide information regarding a statement of estimated regulatory cost, or to provide a proposal for a lower cost regulatory alternative, must do so in writing within 21 days of this notice.

SPECIFIC AUTHORITY: 373.044, 373.113 FS.

LAW IMPLEMENTED: 373.413, 373.416, 373.418, 373.426, 373.461 FS.

A HEARING WILL BE HELD AT THE TIME, DATE AND PLACE SHOWN BELOW:

TIME AND DATE: Following the regularly scheduled Governing Board Meeting, which begins at 9:00 a.m., June 12, 2002

PLACE: St. Johns River Water Management District Headquarters, 4049 Reid Street, Palatka, Florida 32177

THE PERSON TO BE CONTACTED REGARDING THE PROPOSED RULE IS: Norma Messer, Rules Coordinator, Office of General Counsel, St. Johns River Water Management District, P. O. Box 1429, Palatka, Florida 32178-1429, (386)329-4459, Suncom 860-4459, email nmesser@sjrwmd.com.

THE FULL TEXT OF THE PROPOSED RULE IS:

40C-4.091 Publications Incorporated by Reference.

(1) The Governing Board hereby adopts by reference:

(a) Part I "Policy and Procedures," Part II "Criteria for Evaluation," subsections 18.0, 18.1, 18.2, and 18.3 of Part III and Appendix K "Legal Description Upper St. Johns River Hydrologic Basin," "Legal Description Ocklawaha River Hydrologic Basin," "Legal Description of the Wekiva River Hydrologic Basin," "Legal Description of the Econlockhatchee River Hydrologic Basin," "Legal Description of the Sensitive Karst Areas Basin, Alachua County," "Legal Description Tomoka River Hydrologic Basin," "Legal Description Spruce Creek Hydrologic Basin," "Legal Description of the Sensitive Karst Areas Basin, Marion County," and "Legal Descriptions of the Lake Apopka <u>Hydrologic Drainage</u> Basin," and Appendix M "Regional Watersheds for Mitigation Banking," of the document entitled "Applicant's Handbook: Management and Storage of Surface Waters," effective <u>10-11-01</u>.

(b) through (c) No change.

(2) No change.

APPLICANT'S HANDBOOK SECTION

11.0 Basin Criteria

Chapter 40C-41, F.A.C., and this section establish additional criteria which are to be used in reviewing applications for permits in certain hydrologic basins. These basins are:

- (a) Upper St. Johns River Hydrologic Basin
- (b) Ocklawaha River Hydrologic Basin
- (c) Wekiva River Hydrologic Basin
- (d) Econlockhatchee River Hydrologic Basin
- (e) Tomoka River Hydrologic Basin
- (f) Spruce Creek Hydrologic Basin
- (g) Sensitive Karst Areas Basin
- (h) Lake Apopka Hydrologic Basin

See Figure 11.0-1 for a description of the areas contained within the Upper St. Johns River Hydrologic Basin, the Ocklawaha River Hydrologic Basin, the Wekiva River Hydrologic Basin, and the Econlockhatchee River Hydrologic Basin, the Tomoka River Hydrologic Basin and the Spruce Creek Hydrologic Basin. See Figures 11.0-2, 11.0-3, and 11.0-4 for a description of the areas contained within the Sensitive Karst Areas Basin. See Figure 11.0-5 for a description of the areas contained within the Lake Apopka Hydrologic Basin. A description of the Hydrologic Basin boundaries is available in Appendix K.

INSERT FIGURE 11.0-5

11.1 through 11.6 No change.

- 11.7 Lake Apopka <u>Hydrologic</u> Drainage Basin
 - (a) Pursuant to Section 373.461(3)(a), F.A.C., the total phosphorus criterion for Lake Apopka is 55 parts per billion. To meet this total phosphorus criterion, the applicant must provide reasonable assurance of compliance with the following total phosphorus discharge limitations and comply with the relevant monitoring requirements in Sections 11.7(b) through 11.7(e): This phosphorus criterion shall be used to establish phosphorous discharge limitations for all permits within the Lake Apopka Drainage Basin authorizing discharges, directly or indirectly, into Lake Apopka, the Lake Level Canal, and the McDonald Canal.
 - (1) Sites Within Lake Apopka Hydrologic Basin Applicants required to obtain a permit pursuant to Chapters 40C-4, 40C-40, 40C-42, or 40C-44, F.A.C., for a surface water management system located within the Lake Apopka Hydrologic Basin shall demonstrate: (i) that the system provides stormwater treatment equivalent to or greater than any of the applicable stormwater treatment options contained in Table 11.7-1 for the removal of total phosphorus; (ii) that the post-development total phosphorus load discharged from the project area will not exceed the pre-development total phosphorus load discharged from the project area; or (iii) that the system, under the soil moisture conditions described in Section 10.3.8(a), will not discharge water to Lake Apopka or its tributaries for the 100-year, 24-hour storm event. Systems described under Section 11.7(a)(1)iii. shall be considered to discharge to a land-locked lake that must meet the criteria in Section 10.4.2. Any alteration of a system originally permitted pursuant to Section 11.7(a)(1)iii. which results in an increase in discharge of water to Lake Apopka or its tributaries shall be considered an interbasin diversion that must meet the criteria in Sections 11.7(a)(2) and 11.7(e).
 - (2) Interbasin Diversion of Water to Lake Apopka Hydrologic Basin

Applicants required to obtain a permit pursuant to Chapters 40C-4, 40C-40, 40C-42, or 40C-44, F.A.C., for a surface water management system that will cause the importation of water from another hydrologic basin into the Lake Apopka Hydrologic Basin shall not discharge any phosphorus from the project area to Lake Apopka or its tributaries, unless the applicant implements measures to reduce the existing total phosphorus load to Lake Apopka or its tributaries from another existing source by at least an equivalent amount of total phosphorus. The imported water shall consist only of stormwater runoff. The imported water shall not be discharged to Lake Apopka or its tributaries when the water level of Lake Apopka is in Zone A of the Lake Apopka Regulation Schedule set forth in Table 11.7-2. All measures to reduce existing phosphorous loads to Lake Apopka or its tributaries must be constructed and operating in compliance with the environmental resource permit prior to any importation of water into the Lake Apopka Hydrologic Basin. Measures that reduce existing phosphorous loads to Lake Apopka or its tributaries shall not include those measures taken on the District's land.

(b) Monitoring for Retention Systems

A surface water management system permitted under Section 11.7(a)(1)i. which utilizes only retention, shall be monitored as set forth in this paragraph. Water elevations in such a system shall be monitored from the date that construction of the system is completed or any part of the system is used for its intended purpose, whichever is sooner. The monitoring shall continue for three years following completion of construction of the entire system, including all associated residential, commercial, transportation, or agricultural improvements. If the results of the monitoring indicate that the system is not recovering the treatment volume in accordance with the permitted design, then the permittee shall either perform maintenance on the system, or obtain a modification to the permit and implement measures, to bring the system into compliance, and in either event the monitoring shall continue for three years after the date the system is brought into compliance.

(c) Monitoring for Systems Permitted Under Section <u>11.7(a)(1)iii.</u>

A surface water management system permitted under Section 11.7(a)(1)iii., shall be monitored as set forth in this paragraph. Water elevations in such a system shall be monitored from the date that construction of the system is completed or any part of the system is used for its intended purpose, whichever is sooner. The monitoring in such a system shall continue for ten years following completion of construction of the entire system, including all associated residential, commercial, transportation, or agricultural improvements. If the results of the monitoring indicate that either the system is not recovering storage in accordance with the permitted design or causes water to be discharged to Lake Apopka or its tributaries for events less than the 100-year, 24-hour storm event, then the permittee shall either perform maintenance that brings the system into compliance or obtain a modification to the permit and implement measures to bring the system into compliance, and in either event the monitoring shall continue for three years after the date the system is brought into compliance.

(d) Monitoring for Other Systems

A surface water management system, other than a system described in Sections 11.7(b), 11.7(c) or 11.7(e), shall be monitored as set forth in this paragraph. The total phosphorus load from the project area shall be monitored from the date that construction of such a system is completed or any part of the system is used for its intended purpose, whichever is sooner. The monitoring shall continue for three years following completion of construction of the entire system, including all associated residential, commercial, transportation, or agricultural improvements. If the results of the monitoring indicate that post-development total phosphorus loads exceed pre-development total phosphorus loads, then the permittee shall either perform maintenance on the system, or obtain a modification to the permit and implement measures, to reduce the total phosphorus loads to no more than pre-development levels, and in either event the monitoring shall continue for three years after the date the system is maintained or modified as described herein.

(e) <u>Monitoring for Interbasin Diversion of Water to</u> <u>Lake Apopka Hydrologic Basin</u> <u>A surface water management system described in</u>

A surface water management system described in Section 11.7(a)(2) shall be monitored as set fort in this paragraph. The total phosphorus load shall be monitored from: (i) any system designed to reduce the existing total phosphorus load to Lake Apopka or its tributaries, and (ii) the system that is importing water to the Lake Apopka Hydrologic Basin. Monitoring of the system that is importing water to the Lake Apopka Hydrologic Basin shall commence from the date that construction of such system is completed or any part of the system is used for its intended purpose, whichever is sooner. Monitoring of systems designed to reduce the existing total phosphorus load to Lake Apopka or its tributaries shall commence from the date that construction of such system is completed. Monitoring shall continue for as long as water is imported from the system to the Lake Apopka Hydrologic Basin. If monitoring results indicate that the reductions in total phosphorus load are less than that in the imported water, then the permittee shall either perform maintenance or obtain a permit modification to bring the system(s) into compliance.

(f) Determination of Pre-development Total Phosphorus Loads

Pre-development total phosphorus loads shall be based upon the land uses in place as of (effective date) and shall be calculated by: monitoring the total phosphorus loads from the project area for a period of one year prior to construction, alteration, abandonment, or removal of the proposed or existing system; or calculating total phosphorus loads for the same land uses from the scientific literature. That calculation of pre-development total phosphorus loads shall be adjusted by interpolation or extrapolation to reflect average annual rainfall conditions.

(g) Inspecting Systems

Systems subject to the inspection requirements in subsection 40C-42.029(1), F.A.C., which were permitted on or after (effective date) and which were also subject to the phosphorus discharge limitations in Section 11.7(a), shall be inspected by the operation and maintenance entity within one year after completion of construction and every year thereafter.

STORMWATER TREATMENT CRITERIA TO ACHIEVE NO NET INCREASE IN POST-DEVELOPMENT LOADINGS WITHIN THE LAKE APOPKA HYDROLOGIC BASIN

LAND USE	DOMINANT	RETENTION	RETENTION/
CATEGORY	SOIL	ONL \mathbf{V}^1	WET DETENTION
	GROUP	ONET	OPTION ²
Low-Density	А	2.75"	1.00"/14 days
Residential	В	1.75"	0.50"/14 days
(max. 15% impervious)	С	1.25"	0.50"/14 days
	D	1.00"	0.25"/14 days
Single-Family	А	2.50"	1.00"/14 days
Residential (max. 25% impervious)	В	2.00"	0.75"/14 days
	С	1.75"	0.75"/14 days
	D	1.50"	0.75"/14 days
Single-Family Residential (max. 40% Impervious)	А	3.75"	1.25"/14 days
	В	2.50"	0.75"/14 days
	С	2.00"	0.75"/14 days
	D	1.75"	0.50"/14 days
Multi-	А	4.00"	2.50"/14 days
Family	В	3.75"	2.00"/14 days
Residential (max. 65% impervious)	С	3.00"	1.50"/14 days
	D	2.75"	1.50"/14 days
Commercial (max. 80% impervious)	А	4.00"	2.75"/14 days
	В	3.00"	1.75"/14 days
	С	2.50"	1.50"/14 days
	D	2.25"	1.25"/14 days
Highway	А	4.00"	2.00"/14 days
(max. 50%	В	3.00"	1.50"/14 days
impervious)	С	2.50"	1.25"/14 days
	D	2.25"	1.00"/14 days
Highway	А	4.00"	2.75"/14 days
(max. 75%	В	3.75"	2.25"/14 days
impervious)	С	2.75"	1.75"/14 days
	D	2.25"	1.25"/14 days

1. Required dry retention volume (inches of runoff over project area)

2. Required dry retention volume (inches of runoff over project area) followed by wet detention with listed minimum residence time

ADD FIGURE 11.7.2

NAME OF PERSON ORIGINATING PROPOSED RULE: Jeff Elledge, Director, Department of Water Resources, St. Johns River Water Management District, P. O. Box 1429, Palatka, Florida 32178-1429, (386)329-4347

NAME OF SUPERVISOR OR PERSON WHO APPROVED THE PROPOSED RULE: Governing Board of the St. Johns River Water Management District

DATE PROPOSED RULE APPROVED BY AGENCY HEAD: April 9, 2002

DATE NOTICE OF PROPOSED RULE DEVELOPMENT PUBLISHED IN FAW: December 29, 2000

If any person decides to appeal any decision with respect to any matter considered at the above listed public hearing, such person may need to ensure that a verbatim record of the proceeding is made to include testimony and evidence upon which the appeal is to be based.

Anyone requiring special accommodation to participate in this meeting is requested to advised the District at least 5 work days before the meeting by contacting Linda Lorenzen, (386)329-4262, or (386)329-4450(TDD).

WATER MANAGEMENT DISTRICTS

Publications Incorporated by Reference

St. Johns River Water Management District RULE TITLE:

RULE NO.: 40C-4.091

PURPOSE AND EFFECT: The St. Johns River Water Management District proposes to amend the drainage basin and regional watershed figures and tables which are part of the Applicant's Handbook: Management and Storage of Surface Waters and are relevant to the review of applications for environmental resource permits (ERP) and mitigation bank permit applications. The District proposes to amend Figure 12.2.8-1 entitled "St. Johns River Water Management District Drainage Basins" and the figure in Appendix M entitled "St. Johns River Water Management District Regional Watersheds for Mitigation Banking." The drainage basins on Figure 12.2.8-1 define the geographical scope of the evaluation of whether a regulated activity will cause unacceptable cumulative impacts upon wetlands and other surface waters. The regional watersheds in Appendix M are used in the analysis of ecological benefits of proposed mitigation banks, are considered in the establishment of mitigation bank service areas, and are used as part of the determination of the number of mitigation credits needed to offset a given wetland impact. Specifically, the District proposes to amend Figure 12.2.8-1 by revising the Northwest boundary between drainage basins 4, 5,

and 6, in the vicinity of Mill Dam Branch, Puncheon Gum Swamp, and Pablo Creek in Duval County, and revising part of the boundary between drainage basins 16 and 17 in the vicinity of the Southeast corner of Flagler County (in Sections 17-19, Township 14 South, Range 31 East). The District proposes to amend Appendix M by revising the Northwest boundary between regional watersheds 4, 5 and 6, in the vicinity of Mill Dam Branch, Puncheon Gum Swamp, and Pablo Creek in Duval County, and revising part of the boundary between regional watersheds 16 and 17 in the vicinity of the Southeast corner of Flagler County (in Section 17-19, Township 14 South, Range 31 East).

SUMMARY: The proposed rules amend the drainage basin and regional watershed figures (Fig. 12.2.8-1 and figure in Appendix M) in the Applicant's Handbook: Management and Storage of Surface Waters.

SUMMARY OF STATEMENT OF ESTIMATED REGULATORY COST: None prepared.

Any person who wishes to provide information regarding the statement of estimated regulatory costs, or to provide a proposal for a lower cost regulatory alternative, must do so in writing within 21 days of this notice.

IF REQUESTED WITHIN 21 DAYS OF THIS NOTICE, A HEARING WILL BE HELD AT THE TIME, DATE AND PLACE SHOWN BELOW:

TIME AND DATE: Following the regularly scheduled Governing Board Meeting, which begins at 9:00 a.m., June 12, 2002

PLACE: St. Johns River Water Management District Headquarters, 4049 Reid Street, Palatka, Florida 32177

SPECIFIC AUTHORITY: 373.044, 373.113, 373.414, 373.4136, 373.418 FS.

LAW IMPLEMENTED: 373.016(2), 373.413, 373.4135, 373.4136, 373.414(8), 373.416, 373.418, 373.426 FS.

THE PERSON TO BE CONTACTED REGARDING THE PROPOSED RULE DEVELOPMENT IS: Norma Messer, Rules Coordinator, Office of General Counsel, St. Johns River Water Management District, P. O. Box 1429, Palatka, Florida 32178-1429, (386)329-4459, Suncom 860-4459, or email nmesser@sjrwmd.com

THE FULL TEXT OF THE PROPOSED RULE IS:

40C-4.091 Publications Incorporated by Reference. (1) The Governing Board hereby adopts by reference: (a) Part I "Policy and Procedures," Part II "Criteria for Evaluation," subsections 18.0, 18.1, 18.2, and 18.3 of Part III and Appendix K "Legal Description Upper St. Johns River Hydrologic Basin," "Legal Description Ocklawaha River Hydrologic Basin," "Legal Description of the Wekiva River Hydrologic Basin," "Legal Description of the Econlockhatchee River Hydrologic Basin," "Legal Description of the Sensitive Karst Areas Basin, Alachua County," "Legal Description Tomoka River Hydrologic Basin," Legal Description Spruce Creek Hydrologic Basin," "Legal Description of the Sensitive Karst Areas Basin, Marion County," and "Legal Descriptions of the Lake Apopka Drainage Basin," and Appendix M "Regional Watersheds for Mitigation Banking," of the document entitled "Applicant's Handbook: Management and Storage of Surface Waters," effective ______ 10-11-01. (b) through (c) No change.

(2) No change.

ADD FIGURE 12.2.8-1

ADD APPENDIX M

NAME OF PERSON ORIGINATING PROPOSED RULE: Thomas I. Mayton, Sr. Asst. General Counsel, Office of General Counsel, St. Johns River Water Management District, P. O. Box 1429, Palatka, Florida 32178-1429, (386)329-4108 NAME OF SUPERVISOR OR PERSON WHO APPROVED THE PROPOSED RULE: Governing Board of the St. Johns River Water Management District

DATE PROPOSED RULE APPROVED BY AGENCY HEAD: April 9, 2002

DATE NOTICE OF PROPOSED RULE DEVELOPMENT PUBLISHED IN FAW: March 8, 2002

If any person decides to appeal any decision with respect to any matter considered at the above listed public hearing, such person may need to ensure that a verbatim record of the proceeding is made to include testimony and evidence upon which the appeal is to be based.

Anyone requiring special accommodation to participate in this meeting is requested to advised the District at least 5 work days before the meeting by contacting Ann Freeman, (386)329-4101, or (386)329-4450(TDD).

WATER MANAGEMENT DISTRICTS

St. Johns River Water Management District

RULE TITLES:	RULE NOS.:
Policy and Purpose	40C-41.011
Basin Boundaries	40C-41.023
Implementation	40C-41.033
Application of Chapter	40C-41.043
Exemptions	40C-41.051
Conditions for Issuance of Permits	40C-41.063

PURPOSE AND EFFECT: The purpose and effect of this proposed rule amendment is to establish discharge limitations for total phosphorus for surface water management systems which are located in the Lake Apopka Hydrologic Basin or which discharge into Lake Apopka or its tributaries. The proposed rule amendments create new figure 41-5 that generally depicts the areas contained within the Lake Apopka Hydrologic Basin. Additionally, the proposed rule amendments will establish an exemption from the discharge limitations for stormwater management systems exempted under existing Rule 40C-42.0225, F.A.C. Furthermore, the proposed amendments will clarify that systems qualifying for a noticed general permit under Chapter 40C-400, F.AC., are exempted from the District's basin rules.

SUMMARY: The proposed rule amendment would establish post-development total phosphorus discharge limitations for discharges to Lake Apopka or its tributaries, pursuant to section 373.461, F.S., create two new figures depicting the Lake Apopka Hydrologic Basin, and establish exemptions.

SUMMARY OF STATEMENT OF ESTIMATED REGULATORY COST: No statement of estimated regulatory cost has been prepared.

Any person who wishes to provide information regarding a statement of estimated regulatory cost, or to provide a proposal for a lower cost regulatory alternative, must do so in writing within 21 days of this notice.

SPECIFIC AUTHORITY: 373.044, 373.113, 373.414, 373.418 FS.

LAW IMPLEMENTED: 373.413, 373.416, 373.418, 373.426, 373.461 FS.

A HEARING WILL BE HELD AT THE TIME, DATE AND PLACE SHOWN BELOW:

TIME AND DATE: Following the regularly scheduled Governing Board Meeting, which begins at 9:00 a.m., June 12, 2002

PLACE: St. Johns River Water Management District Headquarters, 4049 Reid Street, Palatka, Florida 32177

THE PERSON TO BE CONTACTED REGARDING THE PROPOSED RULE IS: Norma Messer, Rules Coordinator, Office of General Counsel, St. Johns River Water Management District, P. O. Box 1429, Palatka, Florida 32178-1429, (386)329-4459, Suncom 860-4459, email nmesser@sjrwmd.com.

THE FULL TEXT OF THE PROPOSED RULE IS:

40C-41.011 Policy and Purpose.

The rules in this chapter establish additional surface water management standards and criteria for the Upper St. Johns River Hydrologic Basin, the Ocklawaha River Hydrologic Basin, the Wekiva River Hydrologic Basin, the Econlockhatchee River Hydrologic Basin, the Tomoka River Hydrologic Basin, the Spruce Creek Hydrologic Basin, and the Sensitive Karst Areas Basin, and the Lake Apopka Hydrologic Basin, which insure that development within the basins incorporates the appropriate water quantity and water quality control and other environmental measures necessary to protect the integrity of the public investments in the basins and which minimizes adverse impacts to the water resources of the District. Standards and criteria delineated in this chapter are in addition to those criteria specified in Chapters 40C-4, 40C-40, and 40C-42, and 40C-44, F.A.C., in accordance with 40C-41.043, F.A.C. The standards, criteria, exemptions, and additional requirements specified in this chapter are not intended to supersede or rescind the terms and conditions of any valid surface water management permit issued by the District prior to the effective date of this chapter.

40C-41.023 Basin Boundaries.

(1) through (6) No change.

Specific Authority 373.044, 373.113, 373.171, 373.415 FS. Law Implemented 373.413, 373.415, 373.416, <u>373.418</u>, 373.426 <u>373.461</u> FS. History–New 12-7-83, Amended 5-17-87, 8-30-88, 4-3-91, 9-25-91, 11-25-98.

Insert Figure 41-5

(7) The Lake Apopka Hydrologic Basin is that area generally depicted in Figure 41-5 and defined in Applicant's Handbook, Appendix K as incorporated by reference in rule 40C-4.091, F.A.C.

Specific Authority 373.044, 373.113, 373.171 FS. Law Implemented 373.413, 373.416, 373.426 FS. History–New 12-7-83, Amended 5-17-87, 8-30-88, 4-3-91, 9-25-91, 11-25-98._____.

40C-41.033 Implementation.

(1) The effective date of this chapter is December 7, 1983, for the criteria of subsections 40C-41.063(1) and (2); May 17, 1987, for the standards of paragraphs 40C-41.063(3)(a) and (b); August 30, 1988, for the standards and criteria of paragraphs 40C-41.063(3)(c), (d) and (e); April 3, 1991, for the standards and criteria in subsection 40C-41.063(5); and September 25, 1991 for the criteria of subsections 40C-41.063(7), and 11-25-98 for the criteria of subsection 40C-41.063(6), and (effective date) for the standards and criteria in subsection 40C-41.063(6).

(2) No change.

Specific Authority 373.044, 373.113, 373.171 373.415 FS. Law Implemented 373.413, 373.415, 373.416, 373.426. <u>373.461</u> FS. History–New 12-7-83, Amended 5-17-87, 8-30-88, 4-3-91, 9-25-91, 11-25-98.

40C-41.043 Application of Chapter.

(1) All projects located within the Upper St. Johns River Hydrologic Basin, the Ocklawaha River Hydrologic Basin, the Wekiva River Hydrologic Basin, or the Econlockhatchee River Hydrologic Basin, the Tomoka River Hydrologic Basin, or the Spruce Creek Hydrologic Basin, or the Lake Apopka Hydrologic Basin, requiring permits pursuant to rule 40C-4.041, F.A.C., shall be constructed, operated, maintained, altered, abandoned and removed in accordance with the standards and criteria specified in rules 40C-41.063, and either sections 40C-4.301 and 40C-4.302, or 40C-40.302, and 40C-41.063, F.A.C., unless specifically exempted in rule 40C-41.051, F.A.C., or otherwise provided in subsection 40C-41.043(3) or 40C-41.043(4), F.A.C. The most restrictive criteria will be applicable unless the applicant provides reasonable assurance that the purposes and intent of this chapter and chapter 40C-4, F.A.C., will be fulfilled using alternate criteria.

(2) No change.

(3) Stormwater management systems requiring permits pursuant to rule 40C-42.022, F.A.C., that will be located within the Lake Apopka Hydrologic Basin or will discharge water to Lake Apopka or its tributaries, shall be constructed, operated, maintained, altered, abandoned and removed in accordance with the standards and criteria specified in rule 40C-42.023, F.A.C., and subsection 40C-41.063(8), F.A.C.

(4) Agricultural surface water management systems requiring permits pursuant to rule 40C-44.041, F.A.C., that will be located within the Lake Apopka Hydrologic Basin or will discharge water to Lake Apopka or its tributaries, shall be constructed, operated, maintained, altered, abandoned and removed in accordance with the standards and criteria specified in Rule 40C-44.301, F.A.C., and subsection 40C-41.063(8), F.A.C.

Specific Authority 373.044, 373.113, 373.171, 373.415 FS. Law Implemented 373.413, 373.415, 373.416, <u>373.418</u>, 373.426 <u>373.461</u> FS. History–New 12-7-83, Amended 5-17-87, 8-30-88, 4-3-91, 9-25-91, 10-3-95, 11-25-98.

40C-41.051 Exemptions.

(1) No change.

(2) <u>A single family dwelling unit</u> The following systems located wholly or partially within the Tomoka River Hydrologic Basin or the Spruce Creek Hydrologic Basin, provided the unit is not part of a larger common plan of <u>development or sale</u>, is are exempted from the standards and criteria in subsection 40C-41.063(6), F.A.C., and section 11.5, Applicant's Handbook: Management and Storage of Surface Waters <u>:</u>

(a) A single family dwelling unit provided the unit is not part of a larger common plan of development or sale.

(b) Systems that qualify for a noticed general permit pursuant to chapter 40C-400, F.A.C., and which comply with the requirements of such noticed general permit.

(3) Stormwater management systems exempted in rule 40C-42.0225, F.A.C., which are either located wholly or partially within the Lake Apopka Hydrologic Basin or which discharge water to Lake Apopka or its tributaries, are exempted from the standards and criteria in subsection 40C-41.063(8), F.A.C.

(4) Systems that qualify for a noticed general permit under Chapter 40C-400, F.A.C., are exempted from the standards and criteria in Rule 40C-41.063, F.A.C., and Sections 11.0 – 11.7, Applicant's Handbook: Management and Storage of Surface Waters.

Specific Authority 373.044, 373.113, 373.171 FS. Law Implemented 373.413, 373.416, 373.426. 373.461 FS. History-New 4-3-91, Amended 11-25-98.

40C-41.063 Conditions for Issuance of Permits.

(1) through (7) No change.

(8) Any surface water management system that requires a permit pursuant to Chapters 40C-4, 40C-40, 40C-42, or 40C-44, F.A.C., and that will be located within the Lake Apopka Hydrologic Basin or will discharge water to Lake Apopka or its tributaries, must comply with the requirements of Section 11.7, Applicant's Handbook: Management and Storage of Surface Waters, adopted by reference in subsection 40C-4.091(1), F.A.C.

Specific Authority 373.044, 373.113, 373.414, 373.415, 373.418 FS. Law Implemented 373.413, 373.414, 373.415, 373.416, 373.418, 373.426, <u>373.461</u> FS. History–New 12-7-83, Amended 5-17-87, 8-30-88, 8-1-89, 4-3-91, 9-25-91, 7-14-92, 10-3-95, 11-25-98, 10-11-01.______.

NAME OF PERSON ORIGINATING PROPOSED RULE: Jeff Elledge, Director, Department of Water Resources, St. Johns River Water Management District, P. O. Box 1429, Palatka, Florida 32178-1429, (386)329-4347

NAME OF SUPERVISOR OR PERSON WHO APPROVED THE PROPOSED RULE: Governing Board of the St. Johns River Water Management District

DATE PROPOSED RULE APPROVED BY AGENCY HEAD: April 9, 2002

DATE NOTICE OF PROPOSED RULE DEVELOPMENT PUBLISHED IN FAW: December 29, 2000

If any person decides to appeal any decision with respect to any matter considered at the above listed public hearing, such person may need to ensure that a verbatim record of the proceeding is made to include testimony and evidence upon which the appeal is to be based.

Anyone requiring special accommodation to participate in this meeting is requested to advised the District at least 5 work days before the meeting by contacting Linda Lorenzen at (386)329-4262, or (386)329-4450(TDD).

WATER MANAGEMENT DISTRICTS

St. Johns River Water Management DistrictRULE TITLE:RULE NO.:

Requirements for Issuance 40C-42.023 PURPOSE AND EFFECT: The purpose and effect of this

proposed rule amendment is to establish discharge limitations for total phosphorus for stormwater management systems which are located in the Lake Apopka Hydrologic Basin or which discharge into Lake Apopka or its tributaries.

SUMMARY: The proposed rule amendment would establish post-development total phosphorus discharge limitations for discharges to Lake Apopka or its tributaries, pursuant to section 373.461, F.S.

SUMMARY OF STATEMENT OF ESTIMATED REGULATORY COST: No statement of estimated regulatory cost has been prepared.

Any person who wishes to provide information regarding a statement of estimated regulatory cost, or to provide a proposal for a lower cost regulatory alternative, must do so in writing within 21 days of this notice.

SPECIFIC AUTHORITY: 373.044, 373.113, 373.418 FS.

LAW IMPLEMENTED: 373.413, 373.416, 373.418, 373.426, 373.461 FS.

A HEARING WILL BE HELD AT THE TIME, DATE AND PLACE SHOWN BELOW:

TIME AND DATE: Following the regularly scheduled Governing Board Meeting, which begins at 9:00 a.m., June 12, 2002

PLACE: St. Johns River Water Management District Headquarters, 4049 Reid Street, Palatka, Florida 32177 THE PERSON TO BE CONTACTED REGARDING THE PROPOSED RULE IS: Norma Messer, Rules Coordinator, Office of General Counsel, St. Johns River Water Management District, P. O. Box 1429, Palatka, Florida 32178-1429, (386)329-4459, Suncom 860-4459, email nmesser@sjrwmd.com.

THE FULL TEXT OF THE PROPOSED RULE IS:

40C-42.023 Requirements for Issuance.

(1) To receive a general or individual permit under this chapter the applicant must provide reasonable assurance based on plans, test results and other information, that the stormwater management system:

(a) through (c) No change.

(d) Meets any applicable basin criteria contained in <u>Rule</u> 40C-41.063(7) and (8), F.A.C. Chapter 40C-41, F.A.C.

(2) No change.

Specific Authority 373.044, 373.113, 373.171, 373.418 FS. Law Implemented 373.413, 373.416, <u>373.418</u>, <u>373.426</u>, <u>373.461</u> FS. History–New 9-25-91, Amended 3-21-93, 10-3-95, _____.

NAME OF PERSON ORIGINATING PROPOSED RULE: Jeff Elledge, Director, Department of Water Resources, St. Johns River Water Management District, P. O. Box 1429, Palatka, Florida 32178-1429, (386)329-4347

NAME OF SUPERVISOR OR PERSON WHO APPROVED THE PROPOSED RULE: Governing Board of the St. Johns River Water Management District

DATE PROPOSED RULE APPROVED BY AGENCY HEAD: April 9, 2002

DATE NOTICE OF PROPOSED RULE DEVELOPMENT PUBLISHED IN FAW: December 29, 2000

If any person decides to appeal any decision with respect to any matter considered at the above listed public hearing, such person may need to ensure that a verbatim record of the proceeding is made to include testimony and evidence upon which the appeal is to be based.

Anyone requiring special accommodation to participate in this meeting is requested to advised the District at least 5 work days before the meeting by contacting Linda Lorenzen at (386)329-4262, or (386)329-4450(TDD).

WATER MANAGEMENT DISTRICTS

St. Johns River Water Management District

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RULE TITLES:	RULE NOS .:
Performance Standards	40C-44.065
Publications Incorporated by Reference	40C-44.091

PURPOSE AND EFFECT: The purpose and effect of this proposed rule amendment is to establish discharge limitations for total phosphorus for agricultural surface water management systems requiring a permit which are located in the Lake Apopka Hydrologic Basin or which discharge into Lake Apopka or its tributaries. SUMMARY: The proposed rule amendment would establish post-development total phosphorus discharge limitations for discharges to Lake Apopka or its tributaries, pursuant to section 373.461, F.S.

SUMMARY OF STATEMENT OF ESTIMATED REGULATORY COST: No statement of estimated regulatory cost has been prepared.

Any person who wishes to provide information regarding a statement of estimated regulatory cost, or to provide a proposal for a lower cost regulatory alternative, must do so in writing within 21 days of this notice.

SPECIFIC AUTHORITY: 373.044, 373.113, 373.418 FS.

LAW IMPLEMENTED: 373.413, 373.416, 373.418, 373.426, 373.461 FS.

A HEARING WILL BE HELD AT THE TIME, DATE AND PLACE SHOWN BELOW:

TIME AND DATE: Following the regularly scheduled Governing Board Meeting, which begins at 9:00 a.m., June 12, 2002.

PLACE: St. Johns River Water Management District Headquarters, 4049 Reid Street, Palatka, Florida 32177

THE PERSON TO BE CONTACTED REGARDING THE PROPOSED RULES IS: Norma Messer, Rules Coordinator, Office of General Counsel, St. Johns River Water Management District, P. O. Box 1429, Palatka, Florida 32178-1429, (386)329-4459, Suncom 860-4459, email nmesser@sjrwmd.com.

THE FULL TEXT OF THE PROPOSED RULES IS:

40C-44.065 Performance Standards.

(1) through (3) No change.

(4) Agricultural surface water management systems requiring a permit, which will be located in the Lake Apopka Hydrologic Basin or will discharge water to Lake Apopka or its tributaries, must comply with the requirements of subsection 40C-41.063(8), F.A.C.

Specific Authority 373.044, 373.113, 373, 373.171, 373.416, 373.418 FS. Law Implemented 373.016, 373.413, 373.416, 373.418, <u>373.426</u>, <u>373.461</u> FS. History–New 8-11-91, Amended 10-20-92, 7-4-93, 10-3-94.

40C-44.091 Publications Incorporated by Reference.

(2) through (3) No change.

Specific Authority 373.044, 373.113, 373.171, 373.406, 373.416, 373.418 FS. Law Implemented 373.406, 373.413, 373.416, <u>373.418</u>, <u>373.426</u>, <u>373.461</u> FS. History–New 10-20-92, Amended 7-4-93, 10-3-94, 11-1-99.

APPLICANT'S HANDBOOK SECTION

10.2 Harm to the Water Resources Criteria

10.2.1 through 10.2.5 No change.

10.2.6 Agricultural surface water management systems requiring a permit which will be located in the Lake Apopka Hydrologic Basin or which will discharge water to Lake Apopka or its tributaries, must comply with the requirements of subsection 40C-41.063(8), F.A.C., and Section 11.7, Applicant's Handbook: Management and Storage of Surface Waters.

NAME OF PERSON ORIGINATING PROPOSED RULE: Jeff Elledge, Director, Department of Water Resources, St. Johns River Water Management District, P. O. Box 1429, Palatka, Florida 32178-1429, (386)329-4347

NAME OF SUPERVISOR OR PERSON WHO APPROVED THE PROPOSED RULE: Governing Board of the St. Johns River Water Management District

DATE PROPOSED RULE APPROVED BY AGENCY HEAD: April 9, 2002

DATE NOTICE OF PROPOSED RULE DEVELOPMENT PUBLISHED IN FAW: December 29, 2000

If any person decides to appeal any decision with respect to any matter considered at the above listed public hearing, such person may need to ensure that a verbatim record of the proceeding is made to include testimony and evidence upon which the appeal is to be based.

Anyone requiring special accommodation to participate in this meeting is requested to advised the District at least 5 work days before the meeting by contacting Linda Lorenzen at (386)329-4262, or (386)329-4450(TDD).

WATER MANAGEMENT DISTRICTS

Southwest Florida Water Management District RULE CHAPTER TITLE: **RULE CHAPTER NO.:** Procedural 40D-1 RULE TITLES: RULE NOS.: Limiting Conditions 40D-1.6105 40D-1.659 Forms and Instructions PURPOSE AND EFFECT: The purpose of the proposed amendment to Rule 40D-1.659, F.A.C., is to adopt, by incorporation, a form for use in the transfer of water use permits to subsequent owners of the property on which the permitted water withdrawal facilities are located. The purpose of the proposed amendment to Rule 40D-1.6105, F.A.C., is to allow subsequent land owners to transfer permits by submitting a copy of the legally recorded deed to the property covered by the permit in lieu of obtaining the signature of the original permittee on the transfer form.

SUMMARY: The proposed amendments will adopt a form for use in the transfer of water use permits and allow permits to be transferred to subsequent land owners without the signature of the original permittee on the transfer form.

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT MANAGEMENT AND STORAGE OF SURFACE WATERS

RULE CHAPTER TITLE: Management and Storage of Surface Waters RULE TITLE: Publications Incorporated by Reference RULE CHAPTER NO.: 40C-4, F.A.C. RULE NO.: 40C-4.09 1, F.A.C.

SUMMARY OF THE RULE:

This rule establishes a phosphorous criterion for Lake Apopka.

SUMMARY OF THE HEARING

The amendments to Section 40C-4.091, F.A.C., were presented to and approved by the Governing Board of the St. Johns River Water Management District on June 11, 1996, for publication in the Florida Administrative Weekly. The amendments were published June 28, 1996, in Volume 22, Number 26. A public hearing was not requested by the public and the District did not hold one of its own accord.

FACTS AND CIRCUMSTANCES JUSTIFYING THE RULE

This rule establishes a phosphorous criterion for Lake Apopka pursuant to the mandate of Chapter 96-207, Laws of Florida (to be codified as section 373.461, Florida Statutes). This phosphorous criterion will be used to establish discharge limitations for all regulated activities within the Lake Apopka Drainage Basin that are permitted to discharge, directly or indirectly, into Lake Apopka, the Lake Level Canal, and the McDonald Canal.

ST. JOHNS RIVER WATER MANAGEMENT

RULE TITLE:

RULE NO.: 40C-4.091, F.A.C.

Publications Incorporated by Reference

40C-4.091 Publications Incorporated by Reference.

(1) The Governing Board hereby adopts by reference:

(a) Part I "Policy and Procedures," Part II "Criteria for Evaluation," subsections 18.0, 18.1, 18.2, and 18.3 of Part III and Appendix K "Legal Description Upper St. Johns River Hydrologic Basin," "Legal Description Ocklawaha River Hydrologic Basin," "Legal Description of the Wekiva River Hydrologic Basin," "Legal Description of the Econlockhatchee River Hydrologic Basin," "Legal Description of the Sensitive Karst Areas Basin, Alachua County," "Legal Description Tomoka River Hydrologic Basin," "Legal Description Spruce Creek Hydrologic Basin," "Legal Description of the Sensitive Karst Areas Basin, Marion County," and "Legal Descriptions of the Lake Apopka <u>Hydrologic Drainage</u> Basin," and Appendix M "Regional Watersheds for Mitigation Banking," of the document entitled "Applicant's Handbook: Management and Storage of Surface Waters," effective 3-07-03 10-11-01.

(b) and (c) No change.

(2) No change.

Specific Authority 373.044, 373.046(4), 373.113, 373.413, 373.4136, 373.414, 373.415, 373.416, 373.418, 373.421(2), 373.461(3) FS. Law Implemented 120.60, 373.016(2), 373.042, 373.0421, 373.046, 373.085, 373.086, 373.109. 373.406, 373.413, 373.4135, 373.4136 373.414, 373.4141, 373.415, 373.416, 373.417, 373.418 373.421(2)-(6), 373.423, 373.426, 373.461(3), 380.06(9),403.813(2) FS. History--New 12-7-83, Amended 10-14-84, Formerly 40C- 4.091, Amended 5-17-87, Formerly 40C-4.0091, Amended 8-20-87,

10-1-87, 10-11-87, 11-26-87, 8-30-88, 1-1-89, 8-1-89, 10-19-89, 4-3-91, 9-25-91, 11-12-91, 3-1-92, 7-14-92, 9-8-92, 9-16-92, 11-12-92, 11-30-92, 1-6-93, 1-23-94, 2-27-94, 11-22-94, 10-3-95, 8-20-96, 11-25-98, 12-3-98, 1-7-99, 1-11-99, 8-21-00, 7-8.01, 10-11-01, 3-07-03.

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT APPLICANT'S HANDBOOK MANAGEMENT AND STORAGE OF SURFACE WATERS

11.0 Basin Criteria

Chapter 40C-41, F.A.C., and this section establish additional criteria which are to be used in reviewing applications for permits in certain hydrologic basins. These basins are:

- (a) Upper St. Johns River Hydrologic Basin
- (b) Ocklawaha River Hydrologic Basin
- (c) Wekiva River Hydrologic Basin
- (d) Econlockhatchee River Hydrologic Basin
- (e) Tomoka River Hydrologic Basin
- (f) Spruce Creek Hydrologic Basin
- (g) Sensitive Karst Areas Basin
- (h) Lake Apopka Hydrologic Basin

See Figure 11.0-1 for a description of the areas contained within the Upper St. Johns River Hydrologic Basin, the Ocklawaha River Hydrologic Basin, the Wekiva River Hydrologic Basin, and the Econlockhatchee River Hydrologic Basin, the Tomoka River Hydrologic Basin and the Spruce Creek Hydrologic Basin. See Figures 11.0-2, 11.0-3, and 11.0-4 for a description of the areas contained within the Sensitive Karst Areas Basin. See Figure 11.0-5 for a description of the areas contained within the Lake Apopka Hydrologic Basin. A description of the Hydrologic Basin boundaries is available in Appendix K.



Figure 11.0-5 Lake Apopka Hydrologic Basin

11.1 through 11.6 No change.

- 11.7 Lake Apopka <u>Hydrologic</u> Drainage Basin
- (a) Pursuant to section 373.461(3)(a), F.S.A.C., the total phosphorus criterion for Lake Apopka is 55 parts per billion. <u>To meet this total phosphorus criterion</u>, the applicant must provide reasonable assurance of compliance with the following total phosphorus discharge limitations and comply with the relevant monitoring requirements in section 11.7(b) and relevant inspection requirements of section 11.7(c): This phosphorus criterion shall be used to establish phosphorous discharge limitations for all permits within the Lake Apopka Drainage Basin authorizing discharges, directly or indirectly, into Lake Apopka, the Lake Level Canal, and the McDonald Canal.

(1) Sites Within Lake Apopka Hydrologic Basin

Applicants required to obtain a permit pursuant to chapters 40C-4, 40C-40, 40C-42, or 40C-44, F.A.C., for a surface water management system located within the Lake Apopka Hydrologic Basin shall demonstrate: (i) that the system provides stormwater treatment equivalent to or greater than any of the applicable stormwater treatment options contained in Table 11.7-1 for the removal of total phosphorus; (ii) that the post-development total phosphorus load discharged from the project area will not exceed the pre-development total phosphorus load discharged from the project area; or (iii) that the system, under the soil moisture conditions described in section 10.3.8(a), will not discharge water to Lake Apopka or its tributaries for the 100-year, 24-hour storm event. Systems described under section 11.7(a)(1)iii shall be considered to discharge to a land-locked lake that must meet the criteria in sections 10.4.1 and 10.4.2. Any alteration of a system originally permitted pursuant to section 11.7(a)(1)iii which results in an increase in discharge of water to Lake Apopka or its tributaries shall be considered an interbasin diversion that must meet the criteria in sections 11.7(a)(2) and 11.7(b)(4).

(2) Interbasin Diversion of Water to Lake Apopka Hydrologic Basin

Applicants required to obtain a permit pursuant to chapters 40C-4, 40C-40, 40C-42, or 40C-44, F.A.C., for a surface water management system that will cause the importation of water from another hydrologic basin into the Lake Apopka Hydrologic Basin shall not discharge any phosphorus from the project area to Lake Apopka or its tributaries, unless the applicant implements measures to reduce the existing total phosphorus load to Lake Apopka or its tributaries from another existing source by at least an equivalent amount of total phosphorus. The imported water shall consist only of stormwater runoff. The imported water shall not be discharged to Lake Apopka or its tributaries when the water level of Lake Apopka is in Zone A of the Lake Apopka Regulation Schedule set forth in Figure 11.7-2. All measures to reduce existing phosphorous loads to Lake Apopka or its tributaries must be constructed and operating in compliance with the environmental resource permit prior to any importation of water into the Lake Apopka Hydrologic Basin. Measures that reduce existing phosphorous loads to Lake Apopka or its tributaries shall not include those measures taken on the District's land.

(3) Methodology for Determining Total Phosphorus Loads.

Determination of Pre-Development Total Phosphorus Loads.

Pre-development total phosphorus loads shall be based upon the land uses in place as of March 7, 2003. For systems which have been constructed in accordance with a permit issued pursuant to chapters 40C-4, 40C-40, 40C-42, or 40C-44, F.A.C., at the permit applicant's option, the pre-development total phosphorus loads shall be based upon the land uses in place at the time the prior permit was issued. Pre-development total phosphorus loads shall be determined by: monitoring the total phosphorus loads from the project area for a period of one year prior to construction, alteration, abandonment, or removal of the proposed or existing system; calculating total phosphorus loads using the appropriate mean annual total phosphorus loadings in Table 11.7-3, or calculating total phosphorus loads for predevelopment land uses not listed in Table 11.7-3 using mean annual total phosphorus loadings from the scientific literature. When the predevelopment total phosphorus loads are determined by monitoring, the calculation of pre-development total phosphorus loads shall be adjusted by interpolation or extrapolation to reflect mean annual rainfall conditions.

Determination of Post-Development Total Phosphorus Loads.

Post-development total phosphorus loads shall be based upon the land uses proposed in the permit application and shall be determined by: calculating total phosphorus loads using the appropriate mean annual total phosphorus loadings in Table 11.7-3 and then reducing the total phosphorus load according to the appropriate total phosphorus removal efficiency values for systems listed in Tables 11.7-4 through 11.7-33. For purposes of Tables 11.7-4 and 11.7-6 through 11.7-33, the term "retention" includes stormwater reuse and underdrain and underground exfiltration trench systems as those terms are defined in section 2.0 of the Applicant's Handbook: Regulation of Stormwater Management Systems, Chapter 40C-42, F.A.C., which is adopted by reference in section 40C-42.091(1), F.A.C. The calculation of total phosphorus loads for post-development land uses not listed in Table 11.7-3 or total phosphorus removal efficiency values for systems not listed in Tables 11.7-4 through 11.7-33 may be calculated using mean annual total phosphorus loadings and total phosphorus removal efficiency values from the scientific literature.

(b) Monitoring

(1) Monitoring for Retention Systems.

A surface water management system to be permitted under section 11.7(a)(1)i which utilizes only retention, shall be monitored as set forth in this paragraph. Water elevations in such a system shall be monitored from the date that construction of the system is completed or any part of the system is used for its intended purpose, whichever is sooner. The monitoring shall continue for three years following completion of construction of the entire system, including all associated residential, commercial, transportation, or agricultural improvements. If the results of the monitoring indicate that the system is not recovering the treatment volume in accordance with the permitted design, then the permittee shall either perform maintenance on the system, or obtain a modification to the permit and implement measures, to bring the system into compliance, and in either event the monitoring shall continue for three years after the date the system is brought into compliance.

(2) Monitoring for Systems Permitted Under Section 11.7(a)(1)iii.

A surface water management system to be permitted under section 11.7(a)(1)iii, shall be monitored as set forth in this paragraph. Water elevations in such a system shall be monitored from the date that

construction of the system is completed or any part of the system is used for its intended purpose, whichever is sooner. The monitoring in such a system shall continue for ten years following completion of construction of the entire system, including all associated residential, commercial, transportation, or agricultural improvements. If the results of the monitoring indicate that either the system is not recovering storage in accordance with the permitted design or causes water to be discharged to Lake Apopka or its tributaries for events less than the 100-year, 24-hour storm event, then the permittee shall either perform maintenance that brings the system into compliance or obtain a modification to the permit and implement measures to bring the system into compliance, and in either event the monitoring shall continue for three years after the date the system is brought into compliance.

(3) Monitoring for Other Systems

A surface water management system to be permitted, other than a system described in sections 11.7(b)(1), 11.7(b)(2) or 11.7(b)(4), shall be monitored as set forth in this paragraph. Except as provided below, the total phosphorus load from the project area shall be monitored from the date that construction of such a system is completed or any part of the system is used for its intended purpose, whichever is sooner. The monitoring shall continue for three years following completion of construction of the entire system, including all associated residential, commercial, transportation, or agricultural improvements. If the results of the monitoring indicate that post-development total phosphorus loads exceed pre-development total phosphorus loads, then the permittee shall either perform maintenance on the system, or obtain a modification to the permit and implement measures, to reduce the total phosphorus loads to no more than pre-development levels, and in either event the monitoring shall

continue for three years after the date the system is maintained or modified as described herein.

No monitoring shall be required under section 11.7(b)(3) when an applicant demonstrates that the system provides stormwater treatment equivalent to or greater than any of the applicable stormwater treatment options contained in Table 11.7-1 for the removal of total phosphorus. Alternatively, no monitoring shall be required under section 11.7(b)(3) when an applicant demonstrates that the post-development total phosphorus load discharged from the project area will not exceed the pre-development total phosphorus load discharged from the project area when determined using the appropriate mean annual total phosphorus loadings and total phosphorus removal efficiency values from Tables 11.7-3 through 11.7-33.

(4) Monitoring for Interbasin Diversion of Water to Lake Apopka Hydrologic Basin

A surface water management system to be permitted under in section 11.7(a)(2) shall be monitored as set forth in this paragraph. The total phosphorus load shall be monitored from: (i) any system designed to reduce the existing total phosphorus load to Lake Apopka or its tributaries, and (ii) the system that is importing water to the Lake Apopka Hydrologic Basin. Monitoring of the system that is importing water to the Lake Apopka Hydrologic Basin shall commence from the date that construction of such system is completed or any part of the system is used for its intended purpose, whichever is sooner. Monitoring of systems designed to reduce the existing total phosphorus load to Lake Apopka or its tributaries shall commence from the date that construction of such system is completed. Monitoring shall continue for as long as water is imported from the system to the Lake Apopka Hydrologic Basin. If monitoring results indicate that the reductions in total phosphorus load are less than that in the imported water, then the permittee shall either perform maintenance or obtain a permit modification to bring the system(s) into compliance.

(c) Inspecting Systems

Systems subject to the inspection requirements in subsection 40C-42.029(1), F.A.C., which were permitted on or after March 7, 2003 and which were also subject to the phosphorus discharge limitations in section 11.7(a), shall be inspected by the operation and maintenance entity within one year after completion of construction and every year thereafter.

STORMWATER TREATMENT CRITERIA TO ACHIEVE NO NET INCREASE IN POST-DEVELOPMENT LOADINGS WITHIN THE LAKE APOPKA HYDROLOGIC BASIN

LAND USE CATEGORY	HYDROLOGIC SOIL GROUP	RETENTION ¹ ONLY ²	RETENTION ¹ / WET DETENTION OPTION ³
Low-Density Residential (max. 15% impervious)	A B C D	2.75" 1.75" 1.25" 1.00"	1.00"/14 days 0.50"/14 days 0.50"/14 days 0.25"/14 days
Single-Family Residential (max. 25% impervious)	A B C D	2.75" 2.00" 1.75" 1.50"	1.00"/14 days 0.75"/14 days 0.75"/14 days 0.50"/14 days
Single-Family Residential (max. 40% impervious)	A B C D	3.75" 3.00" 2.00" 1.50"	1.25"/14 days 1.00"/14 days 0.75"/14 days 0.50"/14 days
Multi- Family Residential (max. 65% impervious)	A B C D	4.00" 3.75" 3.25" 2.75"	2.50"/14 days 2.00"/14 days 1.75"/14 days 1.50"/14 days
Commercial (max. 80% impervious)	A B C D	4.00" 3.75" 2.75" 2.25"	2.75"/14 days 2.25"/14 days 1.50"/14 days 1.25"/14 days
Highway (max. 50% impervious)	A B C D	4.00" 3.00" 2.50" 2.25"	2.00"/14 days 1.50"/14 days 1.25"/14 days 1.00"/14 days
Highway (max. 75% impervious)	A B C D	4.00" 3.75" 2.75" 2.25"	2.75"/14 days 2.25"/14 days 1.75"/14 days 1.25"/14 days

- For purposes of this Table, the term "retention" includes stormwater reuse and underdrain 1. and underground exfiltration trench systems as those terms are defined in section 2.0 of the Applicant's Handbook:Regulation of Stormwater Management Systems, Chapter 40C-42,F.A.C., which is adopted by reference in section 40C-42.091(1), F.A.C.
- Required dry retention volume (inches of runoff over project area)
- <u>2</u> 1. <u>3 2.</u> Required dry retention volume (inches of runoff over project area) followed by wet detention with listed minimum residence time



MEAN ANNUAL LOADINGS OF TOTAL PHOSPHORUS FOR LAND USE TYPES IN THE LAKE APOPKA HYDROLOGIC BASIN

LAND USE CATEGORY	TC	MEAN A DTAL PHOSF (kg/a	ANNUAL PHORUS LOA ac-yr)	AD
	HSG A	HSG B	HSG C	HSG D
Low-Density Residential (max. 15% impervious)	0.069	0.135	0.215	0.284
Single-Family Residential (max. 25% impervious)	0.227	0.286	0.383	0.465
Single-Family Residential (max. 40% impervious)	0.250	0.333	0.446	0.536
Multi-Family Residential (max. 65% impervious)	1.082	1.156	1.257	1.336
Commercial (max. 80% impervious)	0.899	0.916	0.943	0.964
Highway – max. 50% impervious	0.710	0.756	0.817	0.871
Highway – max. 75% impervious	1.053	1.076	1.106	1.133
Agriculture – Pasture	0.026	0.118	0.239	0.347
Agriculture – Crops, Ornamentals, Nurseries	0.040	0.180	0.366	0.531
Agriculture – Groves	0.007	0.036	0.079	0.123
Open Land/Recreational/Fallow Groves and	0.004	0.017	0.035	0.051
Cropland				
Forests/Abandoned Tree Crops	0.004	0.021	0.045	0.070

HSG = Hydrologic Soil Group

REMOVAL EFFICIENCIES FOR TOTAL PHOSPHORUS IN DRY RETENTION SYSTEMS THAT MEET THE DESIGN AND PERFORMANCE CRITERIA IN RULE 40C-42.026, F.A.C.

I AND	HSG A		HSG B		HSG C		HSG D	
USE	STANDARD	OFW	STANDARD	OFW	STANDARD	OFW	STANDARD	OFW
Low-Density Residential (max. 15% impervious)	%82	82%	67%	74%	63%	72%	60%	71%
Single-Family Residential (max. 25% impervious)	%06	92%	78%	83%	69%	77%	65%	74%
Single-Family Residential (max. 40% impervious)	84%	88%	72%	80%	65%	75%	63%	73%
Multi-Family Residential (max. 65% impervious)	74%	83%	%69	%62	64%	75%	62%	74%
Commercial (max. 80% impervious)	65%	76 %	63%	74%	62%	72%	61%	71%
Highway (max. 50% impervious)	75%	85%	20%	80%	65%	76%	63%	74%
Highway (max. 75% impervious)	65%	76%	63%	74%	62%	72%	61%	71%
andard - Meets design	and performance	criteria in	rule 40C-42.026, F	⁷ .A.C., for	discharges to Clas	s III water	ş	

- Meets design and performance criteria in rule 40C-42.026, F.A.C., for discharges to Class I, Class II, or Outstanding Florida Waters

FW
TABLE 11.7-5

REMOVAL EFFICIENCIES FOR TOTAL PHOSPHORUS IN WET DETENTION SYSTEMS THAT MEET THE DESIGN AND PERFORMANCE CRITERIA IN RULE 40C-42.026, F.A.C.

Residence Time (days)	Phosphorus Removal Efficiency (%)
14	61.5
21	64.5

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Low-Density Residential (max. 15% impervious) For Hydrologic Soil Group A

Retention Depth	Annual Total P Removal (%)				
(inches)	Dry Retention ¹	Rete	Retention / Wet Detention²		
(t _d =7 days	t _d =14 days	t _d =21 days	
0.25	70	86	88	89	
0.50	78	90	92	92	
0.75	82	92	93	94	
1.00	85	93	94	95	
1.25	88	94	95	96	
1.50	90	95	96	96	
1.75	91	96	96	97	
2.00	92	96	97	97	
2.25	93	97	97	97	
2.50	93	97	97	98	
2.75	94	97	98	98	
3.00	95	98	98	98	
3.25	96	98	98	99	
3.50	97	98	99	99	
3.75	97	99	99	99	
4.00	98	99	99	99	

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Low-Density Residential (max. 15% impervious) For Hydrologic Soil Group B

Retention Depth	Annual Total P Removal (%)				
(inches)	Dry Retention ¹	Re	Retention / Wet Detention²		
(inclice)	Dry Retention	t _d =7 days	t _d =14 days	t _d =21 days	
0.25	53	78	82	83	
0.50	67	85	87	88	
0.75	74	88	90	91	
1.00	79	91	92	93	
1.25	83	92	93	94	
1.50	85	93	94	95	
1.75	88	94	95	96	
2.00	89	95	96	96	
2.25	90	96	96	97	
2.50	92	96	97	97	
2.75	93	97	97	97	
3.00	93	97	97	98	
3.25	94	97	98	98	
3.50	94	97	98	98	
3.75	95	98	98	98	
4.00	95	98	98	98	

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Low-Density Residential (max. 15% impervious) For Hydrologic Soil Group C

Retention Depth	Annual Total P Removal (%)			
(inches)	Dry Retention ¹	ion ¹ Retention / Wet Detention ²		
()		t _d =7 days	t _d =14 days	t _d =21 days
0.25	46	75	79	81
0.50	63	83	86	87
0.75	72	87	89	90
1.00	78	90	91	92
1.25	82	92	93	94
1.50	85	93	94	95
1.75	87	94	95	96
2.00	89	95	96	96
2.25	91	96	96	97
2.50	92	96	97	97
2.75	93	97	97	97
3.00	94	97	97	98
3.25	94	97	98	98
3.50	95	98	98	98
3.75	95	98	98	98
4.00	96	98	98	98

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Low-Density Residential (max. 15% impervious) For Hydrologic Soil Group D

Retention Depth	Annual Total P Removal (%)			
(inches)	Dry Retention ¹	Retention / Wet Detention ²		
(inclies)	Dry Retention	t _d =7 days	t _d =14 days	t _d =21 days
0.25	42	74	78	79
0.50	60	82	85	86
0.75	71	87	89	90
1.00	78	90	91	92
1.25	82	92	93	94
1.50	85	93	94	95
1.75	88	94	95	96
2.00	90	95	96	96
2.25	91	96	97	97
2.50	92	96	97	97
2.75	93	97	97	98
3.00	94	97	98	98
3.25	95	98	98	98
3.50	95	98	98	98
3.75	96	98	98	98
4.00	96	98	99	99

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Single Family Residential (max. 25% impervious) For Hydrologic Soil Group A

Retention Depth	Annual Total P Removal (%)				
(inches)	Dry Retention ¹	Dry Retention ¹ Retention ²			
(Dry Retention	t _d =7 days	t _d =14 days	t _d =21 days	
0.25	82	92	93	94	
0.50	90	95	96	96	
0.75	92	96	97	97	
1.00	94	97	98	98	
1.25	95	98	98	98	
1.50	96	98	98	98	
1.75	96	98	99	99	
2.00	97	98	99	99	
2.25	97	99	99	99	
2.50	98	99	99	99	
2.75	98	99	99	99	
3.00	98	99	99	99	
3.25	99	99	99	99	
3.50	99	99	100	100	
3.75	99	100	100	100	
4.00	99	100	100	100	

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Single Family Residential (max. 25% impervious) For Hydrologic Soil Group B

Retention Depth	Annual Total P Removal (%)			
(inches)	Dry Retention ¹	Retention ¹ Retention / Wet Detention ²		
(t _d =7 days	t _d =14 days	t _d =21 days
0.25	65	84	87	88
0.50	78	90	91	92
0.75	83	92	94	94
1.00	87	94	95	95
1.25	89	95	96	96
1.50	91	96	96	97
1.75	92	96	97	97
2.00	93	97	97	98
2.25	94	97	98	98
2.50	95	98	98	98
2.75	95	98	98	98
3.00	96	98	98	98
3.25	96	98	99	99
3.50	96	98	99	99
3.75	97	99	99	99
4.00	97	99	99	99

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Single Family Residential (max. 25% impervious) For Hydrologic Soil Group C

Retention Depth	Annual Total P Removal (%)				
(inches)	Dry Retention ¹	Retention / Wet Detention ²			
(inclics)	Dry Retention	t _d =7 days	t _d =14 days	t _d =21 days	
0.25	54	79	82	84	
0.50	69	86	88	89	
0.75	77	90	91	92	
1.00	82	92	93	94	
1.25	85	93	94	95	
1.50	88	95	95	96	
1.75	90	95	96	96	
2.00	91	96	97	97	
2.25	92	97	97	97	
2.50	93	97	97	98	
2.75	94	97	98	98	
3.00	95	98	98	98	
3.25	96	98	98	98	
3.50	96	98	98	99	
3.75	96	98	99	99	
4.00	97	98	99	99	

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Single Family Residential (max. 25% impervious) For Hydrologic Soil Group D

Retention Depth	Annual Total P Removal (%)					
(inches)	Dry Retention ¹	Re	Retention / Wet Detention ²			
(inclues)	Dry Retention	t _d =7 days	t _d =14 days	t _d =21 days		
0.25	48	76	80	81		
0.50	65	84	86	87		
0.75	74	88	90	91		
1.00	81	91	93	93		
1.25	84	93	94	94		
1.50	87	94	95	95		
1.75	89	95	96	96		
2.00	91	96	96	97		
2.25	92	96	97	97		
2.50	93	97	97	98		
2.75	94	97	98	98		
3.00	95	98	98	98		
3.25	95	98	98	98		
3.50	96	98	98	98		
3.75	96	98	99	99		
4.00	97	98	99	99		

- 1. Dry retention alone.
- 2. Dry retention followed by wet detention with various residence times.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Single Family Residential (max. 40% impervious) For Hydrologic Soil Group A

Retention Depth	Annual Total P Removal (%)			
(inches)	Dry Retention ¹	Retention / Wet Detention ²		
()	219 100001000	t _d =7 days	t _d =14 days	t _d =21 days
0.25	71	90	93	94
0.50	86	95	96	97
0.75	90	97	98	98
1.00	93	97	98	99
1.25	94	98	99	99
1.50	95	98	99	99
1.75	96	99	99	99
2.00	97	99	99	99
2.25	97	99	99	99
2.50	97	99	99	99
2.75	98	99	99	100
3.00	98	99	99	100
3.25	98	99	100	100
3.50	98	99	100	100
3.75	99	100	100	100
4.00	99	100	100	100

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Single Family Residential (max. 40% impervious) For Hydrologic Soil Group B

Retention Depth	Annual Total P Removal (%)			
(inches)	Dry Retention ¹	Retention ¹ Retention ²		
(Dry Netendon	t _d =7 days	t _d =14 days	t _d =21 days
0.25	61	86	90	92
0.50	77	92	94	95
0.75	83	94	95	97
1.00	87	95	97	97
1.25	89	96	97	98
1.50	91	97	98	98
1.75	93	97	98	99
2.00	94	98	98	99
2.25	94	98	99	99
2.50	95	98	99	99
2.75	95	99	99	99
3.00	96	99	99	99
3.25	97	99	99	99
3.50	97	99	99	99
3.75	97	99	99	99
4.00	97	99	99	99

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Single Family Residential (max. 40% impervious) For Hydrologic Soil Group C

Retention Depth	Annual Total P Removal (%)				
(inches)	Dry Retention ¹	Ret	Retention / Wet Detention²		
(Dry netendon	t _d =7 days	t _d =14 days	t _d =21 days	
0.25	51	82	87	90	
0.50	68	88	91	93	
0.75	77	92	94	95	
1.00	83	94	95	96	
1.25	86	95	96	97	
1.50	89	96	97	97	
1.75	91	96	97	98	
2.00	92	97	98	98	
2.25	93	97	98	98	
2.50	94	97	98	98	
2.75	95	98	98	98	
3.00	95	98	98	99	
3.25	96	98	98	99	
3.50	96	98	99	99	
3.75	97	98	99	99	
4.00	97	98	99	99	

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Single Family Residential (max. 40% impervious) For Hydrologic Soil Group D

Retention Depth	Annual Total P Removal (%)				
(inches)	Dry Retention ¹	Retention ¹ Retention / Wet Detention ²			
(includy)	Dry Retention	t _d =7 days	t _d =14 days	t _d =21 days	
0.25	48	82	87	90	
0.50	65	88	91	93	
0.75	75	91	94	95	
1.00	81	93	95	96	
1.25	85	95	96	97	
1.50	88	96	97	98	
1.75	90	96	97	98	
2.00	92	97	98	98	
2.25	93	97	98	99	
2.50	94	98	98	99	
2.75	94	98	99	99	
3.00	95	98	99	99	
3.25	96	98	99	99	
3.50	96	99	99	99	
3.75	97	99	99	99	
4.00	97	99	99	99	

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Multi Family Residential (max. 65% impervious) For Hydrologic Soil Group A

Retention Depth	Annual Total P Removal (%)				
(inches)	Dry Retention ¹	Re	tention / Wet	Detention ²	
(inches)	Dry Retention	t _d =7 days	t _d =14 days	t _d =21 days	
0.25	53	78	82	83	
0.50	74	88	90	91	
0.75	83	92	94	94	
1.00	88	95	96	96	
1.25	91	96	97	97	
1.50	93	97	97	98	
1.75	95	98	98	98	
2.00	95	98	98	98	
2.25	96	98	98	99	
2.50	97	98	99	99	
2.75	97	99	99	99	
3.00	97	99	99	99	
3.25	98	99	99	99	
3.50	98	99	99	99	
3.75	98	99	99	99	
4.00	98	99	99	99	

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Multi Family Residential (max. 65% impervious) For Hydrologic Soil Group B

Retention Depth	Annual Total P Removal (%)			
(inches)	Dry Retention ¹	Re	Detention ²	
(inches)	Dry Retention	t _d =7 days	t _d =14 days	t _d =21 days
0.25	49	77	81	82
0.50	69	86	88	89
0.75	79	90	92	92
1.00	85	93	94	95
1.25	89	95	96	96
1.50	91	96	96	97
1.75	92	97	97	97
2.00	94	97	98	98
2.25	95	98	98	98
2.50	95	98	98	98
2.75	96	98	98	99
3.00	96	98	99	99
3.25	97	99	99	99
3.50	97	99	99	99
3.75	98	99	99	99
4.00	98	99	99	99

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Multi Family Residential (max. 65% impervious) For Hydrologic Soil Group C

Retention Depth	Annual Total P Removal (%)				
(inches)	Dry Retention ¹	Retention / Wet Detention ²			
(inches)	Dig netendon	t _d =7 days	t _d =14 days	t _d =21 days	
0.25	45	75	79	81	
0.50	64	84	86	87	
0.75	75	89	90	91	
1.00	82	92	93	94	
1.25	86	94	95	95	
1.50	89	95	96	96	
1.75	91	96	97	97	
2.00	93	97	97	97	
2.25	94	97	98	98	
2.50	95	98	98	98	
2.75	95	98	98	98	
3.00	96	98	98	99	
3.25	96	98	99	99	
3.50	97	98	99	99	
3.75	97	98	99	99	
4.00	97	99	99	99	

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Multi-Family Residential (max. 65% impervious) for Hydrologic Soil Group D

Retention Depth	Annual Total P Removal (%)				
(inches)	Dry Retention ¹	Re	tention / Wet	Detention ²	
(inches)	Dry Retention	t _d =7 days	t _d =14 days	t _d =21 days	
0.25	43	74	78	80	
0.50	62	83	85	86	
0.75	74	88	90	91	
1.00	80	91	92	93	
1.25	85	93	94	95	
1.50	88	95	95	96	
1.75	90	96	96	97	
2.00	92	96	97	97	
2.25	93	97	97	98	
2.50	94	97	98	98	
2.75	95	98	98	98	
3.00	96	98	98	98	
3.25	96	98	99	99	
3.50	97	99	99	99	
3.75	97	99	99	99	
4.00	97	99	99	99	

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Commercial (max. 80% impervious) for Hydrologic Soil Group A

Retention Depth	Annual Total P Removal (%)				
(inches)	Dry Retention ¹	Re	tention / Wet I	Detention ²	
(inches)		t _d =7 days	t _d =14 days	t _d =21 days	
0.25	41	73	77	79	
0.50	65	84	86	87	
0.75	76	89	91	91	
1.00	83	92	93	94	
1.25	88	95	95	96	
1.50	91	96	96	97	
1.75	93	97	97	97	
2.00	94	97	98	98	
2.25	95	98	98	98	
2.50	96	98	98	99	
2.75	97	98	99	99	
3.00	97	99	99	99	
3.25	97	99	99	99	
3.50	98	99	99	99	
3.75	98	99	99	99	
4.00	98	99	99	99	

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Commercial (max. 80% impervious) for Hydrologic Soil Group B

Retention Depth	Annual Total P Removal (%)				
(inches)	Dry Retention ¹	Retention / Wet Detention ²			
(menes)	Dry Retendon	t _d =7 days	t _d =14 days	t _d =21 days	
0.25	41	73	77	79	
0.50	63	83	86	87	
0.75	74	88	90	91	
1.00	81	92	93	93	
1.25	87	94	95	95	
1.50	89	95	96	96	
1.75	92	96	97	97	
2.00	93	97	97	98	
2.25	94	97	98	98	
2.50	95	98	98	98	
2.75	96	98	98	99	
3.00	97	98	99	99	
3.25	97	99	99	99	
3.50	97	99	99	99	
3.75	98	99	99	99	
4.00	98	99	99	99	

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Commercial (max. 80% impervious) for Hydrologic Soil Group C

Retention Depth	Annual Total P Removal (%)				
(inches)	Dry Retention ¹	Re	tention / Wet I	Detention ²	
(menes)	Dry Meteridon	t _d =7 days	t _d =14 days	t _d =21 days	
0.25	39	72	77	78	
0.50	62	83	85	86	
0.75	72	87	89	90	
1.00	80	91	92	93	
1.25	85	93	94	95	
1.50	88	95	96	96	
1.75	91	96	97	97	
2.00	92	97	97	97	
2.25	94	97	98	98	
2.50	95	98	98	98	
2.75	96	98	98	98	
3.00	96	98	99	99	
3.25	97	98	99	99	
3.50	97	99	99	99	
3.75	97	99	99	99	
4.00	98	99	99	99	

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Commercial (max. 80% impervious) for Hydrologic Soil Group D

Retention Depth	Annual Total P Removal (%)				
(inches)	Dry Retention ¹	Retention / Wet Detention²			
(inches)		t _d =7 days	t _d =14 days	t _d =21 days	
0.25	39	72	76	78	
0.50	61	82	85	86	
0.75	71	87	89	90	
1.00	79	90	92	93	
1.25	84	93	94	94	
1.50	88	94	95	96	
1.75	90	96	96	97	
2.00	92	96	97	97	
2.25	94	97	98	98	
2.50	94	97	98	98	
2.75	95	98	98	98	
3.00	96	98	98	99	
3.25	97	98	99	99	
3.50	97	99	99	99	
3.75	97	99	99	99	
4.00	98	99	99	99	

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Highway (max. 50% impervious) for Hydrologic Soil Group A

Retention Depth	Annual Total P Removal (%)				
(inches)	Dry Rotontion ¹	Retention / Wet Detention ²			
(inches)	Dry Retention	t _d =7 days	t _d =14 days	t _d =21 days	
0.25	54	79	82	83	
0.50	75	88	90	91	
0.75	85	93	94	95	
1.00	90	95	96	96	
1.25	92	97	97	97	
1.50	94	97	98	98	
1.75	95	98	98	98	
2.00	96	98	99	99	
2.25	97	99	99	99	
2.50	97	99	99	99	
2.75	98	99	99	99	
3.00	98	99	99	99	
3.25	98	99	99	99	
3.50	98	99	99	99	
3.75	98	99	99	99	
4.00	99	99	99	100	

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Highway (max. 50% impervious) for Hydrologic Soil Group B

Retention Depth	Annual Total P Removal (%)			
(inches)	Dry Retention ¹	Re	tention / Wet D	Detention ²
(menes)		t _d =7 days	t _d =14 days	t _d =21 days
0.25	50	77	81	82
0.50	70	86	89	89
0.75	80	91	92	93
1.00	86	93	94	95
1.25	89	95	96	96
1.50	91	96	97	97
1.75	93	97	97	97
2.00	94	97	98	98
2.25	95	98	98	98
2.50	96	98	98	98
2.75	96	98	99	99
3.00	97	98	99	99
3.25	97	99	99	99
3.50	97	99	99	99
3.75	98	99	99	99
4.00	98	99	99	99

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Highway (max. 50% impervious) for Hydrologic Soil Group C

Retention Depth	Annual Total P Removal (%)			
(inches)	Dry Retention ¹	Re	tention / Wet E	Detention ²
(menes)	Dry Meterition	t _d =7 days	t _d =14 days	t _d =21 days
0.25	47	76	79	81
0.50	65	84	87	88
0.75	76	89	91	91
1.00	83	92	93	94
1.25	87	94	95	95
1.50	89	95	96	96
1.75	91	96	97	97
2.00	93	97	97	97
2.25	94	97	98	98
2.50	95	98	98	98
2.75	96	98	98	98
3.00	96	98	98	99
3.25	97	98	99	99
3.50	97	99	99	99
3.75	97	99	99	99
4.00	98	99	99	99

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Highway (max. 50% impervious) for Hydrologic Soil Group D

Retention Depth	Annual Total P Removal (%)			
(inches)	Dry Retention ¹	Retention / Wet Detention²		
		t _d =7 days	t _d =14 days	t _d =21 days
0.25	44	74	78	80
0.50	63	83	86	87
0.75	74	88	90	91
1.00	81	91	93	93
1.25	85	93	94	95
1.50	89	95	96	96
1.75	91	96	96	97
2.00	92	96	97	97
2.25	93	97	97	98
2.50	94	97	98	98
2.75	95	98	98	98
3.00	96	98	98	99
3.25	96	98	99	99
3.50	97	98	99	99
3.75	97	99	99	99
4.00	97	99	99	99

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Highway (max. 75% impervious)

for Hydrologic Soil Group A

Retention Depth	Annual Total P Removal (%)			
(inches)	Dry Retention ¹	Re	tention / Wet	Detention ²
(inches)	Dry Retention	t _d =7 days	t _d =14 days	t _d =21 days
0.25	41	73	77	79
0.50	65	84	86	87
0.75	76	89	91	91
1.00	83	92	93	94
1.25	88	95	95	96
1.50	91	96	96	97
1.75	93	97	97	97
2.00	94	97	98	98
2.25	95	98	98	98
2.50	96	98	98	99
2.75	97	98	99	99
3.00	97	99	99	99
3.25	97	99	99	99
3.50	98	99	99	99
3.75	98	99	99	99
4.00	98	99	99	99

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Highway (max. 75% impervious) for Hydrologic Soil Group B

Retention Depth	Annual Total P Removal (%)			
(inches)	Dry Retention ¹	Retention / Wet Detention ²		
		t _d =7 days	t _d =14 days	t _d =21 days
0.25	41	73	77	79
0.50	63	83	86	87
0.75	74	88	90	91
1.00	81	91	93	93
1.25	87	94	95	95
1.50	89	95	96	96
1.75	92	96	97	97
2.00	93	97	97	98
2.25	94	97	98	98
2.50	95	98	98	98
2.75	96	98	98	99
3.00	97	98	99	99
3.25	97	99	99	99
3.50	97	99	99	99
3.75	98	99	99	99
4.00	98	99	99	99

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Highway (max. 75% impervious) for Hydrologic Soil Group C

Retention Depth	Annual Total P Removal (%)			
(inches)	Dry Retention ¹	Retention / Wet Detention ²		
		t _d =7 days	t _d =14 days	t _d =21 days
0.25	39	72	77	78
0.50	62	82	85	86
0.75	72	87	89	90
1.00	80	91	92	93
1.25	85	93	94	95
1.50	88	95	95	96
1.75	91	96	97	97
2.00	92	97	97	97
2.25	94	97	98	98
2.50	95	98	98	98
2.75	96	98	98	98
3.00	96	98	99	99
3.25	97	98	99	99
3.50	97	99	99	99
3.75	97	99	99	99
4.00	98	99	99	99

1. Dry retention alone.

Removal Efficiencies for Total Phosphorus Using Various Treatment Options in Highway (max. 75% impervious) for Hydrologic Soil Group D

Retention Depth	Annual Total P Removal (%)			
(inches)	Dry Retention ¹	Re	tention / Wet	Detention ²
(menes)	Dry Retention	t _d =7 days	t _d =14 days	t _d =21 days
0.25	38	72	76	78
0.50	61	82	85	86
0.75	71	87	89	90
1.00	79	90	92	93
1.25	84	93	94	94
1.50	88	94	95	96
1.75	90	96	96	97
2.00	92	96	97	97
2.25	94	97	98	98
2.50	94	97	98	98
2.75	95	98	98	98
3.00	96	98	98	99
3.25	97	98	99	99
3.50	97	99	99	99
3.75	97	99	99	99
4.00	98	99	99	99

1. Dry retention alone.

Complete Rewording of Appendix K

APPENDIX K

LEGAL DESCRIPTION

LAKE APOPKA HYDROLOGIC BASIN

Begin at the Northeast corner of Section 29, Township 22 South, Range 28 East; thence South along the Section lines to the Southeast corner of the Northeast quarter of Section 32, Township 22 South, Range 28 East; thence west along the quarter section line to the Southeast corner of the Northwest quarter of Section 31, Township 22 South, Range 28 East; thence South along the quarter section line to the Southeast corner of the Southwest quarter of Section 31, Township 22 South, Range 28 East; thence West along the Section lines to the Southwest corner of the Southeast quarter of Section 36, Township 22 South, Range 27 East; thence South along the quarter section line to the Southeast corner of the Southwest quarter of Section 1, Township 23 South, Range 27 East; thence West along the Section line to the Southeast corner of Section 2, Township 23 South, Range 27 East; thence South along the Section line to the Southeast corner of Section 11, Township 23 South, Range 27 East; thence West along the Section lines to the Southeast corner of the Southwest quarter of Section 7, Township 23 South, Range 27 East; thence South along the quarter section line to the Southeast corner of the Northeast quarter of the Northwest quarter of Section 18, Township 23 South, Range 27 East; thence West along the south line of the Northeast quarter of the Northwest quarter and along the south line of the Northwest quarter of the Northwest quarter, to the Southwest corner of the Northwest quarter of the Northwest quarter of Section 18, Township 23 South, Range 27 East; thence North along the Section line to the Southwest corner of Section 7, Township 23 South, Range 27 East: thence West along the Section line to the Southwest corner of the Southeast quarter of Section 12, Township 23 South, Range 26 East; thence North along the quarter section line to the Southeast corner of the Southwest quarter of Section 1, Township 23 South, Range 26 East; thence West along the Section lines to the Southwest corner of the Southeast quarter of Section 6, Township 23 South, Range 26 East; thence North along the quarter section line to the Northwest corner of the Northeast quarter of Section 6, Township 23 South, Range 26 East; thence East along the Section line to the Southwest corner of Section 32, Township 22 South, Range 26 East; thence North along the Section line to the Northwest corner of Section 32, Township 22 South, Range 26 East; thence East along the Section line to the Southwest corner of Section 28, Township 22 South, Range 26 East; thence North along the Section line to the Southeast corner of the Northeast Quarter of Section 5, Township 22 South, Range 26 East; thence West along the quarter section line to the Southwest corner of the Northwest Quarter of Section 5, Township 22 South, Range 26 East; thence North along the Section lines to the Northwest corner of Section 32, Township 21 South, Range 26 East; thence East along the Section line to the Northeast corner of the Northwest quarter of Section 32, Township 21 South, Range 26 East; thence North along the quarter section lines to the Northwest corner of the Northeast quarter of Section 20, Township 21 South, Range 26 East; thence East along the Section line to the Southwest corner of Section 16, Township 21 South, Range 26 East; thence North along the Section line to the Northwest corner of Section 16, Township 21 South, Range 26 East; thence East along the Section line to the Southwest corner of the Southeast quarter of Section 9, Township 21 South, Range 26 East; thence North along the quarter section line to the Northwest corner of the Southeast quarter of Section 4, Township 21 South, Range 26 East; thence West along the quarter section line to the Southwest corner of the Northwest quarter of Section 4, Township 21 South, Range 26 East; thence North along the Section line to the Northwest corner of Section 4, Township 21 South, Range 26 East and the South line of Section 33, Township 20 South, Range 26 East; thence West along said South line to the Southwest corner of said Section 33, Township 20 South, Range 26 East; thence North along the section lines to the Northwest corner of Section 28, Township 20 South, Range 26 East; thence East along the section lines to the Southwest corner of the Southeast quarter of Section 24, Township 20 South, Range 26 East; thence North along the quarter section line to the Northwest corner of the Southeast quarter of Section 24, Township 20 South, Range 26 East; thence East along the quarter section line to the Northeast corner of the Southeast quarter of Section 24, Township 20 South, Range 26 East; thence North along the Section line to the Northwest corner of Section 19, Township 20 South, Range 27 East; thence East along the Section lines to the Northwest corner of Section 21, Township 20 South, Range 27 East; thence North along the Section line to the Northwest corner of the Southwest quarter of Section 16, Township 20 South, Range 27 East; thence East along the quarter section line to the Northeast corner of the Southeast quarter of Section 16, Township 20 South, Range 27 East; thence North along the Section line to the Northwest corner of Section 15, Township 20 South, Range 27 East; thence East along the Section line to the Northeast corner of Section 14, Township 20 South, Range 27 East; thence South along the Section lines to the Southeast corner of Section 23, Township 20 South, Range 27 East; thence West along the Section line to the Southwest corner of the Southeast quarter of Section 23, Township 20 South, Range 27 East;

SWIM Plan for Lake Apopka

thence South along the quarter section line to the Northwest corner of the Northeast quarter of Section 35, Township 20 South, Range 27 East; thence East along the Section line to the Northeast corner of Section 35, Township 20 South, Range 27 East; thence South along the Section line to the Southeast corner of Section 35, Township 20 South, Range 27 East; thence East along the Section line to the Southwest corner of the Southeast quarter of Section 36, Township 20 South, Range 27 East; thence North along the quarter section line to the Northwest corner of the Southeast quarter of Section 36, Township 20 South, Range 27 East; thence East along the quarter section line to the Northeast corner of the Southeast quarter of Section 36, Township 20 South, Range 27 East; thence North along the Section line to the Northwest corner of Section 31, Township 20 South, Range 28 East; thence East along the Section lines to the Northeast corner of the Northwest quarter of Section 33, Township 20 South, Range 28 East; thence South along the quarter section lines to the Southeast corner of the Southwest quarter of Section 9, Township 21 South, Range 28 East; thence East along the Section line to the Northwest corner of the Northeast quarter of the Northeast quarter of Section 16, Township 21 South, Range 28 East; thence South along the quarter-quarter Section lines to the Southwest corner of the Southeast quarter of the Southeast quarter of Section 16, Township 21 South, Range 28 East; thence West along the Section line to the Southwest corner of the Southeast quarter of Section 16, Township 21 South, Range 28 East; thence South along the quarter section line to the Southeast corner of the Southwest quarter of Section 21, Township 21 South, Range 28 East; thence West along the Section line to the Southeast corner of Section 20, Township 21 South, Range 28 East; thence South along the Section line to the Southeast corner of Section 32, Township 21 South, Range 28 East; thence West along the Section line to the Southwest corner of the Southeast quarter of Section 32, Township 21 South, Range 28 East; thence South along the quarter section line to the Southwest corner of the Northeast quarter of Section 8, Township 22 South, Range 28 East; thence East along the quarter section line to the Southeast corner of the Northeast quarter of Section 8, Township 22 South, Range 28 East; thence South along the Section line to the Southeast corner of Section 8, Township 22 South, Range 28 East; thence West along the Section line to the Southeast corner of Section 7, Township 22 South, Range 28 East; thence South along the Section line to the Southeast corner of the Northeast quarter of Section 18, Township 22 South, Range 28 East; thence West along the quarter section line to the Northeast corner of the Southeast quarter of Section 13, Township 22 South, Range 27 East; thence South along the Section line to the Southeast corner of Section 13, Township 22 South, Range 27 East; thence West along the Section line to the Southwest corner of the Southeast quarter of Section 13, Township 22 South, Range 27 East; thence South along the quarter section line to the Northwest corner of the Northeast quarter of Section 25, Township 22 South, Range 27 East; thence East along the Section lines to the Northeast corner of Section 29, Township 22 South, Range 28 East, and the Point of Beginning.

NOTE: This description is based on U.S. Geological Survey 7.5 minute series quadrangle maps and St. Johns River Water Management District Hydrologic Basin maps.

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

RULE TITLE:	RULE No.:
Policy and Purpose	40C-41.011, F.A.C.
Basin Boundaries	40C-41.023, F.A.C.
Implementation	40C-41.033, F.A.C.
Application of Chapter	40C-41.043, F.A.C.
Exemptions	40C-41.051, F.A.C.
Conditions for Issuance of Permits	40C-41.063, F.A.C.

40C-41.011 Policy and Purpose. The rules in this chapter establish additional surface water management standards and criteria for the Upper St. Johns River Hydrologic Basin, the Ocklawaha River Hydrologic Basin, the Wekiva River Hydrologic Basin, the Econlockhatchee River Hydrologic Basin, the Tomoka River Hydrologic Basin, the Spruce Creek Hydrologic Basin, and the Sensitive Karst Areas Basin, and the Lake Apopka Hydrologic Basin, which insure that development within the basins incorporates the appropriate water quantity and water quality control and other environmental measures necessary to protect the integrity of the public investments in the basins and which minimizes adverse impacts to the water resources of the District. Standards and criteria delineated in this chapter are in addition to those criteria specified in chapters 40C-4, 40C-40, and 40C-42, and 40C-44, F.A.C., in accordance with 40C-41.043, F.A.C. The standards, criteria, exemptions, and additional requirements specified in this chapter are not intended to supersede or rescind the terms and conditions of any valid surface water management permit issued by the District prior to the effective date of this chapter.

Specific Authority 373.044, 373.113, 373.171, 373.415 FS. Law Implemented 373.413, 373.415, 373.416, <u>373.418</u>, 373.426, <u>373.461</u> FS. History--New 12-7-83, Amended 5-17-87, 8-30-88, 4-3-91, 9-25-91, 11-25-98, <u>3-07-03</u>.

40C-41.023 Basin Boundaries.

(1) through (6) No change.

Insert Figure 41-5

(7) The Lake Apopka Hydrologic Basin is that area generally depicted in Figure 41-5 and defined in Applicant's Handbook, Appendix K as incorporated by reference in rule 40C-4.091, F.A.C.

Specific Authority 373.044, 373.113, 373.171 FS. Law Implemented 373.413, 373.416, 373.426 FS. History--New 12-7-83, Amended 5-17-87, 4-3-91, 9-25-91, 11-25-98, <u>3-07-03</u>.

40C-41.033 Implementation.

(1) The effective date of this chapter is December 7, 1983, for the criteria of subsections 40C-41.063(1) and (2); May 17, 1987, for the standards of paragraphs 40C-41.063(3)(a) and (b); August 30, 1988, for the standards and criteria of paragraphs 40C-41.063(3)(c), (d) and (e); April 3, 1991, for the standards and criteria in subsection 40C-41.063(5); and September 25, 1991 for the criteria of subsection 40C-41.063(7), and 11-25-98 for the criteria of subsection 40C-41.063(6), and March 7, 2003, for the standards and criteria in subsection 40C-41.063(8).

(2) No change.

Specific Authority 373.044, 373.113, 373.171 373.415 FS. Law Implemented 373.413, 373.415, 373.416, 373.426<u>, 373.461</u> FS. History--New 12-7-83, Amended 5-17-87, 8-30-88, 4-3-91, 9-25-91, 11-25-98<u>, 3-07-03</u>.

40C-41.043 Application of Chapter.

(1) All projects located within the Upper St. Johns River Hydrologic Basin, the Ocklawaha River Hydrologic Basin, the Wekiva River Hydrologic Basin, or the Econlockhatchee River Hydrologic Basin, the Tomoka River Hydrologic Basin, or the

Spruce Creek Hydrologic Basin, or the Lake Apopka Hydrologic Basin, requiring permits pursuant to rule 40C-4.041, F.A.C., shall be constructed, operated, maintained, altered, abandoned and removed in accordance with the standards and criteria specified in <u>rules 40C-41.063</u>, and either sections 40C-4.301 and 40C-4.302, or 40C-40.302, and 40C-41.063, F.A.C., unless specifically exempted <u>in rule 40C-41.051</u>, F.A.C., or otherwise provided in <u>subsection 40C-41.043(3) or 40C-41.043(4)</u>, F.A.C. The most restrictive criteria will be applicable unless the applicant provides reasonable assurance that the purposes and intent of this chapter and chapter 40C-4, F.A.C., will be fulfilled using alternate criteria.

(2) No change.

(3) Stormwater management systems requiring permits pursuant to rule 40C-42.022, F.A.C., that will be located within the Lake Apopka Hydrologic Basin or will discharge water to Lake Apopka or its tributaries, shall be constructed, operated, maintained, altered, abandoned and removed in accordance with the standards and criteria specified in rule 40C-42.023, F.A.C., and subsection 40C-41.063(8), F.A.C.

(4) Agricultural surface water management systems requiring permits pursuant to rule 40C-44.041, F.A.C., that will be located within the Lake Apopka Hydrologic Basin or will discharge water to Lake Apopka or its tributaries, shall be constructed, operated, maintained, altered, abandoned and removed in accordance with the standards and criteria specified in rule 40C-44.301, F.A.C., and subsection 40C-41.063(8), F.A.C. Specific Authority 373.044, 373.113, 373.171, 373.415 FS. Law Implemented 373.413, 373.415, 373.416, <u>373.418</u>, 373.426, <u>373.461</u> FS. History--New 12-7-83, Amended 5-17-87, 8-30-88, 4-3-91, 9-25-91, 10-3-95, 11-25-98, 3-07-03.

40C-41.051 Exemptions.

(1) No change.
(2) <u>A single family dwelling unit</u> The following systems located wholly or partially within the Tomoka River Hydrologic Basin or the Spruce Creek Hydrologic Basin, provided the unit is not part of a larger common plan of development or sale, is are exempted from the standards and criteria in subsection 40C-41.063(6), F.A.C., and section 11.5, Applicant's Handbook: Management and Storage of Surface Waters.

(a) A single family dwelling unit provided the unit is not part of a larger common plan of development or sale.

(b) Systems that qualify for a noticed general permit pursuant to chapter 40C-400, F.A.C., and which comply with the requirements of such noticed general permit.

(3) Stormwater management systems exempted in rule 40C-42.0225, F.A.C., which are either located wholly or partially within the Lake Apopka Hydrologic Basin or which discharge water to Lake Apopka or its tributaries, are exempted from the standards and criteria in subsection 40C-41.063(8), F.A.C.

(4) Systems that qualify for a noticed general permit under Chapter 40C-400, F.A.C., are exempted from the standards and criteria in Rule 40C-41.063, F.A.C., and Sections 11.0 – 11.7, Applicant's Handbook: Management and Storage of Surface Waters. Specific Authority 373.044, 373.113, 373.171 FS. Law Implemented 373.413, 373.416, 373.426, <u>373.461</u> FS. History--New 4-3-91, Amended 11-25-98, <u>3-07-03</u>.

40C-41.063 Conditions for Issuance of Permits.

(1) through (7) No change.

(8) Any surface water management system that requires a permit pursuant to Chapters 40C-4, 40C-40, 40C-42, or 40C-44, F.A.C., and that will be located within the Lake Apopka Hydrologic Basin or will discharge water to Lake Apopka or its tributaries, must comply with the requirements of Section 11.7, Applicant's Handbook: Management and Storage of Surface Waters, adopted by reference in subsection 40C-4.091(1), F.A.C.

Specific Authority 373.044, 373.113, 373.414, 373.415, 373.418 FS. Law Implemented 373.413, 373.414. 373.415, 373.416, 373.418, 373.426, <u>373.461</u> FS. History--New 12-7-83, Amended 5-17-87, 8-30-88, 8-1-89, 4-3-91, 9-25-91, 7-14-92, 10-3-95, 11-25-98, 10-11-01, <u>3-07-03</u>.

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

RULE TITLE:

Requirements for Issuance

RULE NO.: 40C-42.023, F.A.C.

40C-42.023 Requirements for Issuance.

(1) To receive a general or individual permit under this chapter the applicant must provide reasonable assurance based on plans, test results and other information, that the stormwater management system:

(a) through (c) No change.

(d) Meets any applicable basin criteria contained in <u>Rule 40C-41.063(7) and (8),</u> <u>F.A.C.</u> <u>Chapter 40C-41, F.A.C.</u>

(2) No change.

Specific Authority 373.044, 373.113, 373.171, 373.418 FS. Law Implemented 373.413, 373.416, <u>373.418, 373.426, 373.461</u> FS. History--New 9-25-91. Amended 3-21-93, 10-3-95, <u>3-07-03</u>.

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

RULE TITLE:	RULE NO.:
Performance Standards	40C-44.065, F.A.C.
Publications Incorporated by Reference	40C-44.091, F.A.C.

40C-44.065 Performance Standards

(1) through (3) No change.

(4) Agricultural surface water management systems requiring a permit, which will be located in the Lake Apopka Hydrologic Basin or will discharge water to Lake Apopka or its tributaries, must comply with the requirements of subsection 40C-41.063(8), <u>F.A.C.</u>

Specific Authority 373.044, 373.113, 373, 373.171, 373.416, 373.418 FS. Law Implemented 373.016, 373.413, 373.416, 373.418, <u>373.426</u>, <u>373.461</u> FS. History—New8-11-91. Amended 10-20-92, 7-4-93, 10-3-94, <u>3-07-03</u>.

40C-44.091 Publications Incorporated by Reference.

 (1) The Governing Board hereby adopts by reference Part I "Policy and Procedures" and Part II "Criteria for Evaluation," of the document entitled "Applicant's Handbook: Agricultural Surface Water Management Systems, effective, <u>3-07-03</u> 11-1-99.

(2) and (3) No change.

Specific Authority 373.044, 373.113, 373.171, 373.406, 373.416, 373.418 FS. Law Implemented, 373.406, 373.413, 373.416<u>, 373.418, 373.426, 373.461</u> FS. History--New 10-20-92, 7-4-93, 10-3-9, 11-1-99<u>, 3-07-03</u>.

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT APPLICANT'S HANDBOOK AGRICULTURAL SURFACE WATER MANAGEMENT SYSTEMS

APPLICANT'S HANDBOOK SECTION

- 10.2 Harm to the Water Resources Criteria10.2.1 through 10.2.5 No Change
 - 10.2.6 Agricultural surface water management systems requiring a permit which will be located in the Lake Apopka Hydrologic Basin or which will discharge water to Lake Apopka or its tributaries, must comply with the requirements of subsection 40C-41.063(8), F.A.C., and Section 11.7, Applicant's Handbook: Management and Storage of Surface Waters.

APPENDIX B—CHRONOLOGY OF LAKE APOPKA

<u>Year(s)</u>	Event
1821	Seminole village located near lake
1845	First township plats recorded
1893	Apopka-Beauclair Canal dredged from Lake Apopka through Lakes Dora and Eustis to the Ocklawaha River, lowering the water surface of Lake Apopka by 1.2 m (4 ft)
1915	Apopka-Beauclair Canal enlarged and the lake level lowered to 63 ft NGVD 29. WWI prompted the planting of potatoes on the north shore
1917	The north shore no longer farmed because of crop failures
1920	Lake Apopka described in reports as clear, with a luxuriant growth of rooted aquatic plants and good fishing
1922	Sewage discharge begins from Winter Garden
1924	Wastewater discharges begin from fresh fruit preparation
1926	A destructive hurricane hits, and north shore farms revert to marshland
1936	Lake Apopka elevation reaches a high of 69.3 ft NGVD 29 in October
1941	The Zellwood Drainage and Water Control District (ZDWCD) created by special act of the Legislature. Levee constructed on the north side of the lake. Aerial photography indicates rooted, submersed plants and clear water
1942	Drainage water discharges begin from muck farms. First north shore peat farms operating. Lake elevation reaches a low of 65.9 ft NGVD 29
1942-47	Muck farms expand to 3,137 ha (7,745 ac)
1946	Single-strength citrus juice production begins, with wastewater discharged to Lake Apopka. A heavy growth of pondweed (<i>Potamogeton</i> sp.) located

<u>Event</u>

approximately 180 m from shore and extending across the entire lake, except where the water depth exceeds 2.4 m (8 ft), covering an area of 8,100 ha (20,000 ac). Water hyacinth very thick around the edge of the shore, which instigates a hyacinth control program, resulting in an unusually large number of decaying plants in the lake

- 1947 The first algal blooms confirmed by aerial photography in March. 35% of fish are gamefish, and 20% are gizzard shad. The lake reaches an elevation of 68.7 ft NGVD 29 in September and October
- 1948 Wastewater discharges from citrus concentrate production begin. Herbicide (2-4-D) treatments of water hyacinth begin. Apopka-Beauclair Canal upgraded; 57% of fish are gamefish
- 1948–50 Disappearance of rooted aquatic vegetation, frequent algal blooms. The fish population increases ten-fold; large catches reported—69% gamefish. Pondweed completely eradicated
 - 1951 Average annual gross income of fish camps about \$37,000 each
 - 1952 Temporary control structure placed in Apopka-Beauclair Canal. Lake-level stabilization program begun
 - 1956 A permanent lock-and-dam structure placed in Apopka-Beauclair Canal, and water level regulated at 66.5-67.5 ft NGVD 29. Lake elevation reaches 64.04 ft NGVD 29 on August 12 due to effects of drainage and drought. Twenty-one fish camps in operation
 - 1957 Rough fish (mostly gizzard shad) comprise 82% of the fish population.Selective poisoning of gizzard shad and threadfin shad (1,587 tonnes or 1,750 tons) with Rotenone. Dense phytoplankton bloom follows
 - 1958 Selective poisoning of gizzard shad and threadfin shad (4,535 tonnes or 5,000 tons). Dense phytoplankton bloom follows. Apopka-Beauclair Canal deepened
 - 1959 Selective poisoning of gizzard shad and threadfin shad (2,948 tonnes or 3,250 tons). Dense phytoplankton bloom follows. An aquatic survey undertaken. A thick band of panicgrass, maidencane, spike rush, and eelgrass (*Panicum*

<u>Event</u>

geminatum, Panicum hemitomon, Eleocharis sp., and *Vallisneria americana*, respectively) borders most of the lakeshore from Winter Garden west to Oakland. Majority of the northern shore devoid of emergent vegetation. Winter Garden wastewater treatment plant capacity enlarged to 1 mgd

- 1962 Gizzard shad comprise only 30% of the fish biomass, with gamefish rebounding at 50%. A dark brown to orange odorous sludge blanket enters the lake from the canal discharging citrus processing waste. A report of the water quality of Lake Apopka, by the Orange County Health Department, calculates a biochemical oxygen demand loading of 8,400 pounds per day or equivalent to a population of 49,500 from four packing houses and the Winter Garden Citrus Products Cooperative Processing Plant. Approximately 54 tonnes (60 tons) of fish, frogs, snakes, and turtles killed, cause unknown. The algal bloom predominately *Botryococcus* sp.
- 1963 Large fish kill in May. Approximately 4,500–9,000 tonnes of rough fish, 250 tonnes of gamefish (5,000–10,000 tons and 250 tons, respectively) killed. Approximately 7,300 ha (18,000 ac) of farmland under cultivation on the north shore of the lake. USFWS and the U.S. Public Health Service report 160 ppm DDT and DDE and 50 ppm TDE in the fat of largemouth bass and 7 ppm DDT and DDE and 8 ppm TDE in the flesh of bluegill collected from the lake in June
- 1965 Nine fish camps in operation, with an average annual gross income of about \$11,000 each. The Florida State Board of Health estimates the spawning and feeding grounds to be less than 810 ha (2,000 ac) of the lake's 12,150 ha (30,000 ac). A moderate increase in vegetation (*Potamogeton* and *Vallisneria*) along the shore attributed to heavy rainfalls improving light penetration. The lake at elevation 66.2 ft NGVD 29 on October 21
- 1966 The Florida State Board of Health files an injunction against Winter Garden Citrus Products Cooperative Processing Plant. Large fish kill reported. Water samples taken in Apopka-Beauclair Canal reveal 60,000 ppm DDD and other DDT-related metabolites, with traces of dieldrin and lindane
- 1967 Governor Claude Kirk appoints a technical committee consisting of 16 federal, state, and local agencies and advisors. A citizens committee forms to complement the work of the technical committee. Water quality restoration standards set. Laboratory opens at Fisherman's Paradise Fish Camp, staffed

<u>Event</u>

by permanent and temporary personnel. Routine water quality sampling begun. An estimated 9,720 ha (24,000 ac) (double cropping) of vegetable crops harvested. Water hyacinth spraying ceases, except when navigation threatened

- 1968 Lake Apopka Trust Fund enacted by Orange County Commission, funded by Orange and Lake counties. Restoration project placed under authority of Florida Air and Water Pollution Control Commission. Farms hire engineering consultants
- 1969 Winter Garden Citrus Products Cooperative Processing Plant adds nutrient removal process to treat 2.0 mgd of strong waste
- 1970 Gizzard shad constitutes 82% of the fish population
- 1971 Experimental gravity drawdown. Lake level lowered 2.1 ft, from 66.5 to 64.4 ft NGVD 29. Alligator, turtle, bird, snake, and fish mortality
- 1973 A vegetation survey finds only a few sparse patches of stonewort (*Chara*) and *Panicum* on the lakeshore from Winter Garden west to Oakland
- 1974 Four fish camps remain
- 1977 Direct citrus processing wastewater discharges to lake end. Peat mine begins discharge from Pine Island, adjacent to Gourd Neck
- 1980 Direct sewage discharges end as the Winter Garden Pollution Control Facility constructs a percolation/evaporation system. A spill from Tower Chemical Company contaminates the drainage into Gourd Neck in the southwestern portion of the lake with copper and pesticides from a wastewater pond
- 1981 Report published by the University of Florida indicates an increase in eutrophication over a four-year period. A major decline in juvenile alligators observed on Lake Apopka
- 1985 Lake Apopka Restoration Act enacted which creates the Lake Apopka Restoration Council (LARC). A total of \$2.265 million is appropriated to initiate feasibility studies, evaluate restoration techniques, and develop a

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<u>Event</u>

nutrient budget. SJRWMD issues Intent to Deny for Duda and ZDWCD consumptive use applications and requests Cease and Desist Order and criminal charges

- 1986 Initiation of Comprehensive Pilot Projects by SJRWMD
- 1987 Passage of the SWIM Act. Lake Apopka named a priority water body, one of initial seven statewide in need of restoration
- 1988 Initiation of the Marsh Flow-Way Restoration Project. FDEP delegates authority to regulate muck farm discharges to SJRWMD. SJRWMD sues A. Duda & Sons, Inc. (Duda) and ZDWCD for operating without valid discharge permits. SJRWMD signs a consent order with Duda to reduce nutrient loading. On November 16, SJRWMD acquires approximately 633 ha (1,563 ac) from Foley and Eric Hooper for \$5 million. Approximately 552 ha (1,363 ac) of this acquisition traded to Duda for \$300,000 and 749 ha (1,850 ac) contained in their Clay Island Farm. At the same time, Duda gives SJRWMD an option to repurchase Hooper Farms (552 ha or 1,363 ac) for \$4.8 million. Option exercised; closing held on March 28, 1990
- 1989 SJRWMD signs a consent order with ZDWCD to reduce nutrient loading. Consent order is challenged. SJRWMD issues a Management and Storage of Surface Waters (MSSW) permit to Duda to construct a reservoir. SJRWMD issues a consumptive use permit (CUP) to Duda. The SWIM Plan for Lake Apopka is approved by FDEP
- 1990 A demonstration marsh flow-way constructed to test operation efficiency of marsh filtration. A shad harvesting project begun on Lake Denham to test for nutrient removal and food chain effects. The Brady/RICO parcel of 80 ha (198 ac) is acquired for \$83,197 for the marsh flow-way on January 2. The 446ha (1,100-ac) Duda/Whittle parcel is acquired
- 1991 Testing of portable barriers in near-shore areas of Lake Apopka to disrupt wind mixing and stabilize shallow sediments. The ZDWCD consent order upheld after challenge; expires 2001. SJRWMD issues CUP to ZDWCD; expires December 1993. SJRWMD issues an Agricultural Surface Water Management System (SWMS) permit to Zellwin Sand Farm. The Lake Apopka Hydrologic Unit Project initiated to reduce nutrient loading to the lake from muck farms

Event

- 1992 Planting of desirable vegetation in littoral zone areas begun. Duda agricultural discharges meet consent order goals. Wilkinson-Cooper Farm acquired on May 15, as required for marsh flow-way project, at a cost of \$669,296.25 from the P2000 trust fund. C.C. Ranch acquired on May 15 for marsh flow-way project at a cost of \$669,296.25 from the P2000 trust fund. SJRWMD issues CUP to Zellwin Sand Land Farm
- 1993 SWIM Plan updated. Begin pilot-scale mass harvest of rough fish for nutrient removal. SJRWMD issues modified MSSW permit to Duda to operate reservoir; supersedes consent order
- 1994 Initial external nutrient budget finished, and scientific basis for phosphorus (P) load limit completed in draft. Pollutant load limit for P proposed by Governing Board (Chapter 40C-61, *F.A.C.*). SJRWMD signs settlement agreement with Duda concerning nutrient limitations. SJRWMD issues CUP to Duda; expires 2004. SJRWMD issues modified SWMS permit to Zellwin Sand Farm
- SJRWMD proposed rule 40C-61, *F.A.C.*, successfully challenged by ZDWCD.
 Conceptual plan for full-scale marsh flow-way is completed. The 21-ha
 (53-ac) Blunt parcel is acquired on May 29 for \$106,000. The 73-ha (181-ac)
 Boyd-Davis parcel adjacent to the flow-way is acquired for \$474,128. Several small patches of eelgrass observed in lake near north shore
- 1996 Legislation sets a P criterion for the lake, gives SJRWMD legal authority to set a P discharge limitation, and provides \$20 million to acquire farmland. In addition, SJRWMD receives \$26 million from the USDA Wetland Reserve Program. SJRWMD issues CUP to ZDWCD. Orange County estimated to be the fourth fastest growing and the sixth most populated county in the state
- 1997 Design of full-scale marsh flow-way completed and a contractor hired for Phase I construction. The Legislature approves \$45 million for muck farm purchase. Purchase of 2,128-ha (5,254-ac) Zellwin Farms approved by the Governing Board on April 9. Purchase of Duda's Jem Farm (1,377 ha) final on April 10. Purchase of the Grower's Precooler (7 ha), Crakes and Sons (205 ha), and Clarence W. Beall Jr. muck farms (126 ha) approved by the Governing Board for \$3.96 million, \$2.6 million, and \$1.3 million, respectively, on

<u>Event</u>

November 12. SJRWMD renews the Zellwin Sand Farm permit through December 1998. Sixty-three patches of eelgrass totaling 1.16 ha (3.95 ac) and small areas of musk grass (*Chara* spp.) and southern naiad mapped in the lake. From January 1993 through June 1997, commercial fishermen removed 5 million pounds of gizzard shad from the lake. Public workshops held to discuss P discharge limits

- 1998 During 1998, commercial fishermen harvested 1.7 million pounds of gizzard shad from the lake. SJRWMD closes on a total of 3,889 ha (9,602 ac) of farmlands. Shallow flooding of former farmlands to control vegetation begins. In December, several dead pelicans found on the flooded farms. The Zellwood/Mount Dora Christmas Bird Count recorded a North American inland record of 174 species. An estimated 25,000 to 40,000 migrating shorebirds feeding on former farmlands. Drainage begun in ZDWCD Unit II in October and Duda's Jem Farm in November to facilitate soil amendment application
- 1999 In January, deaths of American white pelicans and other fish-eating birds on the former farmlands recognized as excessive, and draining of the farms accelerated to completely dry the area. In February, the U.S. Fish and Wildlife Service (USFWS) concluded that organochlorine pesticides killed the birds, and launched an investigation. SJRWMD and the National Resource Conservation Service launched a scientific investigation of the bird mortality. This pesticide study involved the collection and analysis of more than 1,300 water, soil, and wildlife tissue samples, along with a review of original remediation efforts. Final farmlands purchased for a total of 5,554 ha (13,713 ac) within the North Shore Restoration Area. SJRWMD convenes a technical advisory group to assist investigation of the cause of the bird deaths. Reflooding of the purchased farmlands delayed until the remediation efforts, if needed, were completed. Soil amendment applied to 797 ha (1,968 ac) of Duda Jem Farm for P control, beginning in March. The site for the environmental education center in the Oakland Nature Preserve purchased by the city of Oakland in March
- 2000 Construction of the marsh flow-way and spreading of soil amendment completed. A revised technical memorandum with P loading limit recommendation completed. A Notice of Proposed Rule Development was published in the *Florida Administrative Weekly* on December 29. Between mid-1995 and December 2000, a P reduction of 34% and improved water clarity

<u>Event</u>

(30%) was documented. The Lake Apopka Basin Steering Committee for the Lake Apopka Basin Planning Initiative, a coordinated regional planning effort involving local planning departments, municipalities, Friends of Lake Apopka, the East Central Florida Regional Planning Council, and SJRWMD, established

- 2001 By January 2001, more than 83 patches of submersed aquatic vegetation with a combined area of over 2.63 ha (6.5 ac) had been documented in Lake Apopka. A bioaccumulation study, including funds contributed by NRCS, initiated in February to evaluate risk from pesticide residues through the food chain to fish and then to birds. In June, the Lake Apopka water elevation reaches a low of 62.82 ft NGVD 29 due to drought. Following a public workshop and a contracted review of existing stormwater treatment criteria, the proposed P rule revisions published in the *Florida Administrative Weekly* in December
- 2002 Following receipt of a Biological Opinion from USFWS, a portion of the Duda Jem Farm reflooded, accompanied by extensive monitoring of water chemistry, hydrology, and bird use. Lake Apopka reaches a new low of 62.52 ft NGVD 29 in June due to continued drought. To improve lake access for commercial rough fish harvesting, a dock facility is constructed on the McDonald Canal. Consultations were initiated with EPA and USFWS to begin operation of the flow-way. Remediation of a highly contaminated area was initiated at the NSRA. Over 9,000 tons of soil were excavated from a 2.43-ha (6-ac) site at the former Lust Farm and disposed of off-site. Final rule adoption hearing for the P discharge limitation held in December, rule to be effective March 7, 2003

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APPENDIX C—LAKES INVENTORY

Below are the locations and physical characteristics of the lakes contained within the Lake Apopka drainage basin.

Lalas	Area	Location				Elevation	on Teer	
Lake	(acres)	Lat/Long	Section	Township	Range	(ft NGVD)	LCON	
Alden	33	28°41'54"	32	20	28	62	4	
		81°32'12"						
Anne	9	28°41'17"	6	21	28	87	4	
		81°32'46"						
Apopka	30,671	28°39'06"	29	21	27	66	3	
		81°39'29"						
Avalon	162	28°30'38"	6	23	27	91	4	
		81°38'37"						
Beulah	15	28°32'06"	36	22	27	107	4	
		81°33'49"						
Big Breedlove	5	28°36'40"	34	21	26	77	4	
		81°42'22"						
Black	244	28°31'39"	34	22	27	95	4	
		81°36'07"						
Blacks	28	28°33'54"	15	22	26	79	4	
		81°42'17"						
Blacks Still	34	28°34'24"	15	22	26	79	4	
		81°42'13"						
Bonnet	3	28°32'17"	29	22	28	125	1	
		81°32'04"						
Bronson		28°40'10"	17	21	28	68	4	
		81°32'20"						
Camp	12	28°36'16"	5	22	26	83	4	
		81°43'34"						
Carter	8	28°38'11"	29	21	28	71	4	
		81°32'22"						
Clarence	21	28°33'56"	16	22	26	79	4	
		81°42'43"						
Clearwater	49	28°40'31"	7	21	28	70	4	
		81°33'05"						
Eva	2	28°41'26"	6	21	28	86	4	
		81°32'45"						

SWIM Plan for Lake Apopka

Fanny	10	28°44'28"	21	20	27	82	4
		81°37'09"					
Felter	88	28°31'08"	4	23	26	85	4
		81°43'22"					
Florence	130	28°35'50"	2	22	26	74	4
		81°40'59"					
Francis	36	28°42'12"	32	20	28	59	4
		81°32'26"					
Fuller	36	28°39'45"	17	21	28	68	2
		81°31'47"					
Gem	2	28°40'42"	8	21	28	78	4
		81°31'37"					
Gizzard	5	28°37'39"	28	21	26	82	4
		81°42'55"					
Heininger	23	28°40'56"	7	21	28	68	2
C		81°32'55"					
Hiawatha		28°41'02"	5	21	28	72	4
North		81°31'43"					
Holts	33	28°41'12"	6	21	28	104	3
		81°33'24"					
Johns	2,417	28°32'06"	31	22	27	94	1
		81°37'59"					
Jones	9	28°37'08"	33	21	26	79	4
		81°42'40"					
King	3	28°44'06"	23	20	27	68	4
0		81°35'21"					
Lilv	18	28°32'40"	29	22	28	114	4
5		81°32'05"					
Lost	17	28°31'58"	33	22	26	83	4
		81°43'07"					
Lower Doe	10	28°40'30"	8	21	28	68	3
	-	81°32'17"	-		-		-
Luntz	16	28°30'38"	2	23	27	104	4
	-	20 00 00 81°34'52"		-		-	
Maggiore	30	28°44'12"	22	20	27	84	3
		81°36'21"				• -	-
Marden	20	28°37'52"	29	21	28	69	4
	~~	81°31'45"				20	-
Marion	7	28°41'45"	6	21	28	61	4
	-	81°32'38"	-		-		-

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Marshall	55	28°40'40"	8	21	28	68	3
		81°31'59"					
Maynard	15	28°38'40"	21	21	28	66	4
		81°31'27"					
McKay	6	28°41'22"	1	21	27	89	4
		81°34'17"					
Medicine	11	28°38'26"	20	21	28	71	4
		81°32'28"					
Meeks	18	28°37'42"	28	21	26	81	4
		81°42'35"					
Merritt	24	28°38'02"	27	21	26	76	4
		81°42'17"					
Minore	21	28°44'20"	22	20	27	84	2
		81°36'03"					
Mud	1	28°42'25"	34	20	27	63	4
		81°35'50"					
Mud	4	28°40'40"	7	21	28	69	4
		81°32'48"					
Mud Bottom	1	28°37'04"	33	21	26	79	4
		81°42'25"					
Opal	6	28°39'20"	16	21	28	83	4
1		81°31'12"					
Peach	8	28°35'01"	8	22	28	148	4
		20 00 01 81°31'55"					
Pearl	16	28°32'28"	29	22	28	116	4
		81°31'59"					
Pearl	6	28°41'26"	5	21	28	61	4
1 0011	Ū	81°32'07"	Ū	~-	~~	01	-
Pretty	9	28°43'32"	22	20	26	79	4
Tietty	Ū	20 43 52 81°42'03'	~~	~0	20	10	-
Reaves	22	98°31'39"	36	22	97	105	1
iveu ves	~~	£0 31 5£ 81°33'52"	00	~~	21	100	1
Roper	36	01 33 32 98°30'19"	11	23	97	102	4
noper	00	20 30 12 81°31'52"		20	21	108	1
Rutherford	17	01 J4 J2 28°38'40"	20	91	28	69	1
Rutherioru	17	20 30 40 81029'05"	20	61	20	00	т
Sawarass	1	01 J& UJ 99096'11"	9	99	26	73	1
Pond	I	20 JUII 91010197"	6	66	20	15	4
Sommos	95	01 4U & /	17	91	90	66	Λ
Semmes	20	28°39'20"	17	<i>4</i> ۱	20	00	4
		81~3217					

SWIM	Plan for	Lake	Apopka
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Sheppard	19	28°40'56"	7	21	28	68	3
		81°32'37"					
Standish	50	28°42'02"	31	20	28	64	4
		81°33'08"					
Swan	2	28°44'02"	22	20	27	76	4
		81°35'42"					
Teardrop	9	28°36'59"	32	21	26	82	4
		81°43'48"					
Tilden	59	28°31'10"	3	23	27	94	3
		81°35'36"					
Upper Doe	15	28°40'42"	8	21	28	68	3
		81°32'28"					
Witherington	9	28°40'17"	8	21	28	68	3
		81°32'13"					
Wolfshead	2	28°38'52"	22	21	26	69	1
		81°42'23"					
Yarbo	14	28°30'30"	3	23	27	94	3
		81°35'45"					

Note: Lcon = lake connectivity: 1=inflow, 2=outflow, 3=inflow and outflow, 4=landlocked

APPENDIX D—LAND USE/LAND COVER CATEGORIES

URBAN OR BUILT-UP

Urban or built-up land consists of areas of intensive use with much of the land covered by structures and other impervious surfaces. Included in this category are cities, towns, villages, strip developments along highways, and areas such as those occupied by shipping centers, industrial and commercial complexes, and institutions that may, in some instances, be isolated from urban areas.

AGRICULTURE

Lands which are cultivated to produce food crops and livestock make up the agricultural category. The subcategories of agriculture are as follows: cropland, pastureland, orchards, groves (except citrus), vineyards, nurseries, ornamental horticulture areas, citrus groves, confined feeding operations, specialty farms, and other agriculture.

RANGELAND

Rangeland contains natural vegetation which is capable of being grazed, such as native grasses, grasslike plants, forbs, or shrubs. Generally this land is not fertilized, cultivated, or irrigated.

FOREST

Forest land includes areas that have a tree-crown areal density of 10% or more. Land from which trees have been removed to less than 10% crown closure but which have not been developed for other uses are also included in this classification.

WATER

One definition of water bodies, provided by the Bureau of Census, includes all areas within the land mass of the United States that are predominantly or persistently water covered. This land use classification includes the following: rivers, creeks, canals, and other linear water bodies; inland water bodies; commonly termed lakes; and reservoirs and any other artificial impoundment areas of water.

WETLANDS

Wetlands are those areas where the water table is at, near, or above the land surface for a significant part of the year. The hydrologic regime is such that aquatic or hydrophytic vegetation usually is established. Wetlands are frequently associated with topographic lows. Examples of wetlands include marshes, mudflats, emergent vegetative areas, and swamps. Shallow water areas with submerged aquatic vegetation are classed as "water" and are not included in the wetlands category. Extensive parts of some river floodplains qualify as wetlands.

BARREN LAND

Barren land has very little or no vegetation and limited potential to support vegetative communities. In general, it is an area of bare soil or rock. Barren land categories include beaches, exposed rock, and disturbed lands.

APPENDIX E—PERMITS

Listing of all Chapter 373, Part IV permits (Chapters 40C-4, 40C-40, 40C-42, 40C-44, and 40C-400, *F.A.C.*) for the Lake Apopka Basin

Explanatory Notes

This appendix lists permits for nonpoint sources of water pollution or environmental resource permits in the SJRWMD permit database, and point source permits for the basin in the Florida Department of Environmental Protection (FDEP) permit database as of January 2000.

Environmental resource permits (ERPs) were first issued in 1995. They are a merger of the former wetland dredge and fill permit issued by FDEP and the Management and Storage of Surface Waters (MSSW) permit issued by the water management districts. The purposes of ERPs are to protect wetlands and to ensure that construction takes into account flood protection and the protection of waterways from stormwater pollution. In the SJRWMD database, permits are indexed by section, township, and range. As the Lake Apopka boundaries do not precisely correspond with section, township, and range boundaries, there are some permits in this list that lie across or outside the basin boundaries. All permits are currently in compliance, and no temporary operating permits exist.

Information provided in this appendix includes application number, owner and address, receiving water body, type of use, date the permit was issued, and projected acreage. The type of use is generalized to agricultural (AG), commercial (CM), industrial (ID), governmental (HGV), recreational park (RA), transportation (TR), and residential (RS).

Permits for nonpoint source discharges

Application No.	Owner and Address	Receiving Water Body	Use Type	Date Issued	Projected Acreage
4-069-0013A	A. DUDA & SONS, INC.		AG	10/12/82	470
	P.O. Box 257				
	Oviedo, FL 32765				
4-069-0028A	SWEET BLOSSOM CITRUS CORP.			3/8/83	50
	P.O. Box 129				
	Ferndale, FL 34729				
4-069-0055A	ALLISON & DUNCAN		RS	11/8/83	14
	P.O. Box 460				
	Clermont, FL 34711				
4-069-0087A	FLORIDA CRUSHED STONE		MI	7/10/84	168
4-069-0087AE	1616 South 14 th Street	None	MI	9/9/86	168
	Leesburg, FL 34749				
) <i>G</i>	a (10 /07	
4-4-069-0089A	JALARMY JOINT VENTURE	Johns Lake	MI	3/12/85	575
	P.O. Box 158				
	Minneola, FL 34755				
4 000 01114	ANDEDGON DEAT / COUTTO I MDONIEW	Talas Assaulas) AT	10/11/04	400
4-069-0111A	ANDERSON PEAT/ SCOTTS HYPONEX	Lake Арорка	MI	12/11/84	423
4-069-0111AF	Koute 2, Box 138	Laке Арорка	MI		423
	Winter Garden, FL 34787				
4 060 01224	ANTHONY HICKS	Dolotlokoho Divor	DC	6/11/05	6.5
4-009-0132A	215 E. Dobingon Street	Laka Louisa	по	0/11/03	03
	Orlanda, EL 22801	Lake Louisa			
/_069_0160A	MONITVERDE CROVES		RS	3/11/86	267
4-069-0160AM	5000 South Highway 27	Lake Apopka	RS	9/12/89	207
4-003-0100/4101	Leesburg FL 34748	groundwater	1.5	5/ 12/ 05	
		groundwater			
4-069-0169	ITHACA DEV. CORP	Lake Minnehaha	RS	12/9/86	61
1 000 0100	144-10 15 TH Road	(OFW)	110		01
	Whitestone, NY 11357	()			
4-069-0221A	LAKE EQUITY ASSOCIATES. L.P.	Lake William	RS	6/13/89	113
4-069-0221AM	2 Fieldstone Drive			6/13/95	88
	Winchester, MA 01890				
4-069-0224A	ROBERT A. MANDELL	Wetland system to	RS	6/13/89	110
	1105 Kensington Park Drive	Apopka			
	Altamonte Springs, FL 32714				
4-069-0307A	DANIS ENVIRONMENTAL MNGT CO.	Johns Lake	СМ	4/11/95	10
	P.O. Box 446				
	Killarney, FL 34740				

Application No.	Owner and Address	Receiving Water Body	Use Type	Date Issued	Projected Acreage
4-095-0010A	HOLDEN DEVELOPMENT			2/9/82	45
	204 South Dillard Street				
	Winter Garden, FL 34787				
4-095-0028A	PREMIERE ASSOCIATES, INC.	Black Lake		11/8/83	89
4-095-0028AE	230 Sand Lime Road	Black Lake and		2/12/84	35
4-095-0028AE2	Winter Garden, FL 34787	associated wetlands	RS	1/14/86	35
4-095-0028AE3		Black Lake	RS	4/6/87	27
4-095-0034A	WILLIAM COGGIN			4/09/84	33
	P.O. Box 1225				
	Winter Garden, FL 34787				
4-095-0059A	DON GREER			10/9/84	103
	P.O. Box 2249				
	Orlando, FL 32802				
4-095-0082A	LAKE APOPKA INC.	Lulu Creek,	RS	2/12/85	122
	P.O. Box 246	Lake Apopka			
	Ocoee, FL 34761				
4-095-0105A	BOREN DEVELOPMENT CORP.	Lake Lily	СМ	6/11/85	28
	2625 West State Road 434				
	Longwood, FL 32779				
4-095-0105AM	SCOTTY'S	Lake Lily	СМ	1/9/90	7
	5300 Recker Highway				
	Winter Haven, FL 33882-0939				
4-095-0105AM2-ERP					
		- 1 A 1	<u></u>	0 /11 /07	
4-095-0109AG	CITY OF OCOEE	Lake Apopka	GV	6/11/85	236
				0.110.107	
4-095-0133AC	ERROL LAND DEVELOPMENT CO	Lakes Pearl, Hiawatha		9/12/85	291
	1355 Errol Parkway	and Alden			
	Apopka, FL 32703				
4.005.0150.4		T 1 A11	DC	11 /10 /05	70
4-095-0150A	ERROL LAND DEVELOPMENT CO.	Lake Alden	ĸs	11/12/85	/3
	1355 Errol Parkway				
	Apopka, FL 32703				
4.005.0150.434			TD	0 (0 (00	
4-095-0150AM	LEAINGIUN HUMES	Lake Pearl,	1K	8/6/90	39
	809 South Orlando Avenue, Suite H	Lake Alden			
	WIIIIer Park, FL 32/89				
4 005 0150 4		Laha Alder	DC	19/10/05	0.1
4-095-0158A	CONTRODUCE FINANCIAL SERVICES	Lake Alden	къ	12/10/85	31
	0341 SUNSET DTIVE				
	SUUII MIAIIII, FL 33143				
	1			1	

Application No.	Owner and Address	Receiving Water Body	Use Type	Date Issued	Projected Acreage
4-095-0179A	WALTER DOWMAN	Lower Lake Doe	RS	11/11/86	10
	642 Interlachen Avenue				
	Winter Park, FL 32789				
4-095-0209AC	RICHARD AGREE	DOT drainage canal to		2/10/87	22
	20300 West 12 Mile Road	Black Lake			
	Southfield, MI 48076				
4-095-0211AC	JAMES GILLS	Buchan Pond		3/10/87	278
	1570 U.S. 19 North				
	Tarpon Springs, FL 33589				
4-095-0211ACM	JAMES P. GILLS	Buchan Pond		3/8/88	188
	2418 South Blvd.				
	New Port Richey, FL 33552				
4-095-0222A	PRIMA VISTA UTILITY CO.	None	GV	5/12/87	37
4-095-0222AM	890 SR 434 North		GV	11/5/87	160
	Altamonte Springs, FL 32714				
4-095-0232AGC	ORANGE CO. BOARD. OF CO. COMM.	None		6/9/87	102
	P.O. Box 1393				
	Orlando, FL 32802				
4-095-0233A	DOYLE C. JONES	Lake Tilden	AG	6/9/87	123
4-095-0233AM2	14201 Tilden Road	Lake Tilden	AG	12/11/90	67
	Winter Garden, FL 34787			2/12/96	
4-095-0233AM	DOYLE L. JONES	Lake Tilden	AG	11/17/87	24
	Box 44				
	Windermere, FL 34786				
	-				
4-095-0243AG	ORANGE COUNTY PUBLIC UTILITIES	Lake Marden	GV	9/8/87	700
4-095-0243AGM	109 East Church Street	Lake Marden	GV	5/8/95	2
	Orlando, FL 32802				
4-095-0259A	RICHARD AGREE	DOT drainage canal to	СМ	2/9/88	14
	20300 West 12 Mile Road	Black Lake			
	Southfield, MI 48076				
4 007 0000 A C			DEC	F (0, (00)	10
4-095-0308AC	BRASHK, LTD	Black Lake	RES	5/9/89	48
	P.O. Box 2062				
	Winter Park, FL 32790				
4.007.00004		T - 1	AC	0 /0 /00	0.070
4-095-0309A	A. DUDA AND SONS, INC.	Lake Арорка	AG	8/8/89	2873
4-095-0309AM	P.U. BOX 207, West SK 420	гаке Арорка	AG	10/12/93	28/3
	Uvied0, FL 32/03				
4 005 09194	CDEATED CONSTRUCTION CODD	Laka Ola	DC	0/0/00	195
4-033-0310A	1105 Konsington Park Drive	Lake Ula	103	0/0/09	100
	Altamonte Springs FI 39714				
	r munionic opinigo, r'L 04/14			1	

Application No.	Owner and Address	Receiving Water Body	Use Type	Date Issued	Projected Acreage
4-095-0320AC	ARVIDA-JMB PARTNERS	Black Lake	RS	8/8/09	230
	120 International Parkway 220				
	Heathrow, FL 32746				
4-095-0454A	HUBBARD CONSTRUCTION COMPANY	On-site, landlocked,	MI	2/8/94	120
	1936 Lee Road	unnamed basin			
	Orlando, FL 32789				
4-095-0563A-ERP	VOSS, TEAL, MACCHI, SADLER, ROSS, ET	Johns Lake	RS	9/8/98	111
	2 South Orange Ave.				
	Orlando, FL 32801				
4-095-0571A-ERP	HELLER BROTHERS GROVES		RS	1/12/99	140
	P.O. Box 770249				
	Winter Garden, FL 34777-0249				
4 005 0575 A C EDD	ORANCE CO. BOARD OF CO. COMM		CV		700
4-095-0575AG-ERP	ORANGE CO. BOARD OF CO. COMM.		GV		/00
4-095-0587AC-ERP					
40-069-0009A	JOANNE SNIDER		RS	10/30/84	45
	345 Wade Park Court				
	Davenport, FL 328337				
40-069-0031A	RAIDLE; ROYAL&FEIL LOUIS	Unnamed tributary to	CM	2/5/86	66
	1416 East Robinson Avenue	Lake Apopka			
	Orlando, FL 32801				
40-069-0033A	MONTVERDE GROVES	N/A	RS	2/17/86	112
10-069-0042 Δ	AL BESADE	Little Johns Lake	RS	3/31/87	56
10 000 001211	434 Wildoak Circle	Little Johns Lake	105	0/01/01	
	Longwood FL 32750				
40-069-0073A	GREATER CONSTRUCTION CORP.	Groundwater	RS	5/3/89	110
40-069-0073AM	1105 Kensington Park Drive	off-site wetland	RS	6/5/90	303
	Altamonte Springs. FL 32714	Lake Apopka			
40-069-0079A	JIM DURRANCE	Groundwater	RS	12/5/89	45
	18018 East Apshawa Road	(Land locked basin)			
	Clermont, FL 32711				
40-069-0081AM	ROBERT W. SMITH	Lake Apopka	RS	10/22/92	73
	17204 Fosgate Road				
	Montverde, FL 34756				
40.000.0109.4	AMEDICAN UNIVEDRAL DEVICE INC.	Johns Lake	DC	7/15/01	F 0
40-069-0102A	AWERICAN UNIVERSAL DEVLOP. INC.	Johns Laké	къ	// 15/91	58
	P.U. DUX 208				
	GUIIA, FL 37434				
40-069-0102AM					

Application No.	Owner and Address	Receiving Water Body	Use Type	Date Issued	Projected Acreage
40-069-0116AG	LAKE CO. BOARD OF CO. COMM.	Lake Apopka	GV	3/3/93	5
	315 West Main Street		1		
	Tavares, FL 32778				
40-095-0028A	WADE BRADFORD	Johns Lake	RS	1/5/85	117
40-069-0161AM-ERP					
40-095-0075A	THE HARKINS CORPORATION			12/16/84	15
	549 West Lake Mary Blvd, #108				
	Lake Mary, FL 32746				
40-095-0079A	WINTER GARDEN ASSOCIATES	Black Lake	СМ	3/19/86	10
10.005.0100.1			C 14	4 (00 (07	
40-095-0109A	AGREE DEVELOPMENT CO.	DOT drainage canal to	СМ	1/23/87	8
	20300 West 12 Mile Road	Васк Lake			
	Southfield, MI 48076				
40.005.0199.5	CROWN POINT WOODS INC	Laka Ananka	DC	6/16/97	0.0
40-05J-0122A	P O Box 1547	Laке Арорка	no	0/10/8/	23
	Winter Carden EL 34787				
	Winter Garden, TE 54767				
40-095-0124AG	ORANGE CO. BOARD OF CO. COMM	Groundwater	RS	7/9/87	10
40-095-0124AGM	P O Box 1393	No off-site discharge	TR	3/29/88	8
	Orlando, FL 32802	i to on site discharge	110	0/ 20/ 00	
40-095-0142A	CATALINA HOMES. INC.	Lakes Marshall.	RS	1/4/88	43
40-095-0142AM	644 Ferguson Drive	Marshall Lake and	RS	2/14/89	43
	Orlando, FL 32805				
40-095-0155A	H. L. BEKEMEYER & P. CHRISTENSEN	Lake Apopka	RS	4/5/88	94
40-095-0204A	ARVIDA-JMB PARTNERS	Black Lake	RS	10/11/89	115
40-095-0204AM	120 International Parkway, 220	Black Lake	RS	12/6/89	55
	Heathrow, FL 32746				
40-095-0206A	BRASK, LTD.	Black Lake	RS	11/10/89	48
	P.O. Box 2062				
	Winter Park, FL 32791				
40-095-0158A	WILLIAM LUTRICK	Lake Barton	RS	5/19/88	11
40-095-0158AM	P.O. Box 30004	Lake Barton	СМ	7/19/88	11
	Orlando, FL 32862				
40.005.0200414/ 555	LIELLED DDOTLIEDC INC	Laka Ama-L-		E /E /0F	0
40-090-0099AW-ERP	DO Boy 770240	таке Арорка		3/ 3/ 93	2
	1.0. Dux / 10249 Winter Cardon EL 34777				
	WINEI Galuell, I'L 34///				
40-095-0474 Δ -FRP	WINSDALF HOLDING INC	Lake Clarice	RS	6/13/96	76
10 000 0111A-LIM	2207 Kettle Drive		100	5/ 10/ 00	10
	Orlando, FL 32835				

Application	Owner and Address	Receiving	Use	Date	Projected
1NO.	CITY OF MINITED CADDEN	Water Body	ype		Acreage
40-095-0475AG-EKP	DO Boy 771005	Luiu Creek		1/4/90	0
	P.U. BOX //1003 Winter Corden EL 24777				
	Willer Galden, FL 54777				
40.005.0687A FPP	FIRST ORI ANDO DEVELOPMENT CO INC	Lako Tildon 🛛 🛛 🛛 🖓		19/11/07	43
40-03J-0007A-LIKF	201 South Orange Avenue, Suite 890	Lake I liueli Ko		14/11/37	43
	Orlando, EL 32801				
6-069-01244	COURD NECK SPRINGS INC	Lake Aponka		7/99/99	94
0 000 012 11	P O Box 98	Ешке прорка		17 227 02	~ ~ ~ 1.
	Winter Garden, FL 34787				
6-095-0016A	D.E. DUPPENTHALER	Lake Apopka RS		6/11/90	21
	120 South Dillard Street	F			
	Winter Garden, FL 34787				
4-069-0224AM	GREATER CONSTRUCTION CORP.	RS	CM R	4/9/91	163
4-069-0224AM2	1105 Kensington Park Drive	Unnamed RS	RA C	7/9/90	52
4-069-0224AM3	Altamonte Springs, FL 32714	Lake Apopka RE	S	12/13/94	75
4-069-0272A	LAKE SUE PARK INC	Johns Lake RS		8/11/92	40
	961 Via Lugano				
	Winter Park, FL 32789				
4-069-0274AC	JOOST P ZYDERVELD	Johns Lake RS		10/12/93	97
4-069-0274ACM	2269 Lee Road				
	Winter Park, FL 32789				
4-069-0276A	THE GREATER CONSTRUCTION CORP.	Lost Lake RS		1/12/93	102
4-069-0276AM	P.O. Box 3873	Lost Lake RS		8/9/94	118
	Longwood, FL 32791				
4 000 0077 4				0 /0 /00	400
4-069-0277A	MONTVERDE PROPERTY, LTD.	Lаке Арорка КS		6/8/93	430
4-069-0277AE	1311 South Vineland Road				430
4-009-0277AEIVI	Winter Garden, FL 34787	ĸə	ĸА		430
4 060 0226A EDD	CLEDMONT CROVES INC ET AL	DE	c	2/12/06	200
4-005-0320A-LIKF	D O Box 770228		5 C	2/13/30	299
	Winter Carden, FL 34777		3		
4-069-0340A-ERP	MAGNOLIA DEVELOPMENT INC	RS		9/9/97	57
	12543 Magnolia Cove Court			0/ 0/ 01	
	Clermont, FL 34771				
4-069-0340AM-ERP	DAN DECKER	RS		3/9/99	0.1
	12543 Magnolia Cove Court				
	Clermont, FL 34771				
4-069-0347A-ERP	CONDEV ASSOCIATES	Lake Apopka CN	1	2/10/98	121
	2487 Aloma Avenue				
	Winter Park, FL 32792				

Application No.	Owner and Address	Receiving Water Body	Use Type	Date Issued	Projected Acreage
4-069-0355A-ERP	LEVITT HOMES, INC.	Land-locked	RS	465	119
	7777 Glades Road, Ste. 410				
	Boca Raton, FL 33434				
4-069-0356A-ERP	CENTEX HOMES INC.		RS	11/10/98	175
	151 Southall Lane				
	Maitland, FL 32751-7190				
4-069-0359A-ERP	ROPER MCALLISTER/6E PRT LTD/ROPER		RS CM	6/8/99	223
	P.O. Box 770218				
	Winter Garden, FL 34777				
4-069-0363AG-	LAKE SUMTER COMM. COLLEGE		GV	5/11/99	253
ERP	9501 U.S. Highway 441				
	Leesburg, FL 34788				
4-069-0364AM-ERP	JAYMARK BLDRS & DEV. INC.	Willow Lake	RS	11/9///	30
	230 Mohawk Road				
	Clermont, FL 34711				
4-069-0355AM-ERP	DIAMOND PLAYERS CLUB, L.C.	Land-locked	RA	1/12/99	214
	2700 Sweetwater Country Club Dr.				
	Apopka, FL 32712				
4.005.0100.4		T 11 1 1	ID	0 /11 /00	
4-095-0160A	P K PARTNERSHIP & MCCLURE	Land locked	ID	3/11/86	44
	7620 Lake Underhill Drive	depression near			
	Orlando, FL 32825	ZDWCD			
4.005.09704		Duchon Dond	DC	4 / 19 / 00	9.6
4-095-0270A	JAMES P GILLS	Laka Aldan	ĸs	4/12/00	
	2416 South Doulevalu	Lake Aluen			
	New Port Richey, FL 33552				
4 005 0270 A C M2	OPANCE CO. PUBLIC SCHOOLS	Buchan Dond	CV	6/8/02	19
4-095-0270AGINI5	6200 Chancellor Drive	buchan Poliu	GV	0/ 0/ 93	10
	Orlando EL 22800				
4-095-0270 AM	ΔΡΟΡΚΑΙΑΝΟ DEV CO	Buchan Pond	RS TR	6/13/89	45
4-033-027074141	2600 Maitland Ctr Parkway Suite 232	Duchan I ond	R5 IR	0/13/03	
	Maitland EL 32751				
4-095-0270AM2	U.S. HOME CORP. INC	Lake Alden	RS TR	5/11/93	4
4-095-0270AM4	2600 Maitland Ctr Parkway, Suite 262	Lake Buc	RS	11/9/93	4
4-095-0270AM5	Maitland, FL 32751		RS	1/10/95	23
4-095-0270AM7		Lake Arden	RS	11/10/98	10
4-095-0270AM7E		Lake Alden	RS	1/12/99	4
4-095-0271AC	ROGER HAYDON	Lake Whitnev.		5/9/88	455
	13700 58 Street North, #210	Lake Rhea			
	Clearwater, FL 32792				

Application	Owner and Address	Receiving	Use	Date	Projected
No.		Water Body	Туре	Issued	Acreage
4-095-0284A		Lake Whitney,		10/11/88	310
	13700 58 Street, #210	Lake Rhea			
	Clearwater, FL 32792				
4.005.00404		D-l I-l	DC	1 /0 /00	000
4-095-0343A	ARIVDA JMB PARTNERS	Balce Lake	KS	1/9/90	230
	120 International Parkway, Suite 220				
	Heathrow, FL 32746				
4 007 00404347	DUID CONCLUTE OF ODI ANDO INC			1 /14 /00	000
4-095-0343AMK	DVLP. CONSULIS. OF OKLANDO, INC	васк Lake		1/14/92	230
	5728 Major Bivd., Ste. 306				
	Orlando, FL 32819-7996				
4.005.0945.4	LIVEE DA DK COMMUNITIES INC	Dll. Il	DC	0 /10 /00	
4-095-0345A	FIDE PARK COMMUNITIES INC	Laba Amarila	RS DC	2/13/90	33
4-095-0345AM	5858 Central Avenue, First Floor	Lаке Арорка	ĸs	8/9/94	13
	St. Petersburg, FL 33707				
4 005 0255 4	LIELLED DDOTLIEDS CDOVES	Laha Liha	זת תו	C /11 /00	07
4-095-0555A	HELLER DRUTHERS GRUVES	Lake Lily	ID KS	0/11/90	87 97
4-095-0555AM	P.U. DOX / 70249	Lake Lily	ID	7/13/93	87
	winter Garden, FL 34777				
4 005 02574	MACLUDE DOAD CODDODATION	I also Amombo	DC	7 /0 /00	194
4-090-0007A	MAGUIRE ROAD CORPORATION	Laке Арорка	RS DC	11 /0 /02	124
4-095-0557ANIZ	2001 Mercy Drive, Suite 104		ĸs	11/9/93	90
	Orlando, FL 32808				
4 005 0257 4 1 4212	TEACHEDS INC. AND ANNUUTY ASSOC				
4-095-0557AM3K	720 Third Assence				
	New York NV 10017				
	INEW TOLK, INT 10017				
4 005 0250 4	LECESSE CODDODATION	Laka Liby	DC	5 / 9 / 00	11
4-095-0559A	1412 West Colonial Drive		по	5/ 8/ 90	11
	Orlando, EL 22804				
	Ollalido, FL 52604				
4 005 0416A	HOMES IN DADTNEDSHID INC	Lake Apopka	DC	7/7/09	57
4-055-0410A	225 East 5 th Street	гаке Арорка	no	1/1/52	57
	Apopka EL 22702				
	Арорка, ГЕ 32703				
4-005-0437A	IRPCANC PARTNERSHIP	Johns Lako	PC	4/13/03	54
4-033-0437A	$P \cap Roy 157$	JUIIIS Lake	ILS .	4/ 13/ 33	J4
	Killarnov EL 34740				
	Kilaney, PL 54740				
/0_069_0171Δ	WAYNE H CEY	Iones I ake	RS	4/12/95	83
40-003-017174	15211 Vinola Place	Mud Bottom Lake	105	4/12/33	00
	Montverde EL 34756	Muu Dottoin Lake			
	Wontverde, 1 L 94750				
40-069-0196Δ	CLERMONT CROVES INC ET AL		RS RA	10/11/95	101
10 000-0100/4	P O Boy 770338		100 10/1	10/11/05	101
	Winter Garden FL 34777				
40-069-	LENNAR LAND PARTNERS	Lake Fel	RS	3/1/99	11
0196AM4-ERP	1110 Douglas Ave. Ste. 2040		100	5/ 1/ 00	*1
	Altamonte Springs, FL 32714				

Application No.	Owner and Address	Receiving Water Body	Use Type	Date Issued	Projected Acreage
40-069-0201A-ERP	BANYAN CONSTRUCTION	Jacks Lake, Plum Lake	V1	1/25/96	36
	905-A Jan Mar Court				
	Clermont, FL 34711				
40-095-0012A	WINTER GARDEN DEV CORP		1	5/25/84	56
	P.O. Box 1261				
	Winter Garden, FL 34787				
40-095-0023AO	ORANGE WEST UTILITIES INC			12/6/85	43
	6112 Cheshire Lane				
	Orlando, FL 32819				
10.005.0101 1.0			QU	5 (0 (07	
40-095-0101AG	ORANGE COUNTY PUBLIC UTILITIES	Lake Marden	GV	5/6/8/	53
40.005.0109AM9					
40-095-0102AW12					
40-069-0281A-FRP	GREATER CONSTRUCTION	N/A	RS	11/13/97	59
	P.O. Box 3873		105	11/ 10/ 01	
	Longwood, FL 32791				
40-069-0282A-ERP	SOUTH LAKE HOSPITAL, INC.	N/A	PR	11/18/97	19
	847 Eighth Street				
	Clermont, FL 34711				
40-069-0285AM2-	JAYMARK BUILDERS	Jacks Lake	СМ	3/30/99	2
ERP	230 Mohawk Road				
	Clermont, FL 34711				
40-069-0302A-ERP	HUNTERS LANDING INC.	On-site depression	RS	7/7/98	79
	222 Capital Court				
	Ocoee, FL 34761				
40.060.0204AC EDD	LAKE SUMTED COMM. COLLECE	Landlookad basin	CV	7/99/09	10
40-009-0304AG-EKP	0501 U.S. Highway 441	Landiockeu Dasin	GV	1/22/90	10
	Looshurg FL 34288				
	Leesburg, I'L 34200				
40-069-0316A-ERP	LENNAR LAND PARTNERS		RS	8/10/98	22
40-069-0317A-ERP	7600 Nob Hill		RS	8/10/98	8
	Tamarac, FL 33321				
4-095-0011A	REINER, HARRISON, MASCISLI			6/7/83	35
	P.O. Box 217				
	Winter Garden, FL 34787				
40-069-0345A-ERP	DIAMOND PLAYERS CLUB, LC		RA TR	6/8/99	48
	2700 Sweetwater Country				
	Арорка, FL 32/12				
40.000.0957A EDD	WEST 50 IOINT VENITURE CONDEN ASSO	Johns Laka		5 /17 /00	0.4
40-009-039/A-EKP	2470 Aloma Avonuo	JUIIIIS LAKE		3/11/99	0.4
	Winter Park FI 32700				
	Winter 1 art, 1 L 06/00				

Application No.	Owner and Address	Receiving Water Body	Use Type	Date Issued	Projected Acreage
40-069-0368A-ERP	LANDES CONSTRUCTION INC.			11/5/99	
	12543 Magnolia Cove Court				
	Clermont, FL 34711				
40-069-0374A-ERP	PARK SQUARE HOMES				
	5401 Kirkman Road, Ste 525				
	Orlando, FL 32819				
10.007.0100.1				m (22, (22)	
40-095-0189A	LEXINGTON HOMES	Lake Todd	RS	7/28/89	52
	2367 Coach House Blvd., Suite B	(aka Lake Marion)			
	Orlando, FL 32806				
40 005 0220 A	LEVINCTON HOMES	I aka Aldan wia two	DC	8/28/00	22
40-033-0223A	809 S Orange Avenue Suite H	retention ponds	ILS .	07 207 30	
	Winter Park FI 32789	retention ponds			
			_		
40-095-0266A					
40-095-0267	QUEST PROPERTIES	Black Lake	RS	2/27/92	44
	2611 Technology Dr. Ste. 20				
	Orlando, FL 32804				
40.005.0300A	SUNBREZE INC	Lako Cora		1/30/03	28
40-033-0303A	520 Magnolia Avenue			4/ 30/ 93	
	Orlando EL 32801				
			_		
40-095-0309AM2E					
40-095-0384AG	ORANGE CO. PUBLIC WORKS DIV.	Lake Audie	GV	10/11/94	7
	4200 S. John Young Parkway				
	Orlando, FL 32839				
40.005.02124	CONFORMING	Fischer Lehe	DC	0 /10 /02	70
40-095-0515A	425 Douglas Avenus	Placer Lake	ĸs	8/10/93	70
	Altamonto Springs EL 22714	reall Lake			
	Additione Springs, FL 52714				
40-095-0393A	THE GALE GROUP/STRASBERG CORP.	Lake McKay	ID	10/25/94	26
	2105 Park Avenue North	y			
	Winter Park, FL 32789				
40-095-0473A-ERP					
40.005.0040479		Plack Labo	DC	9 /99 /00	11
40-093-0040473-		DIACK LAKE	r.s	2/23/99	11
40-095-0489A-FRP	RAY AND SYLVIA RICHARDSON	Lake Apopka	PR	2/23/96	1
10 000 0 100/A-LIM	2009 Lauren Beth Avenue		1 10	w/ wo/ JU	1
	Ocoee. FL 34761				
40-095-0491A-ERP	VILLAGE CONSTRUCTION LTD		RS	3/19/96	32
	921 Lexington Parkway				
	Apopka, FL 32712				

Application No.	Owner and Address	Receiving Water Body	Use Type	Date Issued	Projected Acreage
40-095-0502A-ERP	WES BENTON	Johns Lake		8/26/96	0
	1212 S Binion Road				
	Apopka, FL 32703				
40-095-0539A-ERP					
40-095-0639AM-ERP	CHRISTINA SERV. CO. OF FLA., LLC	Black Lake	CM	6/10/99	5
	203 Pigeon Point Road				
	New Castle, DE				
40.005.0714A EDD	DINELOCUMENT CODD	I also Amombo	ID	19/17/07	0
40-095-0714A-ERP	PINELOCH MGM1. CORP.	Lаке Арорка	ID	12/1//9/	0
	200 West Pineloch Avenue				
40-095-0757 Δ M2-	CAMBRIDGE DEVELOPMENT LTD	Lake Reaves	RS	11/25/98	30
ERP	242 N Westmonte Drive		1.5	11/ 23/ 30	
	Altamonte Springs, FL 32714				
40-095-0791A-ERP	BRITT FARMING	Black Lake	RS	8/31/98	43
	71 E. Church Street				
	Orlando, FL 32801				
40-095-0792AG-ERP	CITY OF APOPKA		GV	6/2/98	103
	P.O. Box 1229				
	Apopka, FL 32704-1229				
40-095-0793A-ERP	FIRST ORLANDO DEVELOPMENT CO.	Lake Luntz	RS	7/22/98	40
	201 S. Orange Ave., Ste 890				
	Orlando, FL 32801				
40-095-0795AG-ERP	ORANGE CO. BOARD OF CO. COMM.		GV		1
	4200 S. John Young Parkway				
	Orlando, FL 32839				
40.005.0010A EDD			N/T	0 / 4 /00	
40-093-0810A-ERP			IVII	9/4/98	44
40.005.0815A FPP	OCDEN OPTHODONTICS	Ν/Δ	CM		1
40-055-0615A-EKF	516 S Dillard Street	IN/A	CIVI		1
	Winter Carden FL 34787				
	Winter Garden, TE 54767				
40-095-0827AG-ERP	ORANGE COUNTY	Lake Apopka	TR RS	11/6/98	9
	4200 S. John Young Parkway	Zano i ipopila	110 110		
	Orlando, FL 32839-9205				
40-095-0878A-ERP	JOHNS LAKE LAND TRUST	Johns Lake	RS	3/24/99	41
	1135 East Avenue			1	
	Clermont, FL 34711				
40-095-0884AG-ERP	CITY OF OCOEE		GV	3/5/99	0.03
	150 N. Lakeshore Drive				
	Ocoee, FL 34711				

Application No.	Owner and Address	Receiving Water Body	Use Type	Date Issued	Projected Acreage
40-095-0885-AG-REP	ORANGE CO. BOARD OF CO. COMM.	Unnamed land-locked	GV	3/25/99	0.013
	201 S. Rosaling Avenue	wetland			
	Orlando, FL 32802				
40-095-0889A-ERP	GARY SINGER	Lake Alden	RS	5/27/99	37
	2901 West SR 434, Ste. 141				
	Longwood, FL 32779				
40-095-0894A-ERP	HELLER BROS. GROVES	N/A	RA	4/6/99	2
	P.O. Box 77029				
	Winter Garden, FL 34777-0249				
			2.0	7 (1 (00	50
40-095-0906A-ERP	GREENE, HARRY R. AND JULIA J.	N/A	MI	7/1/99	53
	P.O. BOX 55				
	Killarney, FL 34740				
40.005.0006 A EDD	KADD THOMAS ID TDUSTEE		DA	11/15/00	6
40-095-0900A-ERF	RARR, IHOMAS, JR., IRUSIEE	IN/A	ĸА	11/15/99	0
	Windormoro EL 32786				
	Windermere, FL 52780				
40-095-0926A-FRP	HESS MILTON AND VERNA GAIL	N/A	RS	9/1/99	37
	4413 Down Point Lane		105	0/1/00	
	Windermere, FL 34786				
40-095-0928A-ERP	PAVEX CORPORATION	N/A		12/27/99	21
	2501 NW 48 th St.				
	Pompano Beach, FL 33073				
	•				
40-095-0935A-ERP	BUCKLEY-SHULER PROPERTIES				
	4244 International Pkwy #13		1		
	Atlanta, GA 30354		СМ	11/29/99	13
40-095-62480-1	R. S. HOLLAND			11/29/99	25
	P.O. Box 77038				
	Winter Garden, FL 34777-0308				
6-095-0017AG	CITY OF WINTER GARDEN	Lake Apopka	RA	9/10/91	7
	P.O. Box 1005				
	Winter Garden, FL 34/77				
62001					
02094 40.005.0802A EDD					
40-03J-0692A-EKP 62060					
59199					
40-095-0659Δ-FRP	L WARREN/C COX/P TERRY/L & L KIM		RS	12/3/97	60
-10-000-0002/A-EIU	71 Fast Church Street		10.5	16/3/31	00
	Orlando, FL 32801				
40-095-0068A	THE HARKINS CORPORATION	Lake Alden	RS	10/31/85	15
	549 West Lake Mary Blvd, #108				
	Lake Mary, FL 32746				

SWIM Plan for Lake Apopka

Application No.	Owner and Address	Receiving Water Body	Use Type	Date Issued	Projected Acreage
4-095-0330AG	ORANGE COUNTY PARKS & RECREATION	Lake Apopka	RS	10/9/89	52
	118 West Kaley Street				
	Orlando, FL 32806				
4-095-0336A	SUNSET LAKES LAND DEV CORP	Lakes Roper, Lu, and	RS	2/13/90	96
4-095-0336AM-ERP	P.O. Box 4429	Luntz and unnamed	RS	3/12/96	96
	Winter Park, FL 32793	pond			
40-095-0829A-ERP	EFFIE SMITH		MI	10/16/98	36
	50 East Myrtle Street				
	Apopka, FL 32703				
40-095-0469A-ERP	FLORIDA CONF. OF 7 TH DAY ADVENTISTS	Lake Roper		12/17/96	
	655 North Wymore Road, Suite 101				
	Winter Park, FL 32789				
40-095-0482A-ERP					

Permits for point source discharges

Name	FDEP Number	Expiration Date	Compliance
City of Winter Garden	IO0020109-01	5/1/02	Y
A. Duda & Sons, Inc.	FL105635		
APPENDIX F—GOVERNMENTAL UNITS

Local, regional, state, and federal governmental units that maintain jurisdiction over the water body and the land within a one-mile perimeter of Lake Apopka:

FEDERAL GOVERNMENT

U.S. Environmental Protection Agency, Region 4 345 Courtland Street, NE Atlanta, GA 30365 (800) 282-0289

U.S. Army Corps of Engineers, Jacksonville District P.O. Box 4970 Jacksonville, FL 32232 (904) 232-35940

Federal Emergency Management Agency, Region IV 3003 Chamblee-Tucker Road Atlanta, GA 30341 (770) 229-5200

U.S. Fish and Wildlife Service 75 Spring Street, SW Atlanta, GA 30303

U.S. Geological Survey 12201 Sunrise Valley Drive Reston, VA 22092

U.S. Geological Survey Sanlando Commerce Center 224 W. Central Parkway, Suite 1006 Altamonte Springs, FL 32714 (407)648-4090

National Weather Service (NOAA), Southern Region 819 Taylor Street Fort Worth, TX 76102-6614

SWIM Plan for Lake Apopka

Natural Resources and Conservation Service, State Office 2614 NW 43rd Avenue Gainesville, FL 32607 (352) 338-9500

Natural Resources and Conservation Service, Area 3 Office 613 6th Street, West Palmetto, FL 33651

Consolidated Farm Service Agency, State Office 4440 NW 25th Place Gainesville, FL 32606 (352) 372-8549

Consolidated Farm Service Agency, District Office Box 7553 Lakeland, FL 33807 (813) 533-1084

STATE GOVERNMENT

(Note: s/c = suncom number)

Florida Department of Transportation 605 Suwannee Street Tallahassee, FL 32399-0405 (850) 488-3111; s/c 278-3111

Florida Department of Environmental Protection 3900 Commonwealth Boulevard Tallahassee, FL 32399-3000 (850) 488-1554; s/c 278-1554

Florida Department of Health 2020 Capitol Circle SE, Bin No. A00 Tallahassee, FL 32399-1701 (850) 487-2945

Florida Division of Emergency Management 2555 Shumard Oak Boulevard Tallahassee, FL 32399-2100 (850) 413-9900 Florida Fish and Wildlife Conservation Commission 620 South Meridian Street Tallahassee, FL 32399-1600 (850) 488-4976

University of Florida, IFAS, Dr. Christine Stephens, Dean for Extension 1038 McCarty Hall Gainesville, FL 32611 (352) 392-1761

Lake County Cooperative Extension Service 30205 SR 19 Tavares, FL (407) 343-4101

Orange County Cooperative Extension Service 2350 East Michigan Street Orlando, FL (904) 244-7570

Florida Department of Community Affairs Division of Community Planning 2555 Shumard Oak Boulevard Tallahassee, FL 32399-2100 (850) 487-4545

Florida Department of Agriculture and Consumer Affairs Plaza Level, The Capitol Tallahassee, FL 32399-0810 (850) 488-3022; s/c 278-3022

REGIONAL

St. Johns River Water Management District P.O. Box 1429 Palatka, FL 32178-1429 (386) 329-4500

East Central Florida Regional Planning Council 631 North Wymore Road, Suite 100 Maitland, FL 32751 (407) 623-1075

LOCAL GOVERNMENT

Apopka, City of P.O. Drawer 1229 Apopka, FL 32704 (407) 889-1700

Oakland, City of P.O. Box 377 Oakland, FL 34760 (407) 656-1117

Winter Garden, City of P.O. Box 771005 Winter Garden, FL 34777 (407) 656-4111

Montverde, City of P.O. Box 8 Montverde, FL 34756 (407) 469-2681

Lake County Health Department 421 West Main Street, P.O. Box 1305 Tavares, FL 32778-1305

Lake County Soil and Water Conservation District 12547 Woodlea Road Tavares, FL 32778 (407) 343-2481

Lake County Board of County Commissioners 315 West Main Street Tavares, FL 32778 (407) 343-9850

Lake County Water Authority 107 North Lake Avenue Tavares, FL 32778 (407) 343-3777 Lake County Environmental Management Division 315 West 9th Street Tavares, FL 32778 (407) 343-2351

Lake County Department of Growth Management Planning and Development Services Division 315 West Main Street, P.O. Box 7800 Tavares, FL 32778-7800 (352) 343-9632 (long-range planning) (352) 343-9739 (current planning/zoning)

Orange County Board of County Commissioners P.O. Box 1393 Orlando, FL 32802-1393 (407) 236-7350

Orange County Department of Environmental Protection 2002 East Michigan Street Orlando, FL 32806 (407) 244-7400

Orange County Department of Planning 201 South Rosalind Avenue, 2nd Floor P.O. Box 1393 Orlando, FL 32802-1393 (407) 836-5600

Orange County Health Department 832 West Central Boulevard P O. Box 3187 Orlando, FL 32802-3187

Orange County Soil and Water Conservation District 2002 East Michigan Street Orlando, FL 32806

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APPENDIX H—REPORT SUMMARIES

EXPLANATORY NOTE

This appendix contains, when available, executive summaries or abstracts of reports and publications that have been produced by SJRWMD staff or contractors as a result of the projects listed in this SWIM Plan. Where no executive summary or abstract was included in a report, report conclusions or introductions, if presented, have been substituted. For easy cross-reference, the project from which a report was generated is listed following the citation.

PROJECT SUMMARIES

- Ann, Y. 1996. Phosphorus immobilization by chemical amendments in a constructed wetland. Ph.D. dissertation, University of Florida, Gainesville.
- PROJECTS: North Shore Restoration (LA-3-303-M) and Marsh Flow-Way Restoration (LA-3-301-M)

ABSTRACT

Agricultural lands adjacent to Lake Apopka, Florida, have been converted to a wetland with a goal of treating eutrophic lake water. Flooding of the wetland soil has resulted in a substantial increase in soluble P flux from soil to the overlying water column. A series of laboratory studies were conducted to determine (i) the effectiveness of different chemicals in immobilizing soluble P in recently flooded organic soil, (ii) the effect of chemical amendment application methods on soluble P release to water column, (iii) inorganic P sorption capacity of chemically amended soils and (iv) the P solubility change of chemically amended soils as influenced by soil redox potential.

All amendments (CaCO₃, Ca(OH)₂, CaMg (CO₃)₂, Al₂(SO₄)₃nH₂0, FeCl₃, and mixtures of CaCO₃ with Al₂(SO₄)₃nH₂0 and FeCl₃) enhanced retention of soluble P, and reduction of the P flux to the overlying water column was dependent on the amount of chemical added. Applications of CaCO₃ and Ca(OH)₂ at rates of 7 to 15 g kg⁻¹ were effective in immobilizing up to 62 and 79% of dissolved reactive P (DRP), respectively. Higher CaCO₃ treatments (>15 g kg⁻¹) did not immobilize P any greater than 69%, while Ca(OH)₂ treatment at 75 g kg⁻¹ decreased up to 100% of DRP. Reduction of DRP was proportional to the amount of alum and FeCl₃, with up to 80% of DRP immobilized at rates of 2 and 12 g kg⁻¹ of FeCl₃ and alum, respectively. Relatively higher amounts of

alum were required to minimize DRP concentration in the floodwater as compared with ${\rm FeCl}_{\scriptscriptstyle 3}$ treatments.

In a comparison of chemical application methods, the results obtained from Column study 1 (chemicals were incorporated with whole column soil) and Column study 2 (chemical amendments were applied to the top 3 cm of the soil column) were similar. Phosphorus flux from soil to the overlying water column decreased with the application of amendments as follows: FeCl₃ (1-2 g kg⁻¹) > alum (14.5 g kg⁻¹) >Ca(OH)₂ (11.3 g kg⁻¹) >CaCO₃ (15.3 g kg⁻¹) >Dolomite (126 g kg⁻¹).

Lake Apopka marsh soil had a high equilibrium phosphorus concentration (EPC₀ = 766 μ M P), indicating very high water soluble P. The EPC₀ is defined as the P concentration at which the rates of adsorption and desorption are equal. Phosphorus sorption capacities (S_{max}) of chemically amended soils obtained from an incubation study ranged from 13 to 44 mmol P kg⁻¹ and decreased in the order: alum > Ca(OH)₂ > CaCO₃ > dolomite > FeCl₃ > controls, while the capacities of retaining adsorbed P decreased in the order: Ca(OH)₂ > CaCO₃ > alum > dolomite > FeCl₃ controls. The S_{max} of the alum/FeCl₃ amended soils was highly correlated with CDB-Al/Fe (• < 0.01), Oxalate-Al/Fe (• < 0.05), and HCl-Al/Fe (• < 0.005). The S_{max} of the soils amended with Ca-based materials was also highly correlated with water soluble Ca and 1 M HCl-Ca/Mg (• < 0.005).

Redox potential (Eh) had significant influence on DRP and water soluble Fe of unamended and FeCl₃ amended Lake Apopka marsh soils. Concentrations of the DRP and dissolved Fe at -100 mV in porewater were 8 and 10 times higher than those at 350 mV, respectively. The concentrations began to change significantly at Eh of about 200 mV, indicating that Fe oxidation-reduction processes were occurring. The soils treated with alum and CaCO₃ were shown to be less sensitive to redox potential changes than control and FeCl₃ amended soils.

Apogee Research, Inc. 1996. Lake Apopka economic analysis. Final report for Contract 96G307. Submitted to St. Johns River Water Management District, Palatka, Fla. Bethesda, Md.

PROJECT: Socioeconomic Assessment and Methodology (LA-4-209-F)

EXECUTIVE SUMMARY

This report analyzes the economic effects of converting 14,000 acres of muck farms in the Lake Apopka Agricultural Area (LAAA) to recreational uses and thereby reducing

phosphorus loadings to the lake. Three separate analyses were conducted on behalf of the St. Johns River Water Management District:

- Potential economic losses and other effects associated with a proposed purchase and retirement of 14,000 acres of muck farms in Lake and Orange counties
- Measures to mitigate employment losses associated with land acquisition
- Preliminary estimates of recreation benefits associated with restoration of Lake Apopka

Important findings included (all dollar figures are in 1994 dollars):

- Direct loss of \$62 million a year in vegetable sales is likely.
- Reduction in agricultural output could result in 1,160 fewer jobs if mitigation measures are not taken.
- Direct impacts could result in \$49 million a year less regional output in the absence of restoration measures.
- Property tax impacts likely to be modest.
- LAAA job losses could be largely offset in agriculture and other sectors within the Orlando

Metropolitan Statistical Area:

- New fishing, hunting, and nature observation associated with lake and marsh restoration could reach \$30 million a year in direct and indirect sales by 2021.
- Lake and marsh restoration could generate 588 jobs directly associated with restoration and another 125 jobs in retail, lodging, and other services by 2021.
- Other effects of restoration not estimated in this study, such as increased land values and increased recreation in downstream lakes, could be substantial.

ATRA, Inc. 1997. Environmental risk assessment of a Lake Apopka muck farm wetlands restoration. Prepared for St. Johns River Water Management District, Palatka, Fla.

PROJECT: North Shore Restoration (LA-3-303-M)

EXECUTIVE SUMMARY

This environmental risk assessment of the Duda Farms property was completed to evaluate potential ecological risks and describe how potential risks can be addressed through site management strategies. Characterization of the potential risks relating to past land uses at muck farms on Lake Apopka is of importance because one component of the current effort to restore the lake ecology involves acquisition of surrounding land to re-establish wetlands. Removal of land from agricultural production and the reclamation of wetlands around the edge of the lake has two major beneficial effects. First, these actions can serve to reduce the loading of nutrients and other agriculturallyrelated chemicals into the lake ecosystem. Second is the return of the lake ecosystem to one that is functionally more similar to the original ecology. In converting these properties back to wetlands, however, it is necessary to evaluate the potential risks relating to the existing chemicals that could be realized by the organisms (ecological receptors) that recolonize the site. While the general approach of assessing potential risks and describing available management strategies can be used as part of an areawide strategy, the levels of risk and the chemicals of importance are specific to the particular properties being converted. This report focuses on the specific chemical concentrations and conditions at the Duda property in an effort to characterize the associated risks and describe how these risks can be affected by management strategies.

The risk assessment was carried out using a standard paradigm promoted by the USEPA and other regulatory agencies. The basic approach is to use conservative assumptions (i.e., over-estimations) of the extent of chemical exposure that could result for relevant ecological receptors and to compare this to conservative representations of the toxicity of the pertinent chemicals. Where this model determines that exposures are insufficient to result in doses considered toxic under the intentionally conservative assumptions, it can be concluded with substantial certainty that the potential risks are not significant for the chemicals, receptors, and effects considered. Where the model suggests that exposures could produce unacceptable theoretical risks, a critical evaluation of the assumptions used (weight-of-evidence analysis) and a consideration of the available management strategies for precluding unacceptable exposure is used to characterize the potential for realizing the predicted risks.

There was only one receptor/chemical combination where the risk model predicted that exposures sufficient to produce significant risks could occur (exposure of piscivorous birds to total DDTs). This prediction was based upon conservative assumptions about the size and type of fish consumed by a great blue heron receptor and about the body burden of DDTs that could have accumulated within these fish. It is unlikely that birds would find such large fish available as their primary diet. There are available and feasible methods to control hydrologic conditions, promoting lush vegetative growth and encouraging high sedimentation rates. Thus exposure in the field can be controlled such that significant risks levels will not be reached. To verify the attenuation, methods to monitor sedimentation and bioaccumulation can be used. While monitoring is prudent to ensure that unacceptable or unexpected impacts do not occur, the reduction

in risks anticipated through removing the site from agricultural production and preventing additional releases of the chemicals of concern is clear.

The overall conclusion of the evaluation of the Duda property is that there are no potential risks identified that could not be effectively controlled by the available management strategies, using natural attenuation as the contaminant remediation-method for the farm fields. More intensive remediation methods (e.g., soil removal) have already been applied at specific places on the property where handling or management of chemicals was a regular occurrence. A complete evaluation of remediation alternatives is always necessary prior to recommending a comprehensive solution, and this site is no exception. However, the benefits to the larger ecosystem projected to accrue from the restoration of this property to wetlands is high, particularly in conjunction with the risk reduction associated with the cessation of farming.

ATRA, Inc. 1998. Comparison of muck farm restoration levels to concentrations in Lake Apopka North Shore Restoration Area. Prepared for St. Johns River Water Management District, Palatka, Fla.

PROJECT: North Shore Restoration (LA-3-303-M)

INTRODUCTION

1.1 Area Background—Current and Past Uses

The muck farms currently being considered for restoration were originally part of the lakebed of Lake Apopka. Beginning in the 1940s, the land surrounding the north and northeast corner of Lake Apopka was drained and diked and canals were created for water management. The properties are currently used for agricultural purposes. Due to the introduction of nutrients and other chemicals from sources such as effluent from citrus-processing plants and a wastewater plant, as well as large quantities of agriculture runoff, Lake Apopka is the most seriously impacted aquatic environment in the southern basin of the Oklawaha River catchment (Hand et al. 1996). Lake Apopka and the approximately 12,000 acres of agricultural land under consideration for restoration are shown in Figure 1. The parcels owned by individual farmers may not be adjacent; however, considered together, the parcels represent a contiguous area along the shore of Lake Apopka

The properties, owned by various farmers, have been developed over the years for the purpose of agriculture and in some instances horticulture. The following information

SWIM Plan for Lake Apopka

briefly describes the historical development and production of the agricultural lands proposed for restoration.

The 312-acre property owned by Clarence Beall Jr. was developed for use as a muck farm in the 1940s and has been used for cultivating various vegetable crops including spinach, collards, and celery. Carrots and corn are currently rotated on the Beall property (ABB 1998a).

Clonts farms property was converted to farming in 1949. The parcel includes 643 acres of muck soil and 36 acres of wetlands. The property is currently used for farming and management of surface water. Carrots, celery, sweet corn and parsley are the primary crops (TASK 1998b).

Crakes & Sons property consists of three parcels totaling 509 acres on the north shore of Lake Apopka. Carrots, corn, and radishes are currently grown. Previously grown crops include collard greens, mustard greens, and several types of beans (TASK 1998c).

Duda Farms, Lake Jem farm property consists of two parcels of land developed since the 1940s. Currently, the land and associated structures are used for food processing, vegetable cultivation and water management. The property consists of 2,900 acres including farmland, 200 acres of uplands, 400 acres of wetlands, and 300 acres of sovereign land associated with Lake Apopka (Earth Systems Engineering 1997).

Long Farms property was developed for agricultural farming between 1942 and 1995. The 1,000 acre property is characterized by flat, organic muck soil, with irrigation canals, ditches, and dirt roads. The current crops are carrots, radishes, and sweet corn (TASK 1998a).

Lust Farms consists of 1,458 acres of muck farmland, 33 acres of sand and 1 acre of potential wetland. The property has been utilized for farming since 1942 and the principal crops have been sweet corn, carrots, and radishes (BEM 1997).

Stroup Farms consists of 414 acres on four parcels. The land is currently used for rotating carrot and sweet corn crops throughout the year (ABB 1998b).

Zellwin Farms began in 1947 on 600 acres of property and has expanded to 5,188 acres on two parcels of land. Approximately 1,400 acres are sandy upland and the remainder of the site is characterized by flat, organic muck soil, with irrigation canals and dirt roads. Crops grown on the site include: corn, carrots, mixed lettuce, radishes, cabbages, broccoli, beets, and miscellaneous crops (citrus, watercress, cantaloupe, and various herbs) (Golder Associates 1997).

Restoration Plans—Future Uses

The St. Johns River Water Management District (the District), under the authority of the Lake Apopka Restoration Land Acquisition Project, intends to purchase agricultural lands surrounding the northern corner of Lake Apopka to eliminate a significant source of nutrients (e.g., phosphorus) to the lake. This will be accomplished by the conversion of agricultural land into wetlands. The conversion will not only reduce phosphorus inputs, but also eliminate a source of other agriculture-associated chemicals (e.g., pesticides) which have historically entered the Lake Apopka ecosystem. A secondary effect of this reclamation will be the expansion of ecologically desirable habitat and a recruitment of aquatic species onto the property (ATRA 1997).

The proposed land to be flooded has been delineated at the 69 feet above mean sea level (MSL) contour. Flooding will be controlled by the dike and canal water management system already in place on the farms. The flooded farmland will initially remain separated from Lake Apopka and properties will be monitored following the initial phase of restoration. Long-term monitoring plans will be developed by the District, coordinating with the Florida Department of Environmental Protection (FDEP).

Purpose

The purpose of this assessment is to evaluate the current surface area-weighted average sediment concentrations of chemicals of concern (COC) on the agricultural lands of the northern shore of Lake Apopka, and to predict those same levels following remediation. During earlier evaluations for the Duda farms property, the District developed bulk sediment/soil concentrations to serve as threshold values. The values were referred to as site remedial action levels (SRAL). At the time, the SRALs were not risk-based, but rather selected to reflect ambient levels found throughout the agricultural areas. Any soil sample found to have constituent concentrations above the SRAL was remediated. These same SRALs were used for interim remedial decisions at the additional Apopka agricultural areas.

Following removal of soil in areas exceeding the SRALs on Duda Farms, the overall surface area-weighted average concentrations of toxaphene and DDX (the sum of the concentrations of DDT and its metabolites DDE and DDD) were calculated as part of an environmental risk assessment (ERA) (ATRA 1997). Upon review of this analysis and a regulatory determination by FDEP that the conditions at Duda Farms were suitable for risk management and monitoring strategies as proposed by the District, the surface area-weighted residual concentrations for Duda Farms were designated as muck farm restoration levels (MFRLs). The goal of this assessment is to compare the surface area-

weighted average soil concentrations expected at the proposed Lake Apopka restoration area, after similar remediation, to the MFRLs. If the calculated postremediation concentrations are similar or lower than the MFRLs based upon the Duda farms ERA, then strategies and monitoring plans being developed to manage risks for Duda farms will be anticipated to be applicable and effective for all of the proposed restoration lands.

Approach

Sites with soil chemical concentrations of DDX and toxaphene exceeding the SRALs will be treated as areas to remediate. These were determined to be the chemicals of concern for the proposed muck farm restoration (see section 2.2). Kriging, a geostatistical weighting process, will be used to calculate surface area-weighted average concentrations of constituents remaining in the soil following remediation, to determine whether MFRLs have been met.

Baird, R.A., and J.M. Bateman. 1987. A preliminary assessment of phosphorus precipitationinactivation as a restoration technique in Lake Apopka. Special Publication SJ87-SP5. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Phosphorus Inactivation/Precipitation (LA-4-202-F)

CONCLUSION

Lake Apopka, by virtue of its high pH and high alkalinity, would make an ideal candidate for alum precipitation, from a chemical perspective. But given its size, depth, and extent of muck, the prospects for long term success of alum treatment are suspect. Proceeding to Phase II may answer the question of whether phosphorus cycling from the sediments could be retarded in a lake with an extensive sediment component. It would also allow the accurate calculation of costs for a large-scale project. However, it would remain uncertain how well the floc layer could withstand extensive mixing in the whole 12,150 ha of Lake Apopka.

Battoe, L.E., M.F. Coveney, E.F. Lowe, and D.L. Stites. 1999. The role of phosphorus reduction and export in the restoration of Lake Apopka, Florida. In *Phosphorus biogeochemistry in subtropical ecosystems*. K.R. Reddy, G.A. O'Connor, and C.L. Schelske, eds., 511–526. Boca Raton, Fla.: Lewis Publishers. PROJECT: Implementation of Restoration and Management Techniques (LA-6-802-S)

ABSTRACT

Lake Apopka is a large (125 km²), shallow (Z = 1.6 m) lake in central Florida made hypereutrophic by 50 years of agricultural stormwater discharges from farms on 80 km² of drained littoral marshes. The lake is characterized by high nutrient levels, high turbidity caused by algae and resuspended sediments, and almost no remaining submersed or emergent macrophytic vegetation. Phosphorus loading to Lake Apopka is being reduced through the purchase of the riparian farms and restoration to aquatic habitat. Additional management activities to accelerate recovery of the lake are creation of a treatment wetland to remove nutrients and suspended solids from lake water, removal of gizzard shad (*Dorosoma cepedianum*), and replanting of littoral vegetation. Because of concerns that reduction in phosphorus (P) loading will be ineffective in restoration of Lake Apopka, we have reexamined the empirical and theoretical basis for P load reduction as a lake restoration technique.

Case studies of control of P loading show that a proportional improvement in lake trophic condition often is obtained when a significant reduction in P loading is effected. Restoration of hypereutrophic, shallow, turbid lakes requires reduction in P loading to lower the stability of phytoplankton dominance and increase the stability of macrophyte dominance. Several characteristics of Lake Apopka increase the probability that the lake will respond to reduction in P loading form adjacent farms. First, P loading (approx. 0.55 g P m⁻² yr⁻¹) to the lake during the last 30 years has been elevated about seven-fold compared to prefarming levels, and P loading is dominated by farm discharges. Second, biogeochemical processes will dampen internal loading from P-rich sediments after external loading is reduced. The majority of P enters the lake as soluble reactive P. However, as a result of chemical and biological processes, almost 80% of the P in surficial sediments is in Ca-Mg-bound (33%) or organic (46%) forms resistant to rapid biological uptake.

Since summer 1995, trophic indicators (TP, TSS, Chl, Secchi depth) in Lake Apopka have improved significantly based on an 11-year data set. These changes are consistent with modest reductions in P loading achieved since 1993 through regulatory actions. Recently, patches of submersed vegetation (e.g., *Vallisneria, Chara*) have established naturally at more than 20 sites around the lake.

Battoe, L.E., E.F. Lowe, M.F. Coveney, and D.L. Stites. 1994. Determining restoration goals for Lake Apopka. *Lake Reserv. Manage*. 9(2):54.

PROJECT: Implementation of Restoration and Management Techniques (LA-6-802-S)

ABSTRACT

The primary restoration goal for Lake Apopka was set by the Florida Legislature in the Lake Apopka Restoration Act of 1985, "to return the lake to class III standard." To achieve this at Lake Apopka, water quality standards must be interpreted in light of the primary problem, eutrophication. Nutrient and transparency standards both require estimation of the pre-impacted condition of the lake. To obtain the best estimate of the pre-impacted water quality, we used several independent methods and found that their results consistently predicted total phosphorus (TP) values in narrow range (0.008–0.070 mg/L) that significantly lower than the current concentration (0.220 mg/L). Mass balance modeling, with controllable sources eliminated, resulted in a new equilibrium TP concentration in the same range. This range is an appropriate restoration goal for the lake. Application of Class III standards to estimated pre-impact TP concentrations can be achieved by use of empirical relationships relating depth of macrophytes growth, Secchi depth, compensation depth, TP, and total nitrogen. Sensitivity analysis using these relationships indicates that the standards cannot be met without reduction in the lake concentration of TP to 0.050 mg/L or less.

Belanger, T.V. 1981. Benthic oxygen demand in Lake Apopka, Florida. *Water Research* 15:267–274.

PROJECT: Phytoplankton-Nutrient Interactions (LA-4-104-D)

ABSTRACT

The benthic oxygen demand of Lake Apopka, Florida was determined using laboratory core uptake and flow through system techniques. The core-uptake for five stations in Lake Apopka averaged 67 mg $O_2 m^2$ –h and partitioning experiments indicated that the oxygen uptake was primarily biological, with bacterial respiration dominating. No significant statistical correlations were found between core oxygen uptake rates and TKN levels (r = 0.33), percent volatile solids (r= 0.49), or macroinvertebrate densities (r = 0.59). Sediment oxygen uptake rates (D_s) were logarithmically related to flow rate in the following form $D_s = -A + B$ in flow. Flow-through system sediment oxygen uptake at each station approached similar maximum uptake rates of 130 mg $O_2 m^2$ at high (>200 l h⁻¹) flow rates. Lake Apopka is an extremely shallow, wind mixed system and sediment uptake rates are expected to approximate this value during periods of intense

wind mixing. The relatively low sediment uptake rates obtained for Lake Apopka, a hypereutrophic lake, supports the view that during eutrophication sediment respiration is progressively replaced by respiration in the water column.

Benton, J., D. Douglas, and L. Prevatt. 1991. Oklawaha basin fisheries investigations: Study XII. Lake Apopka fisheries studies. Florida Game and Fresh Water Fish Commission completion report. Wallop-Breaux project F-30-18.

PROJECT: Fishery (LA-4-107-D)

ABSTRACT

Since 1957, the limnetic fish population of Lake Apopka has been found to be dominated by gizzard and threadfin shad. The littoral zone was dominated by centrarchids, which constituted 46% by number and 43% by weight in blocknet samples; however, this habitat covers less than 1% of the lake area. Bluegill was the dominant centrarchid in littoral samples, but proportionally few attained harvestable size. Black crappie were abundant in both littoral and limnetic samples, and an average of 22% were of harvestable size. Black crappie were the preferred species in the creel survey, as anglers spent over 46,000 hours of effort (88% of the total) to harvest 44,000 fish in January through March of 1990. Largemouth bass showed an increase in production since 1973–1976 (Holcomb 1977), but the numbers of young remained very low when compared to other lakes of the Oklawaha chain. The average electrofishing catch rate was poor (0.1 bass/min), and no angler success was documented for largemouth bass. The spring 1990 largemouth bass stocking was unsuccessful. Small size at stocking, low water levels, and predation by black crappie probably contributed to poor survival.

There have been significant improvements for fish species since the 1973–1976 study, as largemouth bass, bluegill, and black crappie in littoral areas increased in number and biomass above the estimates of 1973–1976. In the limnetic portions of the lake, there were significant increases in the number of harvestable black crappie and in brown bullhead biomass.

Substantial improvements in the aquatic habitat must take place before any appreciable reduction in the dominance of shad or improvements in largemouth bass recruitment will occur. Increased lake level fluctuation and expansion and/or revegetation of littoral habitat would contribute to improvements in the sportfish community.

Benton, J., D. Douglas, and D. Watson. 1994. Ichthyofaunal studies as part of the trophic structure manipulation studies. Final report for Segments I–III. Florida Game and Fresh Water Fish Commission, Fisheries Research Laboratory. Special Publication SJ94-SP5. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Trophic Structure Manipulation (LA-4-207-F)

EXECUTIVE SUMMARY

Lakes Denham (257 acres), Apopka (30,319 acres), and Beauclair (1,112 acres) were sampled from January 1989 through June 1992 to assess the fish community of each lake and evaluate the response of Lake Denham's fish community to the removal of a large percentage of gizzard shad. In January of 1990, the SJRWMD installed a plastic mesh barrier to isolate Lake Denham from the other lakes of the Ocklawaha chain. A contractor employed by the SJRWMD removed 87,356 pounds of gizzard shad (340 lbs/acre) in 35 haul seine pulls. This was estimated to be an 82% reduction in the stock of gizzard shad that were vulnerable to capture by the haul seine. In May 1991, the contractor removed 20,040 lbs of gizzard shad (78 lbs/acre) in 13 haul seine pulls, which represented an 88% reduction in the catchable gizzard shad stock. In June 1992, eight haul seine pulls removed only 6,887 lbs of gizzard shad (27 lbs/acre), and the effort was discontinued.

In the shallow water zone of Lake Denham, subharvestable fish of three sportfish species—largemouth bass (less than 9.5 inches) and bluegill or redear sunfish (less than 5.5 inches)—showed significantly (P <0.1) increased abundance during 1991–92 (June through May) from measurements taken during 1989-90 and 1990-91. Lake Beauclair (a control lake) also showed a significant increase during 1991-92 in subharvestable bluegill and an increase (though not statistically significant) in subharvestable redear. No gizzard shad removal was conducted in Lake Beauclair. The influence of other factors that may have caused more juvenile game fish to be produced during this year (temperature, rainfall, or changes in nutrient inputs to the lake) was not explored within the scope of this report. None of the fish communities of the three lakes showed significant increases for harvestable-sized largemouth bass, bluegill, or redear. Gizzard shad abundance in Lake Denham was effectively reduced by the use of a haul seine. Direct methods for measuring gizzard shad abundance (experimental gill nets and 1-acre blocknets) were inconclusive in documenting the decline, but indirect evidence (such as the shift in length frequency from larger to smaller fish) confirmed data derived from the haul seine catch. The gizzard shad population of Lakes Apopka and Beauclair showed no significant changes or trends.

It is not possible to attribute the increase in juvenile sportfish in Lake Denham to gizzard shad removal at this time. Increased sportfish abundance was observed for bluegill and redear sunfish in Lake Beauclair, where gizzard shad were not removed. There has also not been any increase observed in harvestable-sized (adult) sportfish in Lake Denham. Other factors (habitat type and extent) that may influence the abundance of juvenile fish and their subsequent recruitment to harvestable sizes were not considered within the scope of this report. This study should be continued for another season to determine if the increased abundance of juvenile sportfish produce increased numbers of adult fish.

Benton, J., K. Taylor, C. Adams, and R. Hudson. 1995. Methodology and analysis of the gizzard shad population of Lake Apopka in central Florida using sagittal otoliths. Fisheries Research Laboratory, Florida Game and Fresh Water Fish Commission. St. Johns River Water Management District, Palatka, Fla.

PROJECT: Rough Fish Harvesting (LA-3-302-M)

EXECUTIVE SUMMARY

A procedure to assign ages to gizzard shad through the use of a bony structure (sagittal otolith) was developed as a segment of Rough Fish Removal Project requirements (SJRWMD Contract 94W1 19). This procedure will allow the gizzard shad population of Lake Apopka to be analyzed by age groups (cohorts). That information can be used to generate vital data concerning the stock size, growth rates, and biomass of gizzard shad available to the commercially fished gill nets in the Lake Apopka Rough Fish Removal project.

We evaluated an age sample of 290 fish collected in spring of 1994 using a team of four readers. All readers agreed on age assignments for almost 83% of the fish, and three of four readers agreed on ages for 92% of the fish, which indicated that age assignments could be made with consistency. These data showed that commercial gill nets caught fish of two years of age or more, and that females grew faster than males. Males were also shorter-lived than females, few survived beyond two years of age. It is important that gizzard shad be vulnerable to gill net capture in two years, before natural mortality removes a large proportion of the population. There were relatively few fish older than three years of age in the gill net samples (which tended to catch larger fish). We estimated total annual mortality to range from 57% to 85% during the first three years of life through the use of blocknet data collected in 1990 through 1992, and 1994 gill net samples produced an estimate of 58% and 54% for ages two through six. Data to

validate the presumed annular markings on the otoliths are needed for reliable estimation of population parameters, as well as a determination of age- or size-atmaturity which would have bearing on the sustainability of the gizzard shad removal project.

Best, G.R., and M.T. Brown. 1991. Research manual for phase II: The Lake Apopka Marsh Flow-Way Demonstration Project. Prepared for St. Johns River Water Management District, Palatka, Fla. Center for Wetlands, University of Florida, Gainesville.

PROJECT: Marsh Flow-Way Restoration (LA-3-301-M)

SUMMARY

Objectives of this manual were to provide a description of project objectives and detailed methods for meeting those objectives. The manual was dynamic with changes implemented after interactive deliberations between the District and the Center for Wetlands.

The program objectives included the development of natural and planted vegetation and mechanisms for enhancing marsh establishment and studying seed recruitment, dispersal, and storage. Specifically, the scope of work included the following:

- Assess the development of plant communities within the project area.
- Document the natural plant community structure, phenology, and biomass.
- In experimental planting sites, evaluate trends in plant community development as a function of time since planting.
- Compare trends in natural and experimental plant community development.
- Determine phenology of seed production.
- Assess seed viability of several planted and naturally occurring marsh plants.
- Assess role of water in transporting marsh seeds.
- Determine the role that the seed bank plays in plant community dynamics.
- Assess the effect of hydroperiod on seed germination.

Bryant, C.T., and S.F. Shih. 1990. A groundwater flow analysis of Lake Apopka, Florida. Final report to St. Johns River Water Management District, Palatka, Fla. IFAS, University of Florida, Gainesville.

PROJECT: External Nutrient Budget Study (LA-1-101-D)

ABSTRACT

Determination of the subsurface flow of Lake Apopka, Florida is needed for the 1989 water budget calculations. Thirteen test sites have been set up along the shore of Lake Apopka by the St. Johns River Water Management District. The sites measure the various parameters required for subsurface flow and water budget calculations. Potentiometric head is measured by a battery of piezometers installed in a line perpendicular to the lake shore, with four to seven piezometers at varying depths and spacings at each site. The central piezometer at each site is read continuously by a telemetry system, as is the lake stage recorder. The remaining piezometers are read monthly. Hydraulic conductivity is measured by the auger-hoe method every three months at the levee sites, in order to account for compaction and alteration of soil there, and once a year at the non-levee sites. The depth to the confining layer for the Lake Apopka area was estimated by soil logs taken at each site.

Piezometric data from three sites were eliminated from consideration in this study due to their unsatisfactory locations. The shoreline segment lengths of these sites were split up among the sites closest to them to maintain consistent seepage results.

Subsurface flow calculations were performed in four different ways based on Darcy's law. The Darcy's law basis was chosen because it was the most applicable technique for the situation at Lake Apopka. First, seepage was calculated by site using monthly potentiometric head readings from the piezometers at minimum and maximum distance from the lake at each site. The seepage was calculated for that day and multiplied by the number of days in the month. This was done for every month in 1989. Second, the lake was divided into two regions, inflow and outflow. Seepage was then calculated monthly, by region, using the average regional measured data. Third, regression analysis was used to predict daily values for the monthly-read piezometers from the continuously-read central piezometers and lake stage. The predicted values were averaged monthly for each piezometer. Seepage was then calculated by site for each month. Fourth, seepage was calculated monthly, by region, using the average regional using the average regional values obtained from the regression analysis.

The main advantage with using regression analysis is that it can provide a model that predicts seepage from the continuously-read lake stage and central piezometer readings. Calculating seepage by site, using the values obtained from regression analysis, yielded a total of 1,532.69 ac-ft of outflow seepage and only 996.30 ac-ft of inflow seepage. This led to a net result of 536.39 ac-ft of outflow seepage from Lake

Apopka in 1989. Inflow seepage reached a maximum of 170.42 ac-ft in December and fell to a minimum of 50.89 ac-ft in October. Outflow seepage reached a maximum of 179.91 ac-ft in January and fell to a minimum of 59.17 ac-ft in December.

Bryant, C.T., and S.F. Shih. 1990. Hydraulic conductivity analysis of inflow and outflow regions adjacent to Lake Apopka, Florida. In *Proceedings of the Soil and Crop Science Society of Florida* 49:32–36.

PROJECT: External Nutrient Budget Study (LA-1-101-D)

ABSTRACT

Determination of the hydraulic conductivity of the regions adjacent to Lake Apopka, Florida is needed for calculating the subsurface flow. The hydraulic conductivity around the lake was separated by two regions, that is, outflow and inflow regions, respectively. A sample-size analysis was also performed to test the accuracy of the hydraulic conductivity measurements. Results showed that the hydraulic conductivities for outflow and inflow regions were 6.755 ft d⁻¹ and 7.851 ft d⁻¹, respectively. Based on the current number of measurements, the accuracy of these hydraulic conductivities can only reach a 70% level of statistical confidence for both outflow and inflow regions. In general, the accuracy of measurements is expected to reach at least an 80% level of confidence in which about 25 and 40 measurements are needed for outflow and inflow regions, respectively. In other words, an additional 15 measurements for the outflow region and 29 for the inflow region are needed to obtain an 80% level of confidence.

Carrick, H.J., F.J. Aldridge, and C.L. Schelske. 1993. Wind influences phytoplankton biomass and composition in a shallow, productive lake. *Limnol. Oceanog.* 38(6):1179–1192.

PROJECT: Phytoplankton-Nutrient Interactions (LA-4-104-D)

Abstract

Factors that regulate phytoplankton dynamics in shallow, productive lakes are poorly understood. Water-column phytoplankton chlorophyll (avg 105 μ g liter⁻¹) determined on 39 occasions over a 22-month period in shallow (mean depth, 1.7 m) Lake Apopka, Florida, correlated best with average daily windspeed compared with other environmental variables. High phytoplankton biomass reflects wind-induced

resuspension of a meroplanktonic algal maximum (MAM) that exists on the aphotic lake bottom in a layer ~5 cm thick; this assemblage is dominated by microplankton-sized diatoms (>60% of total biomass) that can occur in cellular resting stages. Experiments demonstrate that the MAM can grow and photosynthesize at rates similar to surface populations when exposed to moderate irradiances. Direct inoculation of this meroplanktonic assemblage into surface waters during periods of high wind can account for a doubling in surface phytoplankton and diatom biomass as well as an increase in algal community size. A conceptual model outlines the influence that resuspension of the MAM has on ecosystem structure and function in the lake.

Carrick, H.J., C.L. Schelske, F.J. Aldridge, and M.F. Coveney. 1993. Assessment of phytoplankton waters: Application of dilution bioassays. *Can. J. Fish. Aquat. Sci.* 50(10):2208–2221.

PROJECT: Phytoplankton-Nutrient Interactions (LA-4-104-D)

INTRODUCTION

There is some question as to which primary factors mediate phytoplankton dynamics in tropical and subtropical lakes (Kratzer and Brezonik 1981; Osgood 1982; Canfield et al. 1989), as little research has been conducted on these systems compared with temperate systems (Lewis 1987). The evidence for nutrient limitation in subtropical lakes appears circumstantial because few controlled experiments have actually been conducted to test this hypothesis (cf. Schelske 1989). Relationships between ambient nutrient concentration (i.e., TP and TN) and phytoplankton biomass across a suite of Florida lakes support the idea that the phytoplankton biomass in these lakes is nutrient limited (Canfield 1983). However, additional work has spawned a debate as to whether phytoplankton abundance is under strict nutrient control, given the potential for self-shading at the high levels of biomass supported in some of these lakes (e.g., Agusti et al. 1990).

In this study, we evaluated nitrogen (N) and phosphorus (P) limitation of phytoplankton in productive waters utilizing an approach whereby nutrient enrichment bioassays are coupled with serial dilution of lake water (Paerl and Bowles 1987). Because dilution experiments may be prone to experimental artifacts (e.g., Li 1990; Stockner et al. 1990), the critical assumptions of the technique were also evaluated. This approach is potentially useful because it can serve as experimental evaluation of current management schemes to improve water quality in lakes, such as reduction of nutrient loads (Loehr et al. 1980) or removal of particulate material (phytoplankton and associated nutrients) from the water column of lakes via artificial wetlands (Lowe et al. 1992). The specific objectives of the study were to (1) determine if dilution alters phytoplankton N and P limitation, (2) evaluate the effect of particle reduction on phytoplankton growth yields, and (3) compare our results with the original technique formulated by Paerl and Bowles (1987).

Conrow, R., E. Marzolf, M.F. Coveney, E. Lowe. 2001. Proposal for interim management of the Lake Apopka North Shore Restoration Area. St. Johns River Water Management District, Palatka, Fla.

PROJECT: North Shore Restoration (LA-3-303-M)

SCOPE OF DOCUMENT

We provide here a proposal for interim management of the North Shore Restoration Area. As background we include a brief summary of the environmental conditions in Lake Apopka, describe the major components of the restoration program, and summarize the progress achieved to date. We describe the recent history of land acquisition and the bird mortality event that occurred on the recently purchased properties. We summarize the toxicological data for the new properties, and propose interim flooding and comprehensive monitoring of a portion of the site. We propose additional studies to more precisely quantify site-specific bioaccumulation of organochlorines in wildlife.

Conrow, R., and J. Peterson. 2000. A panel atlas of the major aquatic plants of Lake Apopka, Florida, using global positioning and geographic information systems. Technical memorandum 37. St. Johns River Water Management District, Palatka, Fla.

PROJECT: Littoral Zone Restoration (LA-2-304-M)

INTRODUCTION

Lake Apopka is a 12,465 ha (30,800 ac) lake located in Orange and Lake counties, about 25 km (15 mi) northwest of metropolitan Orlando, Florida. Historically, Lake Apopka was the second largest lake in the state. However, in the 1940s the northern third mostly sawgrass marsh—was isolated by levees from the remainder of the water body. The marsh was drained, and by the end of the decade, farming of row crops had begun in the rich peat soil. Agricultural production in the "muck farms" reached 7,290 ha (18,000 ac) by 1963 (Huffstutler et al. 1965). Along with the increased nutrient load from farming runoff, discharges from citrus processing plants and from a sewage treatment system likely all combined by March 1947 to help fuel the start of persistent major algal blooms. By 1950, much of the rooted aquatic vegetation in the lake had disappeared.

In the ensuing decades, Lake Apopka changed from a clear water, premier bass-fishing lake to a hypereutrophic water body with a trophic state index averaging 82–91. Beginning in the late 1980s, the St. Johns River Water Management District (SJRWMD) began implementing projects to restore Lake Apopka to meet Class III water quality standards (Conrow et al. 1993). As the restoration progresses, one measure of success will be the return of aquatic vegetation throughout the lake. Additionally, introduction of aquatic vegetation along Lake Apopka's shoreline has been promoted by SJRWMD through contractual, volunteer and staff efforts.

Clugston (1963) reported the common aquatic and marsh plants growing in Lake Apopka during a survey conducted in 1959. Chesnut and Barman (1974) performed a comparative survey in 1971 and 1972. Both of those studies provided rough estimates of the abundance of aquatic and shoreline vegetation, and their general locations. In order to compare current conditions with previous surveys and to establish a baseline for quantifying changes in future vegetative coverage, we surveyed the entire lake and delineated existing plant cover using a global positioning system (GPS).

METHODS AND RESULTS

The survey was performed between April and November 1997 using a differential Trimble GPS unit. Accuracy for the GPS unit is rated at 1 to 3 meters; however, duplicate field measurements of fixed points were within 1 meter or less of each other. All GPS data points were collected at 1 second intervals.

Possible submersed vegetation often was identified first, and photographed, from aerial overflights performed several times during the mapping project. These areas were then located by boat and the areas mapped. The general mapping technique was to boat, canoe, or wade along the edges of the vegetation while recording GPS points using a custom-made data dictionary. Data recorded in the data dictionary for each vegetated polygon included dominant species and density, secondary species and density, water depth at the center of the site, and comments (often used to describe the site location or additional species). The number of data points used to map each vegetation feature varied depending upon the polygon size, shape, and accessibility which usually was determined by water depth or tree line. When the land-facing side of the nearshore vegetation could not be physically mapped with the GPS due to poor accessibility, all other sides were mapped and the software connected the first and last GPS points logged.

The collected GPS data were converted to a GIS data layer, or coverage, using Trimble Pathfinder Office[™] Software. In some cases where the GPS software had connected the first and final points of a polygon to generate the land-facing side, ESRI ARC/INFO[®] and ARCVIEW[®] GIS software were used to redraw the land-facing side to more closely follow the shoreline contours. Digital Orthophoto Quadrangle (1995) imagery of the lake was displayed in the background of the vegetated polygons to assist in the editing process.

PRODUCT DISPLAY

In order to display the GIS vegetation coverage, a panel atlas was compiled. The first cover panel map depicts Lake Apopka overlaid with a numbered grid pattern. The vegetation coverage contained in each numbered grid square is shown (at a larger scale) in the corresponding numbered panel map. Common names of vegetation are provided in each panel and Table 1 provides the corresponding scientific names. Only panels of grid squares for which vegetation was found are contained in this compilation. Future iterations of this atlas will document the effects of planting efforts and natural revegetation as the restoration of Lake Apopka progresses.

<u>Common Name</u>	<u>Scientific Name</u>
Bulrush	Scirpus spp.
Cattail	<i>Typha</i> spp.
Chara (muskgrass)	Chara spp.
Duck potato	Sagittaria lancifolia
Eel grass	Vallisneria Americana
Hydrilla	Hydrilla verticillata
Moonvine flower	Ipomea alba
Red maple	Acer rubrum
Spatterdock	Nuphar luteum
Egyptian paspalidium	Paspalidium geminatum
Pickerel weed	Pontederia cordata
Sawgrass	Cladium jamaicense
Torpedograss	Panicum repens
Willow	<i>Salix</i> spp.
Yellow water lily	Nymphaea mexicana

Conrow, R., and J. Stenberg. 1994. Survival and competitive abilities of wetland species in the Lake Apopka demonstration marsh project. *Lake Reserv. Manage*. 9(2):65–66.

PROJECT: Marsh Flow-Way Restoration (LA-3-301-M)

ABSTRACT

The Lake Apopka Marsh Demonstration Project, a 525-acre constructed wetland site on the NW shore of Lake Apopka, Florida, is a test for a full-scale, 5,000-acre project designed to annually filter twice the volume of Lake Apopka through a shallow marsh. A program to sample the colonization of vegetation was established to determine the ability of small planted "islands" to thrive and withstand encroachment by invasive species such as cattail (*Typha* spp.). To assess development of the naturally occurring

vegetation, nine transects were monitored semi-annually. Monitoring began shortly after initial flooding in October 1990. In 1991, each of three 5-acre blocks were planted in monotypic or mixed plots with 11 native wetland species. A series of plots were either seeded or mulched with soil from a donor wetland, and other control plots were left untreated. The plots were regularly sampled to assess plant community development. The total number of species in the transects fell from 64 in the 1990 survey to 38 in 1993. Cattail has increased coverage in the marsh. The three 5-acre planted blocks differed from each other in the number of species found and the amount of cattail encroachment. Changes in water depths, distance from then inflow, and prior land use may be some of the influencing factors. Planting success or failure for each particular species was similar among the blocks. In the 3 years to date, most planted species maintained their community integrity against the invasion of cattail or any other species. At each site, planted species have migrated past their original borders. Plots containing sawgrass (Cladium jamaicensis) did not survive and were replanted with Juncus effuses. Maidencane (Panicum hemitomon) plots had poor survival. Spikerush (Eleocharis interstincta), and giant bulrush (Scirpus californicus) were most able to invade neighboring sites.

Continental Shelf Associates, Inc. 1988. *Literature review and feasibility analysis report on ichthyofaunal reconstruction as a technique for restoring Lake Apopka*. Special Publication SJ88-SP6. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Ichthyofaunal Reconstruction (LA-4-206-F)

EXECUTIVE SUMMARY

Lake Apopka is highly eutrophic and in need of sound restoration and management. Several restoration options are being considered by the St. Johns River Water Management District, including a relatively new approach called biomanipulation. Biomanipulation or ichthyofaunal reconstruction involves the removal or introduction of fish in order to alter the lake trophic structure and ultimately improve water quality. The goals of this project are to review the available literature on biomanipulation, compile an annotated bibliography on candidate species and biomanipulation, propose candidate fish species for introduction, and design pilot studies to determine the applicability of the proposed introduction/manipulation to the Lake Apopka environment.

The literature review revealed that biomanipulation approaches to lake management are still largely experimental. The results of most studies have been inconclusive. Most

of the reviewed studies were conducted in temperate lakes where fish and plankton communities differ from those in subtropical lakes. Variable conditions, settings, and research designs which characterized most studies made projections to the Lake Apopka environment difficult at best. These problems highlight the need for preliminary studies prior to any attempt at biomanipulation in Lake Apopka.

To date, fish populations have been manipulated in two basic ways in attempts to improve water quality. The first, and most prevalent in the literature, involves removal of visual feeding zooplanktivorous fishes, resulting in enhanced populations of herbivorous zooplankters, which in turn feed upon unwanted algae and consequently improve water quality. The second involves the introduction of a filter-feeding fish to graze directly upon unwanted algae. Removal has been achieved by introduction of predators or by poisoning and restocking with a higher ratio of predators to planktivores.

Despite limited support in the literature, it appears that control of unwanted algae by manipulating filter-feeding fishes may have some merit in subtropical lakes. Filter-feeding fish may suppress algal growth directly by grazing or enhance phytoplankton biomass indirectly by suppressing herbivorous zooplankton and by increasing nutrient availability. If direct effects of algal grazing are not offset by indirect enhancement effects, filter-feeding fish can suppress total phytoplankton biomass.

In Florida, most eutrophic lakes are numerically dominated by filter-feeding gizzard shad. This fact indicates their ineffectiveness at reducing algal biomass through feeding activities. In fact, it has been suggested that gizzard shad populations may enhance phytoplankton growth, and therefore removal of gizzard shad may result in improved water quality. An alternative to gizzard shad removal would be the introduction of another filter-feeding fish to consume suspended matter (phytoplankton, zooplankton, and detritus).

We recommended two filter-feeders, silver and bighead carp, as best suited for pilot studies. Both species have been used in water quality control programs in culture ponds, wastewater treatment, and reservoirs (see Appendix A). This recommendation is tempered by the fact that both species are exotic, and the careless release of such animals could have unpredictable impacts on the entire Oklawaha system. This is why the pilot studies are such an important part of evaluating a proposed introduction. The studies were designed to provide direct information on the utility of silver and bighead carps as algal control agents, but will contribute salient information on ecological effects of the carps on the Lake Apopka environment.

Pilot studies design includes two sequential phases. Phase I involves *in situ* studies at the mesocosm level. Littoral enclosures are proposed as experimental units within which to evaluate the effects of various fish combinations on plankton populations and water chemistry. Preliminary studies will be needed to estimate appropriate stocking densities and number of replicate treatments needed to statistically resolve pertinent water chemistry and plankton questions. In the actual experiment, effects of various combinations of fish (bighead and silver carp, and gizzard shad) on water chemistry and plankton variables will be evaluated by comparison with fishless control enclosures. Weekly monitoring of plankton and chemical variables for the period of one year is recommended. If Phase I results prove positive, Phase II, a small lake level experiment, should follow. The proposed site for Phase II is Lake Carlton, a small lake in the Ocklawaha chain with environmental characteristics similar to Lake Apopka. Lake Carlton would be stocked with the appropriate combination of fish, followed by weekly monitoring of water chemistry and plankton for one year.

In summary, as a lake restoration technique, biomanipulation is still experimental. Other, more proven restoration options should be considered before biomanipulation is attempted. If biomanipulation is chosen as a management strategy, then pilot studies should be conducted first to evaluate the likelihood of success. We identified filterfeeding silver and bighead carp as the best candidate species for experimentation. However, alternatives should be evaluated prior to the introduction of exotic fishes.

Coveney, M.F. 1995. The Lake Apopka Marsh Flow-Way Demonstration Project: Interim progress report. St. Johns River Water Management District, Palatka, Fla.

PROJECT: Marsh Flow-Way Restoration (LA-3-301-M)

EXECUTIVE SUMMARY

The Marsh Flow-Way Demonstration Project is a pilot project of the St. Johns River Water Management District to examine the capacity of a wetland filter to remove suspended sediments and particulate nutrients from Lake Apopka. The project is a 520acre field experiment to gain operational experience and test concepts relating to nutrient removal, hydraulic behavior, and development of vegetation in a wetland system. The demonstration project has answered important questions and clarified major design and operational issues for the projected full-scale flow-way. Results from the demonstration project have provided the necessary scientific and technical basis to proceed with design of the full-scale Marsh Flow-Way Project. Lake Apopka is a large, shallow, hypertrophic lake in central Florida. Phosphorus loading from farms located on drained floodplain marshes has been the primary cause of eutrophication. High algal densities and surficial sediments mixed by wind action limit the transparency of the lake water and prevent growth of submersed, rooted plants. The District has developed a comprehensive restoration plan which will reduce external phosphorus loading rates, remove phosphorus from lake water by filtration in a marsh flow-way and by harvest of rough fish, improve food-web structure through harvest of rough fish, and promote revegetation through increased lake level fluctuation, planting, and restoration of wetlands. Removal of phosphorus from Lake Apopka in algae and suspended sediments will be accomplished through the full marsh flow-way to be constructed in phases on approximately 3,500 acres of floodplain farmland. Other benefits of the full-scale flow-way include a reduction in nutrient loading to Lake Apopka, a reduction in downstream nutrient loading to the Harris Chain, and restoration of wetland habitat.

The Marsh Flow-Way Demonstration Project has shown that hydraulic functioning of the wetland is key to effective nutrient removal. Multiple parallel cells are preferable to a single, large treatment area. Large-scale channelization must be avoided to maximize the hydraulic residence time distribution. Design of the full-scale project will focus on solutions to minimize channelization which may include distributed inlet and outlet structures, internal berms, and deep areas to intercept channelized flow.

Removal rates for phosphorus and suspended matter in the demonstration project achieved target levels under realistic areal hydraulic loading conditions when channelization was absent. Leaching of soluble phosphorus occurred when the soils first were inundated and when soils were dried for consolidation. Flooded fallow conditions before construction on the full site should reduce but will not eliminate leaching. Methods to deal with leaching include soil amendments and recycling of flood waters. Drawdown was a necessary and effective technique to consolidate newly deposited sediment in the demonstration project. The increased bulk density of the sediment after drawdown confirmed earlier projections that the full-scale marsh flowway site contains sufficient volume for sediment storage.

Coveney, Michael F. 2000 (draft). Sedimentary phosphorus stores and accumulation rates and sedimentation coefficient for phosphorus in Lake Apopka. Prediction of steady-state phosphorus concentrations at various phosphorus loading rates. Technical memorandum. St. Johns River Water Management District, Palatka, Fla.

PROJECT: Mathematical Modeling (LA-4-103-D)

INTRODUCTION

The St. Johns River Water Management District (SJRWMD) set by rule (Section 11.6, Applicant's Handbook. Management and Storage of Surface Waters) a phosphorus criterion (target phosphorus concentration in the lake water) for Lake Apopka of 0.055 mg l⁻¹ total phosphorus (TP). This rule followed an examination of historic conditions in Lake Apopka to define goals for restoration of the lake and to derive a target range for TP in the lake water (Lowe et al. 1995; Lowe et al. 1999). The next step to define a loading limit for phosphorus (P) is to establish the maximum P loading to the lake that would achieve the target concentration for TP. This allowable loading was calculated with the steady-state formulation of Vollenweider's 1969 input-output model (Reckhow and Chapra 1983) which predicts mean lakewater concentration of TP as a function of P loading and other variables.

The Vollenweider 1969 model requires a value for the net sedimentation coefficient for P, which we estimated with two approaches: (1) from the net deposition of P in sediments between two sampling occasions in 1968 and 198, and (2) from annual phosphorus budgets measured from 1989 through 1996. Monthly P budgets for 1989 through 1994 also provided data to calculate net sedimentation coefficients for P for short periods of time. We used these values, which represented transient conditions, to examine variables such as P loading that might affect the net sedimentation coefficient in the short-term.

The specific goals of this memorandum are the following:

- Derive the long-term net sedimentation coefficient for P in Lake Apopka by evaluation of net P deposition from sediment data between 1968 and 1987 and from annual phosphorus budgets from 1989 through 1996.
- Evaluate short-term changes in the phosphorus sedimentation coefficient, especially changes resulting from low levels of P loading, from monthly P budgets compiled for 1989–1994.
- Predict the loading of P to Lake Apopka from external sources that would result in a steady-state concentration of TP in the lake water of 0.055 mg l⁻¹.

Coveney, M.F., E.F. Lowe, and L.E. Battoe. 2000. Performance of a recirculating wetland filter designed to remove particulate phosphorus for restoration of Lake Apopka (Florida, USA). Pages 231–237. In *Proceedings of the Seventh International Conference on Wetland Systems for Water Pollution Control*, November 11–16, 2000, Orlando, Fla.

PROJECT: Marsh Flow-Way Restoration (LA-3-301-M)

ABSTRACT

Operation of a 14-km² wetland filter for removal of total phosphorus (TP) from lake water is part of the restoration program for hypereutrophic Lake Apopka, Florida. This system differs from most treatment wetlands because (1) water is recirculated back to the lake and (2) the goal is removal of particulate phosphorus (P), the dominant form of P in Lake Apopka. The operational plan for the wetland is maximization of the rate rather than the efficiency of P removal. The St. Johns River Water Management District operated a 2-km² pilot-scale wetland to examine the capacity of a wetland system to remove suspended sediments and particulate nutrients from Lake Apopka. TP in the inflow from Lake Apopka ranged from about 0.12 to 0.23 mg l^{-1} , and hydraulic loading rate (HLR) varied from 6.5 to 42 m yr⁻¹. The performance of the pilot-scale wetland supported earlier predictions. Mass removal efficiencies for TP varied between about 30% and 67%. A first-order, area-based model indicated a rate constant for TP removal of 55 m yr⁻¹. We compared actual removal of P with model predictions and used modeled performance to examine optimal operational conditions. Correspondence between observed and modeled outflow TP was not good with constant variable values. Monte Carlo techniques used to introduce realistic stochastic variability improved the fit. The model was used to project a maximal rate of P removal of about 4 g P m⁻² yr⁻¹ at P loading 10–15 g P m⁻² yr⁻¹ (HLR 60–90 m yr⁻¹). Data from the pilot wetland indicated that actual rates of P removal may prove to be higher. Further operation of the wetland at high hydraulic and P loading rates is necessary to verify or modify the application of the model.

Coveney, M.F., E.F. Lowe, and L.E. Battoe. 2001. Nutrient removal from eutrophic lake water by wetland filtration. *Ecological Engineering*. Submitted.

PROJECT: Marsh Flow-Way Restoration (LA-3-301-M)

ABSTRACT

A 14-km² wetland filter is part of the restoration of Lake Apopka, Florida, USA. Lake water will be recirculated through the wetland, and the goal is removal of suspended solids and particle-bound nutrients, especially total phosphorus (TP). The St. Johns River Water Management District operated a 2-km² pilot-scale wetland for 29 months. Hydraulic loading rate (HLR) varied from 6.5–65 m yr⁻¹, total suspended solids (TSS) in the inflow varied from 40–180 mg l⁻¹, and TP varied from 0.08–0.38 mg l⁻¹. Mass removal efficiencies were 89–99% for TSS, 30–67% for TP, and 30–52% for total nitrogen unless flows were channelized. A first-order model indicated rate constants for removal of TSS and TP of 107 m yr⁻¹ and 63 m yr⁻¹, respectively. TP (3 g m²) leached from the native organic soils and vegetation upon initial flooding. With soil treatment to prevent release of TP and inlet pumping to maintain 37 m yr⁻¹ HLR, net TP removal would have exceeded 3 g P m-2 yr⁻¹. Design of the full-scale wetland benefited from the pilot project in areas related to nutrient retention, hydraulic function, soil treatment to bind TP, and drawdown to consolidate new deposits.

Coveney, M.F., D.L. Stites, L.E. Battoe, and E.F. Lowe. 1993. Nutrient retention in a restored wetland used for lakewater filtration. ASLO and SWS annual meeting, May 30–June 3, 1993, Edmonton, Alberta, Canada.

PROJECT: Marsh Flow-Way Restoration (LA-3-301-M)

ABSTRACT

A demonstration project at Lake Apopka, Florida, filters hypertrophic lake water through a 2.4-km² wetland to remove particle-bound nutrients. Water was pumped through two wetland cells in series and returned to the lake. Water flow varied from 0.4 to 1.0 m³/s, and mean depths ranged from 0.35 to 0.75 m. Hydraulic residence time in each cell varied between 3 and 12 d. Net retention of particulate matter was >90% in the first cell. Between 30% and 50% of total N was removed in the first cell, with little additional change in the second. Because of P leached from organic soils, each cell initially had negative P removal. As soil leaching declined, P removal efficiencies improved to between 30% and 50%. Leaching declined more rapidly in soils which had been fallow and hydrated. Data on forms of N and P and not areal N and P retention in the wetlands are presented.

Crisman, T.L., and J. Beaver. 1988. Lake Apopka trophic structure. Phase I, final report. St. Johns River Water Management District, Palatka, Fla.

PROJECT: Trophic Structure Manipulation (LA-4-207-F)

CONCLUSION AND RECOMMENDATIONS

In view of the evidence presented in this report, it seems possible that biomanipulation of fish populations in Florida lakes can lead to a significant improvement in water quality. This statement, however, must be qualified in that our study was limited to one season, was conducted over a short temporal span and a complete analysis of the phytoplankton data relative to the zooplankton and chemistry has not been undertaken. A similar enclosure experiment performed during another season, preferably with replicate productivity data, would provide substantial evidence elucidating the nature of the filter-feeder zooplankton-phytoplankton relationship for Florida systems.

Our experiment does provide evidence that the effects of shad and tilapia on plankton community metabolism differed greatly. Although both filter-feeders possess similar grazing and digestive mechanisms, tilapia did not suppress the native cladoceran assemblage, and in fact enhanced their populations. The presence of shad caused wider fluctuations in daily dissolved oxygen concentrations, especially when compared to tilapia, which may stress or kill desirable game fish. There are also indications that the grazing activities of shad promote mineralization and accelerate phosphorous recycling as has been observed in other mesocosms (Crisman and Kennedy 1982; Drenner et al. 1986a).

The dramatically elevated primary productivity and community respiration of the shad bag, combined with the higher assimilable nutrient levels, suggests that in Florida systems which are not as nutrient enriched as Lake Apopka, biomanipulation can be a mitigating factor for cultural eutrophication if blue tilapia is allowed to replace gizzard shad.

Since the zooplankton communities of the tilapia treatment contained 2–4 times the biomass of herbivorous zooplankton than would be expected in a Florida lake of comparable trophy, it is difficult to consider modification of fish populations as a restoration technique in subtropical and tropical systems dominated by small-bodied cladoceran assemblages if it is assumed that the increased abundance of these herbivores will directly reduce phytoplankton standing crops through grazing pressure.

Crumpton, J.E., and W.F. Godwin. 1997. *Rough-fish harvesting in Lake Apopka: Summary report 1993–96.* Special Publication SJ97-SP23. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Rough Fish Harvesting (LA-3-302-M)

EXECUTIVE SUMMARY

Lake Apopka is a shallow, hypertrophic 12,400-hectare (ha) lake located in Lake and Orange counties, and is approximately 24 kilometers (km) northwest of Orlando, Florida. Degradation of the lake began with construction of canals to lower the level of the lake, alteration of the lake marshes to create "muck farms," and the loading of nutrients to the lake from point and nonpoint sources. The first algal bloom reportedly occurred in the lake in 1947. Completion of a water control structure in 1956 on the Apopka-Beauclair Canal dampened long-term water-level fluctuations in the lake. Sport fishing has declined in the lake since the 1950s and lake water quality has deteriorated from nutrient loading to the point that the lake experiences continuous algal blooms. The decreased water clarity has eliminated most submerged vegetation and the continuous sedimentation of algal cells has resulted in accretion of a flocculent sediment layer over one foot thick in most areas of the lake. The lake is currently used primarily for the harvest of catfish, and gizzard shad and recreational fishing remains poor.

The St. Johns River Water Management District (SJRWMD) requested that the Florida Game and Fresh Water Fish Commission (GFC) allow the large-scale harvest of rough fish from the lake. The fish removal would export nitrogen and phosphorus from the lake as well as potentially change the lake food chain. Target fish species were gizzard shad, gar, and tilapia. The suggested method of harvest was by commercial gill nets. Because largemouth bass and sunshine bass had been stocked in the lake and recent creel censuses suggested a potential resurgence of the black crappie stocks, by-catch from the rough-fish harvest would be evaluated to determine any potential detrimental effects of the harvesting activity to the gamefish stocks in the lake.

Permits to harvest target fish species by gill net were issued by the GFC. Ten permits were issued in 1993, 20 in 1994, 30 in 1995 and 1996, and 21 in 1997. The winter-spring fishery usually operated from January through May. The summer-fall fishery was established in 1995 for the warm-weather period of the year. For this fishery, a total of 30 permits to harvest rough fish by commercial gill net was provided to the Organized Fishermen of Florida (OFF) for distribution among its members. In addition, other potential harvesting gear (a modified purse/gill net and a modified "pair trawl") were tested in the lake in 1995 and 1996.

The total catch of gizzard shad from both fisheries ranged from a high of almost 1.7 million pounds in 1994 to a low of about 636,000 pounds in 1995. The average daily catch of gizzard shad ranged from a high of 3,425 pounds/boat/day in 1995 to a low of 2,201 pounds/boat/day in 1997. The highest annual catch of gar was 12,799 pounds in 1995. Catches of tilapia were never of significance.

From January 1993 through June 1997, commercial fishermen harvested a total of about 5,467,484 gizzard shad weighing about 4,888,813 pounds from Lake Apopka. Harvesting removed about 178 fish/acre and exported about 34,322 pounds of phosphorus and 102,665 pounds of nitrogen from the lake. A stock assessment completed in 1995 indicated the most probable population of harvestable gizzard shad prior to the 1995 harvest to be about 3,877,582 fish or about 127 fish/acre. The highest of three estimates for the harvestable gizzard-shad stock in 1996 was about 2,073,744 fish or about 68 fish/acre. The lowest stock estimate for 1996 was about 726,288 harvestable gizzard shad or about 24 fish/acre. The estimated harvest for 1996 was about 1,186,364 shad or about 39 fish/acre. Even allowing for production and growth of young shad, commercial fishermen have apparently harvested a significant portion of the standing stock of adult gizzard shad in the lake. A decline in the lake gizzard-shad stock is further supported by a decrease in mean weight of harvested shad from 1.3 pounds to 0.7 pounds per fish between 1993 and 1996.

A number of unsuccessful attempts were made to market gizzard shad for human consumption which included test marketing of gizzards and roe. Most gizzard shad harvested from Lake Apopka were marketed as bait for the crayfish industry in Louisiana and for the blue-crab fishery in Florida and Louisiana. The economic returns to both the commercial fishermen and fish processor were low or non-existent because of high harvest costs experienced by the fishermen and high processing, shipping, and handling costs experienced by the fish processor. Even when the cost of harvesting and marketing was shared by SJRWMD, the economic incentive to remove gizzard shad from Lake Apopka was very limited and both commercial fishermen and processors will participate in the program only when other fishing opportunities are limited. The catch of non-target fish species from observed commercial gill nets was low with gizzard shad comprising an average of 98% of the total catch. Black crappie was the species taken most often as by-catch with catfish, sunshine bass, redear sunfish, bluegill sunfish, largemouth bass, bowfin, and Atlantic needlefish being taken infrequently. The total gamefish by-catch from all commercially fished gill nets over the 1993-97 period was calculated to be 30,636 fish, or less than one game fish per acre of lake.

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Initial mortality of game fish caught in commercial gill nets during the 5-year period was 1,684 fish. The majority of this mortality was black crappie. A total of 443 game fish taken in commercial gill nets were placed in "holding pens" and observed for 48 hours to determine secondary mortality. High survival of game fish was observed during the winter-spring fishery period (84%). Survival of gill-net caught fish in the summer-fall fishery period was lower (40%); control fish taken by electrofishing experienced similar mortality (50%). Total gamefish mortality from harvesting about 5.5 million gizzard shad was estimated to be about 7,218 fish over the 5-year period of the project.

Modified purse gill nets and trawls were not successful for harvesting gizzard shad in Lake Apopka; however, standard gill nets were found to be an appropriate method for harvesting target fish species from the lake. Catches were adequate for large-scale fish removal and the incidental catch of non-target species was low. The survival of gill-net caught-and-released game fish was very high during the winter-spring fishery period. Warm weather survival was lower, but results were inconclusive because of similar low survival of game fish taken by electrofishing and used as controls. Overall, the impact to game fish from harvesting gizzard shad from the lake was insignificant. Harvesting appeared to have a substantial impact on the gizzard-shad stock and was responsible for significant nutrient removal from the lake. Current market demands for gizzard shad from Lake Apopka is low, and attempts to develop new markets for products form the fish have not been successful. Because of the weak market position, the harvesting of gizzard shad from the lake is not yet self-sustaining.

Crumpton, J.E. 2000. Experimental gill nets in Lake Apopka. Contract 99W308. Florida Fish and Wildlife Conservation Commission. Prepared for St. Johns River Water Management District, Palatka, Fla.

PROJECT: Rough Fish Harvesting (LA-3-302-M)

EXECUTIVE SUMMARY

Historically, Lake Apopka covered an area of about 50,000 acres. The lake was characterized by extensive marshes in the northern portion, clear water with profuse submersed aquatic vegetation, and nationally renowned for its sport fishery. The construction of the Apopka-Beauclair Canal in the 1880s marked a beginning of change in the lake's hydrology. With the 1920s came external nutrient loading beginning with discharges from sewage treatment plants and citrus processing plants. Marshes on the north end of the lake were altered to create muck farms in the 1940s. Increased development of the farms resulted in additional nutrient loading to the lake. A

hurricane in 1947 uprooted most of the submerged vegetation, and the first algal bloom followed shortly thereafter. With the exploitation of the marshes, Lake Apopka is now Florida's fourth largest lake, and since the addition of a dam and lock structure on the Apopka-Beauclair Canal in 1952, has functioned as a reservoir.

The environmental degradation of Lake Apopka has been well documented since the early 1960s. The resulting decline in the sport fishery of the lake has also been well documented. With that degradation came large increases of gizzard shad (*Dorosoma cepedianum*) biomass in the lake.

The St. Johns River Water Management District, under the SWIM program, has conducted experimental management efforts to correct the problems in Lake Apopka, primarily by removing phosphorus and nitrogen from the water by harvesting mass quantities of gizzard shad. Under funding provided through contracts with the District, the Florida Fish and Wildlife Conservation Commission has conducted assessments of the gizzard shad population periodically since 1989. Studies from 1989 through 1992 provided baseline data prior to the commencement of commercial gizzard shad removal activities in 1993. Data collected from 1993 through 2000 have been used to assess changes in the gizzard shad population that have resulted from shad removal activities.

Experimental gill nets (randomly set lakewide) were used to assess shifts in catch-perunit-of-effort, size, and weight of gizzard shad. A total of 10 net sets were made during each sampling regimen. Samples were collected in January and May.

Danek, L.J., and M.S. Tomlinson. 1989. *Bathymetric analysis of Lake Apopka*. Special Publication SJ89-SP6. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Bathymetry (LA-4-106-D)

Abstract

A bathymetric survey consisting of a 347-point, 2,000-ft spaced sampling grid was conducted on Lake Apopka in June 1989. The survey was conducted using a Raytheon Model DE-719 fathometer and LORAN-C for navigation. The depth readings were calibrated, adjusted for lake surface slope, hand contoured, and entered into a GIS computer system for subsequent analysis and plotting. The measured lake surface area is 1.342×10^9 ft² and the volume is 6.453×10^9 ft³ with lake level at 66 ft (MSL) (excluding interstitial water in the sediments and flocculent layer). The mean lake depth is 4.81 ft.

The lake is generally flat with two major erosional trough features: one running approximately east-to-west across the center of the lake and the other along the south and west shoreline. The maximum depth measured (other than the depth at Apopka Springs) was 16.0 ft in the trough along the south shore.

Error analysis of the results indicated the field survey depth data were adjusted to fit the calibration data points with an accuracy of ± 0.25 ft at the 95% confidence level. This corresponds to an error of $\pm 0.335 \times 10^9$ ft³ for the lake volume estimate or about 5%. The surface area and the lake volume calculations made from the metric bathymetry chart and the English-unit chart agreed within 2.0%.

Dean, H., and E. Lowe. 1998. The restoration program for Lake Apopka, Florida. Vol. 5, 313–316. In *Proceedings of Water Environment Federation* 71st Annual Conference and *Exposition*, October 1998, Orlando, Fla.

PROJECT: Implementation of Restoration and Management Techniques (LA-6-802-S)

ABSTRACT

Lake Apopka, a large, shallow, hypertrophic lake in central Florida, is the subject of an ambitious restoration program directed by the St. Johns River Water Management District. Well over \$100 million of local, state, and federal funds have been provided to implement the restoration program. Initiation of the program is under way. The program has four major components: (1) P load reduction,(2) removal of P stored in the lake and removal of suspended solids by wetland filtration,(3) removal of P, restructuring of the lake's food web, and reduction of internal P recycling by harvesting of shad, and (4)stabilization of sediments and creation of habitat by planting shallow areas. P load reduction is the most crucial aspect of the program. Without substantial reduction in the P load all other restoration actions would fail. This essential first step was initiated by efforts to reduce P loading from adjacent farmlands and will be completed by restoration of the majority of farmland to wetland and aquatic habitat. Acquisition efforts are expected to be complete by the fall of 1998. The components of the restoration program will work synergistically. As P load reduction reduces the P concentration, algal abundance will decline and water clarity will increase. Removal of P stored in the lake, through wetland filtration and shad harvesting, will further reduce the P concentration. Removal of suspended sediments by the wetland filter will future increase water clarity. Plantings will improve water clarity locally by reducing sediment resuspension. As water clarity increases, submersed plants can colonize and stabilize lake sediments with positive feedbacks to water clarity and negative feedbacks to the P concentration and algal abundance. A progressive cycle of

plant colonization to greater depths and improving water clarity will return the lake to a macrophytes-dominated, clear-water condition. Since 1995, there have been significant improvements in the condition of Lake Apopka. It is likely that these improvements stem primarily from P load reductions associated with regulatory efforts. Shad harvesting, however, could have played a significant secondary role.

Environmental Research & Design, Inc. 2001. Evaluation of water quality stormwater regulations for the Lake Apopka Basin. Draft final report submitted to St. Johns River Water Management District, Palatka, Fla.

PROJECT: Nutrient Loading Limits Adoption (LA-3-403-M)

INTRODUCTION

This report provides a summary of work efforts performed by Environmental Research & Design, Inc. (ERD) for the St. Johns River Water Management District (District) under Contract SD490AA to evaluate alternative water quality-based stormwater regulations for the Lake Apopka Basin. Previous research performed by the District has indicated that Lake Apopka is a phosphorus-limited ecosystem and, therefore, phosphorus inputs into the lake must be controlled to improve the existing hypereutrophic water quality characteristics.

The primary objective of this study is to develop alternative stormwater regulations for the Lake Apopka Basin which maximize removal of phosphorus from runoff inputs. Based on research performed in Lake Apopka and an evaluation of phosphorus load reductions necessary to improve water quality in the lake, the District has established a general goal of no net increase in phosphorus loadings from nonpoint source inputs entering the lake. To achieve this goal, stormwater regulations must be developed which limit phosphorus loadings discharging from new developments to levels which are equal to or less than loadings discharging from the site under pre-development conditions.

Evaluations performed by ERD for this project are based upon a combination of data sources, including (1) the draft District report by M.F. Coveney titled "Sedimentary Phosphorus Stores, Accumulation Rates, and Sedimentation Coefficients in Lake Apopka: Prediction of the Allowable Phosphorus Loading Rate," dated May 10, 2000, which forms the basis for limiting post-development phosphorus loads to less than or equal to pre-development rates; (2) the draft District report titled "An External Phosphorus Budget for Lake Apopka 1989–1994" by Stites, Coveney, Battoe, and Lowe which provides estimated concentrations of total phosphorus in stormwater runoff entering Lake Apopka from typical land use categories; (3) existing District design and performance criteria for stormwater management systems outlined in Chapter 40C-42 *F.A.C.*; and (4) previous research performed by ERD regarding performance efficiency of typical stormwater management systems.

This report is divided into three separate sections for presentation and discussion of project results. The first section provides an introduction to the report and summarizes work efforts performed by ERD. Section 2 contains a discussion of the methods of analysis used for establishment of hydrologic characteristics, runoff characteristics, and evaluation of treatment system performance. The results of the analyses described in Section 2 are presented in Section 3, including an evaluation of the performance efficiency of existing regulations and an evaluation of required alternative treatment options.

Exponent, Inc. 2000 (draft). Analysis of avian mortality at the North Shore Restoration Area of Lake Apopka in 1998–1999. Prepared for St. Johns River Water Management District, Palatka, Fla. Bellevue, Wash.

PROJECT: North Shore Restoration (LA-3-303-M)

INTRODUCTION

Between mid-December 1998 and early March 1999, an outbreak of avian mortality occurred at the North Shore Restoration Area (NSRA) of Lake Apopka in central Florida. Dead birds of numerous species were recorded, although in terms of total numbers, the American white pelican (*Pelecanus erythrorhynchos*) was the most affected species. More than 400 mortalities were recorded for this species at the NSRA, and similarly high mortality was seen at offsite locations.

The NSRA lies on former agricultural land that was used for the production of vegetables and market crops. Due to past agricultural pest control practices, soils of the NSRA contain elevated residues of organochlorine pesticides, including toxaphene, DDT and its metabolites, and dieldrin. When the agricultural lands were acquired by the St. Johns River Water Management District (SJRWMD) in 1998, they remained flooded, a practice used by farmers after harvesting to control nematodes. The shallow-water habitat thus created was attractive to resident and migratory birds, and resulted in a huge influx of many species of birds to the NSRA.
began, it was believed by wildlife agencies that the elevated organochlorine pesticide levels in flooded soils, particularly toxaphene levels, likely caused the mortality.

Exponent was retained by SJRWMD to investigate the mortality event, specifically to:

- Analyze the underlying causes of the bird mortality at the NSRA
- Determine the levels of pesticides in muck soils that are protective of birds, if pesticides are the cause of mortality
- Determine the most effective management options for preventing such mortality events from occurring in the future.

This technical report addresses the first objective and summarizes our review of key components of the mortality event to analyze the evidence that supports or refutes organochlorine pesticides, specifically toxaphene, as the causal agent of the mortality. As single approach or measurement endpoint is definitive for assigning causality, this report uses a weight-of-evidence that relies on several different components to evaluate causality. The components that are evaluated include:

- Avian population census and mortality data
- Food-web modeling to evaluate exposure of avian species to organochlorine pesticides
- Body residues of organochlorine pesticides in dead birds
- Etiology and pathology of the mortality event.

Each of these components is addressed separately in the following sections, and results are summarized in the Conclusions section where an epidemiological approach is used to evaluate causality. A summary of issues pertaining to analytical methods for toxaphene analysis, which arose from the review of bird tissue data, are included as an appendix to this report.

Fulton, R.S. 1998. Evaluation of drawdown as a restoration technique for Lake Apopka. Technical memorandum 27. St. Johns River Water Management District, Palatka, Fla.

PROJECT: Drawdown and Lake Level Fluctuation (LA-2-208-F)

EXECUTIVE SUMMARY

If excessive external nutrient loading can be controlled, drawdown is one potential mechanism to shift shallow eutrophic lakes from an algal-dominated to a macrophyte-

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dominated stable state. The principal objective of drawdown of Lake Apopka is considered to be re-establishment of diverse and healthy populations of native aquatic vegetation, fish, and wildlife. Extensive beds of submersed and emergent aquatic vegetation are necessary to realize the desired improvements in fish and wildlife. Potential costs, economic impacts, and environmental effects were considered for three drawdown options for Lake Apopka:

- Gravity drawdown to 63.5 ft NGVD
- Pumpdown to 61 ft NGVD
- Pumpdown to 58 ft NGVD

All drawdown options evaluated included a three-month holddown period, with passive refill of the lake from rainfall, runoff, and spring discharges. The timing of drawdown was planned so that the holddown period would occur during the spring germination period for wetland vegetation and refill would begin during the summerfall rainy season. Simulation modeling of the alternative drawdown options was conducted using an existing hydrological model of Lake Apopka. Predicted time to reach the target holddown elevation ranged from five to eleven months. For the gravity drawdown, predicted time from beginning of drawdown to completion of refill was about two years under high rainfall and three years under low rainfall. For the pumpdown options, predicted time to completion of refill was about three years under high rainfall and four years under low rainfall.

Proposed design components of a drawdown included construction of a water retention structure around Apopka Spring to prevent the spring from discharging to the lake during the drawdown period (optional for gravity drawdown), dredging of a channel from the discharge structure to deep trenches in the lake to convey water and allow access for gill-net fish harvesting, the use of the Lake Apopka marsh flow-way to filter discharged water, and construction of a barrier across the Apopka-Beauclair Canal at the existing constriction to prevent backflow into Lake Apopka.

Gravity drawdown would not consolidate a significant area of sediments, but would result in erosive removal of flocculent sediments from shallow littoral areas, reducing sediment depth and increasing bulk density of remaining sediments, which should improve conditions for plant establishment (6–18% of lake area). The pumpdown options would consolidate a significant portion of Lake Apopka sediments (4–24% of lake area), but would also result in a large area of partially consolidated sediments (20–66% of lake area), which are prone to uprooting and forming floating vegetation islands after lake refill.

Vegetative responses to drawdown of Lake Apopka are likely to be primarily invasive exotic (hydrilla) and native (cattail) plant species. Costs for management of the invasive vegetation could be as much as \$17 million. Control of invasive vegetation would conflict with a major objective of drawdown, to stimulate sufficient growth of native aquatic and wetland vegetation to utilized excess nutrients, dampen wind resuspension of sediments, and provide aquatic habitat. Planting of desirable vegetation in conjunction with drawdown would be more compatible with restoration objectives, but planting 10,000 acres of desirable vegetation would cost an estimated \$90 million and would not eliminate the need for control of invasive vegetation. Experience from drawdown of other lakes and analysis of available data indicates that much of the vegetation recruited during the drawdown would not persist long after refill unless other measures are taken to improve water quality in the lake.

Reduction of nutrient loading is estimated to provide water clarity suitable for plant establishment over a large part of the area of Lake Apopka, regardless of whether or not a drawdown is conducted. Improvements in water clarity in Lake Apopka, resulting from nutrient loading reductions are also expected to increase management costs for invasive vegetation. However, it is expected that water clarity improvements will occur gradually, and the resulting responses by invasive plant species can be managed by a low-level maintenance program.

Drawdown is not likely to improve water quality in Lake Apopka. There will probably be a substantial increase in phosphorus concentrations in Lake Apopka following refill, due primarily to a large increase in diffusive flux from lake sediments. Sediment dredging to prevent the diffusive flux would be prohibitively expensive. Over time, diffusive fluxes and water column nutrient concentration will probably decrease, but would not be expected to fall below pre-drawdown levels unless there is a significant decrease in external nutrient loading.

The Lake Apopka marsh flow-way could be used to filter water discharged during pumpdown, and perhaps during gravity drawdown, to reduce water quality impacts on downstream lakes. However, estimated sediment discharges from pumpdown of Lake Apopka are sufficiently to completely fill both the Lake Apopka marsh flow-way and Lake Beauclair. Sediment accumulations would be likely to significantly affect benthic fauna and existing vegetation in both the marsh flow-way and in downstream lakes.

Pumpdown of Lake Apopka would greatly increase nutrient loads to downstream water bodies and substantially increase nutrient concentrations, particularly in Lakes Beauclair and Dora, even if the discharge was filtered through the Lake Apopka marsh flow-way. Gravity drawdown would likely have a measurable detrimental effect on water quality only in Lakes Beauclair and Dora.

Heavy fish mortality is likely to result from the pumpdown options. Following refill, conditions for fish recruitment are likely to be improved in Lake Apopka under all drawdown options, although it is not possible to project the magnitude of fishery response from the limited available data. However, improvements in fish recruitment will probably be temporary, unless other actions are taken to improve water and habitat quality in the lake. Existing efforts to reduce external nutrient loading and improve aquatic habitat in Lake Apopka should support greater vegetative growth in the lake, which would be expected to prolong post-drawdown increases in fish populations.

Item	Gravity drawdown	Pumpdown to 61 feet	Pumpdown to 58 feet
Construction	\$0-\$1,150,000 ¹	\$2,990,000	\$4,025,000
Other potential costs			
Boating access	\$78,100-\$124,300	\$112,100-\$ 190,900	\$129,400-\$ 198,100
loss damages ²			
Vegetation	\$274,500-\$1,712,200	\$1,647,000-\$10,273,500	\$2,745,000-\$17,122,500
management ³			
Gill-net fishery	\$1,037,000	\$1,037,000	\$1,037,000
harvest			

Preliminary cost estimates for the drawdown options are:

¹Range dependent on whether or not a water retention structure is built to prevent discharge from Apopka Spring.

²Ranges are predicted damages for high and low rainfall simulations.

³Ranges are estimated maximum vegetation management costs for cattail and hydrilla, respectively.

As invasive vegetation developing after drawdown is likely to be a mixture of these two species, expected vegetation management costs would likely be intermediate.

In summary, under current levels of external nutrient loading to the lake, drawdown is not expected to provide sustained benefits to the Lake Apopka ecosystem. It is expected that drawdown would not improve water quality in Lake Apopka, but would cause water quality deterioration and substantial sediment accumulation in downstream water bodies, and result in only temporary increases in aquatic vegetation (primarily of invasive species) and fish populations in Lake Apopka. It is recommended that a drawdown of Lake Apopka not be considered until external loading is reduced to approach the level specified in the draft Lake Apopka rule, which is five metric tons of phosphorus annually from controllable sources. Reductions in external phosphorus loading and other ongoing restoration actions may be sufficient to shift Lake Apopka from an algal-dominated to a macrophyte-dominated stable state, but the time period required for recovery is unknown. Drawdown, or other restoration measures, should be considered if it becomes clear that the targeted reduction in phosphorus loading will not yield the expected decrease in phosphorus concentrations, if decreases in phosphorus concentrations do not yield the expected increases in water clarity, or if a significant increase in vegetated aquatic habitat in the lake does not occur within one to two years after achievement of a substantial increase in water clarity. If a decision is made to conduct a drawdown, it is recommended that a gravity drawdown be implemented first, and the positive and negative effects be carefully evaluated for two years after completion of refill before considering a more extreme pumpdown of the lake.

Gale, P.M., and K.R. Reddy. 1994. Carbon flux between sediment and water column of a shallow, subtropical, hypereutrophic lake. *J. Environ. Qual.* 23:965–972.

PROJECT: Internal Nutrient Budget (LA-1-102-D)

ABSTRACT

Field and laboratory experiments were conducted to measure forms, storages, and flux of C in the water-sediment column of a shallow, subtropical, hypereutrophic lake. High gross primary productivity in the lake $(1.4 \pm 0.3 \text{ kg C m}^2 \text{ yr}^{-1})$ was not significantly correlated with any water chemistry parameters measured. This suggested that the phytoplankton community was functioning at maximum levels and under nutrient nonlimiting conditions. Major C input to the lake is through gross primary productivity, of which 90% is lost through heterotrophic and microbial respiration processes within the water column. Resuspension of the bottom sediments was a major of C into the water column, contributing 720 g C m⁻² yr⁻¹. In comparison, diffusive flux of dissolved organic C from the sediment was minimal (1.2 g C m⁻² yr⁻¹), as were external inputs into the water column (20 g C m⁻² yr⁻¹). High productivity of this system has resulted in a net accumulation of C (as sediments) of 118 g C m⁻² yr⁻¹.

Gallagher, E.P., T.S. Gross, and K.M. Sheehy. 2001. Decreased glutathione S-transferase expression and activity and altered sex steroids in Lake Apopka brown bullheads (*Ameiurus nebulosus*). Aquat. Toxicol. 55:223–237.

PROJECT: Fishery (LA-4-107-D)

ABSTRACT

A number of freshwater lakes and reclaimed agricultural sites in central Florida have been the receiving waters for agrochemical and municipal runoff. One of these sites, Lake Apopka, is also a eutrophic system that has been the focus of several case studies reporting altered reproductive activity liked to bioaccumulation of persistent organochlorine chemicals in aquatic species. The present study was initiated to determine if brown bullheads (Ameiurus nebulosus) from the north marsh of Lake Apopka (Lake Apopka Marsh) exhibit an altered capacity to detoxify environmental chemicals through hepatic glutathione S-traserase (GST)-mediated conjugation as compared with bullheads from a nearby reference site (Lake Woodruff). We also compared plasma sex hormone concentrations (testosterone, 17-beta estradiol, and 11 keto-testosterone) in bullheads from the two sites. Female bullheads from Lake Apopka had 40% lower initial rate GST conjugative activity toward 1-chloro-2,4-dinitrobenzene (CDNB), 50% lower activity towards p-nitrobutyl chloride (NBC), 33% lower activity toward ethacrynic acid (ECA), and 43% lower activity toward Delta5-androstene-3, 17dione (Delta(5)-ADI), as compared with female bullheads from Lake Woodruff. Enzyme kinetic analyses demonstrated that female bullheads from Lake Apopka had lower GST-catalyzed CDNB clearance than did female Lake Woodruff bullheads. Western blotting studies of bullhead liver cytosolic proteins demonstrated that the reduced GST catalytic in female Lake Apopka bullheads were accompanied by lower expression of hepatic GST protein. No site differences were observed with respect to GST activities or GST protein expression in male bullheads. Female Lake Apopka bullheads also had elevated concentrations of plasma androgens (testosterone and 11-ketotestosterone) as compared with elevated levels of plasma estrogen but similar levels of androgens as compared with male bullheads from Lake Woodruff. Collectively, our studies indicate the presence of reduced GST protein expression, reduced GST conjugative capacity and altered sex steroid homeostasis in female bullheads from a contaminated field site in Central Florida. The implications of these physiological alterations in terms of pollutant biotransformation and reproduction are discussed.

Geonex. 1998. Lake Apopka demonstration marsh vegetation analysis. Submitted to St. Johns River Water Management District, Palatka, Fla.

PROJECT: Marsh Flow-Way Restoration (LA-3-301-M)

INTRODUCTION

This report serves as a summary of the photointerpretive vegetation change analysis of the St. Johns River Water Management District's Lake Apopka Marsh site from 1990 to 1997. The analysis involved the photointerpretation and digitization of color infrared aerial photography taken of the project site for the following dates: November 1990, October 1991, November 1992, September 1993, September 1994, May 1995, October 1995, May 1996, and April 1997. Vegetative species were identified and coded according to the Wetland Diagnostic Characteristics Classification System that was provided by the District. Digital coverages were analyzed to calculate acreage changes between vegetative species in the Demonstration Marsh and Full Marsh.

Photointerpretation was completed for the North Marsh, South Marsh, and Full Marsh for the October 1995 and April 1997 dates. There was not full aerial coverage of the Full Marsh for the May 1996 time frame and only the North Marsh and South Marsh were photointerpreted for that date. Quality control was performed on all of the maps, which include the three that were photointerpreted by Geonex and six others that were compiled by other sources and supplied to us by the District for quality control.

Godwin, W.F. 1989. Trophic structure manipulation project, Phase II, quality assurance project plan. St. Johns River Water Management District, Palatka, Fla.

PROJECT: Trophic Structure Manipulation (LA-4-207-F)

PROJECT DESCRIPTION

The historical degradation of the Oklawaha Chain of Lakes (Figure 3.1) and of Lake Apopka in particular has been well documented (Brezonik et al. 1978; EPA 1979a; Lowe et al. 1986; Tuschall et al. 1978). This progressive cultural eutrophication of the lake has resulted in the reduction or elimination of many former uses of the water body. Since Lake Apopka is the largest of the Oklawaha chain and the headwater source, any attempt to improve water quality in the remainder of the lakes should logically begin with Lake Apopka.

The Surface Water Improvement and Management Act (SWIM) was enacted in July 1987. This legislation asserted that many of the surface waters of Florida have become or are in danger of becoming degraded and the state was obligated through its various agencies to enhance the environmental and scenic characteristics of these surface waters. Water management districts, in conjunction with the Florida Department of Environmental Regulation (FDER) and other state and local agencies were charged with preparation of a plan to achieve the goal of enhancement of environmental and scenic values of water bodies designated as having regional or statewide significance. Lake Apopka was specifically identified as a high priority water body in need of restoration.

Previous legislation (85-148, Laws of Florida) created the Lake Apopka Restoration Act and established the Lake Apopka Restoration Council (LARC). The District, in conjunction with FDER, other state and local agencies, and the LARC, was mandated the responsibility of determining environmentally sound and economically feasible restoration methods for Lake Apopka.

A District plan for the restoration of the lake was subsequently completed (Battoe et al. 1988). This plan called for the implementation of diagnostic studies on nutrient dynamics and budgets for the lake and for a series of feasibility studies to determine methods which might be applicable to restoration of Lake Apopka to Class III water quality standards. One of the feasibility study areas selected for funding was biomanipulation.

The purpose of this pilot study is to determine if manipulation of the dominant planktivore population in a small hypereutrophic lake will result in measurable changes in the trophic structure of that lake. Data acquired during the project will be used to formulate a plan for nutrient and algal biomass reduction through manipulation of the rough fish population in Lake Apopka. Lake Beauclair will be used as the control for this experiment and an additional background data base will be established for Lake Apopka. The project will be conducted in three segments of approximately one year each following a preliminary screening and lake selection process. Segment I will consist of the establishment of a pre-manipulation database in the experimental and control lakes. During Segment II, the population of gizzard shad (*Dorosoma cepedianum*) will be removed from the experimental lake and database collection will continue in all lakes. In Segment III, database collection will continue and an evaluation will be made of any changes in the experimental lake following rough fish harvesting. The project will commence upon approval of the Quality Assurance Project Plan and continue for a 36-month period.

Sample types, parameters, and sample numbers for surface water quality, biological, and sediment analysis are shown in Tables 3.1, 3.2, 3.3, and 3.4. All field sampling (except fisheries) will be conducted by SJRWMD staff.

Determination of fish community dynamics will be contracted to the Florida Game and Fresh Water Fish Commission and specific measurement parameters are detailed in the

Scope of Work for Ichthyofaunal studies (Attachment 1) and in the Ichthyofaunal Studies Quality Assurance Addition (Attachment 2).

Analysis of macro-zooplankton, bacterioplankton, and ciliated protozoa will be conducted under contract to the University of Florida. Specific parameters to be measured for the zooplankton contract are detailed in the Zooplankton Analysis Quality Scope of Work (Attachment 3), Table 3.4, and in the Zooplankton Analysis Quality Assurance Addition (Attachment 4).

Sediment analysis will be contracted to Hunter/ESE, Inc. Parameters to be analyzed for this portion of the study are shown in Table 3.3. Total nitrogen and total phosphorus will also be analyzed.

Laboratory analysis of surface water samples will be contracted to PPB Environmental Laboratories, Inc. Parameters to be measured are shown in Table 3.2. This contractor will also conduct the analysis of chlorophyll.

Algal productivity sampling and analysis will be conducted by SJRWMD staff.

Godwin, W., S.G. Coyne, and E.A. Gisondi. 1993. An evaluation of methods for removal of rough fish as a restoration technique for Lake Apopka. Technical memorandum 3. St. Johns River Water Management District, Palatka, Fla.

PROJECT: Trophic Structure Manipulation (LA-4-207-F)

EXECUTIVE SUMMARY

The declining environmental quality of surface water in the Ocklawaha basin, and particularly in Lake Apopka, has been a subject of concern for various agencies and private citizens for over 40 years.

In recognition of the persistent water quality and associated environmental problems in this basin, the 1985 Florida legislature directed the St. Johns River Water Management District, in conjunction with the Florida Department of Environmental Regulation, other state and local agencies, and the Lake Apopka Restoration Council, to initiate a pilot restoration program for Lake Apopka. This mandate was reiterated through the Surface Water Improvement and Management Act of 1987.

One potential restoration method selected for further research was manipulation of lake trophic structure (food chain composition) and export in-lake nutrients by depleting planktivorous fish stocks, primarily gizzard shad. Establishment of an efficient and cost-effective method for removing target-fish species was essential in implementing this restoration technique, and an accurate assessment of existing rough fish stocks was necessary in determining the efficacy of various fish removal methods tested.

This project had three major goals. First, to determine the biomass of harvestable gizzard shad stocks in Lakes Denham and Apopka. Second, to test the effectiveness of fishing techniques in Lake Apopka which are most often used for harvesting open-water fish stocks such as gizzard shad. Third, to estimate the cost and extent of nutrient export from fish removal and compare the results with other potential methods.

The District, in cooperation with the Florida Game and Fresh Water Fish Commission, initiated an effort to test methods for determining gizzard-shad biomass, and to evaluate techniques for shad removal. Three fish removal techniques were selected for testing: haul seine, gill net, and pound net. Two basic principles were established to guide this effort: (1) An acceptable rough-fish removal method must be practical and specifically applicable to Lake Apopka and (2) use of fish toxicant is not a viable option for rough-fish depletion because of the negative impact of leaving large masses of dead fish to decompose in the lake with attendant nutrient release.

Use of a small lake for the pilot fish removal effort resulted in much lower cost for the work and allowed better control of the fish removal process. The selected lake, Lake Denham (256 acres), is near Lake Apopka and was similar in trophic state and food-web structure.

Standard fish sampling techniques using blocknets with rotenone and experimental gill nets of mixed mesh sizes were found to be inadequate to provide accurate information on the abundance of gizzard shad in either Lake Denham or Lake Apopka; therefore, information on the composition of the total fish stock was not available for either lake and only limited information was available on gizzard shad biomass. In Lake Denham, blocknets showed a total gizzard shad biomass of 7 to 21 lb/acre during the same time period when 417 lb/acre of adult gizzard shad were removed from the lake by haul seine. Blocknet data from Lake Apopka were also highly variable and showed similar low biomass levels. Experimental gill net catches showed high variability with the season of the year. Gill net catch results from both Lake Denham and Lake Apopka showed an 84% to 89% decline between the months of January and June each year before and after the fish removal. Results from Lake Apopka samples also showed high seasonal variability.

Because direct census of gizzard shad populations was not feasible using blocknets or gill nets, we used Lake Denham haul seine catch and effort data to estimate the abundance of harvestable gizzard shad in that lake at the beginning and end of the haul seine work by using a standard mathematical equation (Leslie Regression). This could not be done in Lake Apopka because the haul seine was ineffective there. In lieu of numeric data, we used anecdotal information and an assumed relationship between experimental gill net and haul seine catches to project a harvestable gizzard shad stock for Lake Apopka of about 10 million pounds.

In Lake Denham, 35 seine hauls completed between January and April 1990 produced a total fish catch of 112,437 lb. Of this total, 87,057 lb (77%) were gizzard shad. Game fish species comprised 19% of the catch and other rough fish made up the remainder. A Leslie Regression analysis of 1990 haul seine catch and effort data showed an initial harvestable gizzard shad stock of 100,794 lb, or 394 lb/acre of lake surface. The harvestable stock remaining after completion of the haul seine effort was estimated at 13,737 lb, or 54 lb/acre. In 1991, 13 seine hauls completed in May produced a total fish catch of 20,895 lb. Gizzard shad made up 96% (20,040 lb) of the total. The remainder of the catch was game fish species and other rough fish species. A Leslie Regression analysis of 1991 haul seine catch and effort data showed an initial harvestable gizzard shad stock of 22,679 lb, or 88 lb/acre of lake surface. The harvestable stock remaining after completion of the asymptotic at 2,639, or 10 lb/acre.

An analysis of 1990 Lake Denham haul-seine catch data indicated that the initial adult gizzard-shad stock was depleted by 86%. In 1991, the existing adult shad stock was depleted by 88%. The average cost of contracted fish removal by haul seine in Lake Denham was \$0.26 per pound in 1990. A total of 609 lb of phosphorus and 1,915 lb of nitrogen were exported from Lake Denham by this fish removal. The contract cost of nutrient removal was \$36.43 per lb for phosphorus and \$13.62 per lb for nitrogen. Contract cost for the 1991 fish removal was inflated (\$0.36 per pound) because only one contractor submitted a bid for the work; therefore, nutrient removal cost was not calculated for the 1991 haul seine work.

In Lake Apopka, 12 seine hauls were conducted during a 3-week period in April and May 1990. The harvest of gizzard shad from this effort was only 3,475 pounds, even though some hauls covered an area of 160 acres. Because of the small haul seine catches in Lake Apopka, the data were not suitable for any meaningful analysis. Reasons for the low catch efficiency of the haul seine in Lake Apopka included high fish escapement due to the slow seine-closure rate in the flocculent sediments, and the haul-seine contractor's lack of detailed knowledge of fish and sediment distribution in Lake Apopka. The contractor was unable to compensate for these problems within the time and budget constraints of this contract. Two commercial gill nets totaling 400 yards in length were used for fish removal trials in Lake Apopka during a 9-day period in January and February 1991 and a 13-day period in May 1991. In 184 hours of fishing effort, 40,521 pounds of fish were harvested. The catch by weight was composed of about 96% gizzard shad, 3% other rough fish, and almost 1% game fish. All game fish taken in the gill nets were of harvestable size. Initial mortality of game fish released from the gill net averaged less than 10% and occurred only during the warm-weather period (May). No estimate of longer term mortality of released fish was made. The cost of rough-fish removal by this method was \$0.25 per pound. This figure is probably inflated due to the lack of highly competitive bidding for this fish removal contract. Many gizzard shad fishing operations routinely harvest fish by gill net at a market price of \$0.08 to \$0.15 per pound.

We used comparative data from experimental gill nets in Lakes Denham and Apopka, the 1990 Lake Denham haul seine catch data, and reported catch efficiencies for gill net fisheries on migratory species to predict a potential annual shad removal of about 3 million pounds for Lake Apopka. Use of gill nets appears to offer the best potential to achieve the target fish removal. However, this activity must be approved and permitted by the Florida Game and Fresh Water Fish Commission. Their evaluation of the impact of the game fish by-catch from gill nets will likely determine the future use of this fish removal method in Lake Apopka.

Cost for removal of nutrients by gizzard shad harvesting appears to be lower than other methods and fish removal appears to be less problematic than other lake restoration alternatives associated with nutrient reduction such as sediment removal, pumped drawdown, alum treatment, or biochemical and chemical oxidation technology. We project that rough fish harvesting could remove about 11 tons of phosphorus and 33 tons of nitrogen annually from Lake Apopka. Although this level of nutrient depletion alone will have only small effects on overall nutrient dynamics for the lake, it could augment significantly the projected annual phosphorus removal of 33 tons resulting from operation of a large water filtration wetland located adjacent to the lake. The large-scale removal of gizzard shad could also produce beneficial food web effects in the lake.

Gottgens, J.F., and T.L. Crisman. 1992. *Newnans Lake, Florida: Removal of particulate organic matter and nutrients using a short-term drawdown (Phase I)*. Special Publication SJ92-SP23. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Drawdown and Lake Level Fluctuation (LA-4-208-F)

EXECUTIVE SUMMARY

Water-level stabilization is commonly employed in Florida to insure year-round access to lakes. However, stabilized water levels may cause accelerated accumulation of nutrient-rich detritus on the lake bottom. This, in turn, can affect aquatic plant communities, reduce water clarity, and eliminate hard-bottom nesting areas for many sportfish.

A 90-day gravity drawdown of shallow, algal-dominated Newnans Lake (Alachua County, Florida) was initiated by the Florida Game and Fresh Water Fish Commission in April 1989 by removing the flashboards on the outflow dam. The study reported here was designed to measure discharge rates of organic matter and nutrients through flushing and to examine the oxidation and consolidation of exposed littoral substrate in the field and in the laboratory. Sediment characteristics and patterns of sediment deposition and redistribution were also studied and are documented in the Phase II report (Gottgens and Crisman 1992).

Temporary removal of the flashboards on the dam flushed moderate amounts of suspended solids, particulate organic matter (POM), nitrogen (TKN), and phosphorus (TP) from the lake. Elevated concentrations of POM, TKN, and TP in the discharge were only noted during the first month of dewatering, when adequate head differential was present. Storms associated with high winds appeared to promote flushing of organic matter and nutrients, probably due to enhanced resuspension of bottom lake sediment.

Field and laboratory tests did not demonstrate a net oxidative removal of organic matter from exposed areas of the lake bottom. Consolidated sediments remained firm after reflooding, providing improved habitat for rooted macrophytes and fish spawning. Gravity drawdowns are inexpensive and can be effective in removing organic matter and nutrients when they are initiated at high lake stage and coincide with frequent wind events. Routine application of this management technique may produce a periodic rejuvenation of the lake ecosystem in situations where water-level stabilization is required.

Gottgens, J.F., and T.L. Crisman. 1992. Sediments of Newnans Lake: Characteristics and patterns of redistribution following a short-term drawdown (Phase II). Special Publication SJ92-SP24. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Drawdown and Lake Level Fluctuation (LA-4-208-F)

EXECUTIVE SUMMARY

The impact of lowering water level (by short-term drawdown) on deposition and redistribution of organic sediments was studied in eutrophic Newnans Lake, Florida. Sediment transfer was determined by matching marker horizons in pre-drawdown cores with those in cores taken at the same sites after water level returned to normal. These horizons were located by radio-isotope analysis or by direct field evidence of distinct stratigraphy. An average of 6.1 g m⁻²day⁻¹ (N=3) of organic material eroded from the littoral zone by lowering the water depth from 62 to 30 cm for 8 weeks. Littoral sediments with low bulk density eroded fastest and bulk density of remaining substrate increased by an average of 250%. Short-term drawdowns can greatly enhance resuspension of fine littoral substrate. A record of redistribution of this material to the deeper portions of the lake was unclear. Of six profundal sites analyzed for this study, two showed evidence of sediment deposition due to drawdown. Since resuspension of fine sediments influences the ecology of a lake through habitat alteration, release of nutrients, high turbidity and enhanced oxygen demand, erosion processes must be considered when drawdowns are attempted. Finally, data from Phase I and Phase II of this work are summarized, and recommendations for the management of Newnans Lake are provided.

Greening, H., and S. Doyon. 1990. *Environmental and ecological effects of drawdown and enhanced fluctuation for Lake Apopka, Florida*. Special Publication SJ92-SP24. Palatka, Fla.: St. Johns River Water Management District .

PROJECT: Drawdown and Lake Level Fluctuation (LA-4-208-F)

EXECUTIVE SUMMARY

The potential ecological and environmental effects of a drawdown or enhanced lake level fluctuation program for Lake Apopka were assessed by Dames & Moore for the St. Johns River Water Management District as a part of the Lake Apopka SWIM Plan initiative. An extensive literature review and personal interviews were used to formulate a synopsis of the ecological effects of water level drawdown as a management and restoration technique. The application of drawdown or enhanced water level fluctuation to the restoration of Lake Apopka was addressed by evaluating the drawdown and enhanced fluctuation literature and existing studies on Lake Apopka. The literature review indicates that lake drawdown or enhanced water level fluctuation generally results in increased sportfish production, increased macrophyte-associated macroinvertebrate populations, and littoral zone habitat enhancement. Short-term control of nuisance vegetation frequently occurs in cold climates. Drawdown or enhanced fluctuation generally does not result in long-term improvements in water quality, or the control of nuisance macrophytes in warm climates. Significant sediment consolidation typically occurs only following long (>7 month) periods of sediment exposure, and usually only down to within 2 feet of the holddown lake elevation.

The information gained from the literature review was applied to four drawdown/enhanced fluctuation scenarios developed for Lake Apopka. These are:

Scenario 1: Enhanced fluctuation by gravity flow and pumping from 66 ft NGVD (normal pool) to 63 ft NGVD. At 63 ft NGVD, only 8.6% (2,640 acres) of the total lake area will be exposed, although the lake volume will have been reduced by almost 60%. A minimal drainage canal system within the lake will be necessary.

Scenario 2: Drawdown by gravity flow and pumping 62 ft NGVD. At this lake level elevation, 6,980 acres (22.7% of the total lake area) will be exposed and lake volume will have been reduced by almost 77%. A slightly more extensive in-lake drainage system will be needed.

Scenario 3: Drawdown by gravity flow and pumping to 61 ft NGVD. At 61 ft NGVD, 56.3% (17,357 acres) of Lake Apopka sediments will be exposed, while almost 90% of the original lake volume will have been discharged from the lake. Due to the relative isolation of some pockets of remaining water, an extensive in-lake system of drainage pipes or canals will be required to remove enough water to reach a water level of 61 ft NGVD in the lake basin.

Scenario 4: Drawdown by gravity flow and pumping to 60 ft NGVD. At 60 ft NGVD, 85% (26,174 acres) of the total lake area will be exposed, with 95% of the original lake volume having been discharged. An elaborate system of miles of drainage canals or pipes will be required.

The following in-lake effects of a Lake Apopka drawdown are likely to occur:

• Extensive germination of littoral zone vegetation and increased littoral zone habitat. Under Scenario 1, increased germination may be minimal due to the small percentage of total lake sediments exposed.

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- More extensive germination would be anticipated under other scenarios. Longevity of littoral zone habitat enhancement will likely depend upon the degree of sediment consolidation during exposure.
- Increased sportfish populations as a result of increased littoral zone habitat, if sufficient stocks remain in Lake Apopka.
- Extensive cattail germination and growth, likely requiring some degree of management (herbicide or mechanical harvesting), especially for Scenarios 2, 3 and 4.
- Increased macrophyte-associated macroinvertebrate densities following refill but a decrease or elimination of some existing benthic species due to desiccation during dewatering.
- Little or no improvement in water quality (TP, TN, and chlorophyll *a* concentrations) under all drawdown scenarios, based on results from other Florida lake drawdowns.
- Development of a "cap" of consolidated sediments and germinated vegetation if the dewatering period is between three and seven months in duration, which can become dislodged from underlying unconsolidated sediments upon refill and cause "floating islands."
- Sediment exposure for longer than seven months will likely result in significant sediment consolidation down to within two feet of the holddown lake elevation.

The duration of any effects of drawdown or enhanced water level fluctuation observed in Lake Apopka will likely be relatively short-lived (a maximum of 2–6 years). Potential effects of a drawdown or enhanced fluctuation on downstream water bodies include a possible shift in littoral zone plant community structure from nonaquatic species to aquatic species if maximum pool elevations in downstream lakes are maintained during Lake Apopka drawdown and holddown periods; excessive velocities in downstream channels during drawdown, with associated dislodging of sessile organisms; and the probability of significantly increased nutrient and sediment loading to downstream lakes during discharge and storage of Lake Apopka drawdown water.

Gremillion, P.T., and C.E. Mericas. 1988. A literature review and feasibility analysis assessing microbial decomposition as a technique for restoring Lake Apopka. Special Publication SJ92-SP24. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Microbial Decomposition (LA-4-205-F)

EXECUTIVE SUMMARY

As part of the effort to improve water quality in Lake Apopka, International Science & Technology, Inc. (IS&T) has conducted a literature review and preliminary feasibility analysis assessing in situ sediment decomposition as a technique for oxidizing organic lake sediments and decreasing sediment nutrient loading to the water column. This technique applies biochemical or chemical processes, or a combination of both, and has its origins in wastewater treatment technology.

Four specific techniques for sediment decomposition were investigated: microbial inoculation, denitrification, hydrogen peroxide addition, and ozonation. Thorough investigation of research and field applications of sediment oxidation techniques required a review of the peer-reviewed and "grey" literature, as well as interviews with scientists and lake managers with experience in this field and commercial vendors of these technologies.

BACKGROUND

Decreasing the organic content of sediments has the potential for improving water quality in eutrophic lakes by decreasing the oxygen demand of the sediments on the water column, inhibiting nutrient cycling from the sediments to the water column, and increasing the depth of the water column through sediment consolidation.

Natural systems accumulate excess organic material when biological productivity exceeds the capacity to decompose this material. This can be the result of nutrient limitation, the presence of toxins, or other adverse environmental conditions that constrain decomposition. Sediment treatment research focuses on accelerating decay processes through combinations of chemical, mechanical, and biological intervention.

The sediments in Lake Apopka are moderately organic and subject to "intense microbial activity and anaerobic conditions" (Reddy et al. 1988). Anaerobic conditions are reflected in extremely high ammonium concentrations. Active denitrification is indicated by very low nitrate concentrations. The sediment has undergone significant microbial degradation, but the remaining degradable organic material in the sediments appears to be far from depleted, as reflected by the anaerobic conditions and high concentrations of ammonia. In addition, anaerobic conditions in the sediments may be sustained by the continual deposition of dead algal cells and allochthonous organic material. Sediment accretion rates average approximately 1 cm/year (Pollman, pers. comm.).

BIOCHEMICAL OXIDATION TECHNIQUES

There are two technologies that attempt to induce microbial sediment oxidation. The first relies on the introduction of non-native microorganisms to both aerobic and anaerobic sediment environments. The second relies on native bacterial populations stimulated by introduced nitrate to oxidize sediments by denitrification under anaerobic conditions.

<u>Introduced Microorganisms</u>. Non-native microorganisms are introduced into eutrophic lakes with the intention of removing particulate and dissolved organic material from the water column and sediments through enhanced aerobic and anaerobic bacterial activity, including denitrification. The products are composed of mixtures of bacterial species that are reported to be free of Salmonella and related pathogens. Most manufacturers of microbial treatments claim that their products work under both aerobic and anaerobic conditions, but that aerobic conditions are preferable and can be induced through mechanical aeration.

Hanson (1981) conducted the most extensive investigation to date of in situ sediment digestion techniques, including aeration and microbial inoculation. The results indicated no detectable difference between sediments inoculated with the commercial product and the untreated controls. The author concluded that inoculating sediments with the correct mix of aerobes that have already developed the specific decay mechanisms required "may be very difficult, if it is possible at all." Other researchers have reported similar negative results in evaluating the effectiveness of microbial inoculations (Jewell and McCarty 1970; Foree and McCarty 1971; Boyd et al. 1984; Tucker and Lloyd 1986; Muller 1987; Palmer et al. 1987; Blouin et al. 1988).

The technology of microbial inoculation to improve water quality is based on highly controversial scientific theories. Controversy centers on the principal that if it is environmentally possible for a substrate to be used as an energy source, mechanisms will have developed over time to efficiently use that substrate. Given the general capability of native microbial populations to adapt to complex substrate types, the presence of excessive substrate (accumulated organic material) indicates that accretion rates are greater than the processing rates of the microbial population. This could be caused by nutrient limitation or toxicity (Jewell and McCarty 1971). Either of these conditions would also limit the effectiveness of introduced microorganisms (unless toxins to native populations were non-toxic to introduced microbes).

The most compelling argument against the efficacy of commercial microbial products is the absence of published accounts of success in applying these products to eutrophic lakes. No support for the use of microbial inoculation as a lake restoration method can be found in the peer reviewed scientific literature. The few refereed journal articles documenting microbial inoculation conclude that the treatment is ineffective and theoretically unsound (Boyd et al. 1984; Hanson 1981). Without exception, the professional limnologists and aquatic scientists contacted during this investigation expressed the opinion that the addition of microbial products to promote sediment decomposition and lake restoration has little theoretical basis and no credible evidence to substantiate the claims made by the manufacturers. It was concluded that further investigation regarding the application of commercial microbial products to the restoration of Lake Apopka is not warranted.

The cost of microbial inoculation can vary considerably, depending on whether mechanical aeration is included in the project design. Based on manufacturers' recommended doses, areal costs range from \$6 to \$25 per hectare. These costs include only the purchase of the microbial product. Costs associated with application, environmental monitoring, or additional water conditioning, such as aeration or treatment with chemical precipitants, are not included.

<u>Nitrate Application.</u> Lake restoration techniques involving nitrate application rely on the stimulation of biochemical denitrification. The principal objective is to inactivate sediment phosphorus through nitrate-induced reactions, but a related effect of the treatment is anaerobic sediment oxidation through denitrification. The mechanism of phosphorus inactivation is the sorption of phosphate onto insoluble ferric, Fe(III), oxides and hydroxides under oxidizing conditions. Cooke et al. (1986) observed that in shallow lakes with high pH and temperature, iron redox reactions may not control phosphate release. In such systems nitrate application may not inactivate phosphate, although sediment oxidation would still occur under reducing conditions.

Laboratory studies by Hanson (1981) and Szewczyk (1984) examined the effectiveness of nitrate application in oxidizing organic sediments and found nitrate application to be a promising technology, concluding that readily degradable organic material was effectively decomposed without adverse impact to the water column. Neither investigator reported any reduction in sediment volume at any nitrate dose. Unfortunately, neither study examined the efficiency of denitrification or inhibition of phosphorus recycling. There are mixed, but generally positive reports of the success of nitrate addition treatments (Forsberg 1987; Lingren 1986; Ripl 1979; Willenbring et al. 1984; Verner 1985; Ripl 1985; Foy 1986).

The success of nitrate application appears to be related to site-specific conditions, including sediment chemical characteristics. It is evident that denitrification occurs intensely in the sediments in Lake Apopka. Thus, there may be substantial oxidation of

organic material occurring routinely in the upper sediments of the lake. Conditions in the lake appear to be suitable for nitrate application; a shallow, subtropical system with a productive, aerobic, well-mixed water overlying the sediments. The capability for this technology to control phosphorus release in the highly productive environment of Lake Apopka is uncertain. Field investigations will be required to assess the efficacy of the technique.

Ripl (1985) developed application technology and equipment, known as RIPLOX, to inactivate phosphorus and oxidize organic sediments through the addition of calcium nitrate in conjunction with lime and ferric chloride. This technology is marketed in the United States by Aqua Technique, distributor of the RIPLOX technology. Aqua Technique provides the mechanical apparatus for injecting calcium nitrate into lake sediments and the technical expertise in developing treatment designs for specific projects. Application costs for nitrate treatment depend on the specific dose of calcium nitrate needed and on whether additional chemicals, such as lime or ferric chloride are required. Treatment costs reported in the literature range from \$0.74/m to \$1.33/m.

CHEMICAL OXIDATION TECHNOLOGY

Organic sediments can be decomposed by reactions involving chemical free radicals which form from compounds with highly reactive oxygen groups. The two chemical oxidants examined in this study, hydrogen peroxide and ozone, have been applied for both water treatment and lake sediment oxidation. Application of either technology would require isolating a several hectare area of lake and introducing either liquid or gas into the flocculent sediments.

<u>Hydrogen Peroxide</u>. Hydrogen peroxide (H_2O_2) is commonly used in wastewater pretreatment for BOD, odor, and solids removal (Cole et al. 1974, 1976; Weber 1972). Research in the use of H_2O_2 for lake management has been conducted in field experiments by Barroin (1980) and laboratory experiments by Barroin and Feuillade (1986), Hanson (1981), Soares (1980), and Szewczyk (1984). Soares (1980) conducted laboratory studies on the biological effects of H_2O_2 application to eutrophic lake sediments. H_2O_2 treatments resulted in the complete elimination of benthic macrofauna, and possibly microflora as well, with subsequent recolonization by sulfur-reducing bacteria. Mortality resulted from oxidation by the H_2O_2 , but also by H_2O_2 reaction products such as sulfide, ammonium, and copper. Following oxidation, the onset of reducing conditions was observed, presumably brought on by the renewed activity of reducing bacteria. The H_2O_2 application was effective in removing 30% of the COD.

Hanson (1981) and Szewczyk (1984) included hydrogen peroxide treatment in their studies of in situ sediment consolidation techniques. Hanson reported highly efficient

oxidation of organic sediments with increases in concentrations of dissolved carbon, phosphorus, and nitrogen and pH depression in the water column. He concluded that H_2O_2 treatment was the most effective method tested. The author recommended a post-treatment lime application to adjust pH, and a final treatment for uptake of soluble nutrients and organic carbon, using either nitrate or aeration combined with microbial inoculation. Szewczyk (1984) concluded that while the sediment oxidation capacity of H_2O_2 was great, the high cost and adverse environmental impacts render the technology impractical.

The effectiveness of chemical oxidation in lakes is offset to some extent by the profound impact of reaction by-products on overlying water quality. Followup treatment is necessary to precipitate nutrients from the water column. The choice of potentially applicable precipitants includes lime, alum, and ferric chloride, all of which are widely used in water treatment and lake management. Another secondary effect of chemical oxidation is a post-treatment pH decrease of 2 to 4 units. In-lake treatment operations (experimental or full-scale), will require a substantial secondary treatment program applying lime, or some other neutralizing agent to adjust the water column pH. It may be possible to use lime for both pH adjustment and precipitation. The extent of the treatment necessary will depend on iron concentrations in the sediment relative to the quantity of nutrients suspended. The cost of this additional treatment could easily equal or exceed the cost of initial oxidant application.

The application of H_2O_2 on an operational scale would be logistically complex and labor intensive. Liquid hydrogen peroxide is available in bulk as a 35% or 70% solution. The 35% solution has a cost of 0.107/kg, not including delivery. Cost for treatment is approximately 48/m. Additional costs would include product delivery, application equipment costs, and labor.

<u>Ozone</u>. Ozone (O₃), like H_2O_2 , is used in water treatment for its powerful oxidizing capability but is poorly documented as a lake management technology. Other than a project report (Water Management, Inc.), Hanson (1981) provides the only known report of ozone application to oxidize lake sediments. Oxidation of organic material was significantly lower than H_2O_2 treatments and was comparable to removal observed in nitrate treatments. Sediment volume decreased significantly. The response of the water column to sediment ozonation is analogous to that of H_2O_2 treatments, and the secondary treatment requirements are identical.

Ozonation would probably be highly effective in decomposing the UCF and CF sediment fractions in Lake Apopka. Additionally, organic material in the water column would be oxidized, including phytoplankton cells. Secondary treatment with a chemical precipitant would remove the resulting soluble nutrients from the water column and

seal the sediments with a relatively insoluble surface layer. The result would be a deeper water column with a more consolidated lake bottom, and environmental conditions conducive to the establishment of rooted macrophytes.

Implementing an effective ozonation program on Lake Apopka would be logistically complex. Ozone can be generated on-site, eliminating the problem of bulk shipping highly corrosive liquids (e.g., H_2O_2). The nature of the treatment would require that confined areas be treated sequentially as batch reactors. An enclosure in the lake would be required to hydraulically contain the area being treated. Following initial treatment with the chemical oxidant, the water would undergo treatment to remove dissolved nutrients and suspended residual organic material. After completion of the treatment, the enclosure would be moved to a new area and the process would be repeated.

Traditionally, cost has been the limiting factor in applying ozonation as a treatment technology. Recent advances in ultraviolet (UV) light technology have resulted in the development of a relatively inexpensive method of generating a "highly reactive ionized oxygen gas plasma," known as "activated oxygen," and commercially produced under the trademark "PHOTOZONE" (Water Management, Inc.). The manufacturer claims that PHOTOZONE generation requires 3–5 kw hours to produce one pound of ozone, in comparison with 8–12 kw hours to produce one pound of ozone using conventional methods. PHOTOZONE has been used in lake management. Interestingly, the PHOTOZONE representative contacted for this study stated that PHOTOZONE no longer markets their product for lake management projects.

Energy consumption will be the most expensive aspect of ozonation. Considering literature values of approximately 5 kw hr to generate 1 pound of ozone, Hanson's (1981) ozone dose of 75 g O_3/L of sediment, and energy costs of \$0.041/kw hr (supplied by Florida Power and Light), energy costs to oxidize the UCF and CF sediments in Lake Apopka would be approximately \$3 billion.

PUBLIC HEALTH IMPLICATIONS

None of the biological or chemical products considered in this study appear to present a human health hazard. Genetically engineered organisms were specifically excluded. A possible public health risk indirectly related to any remediation efforts is the release from the sediments (and consequent activation) of the pathogenic amoeba, *Neaglaria fowleri*. This organism has been demonstrated to cause disease and death in humans in subtropical waters including lakes in central Florida. Generally the organism exists as a non-pathogenic encysted form in sediments until water temperatures exceed approximately 32° C, whereupon it converts to a free-living form and can enter the human body through mucous membranes. The existence of this organism in Lake

Apopka has not been investigated for this study. However, prior to implementation of in-lake restoration activities, population studies are recommended to determine initial densities and, more important, to determine what, if any, effects may result from large-scale disturbance of the organic sediments that may harbor the dormant cysts of this organism.

CONCLUSIONS AND RECOMMENDATIONS

Of the technologies examined in this study, nitrate application and ozonation exhibited potential for immediate field testing in Lake Apopka. Chemical oxidation technologies would be substantially more costly than nitrate application (Table E-1). The cost of initial application alone to Lake Apopka would probably exceed \$3 billion for ozonation and \$7 billion for hydrogen peroxide application, and extensive secondary treatment would be required in addition to that cost for water quality mitigation. Nitrate application, was therefore selected as the most economical and technically feasible in situ lake restoration technique. Specific conclusions and recommendations regarding each technology are provided below.

The theoretical framework that describes the mechanisms by which microbial inoculation should work is not supported by experimental data and is highly controversial. There is no evidence to indicate that application of this technology to Lake Apopka would bring about the desired responses of sediment decomposition or suppressed nutrient cycling. The technology of microbial inoculation currently provides a very low probability of success in field applications. Field tests of this technology are not recommended.

The injection of calcium nitrate into anaerobic sediments has been demonstrated to oxidize organic sediments through denitrification and inactivate phosphorus through co-precipitation with ferric hydroxide. The chemistry and biochemistry of the processes involved in this technology have been established through field and laboratory experimentation. Thus, there is adequate theoretical and practical information available to develop reasonable designs for field trials of the technology. Field evaluation of this technology is recommended.

Published reports of field and laboratory experiments using H_2O_2 and ozone show them to be highly effective in oxidizing organic sediments. Any application of chemical oxidation technology must be followed by treatment to inactivate dissolved nutrients and residual particulate organic material.

It is recommended that H_2O_2 and ozonation not be considered for field tests, because of excessive treatment costs and the logistic implications of large-scale treatment operations (e.g., bulk H_2O_2 or ozone generation requirements).

Gross, T.S., and N. Kernaghan. 2002. Endocrine disrupting effects of chlorinated hydrocarbons in fish and alligators in central Florida. SIS#1998. Progress report accessed on 3/4/02. Available at [http://www.fcsc.usgs.gov/Environmental_Contaminants/Contaminant_Current_ Projects]. Florida Caribbean Science Center, Gainesville.

PROJECT: Fishery (LA-4-107-D)

PROGRESS

The results from year 3 efforts continue to demonstrate endocrine disruption in wildlife (fish and alligators) for lakes from central Florida. These endocrine-disrupting effects are observed in association with and strongly correlated to increased concentrations of chlorinated hydrocarbon environmental contaminants. Although, our experimental efforts with DDE clearly indicate endocrine-disrupting effects in largemouth bass and alligators, they do not support our previous hypothesis of a causative relationship between DDE and altered egg hatchability in alligators. However, our year 3 results do indicate a significant relationship between DDE exposure and alligator neonatal mortality as well as altered neonatal immune function. Our efforts also suggest the utility of gonadal culture techniques as testing and screening methods for the effects of chlorinated hydrocarbons on gonadal steroidogenesis. Overall, these experimental efforts indicate contaminant induced endocrine disruption in wildlife and several effective biomarkers (i.e., estradiol, testosterone, 11-ketotestosterone, virellogenin, etc.) with which to study these effects. These methods should enable continued evaluation of wildlife populations, most critically evaluations of wildlife populations in contaminated sites currently undergoing reclamation. The ongoing examination of wildlife within these reclaimed muck farm sites demonstrates the utility of our biomarkers as a valid monitor of reclamation success and wildlife reproductive/endocrine health.

Gross, T.S., M. Sepulveda, S.D. Ruessler, J.N. Wiebe, and C.M. Wieser. 2002. Microcosm and mesocosms evaluation of the bioaccumulation of chlorinated pesticides in the North Shore Restoration Areas. SIS#4944. Progress report accessed on 3/4/02.

Available at

[http://www.fcsc.usgs.gov/Environmental_Contaminants/Contaminant_Current _Projects]. Florida Caribbean Science Center, Gainesville.

PROJECT: Fishery (LA-4-107-D)

PROJECT DESCRIPTION

During the fall of 1998 and winter of 1999, a significant bird mortality event occurred on the former agricultural property on the north shore of Lake Apopka, an area now known as the North Shore Restoration Area (NSRA). Although the cause of this event still is unclear, the USFWS has linked this mortality to organochlorine pesticide (OC) toxicosis. However, two risk assessments have failed to indicate a risk for acute mortality from OC concentrations in soil/sediments or in fish. Extensive evaluations of pesticides in the NSRA preceded and followed the bird mortality event. However, uncertainty remains concerning the causes of the mortality and concerning risks from OC pesticide residues in organic soils, and this uncertainty has limited the ability of the St. Johns River Water Management District and the NRCS to proceed with the restoration of the NSRA. A primary uncertainty for evaluating risk from OC pesticide residues is the rate of bioaccumulation of OCs from soils/sediments through the food chain to fish and then to birds. The OCs of potential concern in the NSRA are toxaphene, DDT and its metabolites DDE and DDD, and based on some bird tissue levels, dieldrin. In addition, the NSRA soils contain a high level of organic matter, which enable a high OC burden. Areas with similar high organic matter contents have not been studied, nor has environmental fate modeling for OCs been evaluated in these or similar high organic conditions. It is, therefore, unclear whether the magnitude of bioaccumulation reported for other extensively studied areas can be directly and validly applied to the NSRA. In addition, toxaphene has little or no bioaccumulation data in the literature. Therefore, three phases of study are necessary initial components of restoration efforts for the NSRA: (1) laboratory microcosms, (2) field-scale mesocosms, and (3) bird feeding studies. Previous ecological risk assessments have utilized the biota-sediment accumulation factor (BSAF) to estimate the bioaccumulation of OCs from sediments into the food chain, including fish and ultimately birds. Indeed, macroinvertebrates, amphibians, and fish serve as important and critical links in the transfer of sediment-associated chemicals to higher trophic levels, such as birds. The BSAF is a relatively simplistic environmental fate model that characterizes the bioaccumulation of lipophilic OCs as a function of organic carbon in sediments and/or as a percent of lipid in aquatic organisms. However, little data currently exist for the primary OCs and at the high organic levels found in the NSRA. The proposed microcosm studies will enable the assessment/determination of BSAFs for OCs from

soil/sediment in the NSRA. In addition to base funds, funding is also provided by the St. Johns River Water Management District.

Gross, T.S., and M. Sepulveda. 2002. Chlorinated hydrocarbons and developmental toxicity in wildlife. SIS#4292. Progress report accessed on 3/4/02. Available at [http://www.fcsc.usgs.gov/Environmental_Contaminants/Contaminant_Current_Projects]. Florida Caribbean Science Center, Gainesville.

PROJECT: Fishery (LA-4-107-D)

PROJECT DESCRIPTION

From human activity during recent decades, the environment has been contaminated with a variety of xenobiotic compounds. Indeed, contaminants have been found even in areas remote from direct industrial and other cultural influences. Though we know that these xenobiotics modify genetic, biochemical and physiological processes, the mechanisms by which they harm wildlife and humans is poorly understood. To fully understand how pollution by xenobiotic agents affects organisms, we must elucidate their mechanisms fro genes to ecosystems. The ubiquitous distribution of these contaminants and their multi-generational effects on reproductive, endocrine, and developmental systems demand that additional studies be performed. These studies should identify important animal indicators (sentinels) of contaminant exposure, as well as elucidate possible important markers, biomarkers, of modified function that could be used to develop diagnostic procedures. This project focuses on providing biochemical data needed to elucidate specific factors (e.g. hormones and proteins) as bioindicators of contaminant-induced modifications of biological function in wildlife. The broad program project goal is to identify sensitive toxic endpoints and sensitive populations for chlorinated hydrocarbon toxicity. As a portion of this program, this project will seek to evaluate the endocrine-disrupting effects of chlorinated hydrocarbon contamination on wildlife species within a central Florida lake, Apopka, with an associated EPA SuperFund site. This particular project will examine alligators and fish for endocrine-disruption, alterations of sexual development and the identification of biomarkers for contaminant exposure. Portions of this project will also be integrated with other projects that examine immuno-toxic effects, stress proteins and an evaluation of potentials for human health effects. This project, overall, will contribute to our ability to assess the environmental impact of chlorinated hydrocarbons on wildlife.

Gross, T.S., and J. Wiebe. 2002. Immuno-toxicity and endocrine disruption in Lake Apopka alligator neonates. SIS#2002. Progress report accessed on 3/4/02. Available at [http://www.fcsc.usgs.gov/Environmental_Contaminants/Contaminant_Current _Projects]. Florida Caribbean Science Center, Gainesville.

PROJECT: Fishery (LA-4-107-D)

PROGRESS

In studies now in progress concerning effects of endocrine disrupters on reproduction in alligators in Florida lakes, we observed that hatchlings from some clutches collected from Lake Apopka were weak, in some cases to the point of being unable to extricate themselves from their eggshells without assistance, and that many such hatchlings appeared to be anemic. We recently examined bone marrow, thymus, and spleen from such hatchlings, and compared their tissues to those of hatchlings from clutches collected from Lake Woodruff. We found that the bone marrow of Lake Apopka hatchlings was hypoplastic compared with that of the Lake Woodruff hatchlings, thereby probably accounting for the observed anemia. The spleens and thymuses of the Apopka hatchlings also appeared to be hypocellular, although not so profoundly as the bone marrow. From these observations it seemed likely that Lake Apopka alligators might have defects in immunity. To test this hypothesis, we conducted a preliminary experiment in which 6-month-old alligators hatched from eggs from Lake Apopka and from eggs from Lake Woodruff were immunized by injection of sheep red blood. Blood samples were collected for determination of antibody titers to SRBC. Mean titers for Lake Apopka alligators were significantly lower than those for the Lake Woodruff alligators. We interpret these results to strongly suggest that young Lake Apopka alligators suffer from defective T cell dependent humoral immunity, probably as a result of abnormal development and contaminant exposure.

Gross, T.S., R. Roberts, J.M. de Oca, and H.F. Percival. In preparation. Sex reversal in freshwater turtles as a response to estrogenic environmental contaminants. University of Florida, Gainesville.

PROJECT: Fishery (LA-4-107-D)

Abstract

Previous efforts have demonstrated alterations in reproductive development and endocrine function for neonatal alligators (Alligator mississippiensis; 7, 8, 9) and turtles (Chrysemys nelsoni; 7, Gross et al., in preparation) from a contaminated lake in Florida. These data demonstrate demasculinization of neonates and suggest estrogenic-pesticide contamination as a contributing factor. The current study examined effects of several potentially estrogenic-environmental contaminants on reproductive development in a species of freshwater turtle, Chrysemys nelsoni. Eggs were incubated at 26°C and divided into several treatment groups: control (n=30), oil/ethanol (n=30), DDE, DDT, dicofol, atrazine, dieldrin, toxaphene or estradiol (1, 10, and 100 μ g/egg; n=25 for each treatment type and dose). Only 83% of the control eggs hatched, whereas treated eggs exhibited an overall 62% hatchability. Allantoic fluids and gonads were collected at hatching and analyzed respectively for estradiol and testosterone, and histological sex identification. Allantoic estradiol concentrations increased in response to estradiol (regardless of hatchling sex) and toxaphene (for male hatchlings) but with little or no increase for other treatments. Allantoic testosterone concentrations were reduced following DDE, dicofol, DDT, atrazine, and dieldrin treatments, whereas toxaphene and estradiol treatments did not alter testosterone regardless of hatchling sex. Most important, treatments significantly altered the sex of resulting offspring (percent male): controls=90%, estradiol=13%, DDE=46%, DDT=76%, dicofol=83%, atrazine=73%, and toxaphene=63%. These results indicate that treatment of turtle eggs with estradiol or various endocrine-disrupting contaminants results in significantly altered gonadal endocrine function as well as sex reversal.

Guillette, L.J., Jr. 1995. Endocrine disrupting environmental contaminants and developmental abnormalities in embryos. *Human and Ecological Risk Assessment* 1(2):25–36.

PROJECT: Fishery (LA-4-107-D)

CONCLUSIONS

Finally, how should the wildlife data be viewed? As stated above, these studies do not show cause and effect—they cannot, as there are no control populations! However, excellent data are available from laboratory studies which support the interpretation that the abnormalities recorded in many wildlife populations can be related to endocrine disruption during embryonic development. Our understanding of these problems in free-ranging wildlife populations is thus going to be based on a weight of

evidence-ecoepidemiological-approach (Fox 1991). Like the intense 'smoking and lung cancer' debate of the last two decades, some critics today tell us there is no cause and effect relationship between wildlife health problems and environmental pollution. True, we can not prove a relationship between any pesticide and specific problems in free living wildlife or for that matter, human populations. It took an epidemic of lung cancer to provide the stimulus for the scientific community to obtain the weight of evidence needed to show that a relationship does exist between smoking and lung disease as well as to begin the change in societal perceptions and public health responses to tobacco use. Likewise, we will never have causal data on the relationship between most pesticides and specific health effects in humans—except on a serendipitous or an accidental basis—for it would be immoral and unethical to obtain such information through controlled experiments on humans.

It is clear that over the last two decades a number of reproductive abnormalities have increased dramatically, almost to epidemic proportions. These include rises in breast and gonadal cancers, infertility, and birth defects of the reproductive tract. The explanation for these increases is still forthcoming but recent hypotheses suggest that these increases can be understood if they are considered as occurring during embryonic development. Rodent studies are showing us that these hypotheses are clearly valid. Do wildlife provide us with lessons for our own public health? Yes, and we should begin to look and listen more attentively. As similar problems of embryonic origin are recorded in wildlife and human populations, it suggests we look to the environment for the causal agents and it is important we test, with creativity and objectivity, all plausible hypotheses.

Guillette, L.J., Jr., J.W. Brock, A.A. Rooney, and A.R. Woodward. 1999. Serum concentrations of various environmental contaminants and their relationship to sex steroid concentrations and phallus size in juvenile American alligators. *Arch. Environ. Contam. Toxicol.* 36:447–455.

PROJECT: Fishery (LA-4-107-D)

ABSTRACT

Recent studies have reported a number of abnormalities in the hatchling and juvenile alligators of Lake Apopka, Fla. (USA). These abnormalities include modifications of plasma concentrations of sex steroids in males and females as well as abnormalities in gonadal morphology, gonadal enzyme activity, and steroidogenesis. Embryonic exposure to environmental contaminants in the eggs has been hypothesized to be the causal agent for these changes. However, posthatchling exposure can also contribute to changes in reproductive and endocrine functioning. We have detected serum concentrations of 16 to 18 organochlorine pesticides or metabolites (OCs) and 23 of 28 congener-specific polychlorinated (PCBs) examined in juvenile alligators from Lake Apopka, Orange Lake, and Lake Woodruff National Wildlife Refuge. Lake Apopka juveniles had significantly elevated serum concentrations of p,p'-DDE, dieldrin, endrin, mirex, oxychlordane, Σ DDTs, and Σ PCBs compared to juveniles from the other lakes. Further, we observed no correlations between serum contaminant concentrations and sex steroid concentrations (estradiol-17beta and testosterone). However, serum testosterone was significantly lower in males from Lake Apopka and Orange Lake compared to Lake Woodruff NWR. We did not observe relationships between phallus size or other body parameters and serum contaminant levels. Phallus size was smaller in males from Lake Apopka even after adjustment for body size. We suggest that the observations previously reported for juvenile alligators—and observed again in this study—are apparently not associated with the current serum levels of the environmental contaminants we measure, but could be due to exposures during embryonic development to these or other pollutants. Future studies must determine if a causal relationship exists between the contaminants found in alligator eggs and abnormalities observed in the hatchlings and persisting in juveniles.

Guillette, L.J., Jr., and D.A. Crain. 1996. Endocrine-disrupting contaminants and reproductive abnormalities in reptiles. *Comments Toxicology* 5(4–5):381–399.

PROJECT: Fishery (LA-4-107-D)

ABSTRACT

Recent studies show that environmental contamination of reptiles is associated with population declines due to lethal and reproductive effects of the contaminants in embryos, juveniles, or adults, developmental abnormalities of embryos, including major teratogenic effects in turtles and more subtle effects on the development of the reproductive system of alligators, and abnormalities of the endocrine system. We examine the data available on abnormalities of the reproductive system in reptiles induced by endocrine-disrupting xenobiotics. We discuss the role of these xenobiotics in light of experimental evidence showing that estrogenic steroids are capable of stimulating sex reversal—male to female—in developing reptilian embryos exhibiting environmental sex determination. A hypothesis is presented suggesting that any compound that disrupts the normal steroid milieu of the developing embryo will have significant, life-long consequences on sex determination and the organization and

function of the reproductive system. These endocrine-disrupting compounds may directly influence embryonic development by altering the steroid dynamics that facilitate sex determination.

Guillette, L.J., Jr., D.A. Crain, A.A. Rooney, and D.B. Pickford. 1995. Organization versus activation: The role of endocrine-disrupting contaminants during embryonic development in wildlife. *Environ. Health Perspect.* 103(7):157–164.

PROJECT: Fishery (LA-4-107-D)

ABSTRACT

Many environmental contaminants disrupt the vertebrate endocrine system. Although they may be no more sensitive to endocrine-disrupting contaminants (EDCs) than other vertebrates, reptiles are good sentinels of exposure to EDCs due to the lability in their sex determination. This is exemplified by a study of alligators at Lake Apopka, Florida, showing that EDCs have altered the balance of reproductive hormones resulting in reproductive dysfunction. Such alterations may be activationally or organizationally induced. Much research emphasizes the former, but a complete understanding of the influence of EDCs in nature can be generated only after consideration of both activational and organizational alterations. The organizational model suggests that a small quantity of an EDC, administered during a specific period of embryonic development, can permanently modify the organization of the reproductive, immune, and nervous systems. Additionally, this model helps explain evolutionary adaptations to naturally occurring estrogenic compounds, such as phytoestrogens.

Guillette, L.J., Jr., T.S. Gross, D.A. Gross, A.A. Rooney, and H.F. Percival. 1995. Gonadal steroidogenesis in vitro from juvenile alligators obtained from contaminated or control lakes. *Environ. Health Perspect.* 103(4):31–36.

PROJECT: Fishery (LA-4-107-D)

ABSTRACT

The ubiquitous distribution of many contaminants and the nonlethal, multigenerational effects of such contaminants on reproductive, endocrine, and immune systems have led to concerns that wildlife worldwide are affected. Although the causal agents and effects are known for some species, the underlying physiological mechanisms associated with

contaminant-induced reproductive modifications are still poorly understood and require extensive research. We describe a study examining the steroidogenic activity of gonads removed from juvenile alligators (*Alligator mississippiensis*) obtained from contaminated or control lakes in central Florida. Synthesis of estradiol-17 β (E₂) was significantly different when ovaries from the contaminated and control lakes were compared *in vitro*. Additionally, testes from males obtained from the contaminated lake, Lake Apopka, synthesized significantly higher concentrations of E₂ when compared to testes obtained from control males. In contrast, testosterone (T) syntheses from all testes examined in this study displayed a normal pattern and produced concentrations greater than that observed from ovaries obtained from either lake. Interestingly, the pattern of gonadal steroidogenesis differs from previously reported plasma concentrations of these hormones obtained from the same individuals. We suggest that the differences between the *in vivo* and *in vitro* patterns are due to modifications in the hepatic degradation of plasma sex steroid hormones.

Guillette, L.J., Jr., T.S. Gross, G.R. Masson, J.M. Matter, H.F. Percival, and A.R. Woodward. 1994. Development abnormalities of the gonad and abnormal sex hormone concentrations in juvenile alligators from contaminated and control lakes in Florida. *Environ. Health Perspect.* 102:680–688.

PROJECT: Fishery (LA-4-107-D)

ABSTRACT

The reproductive development of alligators from a contaminated and a control lake in central Florida was examined. Lake Apopka is adjacent to an EPA Superfund site, listed due to an extensive spill of dicofol and DDT or its metabolites. These compounds can act as estrogens. Contaminants in the lake also have been derived from extensive agricultural activities around the lake that continue today and a sewage treatment facility associated with the city of Winter Garden, Florida. We examined the hypothesis that an estrogenic contaminant has caused the current failure in recruitment of alligators on Lake Apopka. Supporting data include the following: at 6 months of age, female alligators from Lake Apopka had plasma estradiol-17 β concentrations almost two times greater than normal females from the control lake, Lake Woodruff. The Apopka females exhibited abnormal ovarian morphology with large numbers of polyovular follicles and polynuclear oocytes. Male juvenile alligators had significantly depressed plasma testosterone concentrations comparable to levels observed in normal Lake Woodruff females but more than three times lower than normal Lake Woodruff males. Additionally, males from Lake Apopka had poorly organized testes and

abnormally small phalli. The differences between lakes and sexes in plasma hormone concentrations of juvenile alligators remain even after stimulation with luteinizing hormone. Our data suggest that the gonads of juveniles from Lake Apopka have been permanently modified *in ovo*, so that normal steroidogenesis is not possible, and thus normal sexual maturation is unlikely.

Guillette, L.J., Jr., D.B. Pickford, D.A. Crain, A.A. Rooney, and H.F. Percival. 1995. Reduction in penis size and plasma testosterone concentrations in juvenile alligators living in a contaminated environment. *Gen. Comp. Endocrinol.* 101:32–42.

PROJECT: Fishery (LA-4-107-D)

ABSTRACT

The development of the male reproductive ducts and external genitalia in vertebrates is dependent on elevated androgen concentrations during embryonic development and the period of postnatal growth. We have observed that a population of juvenile alligators living on Lake Apopka exhibit significantly smaller penis size (24% average decrease) and lower plasma concentrations of testosterone (70% lower concentrations) when compared to animals of similar size on Lake Woodruff. In addition to smaller phalli, no relationship exists between plasma testosterone concentrations and penile size in males form Lake Apopka, whereas a positive relationship exists for males form Lake Woodruff. The alligators on Lake Apopka are known to have elevated concentrations of the antiandrogenic DDT breakdown product p,p'-DDE stored in their fat. We suggest a number of hypotheses that could explain the modification in the phenotype of the juvenile male living in Lake Apopka. These modifications in phenotype include a smaller penis size, lower plasma androgens present.

Hackett, W.C., and O.C. Thompson. 1991. *Biofermentation pilot study for water hyacinth and gizzard shad composting*. Special Publication SJ91-SP13. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Rough Fish Harvesting (LA-3-302-M)

EXECUTIVE SUMMARY

A pilot study using biofermentation technology developed by Agron Corporation (South Charleston, Ohio) for composting gizzard shad and water hyacinths was conducted by Agron Corporation for the St. Johns River Water Management District. The purpose of this study was to determine if gizzard shad and water hyacinths can be composted into a product that has market value. Water hyacinths and gizzard shad are potentially harvested in large quantities from lake restoration, aquatic macrophyte management, and fisheries management programs. The subsequent transformation of this raw biomass into a marketable product could function as a partial or full subsidy for these restoration and management programs.

Biofermentation is a process which utilizes naturally occurring aerobic bacteria to biologically alter the characteristics of organic waste. In this pilot study, different mixtures of water hyacinths, gizzard shad, poultry and cattle manure, and scallop offal were biofermented. It was found that water hyacinths alone do not ferment well. Biofermentation was greatly improved when gizzard shad, poultry or cattle manure, or scallop offal were used in conjunction with water hyacinths. In order to reduce the high moisture content of water hyacinths, some dehydration and mixing of the plant biomass with a high carbon material such as sawdust or newspaper was necessary.

The 1:1 ratio of water hyacinths to gizzard shad biomass used in one of the biofermentation trials resulted in odor, fly, and maggot problems during all three stages of the biofermentation process. Consequently, future biofermentation trials using gizzard shad will have to reduce the relative proportion of gizzard shad to help reduce the chances for odor, fly, and maggot problems. None of these problems were observed in any of the other trials in this study; gizzard shad were used in only one trial, however.

Recommendations made by Agron Corporation for future studies of water hyacinth and gizzard shad composting are incorporated into two additional study phases. Phase II would examine the effectiveness of the water hyacinth and gizzard shad Fermway (the biofermentation end-product) as a fertilizer on test plots of vegetables at nearby Lake Apopka muck farms.

Should large-scale gizzard shad and water hyacinth harvesting programs be initiated in the restoration of Lake Apopka, a Phase III project could incorporate a full-scale biofermentation center which could utilize harvested water hyacinths and gizzard shad from the lake restoration efforts. A biofermentation center as outlined in Phase III could produce about 8,700 tons of Fermway per year.

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Havens, K.E., H.J. Carrick, E.F. Lowe, and M.F. Coveney. 1999. Contrasting relationships between nutrients, chlorophyll *a*, and Secchi transparency in two shallow subtropical lakes: Lakes Okeechobee and Apopka (Florida, USA). *Lake Reserv. Manage*. 15(4)298–309.

PROJECT: Restoration Monitoring (LA-6-803-S)

ABSTRACT

Ten years of monthly water quality data were compared from two large shallow lakes in Florida, USA—Lakes Okeechobee and Apopka. Seasonal changes in trophic state index (TSI) values and log-log regression models relating total phosphorus (TP), total nitrogen (TN), chlorophyll a (CHLA), and Secchi transparency (SD) were considered. The objective was to quantify the extent to which empirical models might vary due to the heterogeneous nature of benthic-pelagic coupling that can occur in shallow lakes. In the offshore region of Lake Okeechobee, TP and SD-based TSI values increase dramatically during winter, while CHLA-based TSI declines. These changes coincide with the windy season in south Florida, when average wind velocities can exceed 20 km h super (-1). Resuspension of bottom sediments occurs and this reduces light penetration to the extent that the growth of phytoplankton is inhibited. During summer, winds are calm, and these conditions occur less often. Log-log regression models of CHLA vs. TP have a negative slope during winter and a positive slope during summer in offshore Lake Okeechobee. The slope of SD vs. CHLA models displays the opposite seasonal pattern. Seasonal changes are considerably muted in the near-shore region, where sediments are more consolidated and where shallower depths reduce the severity of light suppression of phytoplankton growth. The magnitude of seasonal variation in TSI values in Lake Apopka is muted, perhaps because seasonal variation in wind velocity is less than in the region of Lake Okeechobee. Hypereutrophic levels of nutrients, CHLA, and SD occur year-round. The log-log regression models of CHLA vs. TP and CHLA vs. TN are highly significant, and light availability does not appear to limit rates of algal production. Frequent resuspension events may occur, but negative effects on phytoplankton may be mitigated by (1) shallower depth; (2) a greater presence of viable algae in the surface sediments that might "seed" the water column with phytoplankton; (3) high concentrations of soluble nutrients in sediments that might stimulate algal growth; and (4) lower concentration of light-attenuating inorganic particles than in Lake Okeechobee. The results indicate that a high degree of variability in both the seasonal patterns and relationships among nutrients, CHLA, and transparency can occur in shallow subtropical lakes, even when they share common features (e.g., geographic location, large size, wind patterns). This finding has practical implications regarding the use of regression models in the context of shallow lake

management. Models may be quite useful on a lake-by-lake basis (e.g., in Lake Apopka they have successfully been used in eutrophication management), but considerable care should be taken when generalizing models to other lake ecosystems.

Heaney, J.P., T.D. Feather, and M. Shafer. 1989. Development of a socio-economic assessment methodology with applications to the Lake Apopka Basin. Special Publication SJ89-SP5. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Socioeconomic Assessment and Methodology (LA-2-209-F)

SUMMARY

The purposes of this study were to develop an evaluation procedure and associated software for performing a socioeconomic assessment on a water project and to apply this methodology to the Lake Apopka Basin in central Florida.

The socioeconomic analysis provides decision makers with valuable information on the benefits and disbenefits of each of the alternatives under consideration. A wide variety of techniques have been developed over the years to do these evaluations ranging from simple benefit-cost analyses to complex multi-objective optimization models. The federal government has sponsored development of standardized procedures for doing these analyses. The most recent summary of these methods is contained in the Principles and Guidelines (1983). These guidelines cover the following areas of water resources: municipal and industrial water supply; agricultural floods, erosion, sedimentation, irrigation, and drainage; and urban floods, hydropower, navigation, recreation, and commercial fishing. Conspicuously absent from this list is environmental quality which is not covered in the National Economic Development portion of the federal guidelines. Environmental quality is treated as a separate objective which is not quantified in monetary terms. Thus, additional effort was expended in incorporating this important purpose.

The literature review of analysis techniques covered conventional benefit-cost analysis, multi-objective analysis, risk analysis, social choice modeling, expert systems, decision support systems, and environmental impact analyses. For the application to Lake Apopka, emphasis was given to two general categories of benefits: (1) agricultural irrigation, drainage, and flood damages, and (2) environmental quality, recreation, and property values.
The performance of a system can be described by its reliability, resiliency, and vulnerability. In order to analyze the full suite of benefits and disbenefits, it is essential to do a continuous simulation of how the system performs on a day-to-day basis. Also, it is essential to define threshold values outside (e.g., above or below) of which the system has "failed" and an "event" has occurred. The spreadsheet model presented in Chapter 3 allows these events of interest to be extracted from the database and input to the benefit estimation model(s).

Flood and drought damages to agricultural areas can be estimated using a spreadsheet model called ADAM (Agricultural Damage Assessment Model) that does a detailed continuous month to month tracking of farm operations. Flood and/or drought events interrupt the planned activity and the farmer adjusts as best he can to reduce his losses. The model application to the muck farm areas north of Lake Apopka was presented in Chapter 4.

The benefits of environmental quality enhancement include improved health, productivity, and recreation/aesthetics. Techniques exist for measuring the direct recreation benefits. Recently, techniques have also been developed to estimate the so-called non-user benefits. We prefer to use the name environmental quality (EQ) benefits, i.e., benefits that accrue to the general public from an improvement in environmental quality. These EQ benefits are the sum of:

- Option value—value placed on having the option of using an environmental resource
- Existence value—benefit of knowing an environmental resource exists
- Bequest value—value of preserving a resource for future generations

These EQ benefits have been shown to represent a significant part of total benefits because a strong general concern exists for protecting the environment, and a willingness to pay for such programs in order to protect not only nearby water supply or recreational facilities but also to support programs far removed from their locale, e.g., the Amazon. One reason that these EQ benefits are significant is the large number of people who derive these benefits. While survey techniques have been used to estimate EQ benefits, a more direct measure is available in Florida thanks to recent environmental restoration programs that have committed large funds to support these activities. Such commitments represent a direct measure of voluntary willingness to pay to clean up and/or protect vital areas such as Lake Apopka, Lake Okeechobee, the Indian River, Tampa Bay, and the Everglades.

Procedures for evaluating recreation benefits using the unit day value method, the travel cost method, and the contingent value method are described in the literature. The results of these studies were summarized for various use categories.

The socioeconomic methodology was used to estimate the benefits and disbenefits associated with the past and projected activities associated with Lake Apopka. This lake has been impacted by man's activities for more than a century. The initial impacts on the lake were the result of a navigation canal, completed in 1893. This canal also lowered the lake level by four feet, leaving an estimated 20,000 acres of lake bottom dry enough for cultivation. However, it was not until the early 1940s when the Zellwood Drainage and Water Control District succeeded in developing a dike, canal, and pump system that provided adequate water management to bring this land under cultivation.

In its natural state and through the 1950', Lake Apopka was world renowned for its sport fishing. However, the fishing declined rapidly as the water quality of the lake continued to degrade due to continued back pumping of nutrient rich drainage waters from the muck farms into the lake. At present, the lake is one of the most polluted in the State of Florida and is the subject of major activities attempting to significantly improve its quality so that it can support a variety of recreational activities including fishing, boating, swimming, and passive recreation.

The area around Lake Apopka has experienced very rapid population growth during the past thirty years with the population of Lake and Orange counties increasing over five-fold from 151,000 in 1950 to 816,000. Land use trends in the area indicate that the Lake Apopka area will experience a transition from agricultural to urban activities.

The socioeconomic analysis is directed to estimating the benefits and disbenefits associated with man's past, present, and projected uses of Lake Apopka. Benefits accrue due to uses of the lake that result in an enhanced profitability of activities due to water management activities such as lowering the lake level and installing protective works to permit intense farming activity on the muck lands at the north end of the lake. Disbenefits accrue when man's activities degrade the quality of the lake's water and/or modify the lake levels in such a way that other beneficial uses such as recreation are impaired or precluded.

CONCLUSIONS

With regard to socioeconomic analysis techniques, a wide variety of methods have been developed in the past thirty years. The emphasis has been on normative optimization models that can prescribe the optimal solution. Unfortunately, it is necessary to greatly simplify the description of the actual problem to satisfy the rigid strictures of the

optimization models, e.g., linear functions, normal distributions, simple production functions. Thus, the results may not be a realistic appraisal of the actual situation. Because of this focus on modeling, databases have not been developed on benefits, costs, risk levels, etc., or how these impacts are distributed among the affected groups. Thus, our approach was to use standard benefit-cost analysis procedures with an emphasis on developing reliable databases for conditions that exist in the St. Johns River Water Management District and related areas.

It is essential to develop quantifiable measures of system performance, than to actually measure these quantities and see how well they perform against prespecified criteria such as keeping the lake stage above a pre-set elevation. Given such a system, it is possible to directly evaluate performance and suggest improved operating policies. However, in the absence of actual and not just estimated values, it is difficult to develop cogent control strategies.

A continuous simulation model is essential to evaluate the socioeconomic impacts of various water management strategies on farming activities and vice versa. The lake regulation schedules affect the rate at which water seeps into the muck farms. The farmers' activities affect the lake levels and its quality through their significant pumping activities during and following storm events. The farmer has a relatively wide variety of choices available including the selection and timing of crops, the design and operation of the water management system, and the method of response to high or low water stress conditions. Ideally, the simulation model could incorporate these decision rules into the analysis. This would require close cooperation with the farmers since they best know their operation.

For Lake Apopka, the public has committed about \$40 million to help restore this lake. Averaging this commitment over the 800,000 people living in Orange and Lake counties, we obtain a current cost of \$50/capita. Amortizing this expenditure over an infinite planning horizon at an interest rate of 10% yields an equivalent benefit or willingness to pay of \$5.00/capita/year. Equivalently, the damages to these people from the present state of Lake Apopka are at least \$5.00/capita/year.

The primary gap in recreation benefit assessments is lack of site-specific data. The methodology is straightforward.

The results of the application of the socioeconomic procedures to Lake Apopka were summarized in Figures 6-19. The diking and pumping activities have allowed high valued agricultural activity to thrive in the muck farm area north of Lake Apopka. Based on a detailed modeling of monthly agricultural activities, the estimated present net revenue from the muck farm activities is \$6.4 million per year. This value is assumed to be constant (as measured in 1989 dollars) over the 60-year period from 1960 to 2020. This gain represents a private gain in that the farmers are able to capture all of these net revenues. Offsetting this gain are three categories of losses: decreased direct recreation values, lowered environmental quality to the general public, and decline in property values to the riparian owners. The losses in direct recreational value range from a low of \$1.14 million in 1960 to a high of \$4.6 million by the year 2020. The primary recreation value affected is boating activities. The largest loss is the loss in environmental quality suffered by the general public. The equivalent annual per capita loss is \$5.00 per capita per year. This loss ranges from \$0.8 million in 1960 to \$6.93 million by the year 2020. The reason that this loss increases so substantially is that the population in the year 2020 is expected to be nearly four times greater in 2020 than it was in 1960, an increase from 321,000 to 1,259,000. The last loss category is the loss in value of waterfront property along Lake Apopka. This loss is estimated to be a constant \$0.2 million per year based on a decrease in water front property value of \$100 per front foot.

The net effect of these gains and losses is that a positive net benefit accrued during the early years of muck farming. However, by the 1980s, the net value became negative, and it is projected to become increasingly negative in the future if restoration is not done. The projected annual loss by the year 2020 is \$4.73 million per year.

The citrus groves at the southern end of the lake have had a long-term concern regarding the effect of lowered lake levels on their freeze protection. While this technical question is not fully resolved, it is possible to estimate the economic consequences using crop insurance rates. The expected increase in crop insurance would be \$7,900 per year. This issue is expected to become less critical as the citrus lands shift to urban uses.

The flood and drought damages to the muck farms with the existing water control system were investigated. The results indicate that the current system provides a high level of protection to the farmers and so they have not suffered any substantial crop damages due to water problems.

A preliminary analysis of the impact of restrictions on muck farm backpumping indicate that the farmers would suffer losses but not in direct proportion to the reduction in available land since they only use all of the available land during a few months of the year, and they could reschedule their farming activities to minimize these impacts. Unfortunately, due to lack of data, it was not possible to do a detailed analysis of this alternative. Overall, the situation facing the Lake Apopka Basin is similar to problems throughout the country and around the world. In the United States, agricultural policies for many years have encouraged the development of wetland areas. During the period from the mid-1950s to the mid-1970s, 87% of the wetland losses in the United States were attributable to agricultural development. Florida is a leader in trying to reverse these trends by making major efforts to reverse this trend and to restore these systems.

Johnson, W.E., and J.E. Crumpton. 1998. Lake Apopka fish population assessment. Final report for Contract #97W121 for St. Johns River Water Management District, Palatka, Fla. Florida Game and Fresh Water Fish Commission, Eustis, Fla.

PROJECT: Fishery (LA-4-107-D)

EXECUTIVE SUMMARY

The environmental degradation of Lake Apopka (12,400 ha) is well known. The impact of this degradation, in causing declines in the sport fishery of Lake Apopka, has also been documented. Principal point sources of nutrient loading to the lake were eliminated between 1977 and 1980, and agricultural discharges from farming operations have been reduced since 1992. The St. Johns River Water Management District, under the SWIM program, has begun experimental management efforts to correct the problems in Lake Apopka. The Florida Game and Fresh Water Fish Commission conducted assessments of the fish population between 1973 and 1984, and 1988–1993. These studies documented fish population trends and provided baseline data prior to the commencement of the fish population of Lake Apopka to provide the most current data.

The St. Johns River Water Management District provided funding to the Florida Game and Fresh Water Fish Commission to assess the fish population of Lake Apopka in 1997. Littoral fish populations were evaluated by 0.1 hectare blocknet samples (N = 16), and data were proportioned by major habitat types (open/brush shoreline, 44%; cattails (*Typha* spp.), 38%; bulrush (*Scirpus californicus*), 5%; and grasses (*Paspalum* sp. and *Panicum* spp.), 3%). Littoral sport fish species were also evaluated by bimonthly electrofishing samples (N = 30 per sample month). Fall trawl samples were taken (N = 50) to assess limnetic black crappie (*Pomoxis nigromaculatus*) and catfish populations, and experimental gill nets (N = 30) were fished January, March, and May 1977 to evaluate limnetic gizzard shad (*Dorasoma cepedianum*) populations. Blocknet samples taken in the littoral zone of Lake Apopka in 1997 resulted in a mean fish biomass of 113.6 kg/ha (data were proportioned by habitat type). Six species (of 24 collected) composed 78% of the fish biomass: bluegill (*Lepomis macrochirus*) (27.2%), black crappie (22.4%), redear sunfish (*Lepomis microlophus*) (8.9%), warmouth (*Lepomis gulosus*) (7.3%), Florida gar (*Lepisosteus platyrhincus*) (5.7%) and blue tilapia (*Tilapia aurea*) (5.5%). The proportioned mean biomass of the 1989–1991 sample period was 226.7 kg/ha. A decrease in blue tilapia mean biomass from 61.3 kg/ha (27%) in 1989–1991 to 6.2 kg/ha in 1997 contributed the largest proportion of the change. The mean biomass of dominant sport fish collected in 1997 was 37% less for black crappie (25.4 kg/ha) when compared to 1989–1991 (40.2 kg/ha), while no difference was found for bluegill and redear sunfish.

Small bluegill and threadfin shad dominated fish numbers in the littoral samples. Numbers of harvestable-size sport fish in littoral samples were dominated by black crappie (53/ha \ge 24 cm total length (TL)), bluegill (52/ha \ge 16 cm TL) and redear sunfish (20/ha \ge 16 cm TL). Numbers of these harvestable-size species were at least 49% lower when compared to values from 1989–1991 for black crappie (121/ha), bluegill (104/ha) and redear sunfish (56/ha). The number of bluegill and redear sunfish less than 16 cm TL was greater in 1997.

Largemouth bass (*Micropterus salmoides*) composed 16.5 kg/ha (7.3%) of the proportioned mean littoral biomass in 1989–1991 blocknet samples and 6.2 kg/ha (5.4%) in 1997 samples, a 62% reduction. Mean numbers of largemouth bass, proportioned by habitat type, in 1997 were: 12/ha for total bass, 2/ha for young-of-the-year bass, 9/ha for bass \geq 26 cm TL and 1/ha for bass \geq 36 cm TL. These values were lower compared to 1989–1991 data of 20/ha for total largemouth bass, 6/ha for young-of-the-year bass, 15/ha for bass \geq 26 cm TL and 9/ha for bass \geq 36 cm TL. The average electrofishing catch rate for largemouth bass \geq 24 cm TL in 1997 (0.2/5 min) was also substantially lower compared to annual values from 1989–1992 (range = 0.4–0.5/5 min).

Large differences were noted when littoral blocknet data were compared by habitat type. Total fish biomass in 1997 averaged 65.6 kg/ha in sites devoid of all vegetation, 132.3 kg/ha in cattails, 327.2 kg/ha in bulrush, and 676.8 kg/ha in grass sites. Biomass of sport fish followed a similar trend among habitats. Black crappie ranged from an average biomass of 14.9 kg/ha in open areas to 202.5 kg/ha in grass sites; largemouth bass ranged from 1.0 kg/ha in open areas to 56.0 kg/ha in grass sites; bluegill ranged from 15.6 kg/ha in open areas to 224.6 kg/ha in grass sites; and redear sunfish ranged from 6.8 kg/ha in open areas to 27.5 kg/ha in grass sites. An increasing trend of average biomass for all four principle sport fish species in grass sites occurred from the

1973–1976 and 1989–1991 periods to 1997 (only grass bulrush sites were sampled by blocknet in 1973–1976).

Trawl catches in the limnetic area of Lake Apopka were dominated by black crappie, white catfish (*Ameiurus catus*), bluegill, and brown bullhead catfish (*Ameiurus nebulosus*). Catch per trawl for total black crappie (14.5/trawl in 1997 was the lowest compared to samples taken 1992 (22.9/trawl) and 1993 (28.4 trawl), while the 1997 average value for black crappie \geq 24 cm TL (0.5/trawl) was intermediate among years. Low catch rates for total black crappie were attributed to a weak 1997 year class (crappie < 15 cm TL). White catfish catch increased from 1.9/trawl in 1992, to 6.4 trawl in 1993, to 12.0 trawl in 1997; surpassing values for brown bullhead catfish (7.7/trawl). Although 99% of the bluegill were less than 16 cm TL (modal TL = 10 cm), catch rates increased from 0.5/trawl in 1992, to 2.6/trawl in 1993, to 11.0/trawl in 1997.

Past blocknet samples demonstrated that gizzard shad dominated the fish biomass in the limnetic area of Lake Apopka., Experimental gill nets samples taken in 1997 produced catches of gizzard shad which composed 94% by number and 90% by weight of the total catch. The average catch rate of gizzard shad (25/hr) in 1997 was lower than any year sampled from 1989–1992 (modal rage = 31–38 cm TL). Low catch rates and reduced size of gizzard shad collected in experimental gill nets suggested a substantial impact has occurred on the population from commercial gizzard shad harvest in Lake Apopka.

When compared to blocknet samples taken from 1989–1991, average total biomass and numbers of harvestable-size sport fish were lower or unchanged in 1997 samples. All parameters used to measure the largemouth bass population were lower in 1997. Although bluegill and redear sunfish populations were dominated by small size classes (as in the past), total numbers were increased in samples taken in both littoral blocknets and limnetic areas. A weak year class of black crappie was produced in 1997, which contributed to lower average total numbers sampled by blocknet and trawl. The average number of black crappie ≥ 24 cm TL collected in trawl samples was similar to past data. Although rooted aquatic vegetation constitutes less than 1% of the surface area of Lake Apopka, data collected from blocknet samples indicated that expansion of this type of habitat is vital to the sport fish population and to the ultimate goal of restoring the sport fishery of Lake Apopka.

Kenney, W.F., C.L. Schelske, and A.D. Chapman. 2001. Changes in polyphosphate sedimentation: a response to excessive phosphorus enrichment in a hypereutrophic lake. *Can. J. Fish. Aquat. Sci.* 58(5):879–887.

PROJECT: Phytoplankton-Nutrient Interactions (LA-4-104-D)

ABSTRACT

Historic changes in lake phosphorus (P) loading are often determined in paleolimnological investigations by assessing stratigraphic changes in sediment total P. Polyphosphate (poly-P) in sediments may provide additional information on historic lake trophic status, because phytoplankton store surplus P intracellularly as poly-P when supplies exceed growth requirements. We hypothesize that phytoplankton (i.e., cyanobacteria and diatoms) with stored poly-P can remain intact and viable for many decades after sedimentation and that sedimented poly-P is not geochemically reactive. We tested our hypotheses with sediment cores from Lake Apopka, Fla., USA, where P loading has increased ~7-fold since the 1920s and phytoplankton biomass is nitrogen limited owing to excessive P enrichment. We show that sedimented poly-P is mobilized by sample drying (i.e., becomes water soluble, geochemically reactive, and bioavailable); that anthropogenic P enrichment is expressed in the sediment record as increasing concentrations of poly-P; and that, consequently, sedimentary poly-P is a sensitive indicator of historic excessive P enrichment. Sedimentary poly-P is not geochemcially reactive; thus, it represents biological attenuation that may partially ameliorate the effects of excessive P loading.

Locker, S.D., G.R. Brooks, and L.J. Doyle. 1988. *Results of a seismic reflection investigation and hydrogeologic implications for Lake Apopka, Florida*. Special Publication SJ88-SP5. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Seismic Reflection Profiling (LA-1-108-D)

CONCLUSIONS

Seismic reflection profiling in Lake Apopka provides insight to the nature of strata associated with the Floridan Aquifer, shallow solution features, and the character of near surface sediments. Interference from suspected gaseous sediments and intense reflections with multiples from a shallow horizon beneath lake sediments obscured much of the shallow portion of the seismic profiles. Additional field work involving sediment probing and coring is recommended to ground truth seismic interpretations and to provide a basis for more in-depth analyses of the seismic profiles. A sampling program, guided by the seismic reflection survey, would be fundamental to further assessment of stratigraphy and hydrogeology beneath Lake Apopka.

The principal findings are:

- 1. Two primary reflection horizons (A and B) were mapped and appear to correlate to the top of the Ocala Group limestone and top of a low porosity zone (dolomite zone) in the Avon Park Formation, respectively. These horizons are irregular and discontinuous, suggestive of paleokarst environments.
- 2. Major structural discontinuities, such as large sinkholes, were not found on the lines surveyed. The primary sequences below the lake appear to be relatively flat lying, but modified by solution processes. However, there is no evidence of active subsidence.
- 3. The structural contour map on horizon B indicates variations in the strata that closely correspond to the top of the Floridan aquifer.
- 4. Shallow near-surface depressions are found in all areas of the lake (13% of tracklines) except in the central-northeast quadrant. These appear to be inherited from underlying Miocene to Eocene age limestone sequences.
- 5. Lake sediments appear to contain various amounts of gas (probably biogenically derived) that probably causes a fuzzy wipe-out zone in areas of high concentrations.
- 6. From the seismic reflection data we cannot be unequivocal about the hydrologic conditions related to exchange of water with the Floridan aquifer. However, muddy sediments and an underlying lithified or compact surface suggests that little exchange between lake water and the deeper strata (aquifer) occurs.

A sediment probing and coring program is recommended to ground truth the seismic interpretations presented herein and to construct accurate stratigraphic sections for a more direct assessment of hydrogeology beneath Lake Apopka.

Lowe, E.F., L.E. Battoe, D.L. Stites, and M.F. Coveney. 1992. Particulate phosphorus removal via wetland filtration: an examination of potential for hypertrophic lake restoration. *Environmental Management* 16(1):67–74.

PROJECT: Marsh Flow-Way Restoration (LA-3-301-M)

ABSTRACT

Lake Apopka in Florida, USA, is a large (area = 124 km²), hypertrophic (mean total phosphorus = 0.220 g/m^3 ; mean chlorophyll $a = 60 \text{ mg/m}^3$) lake, with a large sedimentary store of available P (1635 X 10⁶ g P). Phosphorus loading from floodplain farms (132 X 10⁶ g P/yr) has been the primary cause of eutrophication. Assuming elimination of farm P loading, the Vollenweider model predicts a decline in equilibrium P concentration from 0.270 to 0.024 g/m³, if the P sedimentation coefficient (s) remains constant. It is likely, however, that the value for s will fall with the elimination of farm loading due to unabated internal P loading from the sediments. Under a worst-case scenario (s = 0), the model predicts that exportation of P from the lake via wetland filtration will greatly accelerate the lake's recovery. Recirculation of lake water through a 21-km², created wetland and elimination of farm P loading is projected to result in a negative P balance for the lake (-23 X 10^6 g P/yr) leading to depletion of P stores in the lake in about 60 years. The estimated cost of the project, \$20 million, is less than 3% of the estimated cost of dredging. A 3.65-km² demonstration project is under way to test and refine the wetland filtration technique. We believe the technique could be costeffective for other hypertrophic lakes.

Lowe, E.F., L.E. Battoe, M.F. Coveney, C.L. Schelske, K.E. Havens, E.R. Marzolf, and K.R. Reddy. 2001. The restoration of Lake Apopka in relation to alternative stable states: An alternative view to that of Bachmann et al. (1999). *Hydrobiologia* 448:11–18.

PROJECT: Restoration Monitoring (LA-6-803-S)

ABSTRACT

Bachmann et al. (1999) postulated that wind energy initiated, and has maintained, high turbidity in hypertrophic (mean chlorophyll $a = 92 \ \mu g \ l^{-1}$) Lake Apopka, Florida (mean depth =1.6 m; area = 12,500 ha). They asserted that the turbid condition was initiated by a hurricane in late 1947 that destroyed submersed plant beds and that high turbidity has since been maintained by wind-driven resuspension of fluid sediments. In their view, there has been sufficient light for re-establishment of submersed plants over about 38% of the lake bottom but plant growth has been precluded by the fluid character of the sediments. They concluded that the restoration program of the St. Johns River Water Management District, which includes reduction of the phosphorus (P) loading rate, will not restore water clarity or submersed vegetation.

An alternative explanation for Lake Apopka's turbid state is that it was initiated, and has been maintained, by excessive P loading that led to algal blooms and elimination of submersed vegetation through light limitation. The transition to the turbid state was contemporaneous with drainage of 7,300 ha of the floodplain wetland to create polders for farming, beginning in the early 1940s. Lake P budgets indicate that drainage of the farms caused a seven-fold increase in the P loading rate (0.08 g TP m⁻² y⁻¹ to 0.55 g TP m⁻² y⁻¹). Paleolimnological analysis of lake sediments also indicates an increase in the P loading rate in mid-century, concomitant with the decline in submersed vegetation and the increase in phytoplankton abundance. After the increase in P loading, wind disturbance may have accelerated the transition to the turbid state; but, before the increase in P loading, wind disturbance was insufficient to elicit the turbid state, as evidenced by the stability of the clear-water state in the face of 14 hurricanes and 41 tropical storms from 1881–1946.

Measurements of photosynthetically active radiation (PAR) indicate that light limitation has inhibited submersed plant growth except on the shallowest 5% of the lake bottom. Further, the correlation between the diffuse attenuation coefficient (K_{PAR}) and chlorophyll *a* (CHLA) indicates that light limitation would be removed over about 82% of the lake bottom with a reduction in CHLA from 92 µg l⁻¹ to 25 µg l⁻¹.

Recently, following a 40% reduction in the P loading rate, the mean total P (TP) concentration, mean CHLA, and total suspended solids fell by about 30% while mean Secchi depth increased by more than 20%. Submersed plant beds appeared in areas devoid of macrophytes for nearly 50 years. These improvements, during a period with no change in mean wind speeds measured at Lake Apopka, provide the strongest evidence that the turbid state has been maintained by excessive P loading and that the current restoration program, which combines P load reduction with planting and removal of planktivorous fish, will be effective.

Lowe, E.F., D.L. Stites, and L.E. Battoe. 1989. Potential role of marsh creation in restoration of hypertrophic lakes. In *Constructed wetlands for wastewater treatment: Municipal, industrial and agricultural*, D.A. Hammer, ed., 710–717. Proceedings from the First International Conference on Constructed Wetlands for Wastewater Treatment. Chelsea, Mich.: Lewis Publishers.

PROJECT: Marsh Flow-Way Restoration (LA-3-301-M)

INTRODUCTION

The use of wetlands to reduce concentrations of dissolved nitrogen (N) and phosphorus (P) in secondary sewage effluent is well documented. We propose a novel application: the use of wetlands for the restoration of hypertrophic lakes. In a typical sewage treatment wetland, water high in inorganic nutrients passes through the system once, and the management goal is to maximize the nutrient removal efficiency. In our application, water to be treated has high concentrations of nutrients associated with particles and dissolved organic molecules. Water is passed through the system many times rather than once. Goals of this approach are to maximize *power* (nutrient quantity removed per unit of time) and capacity (nutrient permanently stored) rather than efficiency (nutrient fraction removed in a single pass).

DISCUSSION

The efficiency assumed above (30%) is conservative. At least 50% of the P in Lake Apopka's water is associated with living algae; soluble reactive P accounts for another 1–20%. The balance is probably associated with suspended sediments. Thus, 80% or more of the P is particulate and would be filtered by the wetland. Natural wetlands can remove 60–90% of suspended solids in wastewaters; 30% removal is below the minimum expected efficiency (60% efficiency x 80% particulate P = 48% removal). In addition, some soluble P would be expected to be transformed and stored in soil and in plant biomass. South Florida wetlands receiving agricultural wastewater high in soluble reactive P (SRP = 58–67% of total P) removed a minimum of 26% of the P and averaged 55% removal.

Although treatment efficiency must be considered, the primary concern in the proposed system is the amount of nutrient that could be removed annually rather than removal efficiency. As P loading increases, P removal efficiency decreases asymptotically, but the power of nutrient removal increases (Figure 3). For example, at 0.85 m³/s, the areal loading rate would be 0.18 g/m²/yr, the removal efficiency would be about 90%, and the power of nutrient removal would be 5 metric tons. At 14.4 m³/s, the areal loading rate would be 3.1 g P/m²/yr and the removal efficiency would fall to 50%, but 50 metric tons would be removed (a 10-fold increase in power).

Maximum power would be attained at a relatively low efficiency. We believe, however, that the complete efficiency curve is sigmoidal (Figure 3). We expect rapidly declining efficiency at high hydraulic loading due to low retention time and high current velocity. Power would also drop precipitously at these levels.

Wetland creation could be appropriate for restoration of many other hypertrophic lakes. In any application, water must be moved against a hydraulic gradient; thus, economic constraints will always apply. The realized power of nutrient removal will most likely be determined by the cost of moving water. In large-scale applications, funding may limit power to a level well below the maximum. Lake Apopka should provide a useful example of the efficacy of wetland creation in hypertrophic lake restoration.

Lowe, E.F., L.E. Battoe, M. Coveney, D. Stites. 1999. Setting water quality goals for restoration of Lake Apopka: Inferring past conditions. *Lake Reserv. Manage.* 15(2):103–120.

PROJECT: Implementation of Restoration and Management Techniques (LA-6-802-S)

ABSTRACT

Lake Apopka is a large (12,500 ha), hypereutrophic lake in central Florida which is the subject of a state-sponsored restoration program. We used three quantitative methods in concert with an analysis of the history and general character of the lake and drainage basin to infer the past conditions. We specifically examined two past conditions: (1) pristine (before any major anthropogenic disturbance) and (2) antecedent (before a specific, major anthropogenic disturbance). For Lake Apopka the pristine condition ended in the 1890s when a canal was dug which lowered the elevation for surface water outflow. The antecedent condition ended in the late 1940s when most of the lake's 8,900 ha of floodplain marsh was drained for farming. History, general lake and basin characteristics, and the quantitative analysis indicate that Lake Apopka was mesotrophic; with clear-water and native, submersed macrophyte beds; in both the pristine and antecedent conditions. The three quantitative (reference lakes, empirical models, and a loading model) were used to infer the ranges of most probable values in the antecedent condition for total phosphorus, chlorophyll a and Secchi depth. These ranges were $32-51 \text{ mg/m}^3$ for total phosphorus, $8-38 \text{ mg/m}^3$ for chlorophyll *a*, and 1.39–0.76 m for Secchi depth. Lake Apopka has had a history strikingly similar to that described for Dutch lakes affected by cultural eutrophication with proliferation of macrophytes in the clearwater state preceding a rapid transition to the turbid, algaldominated state induced by a large increase in the phosphorus loading rate.

Newman, S., and K.R. Reddy. 1993. Alkaline phosphatase activity in the sediment-water column of a hypereutrophic lake. *J. Environ. Qual.* 22(4):832–838.

PROJECT: Internal Nutrient Budget (LA-1-102-D)

ABSTRACT

Inorganic P limitation in many aquatic systems may be overcome through the enzymatic hydrolysis of organic P compounds. The objective of our study was to determine the effect of dissolved oxygen (DO) of the water column and redox (Eh) status of the sediments on alkaline phosphatase activity (APA) in a shallow hypereutrophic lake, Lake Apopka, located in central Florida. Alkaline phosphatase activity was used as an index of potential organic P mineralization. Lake water incubated in the dark under aerobic and anaerobic conditions for 24 h. Under aerobic conditions, APA increased from 22 to 43 nM min⁻¹ within 24 h. Under anaerobic conditions, no significant change in APA was observed. Neither total soluble P nor soluble-reactive P exhibited significant responses to anoxic conditions in the water column. The increase in APA observed under aerobic conditions was attributed to increased plankton metabolic P demand following depletion of internal cell P. Sediments were incubated under six different Eh levels for 30 d. In combination with APA measurements, sediment organic P was fractionated into labile and nonlabile pools using selected inorganic chemical extractants. Phosphatase hydrolysis activity was positively related to pE + pH (r = -0.81), and humic acid P (r = -0.74). The results of this study suggest that short-term depletion of DO will not affect the enzymatic breakdown of organic P within the water column. Significant reduction in the alkaline phosphatase-dependent hydrolysis of sedimentary organic P will occur under anaerobic conditions; hence, P cycling in highly organic sediments may be severely inhibited.

Olila, O.G., and K.R. Reddy. 1995. Influence of pH on phosphorus retention in oxidized lake sediments. *Soil Sci. Soc. Am. J.* 59:946–959.

PROJECT: Internal Nutrient Budget (LA-1-102-D)

ABSTRACT

Diel pH changes in lake waters resulting from high photosynthetic activity may regulate water-soluble P concentration (WSP) and P sorption by suspended sediments in shallow eutrophic lakes. Laboratory studies were conducted to determine the pH effect on P fractions and P sorption kinetics in oxidized sediment suspensions from two subtropical lakes (Lake Apopka and Lake Okeechobee, Florida). The P sorption rate was calculated for sediment suspensions adjusted to various pH levels: 6.5, 7.0, 8.5, 9.5, and 10.5 for Lake Apopka and 6.5, 7.0, 8.5, 9.5, and 10.5 for Lake Okeechobee. A decrease in pH increased the WSP concentrations in Lake Apopka sediment suspensions but had no effect on WSP concentrations in Lake Okeechobee sediment suspensions. Lake Apopka sediment suspensions at pH 7.0 (ambient) and below did not show net P uptake. Phosphorus uptake for Lake Apopka occurred only when pH was increased to ± 8.5 and when P treatments were increased to ± 27 mmol P kg⁻¹, which resulted in supersaturation with respect to octacalcium phosphate. Phosphate solubility diagrams and mineral equilibria calculations suggest that P uptake by Lake Apopka sediment suspensions at pH ± 8.5 was due to P coprecipitation with CaCO₃ and probable formation of nonapatitic Ca-P compounds. Phosphorus sorption on Lake Okeechobee sediment suspensions followed first-order kinetics for all pH levels studied, with rate constants (*k*) ranging from 0.003 to 0.75 h⁻¹. High P uptake by Lake Okeechobee sediment suspensions could be attributed to two reactive components: (i) amorphous or poorly crystalline Fe and Al oxyhydroxides at pH <7.5, and (ii) Ca/Mg carbonates and other minerals at pH ± 7.5 .

Olila, O.G., K.R. Reddy, and D.L. Stites. 1996. Influence of drying on phosphorus forms and stability in the Lake Apopka Marsh. Final report submitted to St. Johns River Water Management District, Palatka, Fla.

PROJECT: Marsh Flow-Way Restoration (LA-3-301-M)

Our earlier studies showed that floc sediments in the Lake Apopka Marsh Demonstration Project are highly P reactive and have relatively high P retention capacities (Olila and Reddy 1995). However, we have limited information on the stability of P assimilated by these floc materials under various physico-chemical conditions, i.e., changes in water level, hydroperiod, redox potential, pH, and others. This study was conducted to evaluate the changes in P forms and distribution and measure P flux from the floc layer after sediment consolidation for different lengths of time. Increases in P flux during reflooding of a previously drawn down marsh is a significant issue in management, especially in constructed wetlands designed for P removal. In the case of Lake Apopka marsh flow-way, drawdown and sediment consolidation is an important part in building up the soil. Should sediment drying be a necessary practice in managing this marsh, there is a need to study the influence of drawdown and sediment consolidation on P release and stability. This research was conducted with the following objectives: (i) to evaluate the effects of drying periods on soluble reactive P and (ii) to determine the influence of drying and reflooding on P forms and distribution.

Results obtained from this study will provide information on the influence of drying time on P flux into water column. Additional information on feasible minerals or compounds which may control P solubility will be evaluated.

Olila, O.G., K.R. Reddy, and D.L. Stites. 1997. Influence of draining on soil phosphorus forms and distribution in a constructed wetland. *Ecological Engineering* 9:157–169.

PROJECT: Marsh Flow-Way Restoration (LA-3-301-M)

ABSTRACT

Seasonal water-table fluctuations in wetlands can result in flooded and drained conditions in the surface soil. In constructed wetlands, water level drawdown and soil drainage are used in management to consolidate detrital materials, accelerate soil buildup, and provide easy access for other management operations. A greenhouse study was conducted using intact peat soil cores to evaluate the changes in bioavailable P and other fractions following draining and reflooding. Measurements of floodwater dissolved reactive P (DRP) indicated that draining and soil exposure could result in large P flux to the overlying water column. Phosphorus flux in soils drained for 6 weeks was 10-fold higher (334 mg P m⁻² day⁻¹) than in soils drained for 3 weeks (33 mg P m⁻² day⁻¹). Soil exposure also resulted in an increase in bioavailable inorganic P (estimated by KCl extraction) at the expense of labile organic P pool. The KCl-P pool, which was initially less than 2% of total P (TP), increased to 3% and 13% of TP after 3 and 6 weeks draining, respectively. Results suggest that various soil P fractions, particularly those in newly accreted materials, were highly unstable and could be released in a more available form when newly accreted soils undergo drying. Water level drawdown and reflooding could result in significant P release, a possible stimulation of algal blooms and other water quality problems. Therefore, soil characteristics and chemistry and their impact on water quality should be a major consideration when one adopts the flood-drain technique in wetland management.

Parsons Engineering Science, Inc., and GeoSyntec Consultants, Inc. 2000. Review of documentation for the location and remediation of possible pesticide/chemical sites at the North Shore Restoration Area, Lake Apopka, Florida. Winter Park, Fla.

PROJECT: North Shore Restoration (LA-3-303-M)

INTRODUCTION

Parsons Engineering Science, Inc. (Parsons ES) and GeoSyntec Consultants Inc. (GeoSyntec) were contacted by the St. Johns River Water Management District (SJRWMD or the District) to assist SJRWMD with conducting a third-party review of environmental site assessment (ESA) and remediation reports developed by others for portions of the Lake Apopka North Shore Restoration Area (NSRA). The area addressed in this review is shown in Figure 1. The review was undertaken in an effort to help identify potential contamination sources which may have contributed to the recent bird mortalities associated with property within the NSRA.

Lake Apopka Restoration and the NSRA

Farm pollution must be greatly reduced for successful, permanent restoration of Lake Apopka. The Florida Legislature directed that this be accomplished through acquisition and restoration of the floodplain farms and through development of a water reuse and treatment facility for any remaining agriculture.

According to information provided by the District, purchase of the 3,000-acre Duda property completed in 1997 and purchase of essentially all parcels in the 6,000-acre Zellwood Drainage and Water Control District (ZDWCD) Unit 2 area was completed in 1998. Both areas are enrolled in the Federal Wetlands Reserve Program (WRP) of the Natural Resources Conservation Service (NRCS) and make up the active part of the NSRA at Lake Apopka. District holdings in the former Zellwin Sand Farm and in ZDWCD Unit 1 are not currently undergoing restoration. Final negotiations to complete the buy-out of all agricultural lands on the former floodplain are under way as of the writing of this report.

Environmental Audits and Environmental Risk Assessment

Phase I environmental site assessments on all properties in the NSRA were performed in accordance with the District's Phase I ESA standard (Attachment I), which incorporates guidance contained within ASTM Standard E1527. A total of 11 properties were audited, although not all of these are part of the currently active restoration project (9,000 acres). Based on Phase I ESA findings, further Phase II ESAs, Phase III remediation plans, and/or Phase IV remediation action reports were done for each property as required.

The Phase I ESAs as listed by the District located seven airstrips, 17 pesticide mix/load sites 19 pesticide storage areas, 67 petroleum storage sites, 27 equipment maintenance shops, 21 solid waste sites, and one wastewater treatment plant. Of the 178 potential

environmental concerns that were noted, 79 were verified in Phase II. Phases III and IV remediation included the removal of 20,343 tons of soil (about 10,000 tons containing pesticide contaminants) and 3,230 gallons of groundwater. Some 400 soil samples were analyzed for pesticide residues in the environmental assessments and in follow-up sampling.

The Phase I through Phase IV ESAs were performed on a series of agricultural properties previously owned by various farmers. The land on which the farms were developed formerly was part of the lakebed of Lake Apopka. Beginning in the 1940s, the land was drained and a water management system consisting of a series of dikes and canals was installed to accommodate agriculture. Long-term intensive agricultural practices had adversely impacted Lake Apopka and surrounding lands. To eliminate the negative impacts of the farms the Legislature mandated and funded the buyout of the farms. A series of ESA investigations and remedial actions were undertaken to minimize environmentally impacted site "hot spots" within the NSRA area. Upon completion of these efforts, portions of the NSRA was subsequently drained to minimize additional potential ecological impacts.

Parsons ES and GeoSyntec evaluated documents provided by SJRWMD to identify areas of environmental concern (AEC) that could need further evaluation to assist the District in determining if any of the AECs have the potential to be contributing to the bird mortality problem referenced above. The reviewed environmental documents consist of Phase I through Phase IV ESA reports generated as part of the District's legislatively mandated acquisition of the farms within the historic Lake Apopka floodplain. A Phase I ESA typically consists of noninvasive investigations such as visual site inspection, public records review, and interviews with knowledgeable parties, etc. undertaken to determine if regulated materials or conditions capable of adversely impacting the site's environment have been released. A Phase II ESA typically consists of invasive investigations (such as sampling), undertaken to confirm potential impacts based on areas of concern identified in the Phase I investigation. A Phase III ESA is conducted to delineate the extent of contamination in impacted site media (soil, sediment, surface water and groundwater) and to propose plans for remedial activity, and a Phase IV ESA summarizes the remedial activities and the confirmation sampling results.

Specifically, the Parsons/Geosyntec document reviews were conducted to assist SJRWMD in locating possible chlorinated pesticide or other chemical contamination "hot spot" sites remaining in the area that could contribute to ecological impacts and may require further evaluation and/or remediation. Identified contamination contained within the document set provided by the District was evaluated in the course of the

review, including contamination resulting from compounds which may not be specifically identified as acutely toxic to site wildlife. In order to maintain objectivity and focus, the SJRWMD limited the review to the documents they provided. A list of the documents provided appears in Table 1. The specific objectives of this review were as follows:

- Evaluate the procedures, including ASTM-E1527-97, used to identify AECs.
- Consider the appropriateness of the rationale used to draw conclusions and address the identified AECs.
- Identify AECs not identified in previous assessment work.
- Evaluate the analytical methods utilized and the appropriateness of the chemicals of potential concern.
- Develop recommendations for each AEC, as needed.

Percival, H.G. 1994. Lake Apopka's alligators: The end of the ruling reptiles? *Lake Reserv. Manage*. 9(2):102.

PROJECT: Fishery (LA-4-107-D)

ABSTRACT

Current alligator (*Alligator mississippiensis*) density on Lake Apopka is about 10% of that observed prior to 1980; furthermore, it is about 50% of densities in other comparable Florida wetlands. This is due largely to reduced egg viability rates, which on Apopka are about 20% (as opposed to about 50% on six other study areas). As part of a multi-disciplinary team, we investigated influence of microhabitat, clutch temperature, and nesting material on viability, and we compared the effects of these factors across six other Florida wetlands. These characteristics do not explain the reduction in Apopka's egg viability. We tentatively hypothesize that chlorinated hydrocarbon pesticides have reduced the reproductive potential of Apopka's alligators, and we speculate that the situation on Apopka is only the most extreme manifestation of a problem that could be more widespread throughout central Florida. The preface to solving water-resource problems is understanding them. Causal chains in potential contaminant situations can be particularly difficult to trace, and we found that addressing the Apopka problem required a diverse research/management team. We suspect that such teams may become increasingly important for tackling some lake management issues.

Pollman, C.D., D.A. Graetz, F.V. Ramsey, K.R. Reddy, and T.J. Sullivan. 1988. *Feasibility* of sediment removal and reuse for the restoration of Lake Apopka. Special Publication SJ88-SP10. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Sediment Recycling (LA-4-204-F)

EXECUTIVE SUMMARY

Lake Apopka forms the headwaters of the Oklawaha Chain of Lakes, a eutrophic to hypereutrophic chain of lakes located in central Florida approximately 25 km northwest of Orlando. Once a popular resort area noted for its game fishing, Lake Apopka is now ranked as the 17th most eutrophic lake in Florida, largely because of poor sewage treatment practices adopted by the City of Winter Garden and direct backpumping of nutrient-enriched irrigation water into Lake Apopka and the Apopka-Beauclair Canal from low-lying muck farms on the northern shores of the lake. Sewage discharges from Winter Garden on the south shore of Lake Apopka began ca. 1922–1927, followed by muck farm discharges starting in 1942. Although in all likelihood Lake Apopka has always been quite productive, primary productivity historically was dominated by dense stands of macrophytes. Despite high rates of external nutrient inputs, macrophytes continued to dominate until 1947, when hurricanes destroyed large amounts of the bottom vegetation. Opportunistic algal blooms appeared almost immediately and have persisted unabated through the present.

In 1979, the U.S. Environmental Protection Agency (EPA) published a final environmental impact statement (EIS) on the restoration of Lake Apopka. The final EIS recommended a phased restoration program consisting of short- and long-term objectives. Short-term objectives included continued monitoring of in-lake water quality and a demonstration project to examine lake drawdown as a restorative measure; longterm objectives included "continued evaluation of restoration alternatives and methods which would address the lake's internal loading problem." The efficacy of the most promising technique, lake drawdown, was acknowledged to be uncertain and, should drawdown prove infeasible, EPA suggested that "the possibility of dredging the lake and marketing the muck should be pursued."

The St. Johns River Water Management District (SJRWMD) has been charged by the State of Florida legislature to assess the feasibility of restoring Lake Apopka to Class III water quality standards (Chapter 17-3, *F.A.C.*). As part of this legislative mandate, this study revisits the feasibility of dredging Lake Apopka. The economics of sediment reuse, which previously had not been analyzed, are examined in conjunction with recent data on sediment physical and chemical characteristics to develop a cost benefit analysis of dredging, coupled with sediment reuse to restore Lake Apopka to a less-

enriched, more beneficial trophic state. Because of the uncertain economics of sediment reuse specific for Lake Apopka sediments, the objectives of this study were thus twofold:

- 1. Evaluate via the existing literature the feasibility of sediment removal as a means to restore Lake Apopka, using documented case studies of other systems as models in conjunction with extant data for Lake Apopka to assess the effects on surface chemistry of the lake
- 2. Evaluate the market potential for recovered sediment and develop a cost/benefit analysis for using sediment removal to restore Lake Apopka

Dredging has been used with varying degrees of success to restore a number of lakes in North America and Scandinavia. To a very large degree, the success of dredging relates to the adequacy of pre-dredging studies to define the magnitude of the problem. Dredging is generally most feasible in small lakes with organically rich sediment, low sedimentation rates, and long hydraulic residence times. Large lakes have been dredged, but economics become increasingly important as lake surface area increases. Cost increases in larger lakes are non-linear, reflecting not just concomitant increases in material to be removed in larger lakes but also increased pumping costs as a result of increased pumping distance (reflecting head losses due to friction in the pipe conducting dredged material onshore) across larger lakes. The largest lake dredged to date is Vancouver Lake, Washington (1,052 ha). By comparison, Lake Apopka is nearly 12 times larger (surface area = 12,400 ha).

Problems inherent in dredging as a general technique include short-term pulses of nutrient release and liberation of toxic materials (e.g., trace elements and organic pesticides) due to sediment resuspension, oxygen depletion, and potential effects to fisheries, wildlife, and benthic fauna. Other issues concern the ultimate use and stability of dredged material, as well as the treatment and disposal of nutrient-enriched supernatant from dewatered sediments. Pumping costs clearly indicate the need to dispose of dredge spoils near the lake. Finally, the overall efficacy of dredging is still in question despite the number of lakes, which have been dredged; documentation of post dredging effects on lake restoration has been characteristically poor, largely because of limited resources.

Lake Apopka sediments generally consist of a relatively uniform, organic, flocculent material underlain by mostly peaty deposits. In 1987, the organic floc averaged 117 cm depth compared to 80 cm in 1968. Interstitial nutrient concentrations in the floc exceed water column concentrations by over an order of magnitude, and resuspension of this easily disturbed material is believed to be a major contributor to sustained, high rates of algal productivity in the lake. One major area of uncertainty regarding the effectiveness

of the dredging in Lake Apopka is the internal loading characteristics of the underlying peat once it is exposed to the water column by dredging. Interstitial concentrations in the peat also are quite high, and the dynamics of nutrient transport across an oxic peatwater interface are unknown. The peat is believed to be physically more stable than the surficial floc, and resuspension effects on nutrient release in all likelihood would be reduced significantly.

Dredging costs for Lake Apopka were based on removing as much of the sediment floc layer as practicable. A 24-inch is the largest dredge which could operate reasonably in Lake Apopka; with this size dredge, only sediments under the 1.2 m contour would be removed. Under these operating constraints, approximately 10,400 ha would be dredged, giving a total volume of 121.76 x 106 m³ of sediment to be removed. With five 24-inch dredges operating, dredging of Lake Apopka could be accomplished in 5.9 years. Total dredging costs, exclusive of (1) spoil area land acquisition and clearing costs and (2) upland acquisition costs for storage of dried sediment prior to reuse or sale, total \$868,800,000.

Sediment reuse offers only limited ability to recover dredging costs. Approximately 1.43 x 10⁶ metric tons of dried sediment will be removed from Lake Apopka during each year of dredging. The total value of this material as fertilizer approximates \$55,000,000; use as a soil amendment has an estimated yield of \$25,000,000 to \$50,000,000. An upper limit on the economic reuse value of dried Lake Apopka sediment is \$97,400,000; this estimate is based on using Lake Apopka sediment as a growth medium for the ornamental horticulture industry and assumes that the dried sediment has the same value as peat. In all likelihood, the dried sediment will not have the same bulk texture characteristics as peat, and its direct usefulness to the ornamental horticulture industry will be limited. With a 20% mix on Lake Apopka sediment in the growth medium, the current market for Florida peat would yield an estimated \$3,200,000 annual return on Lake Apopka sediment reuse. The option of using Lake Apopka sediment as a potting or growth medium for the ornamental horticulture industry thus defines the minimum cost for dredging: \$771,400,000, which assumes that the upper limit market value of \$97,400,000 from use as a potting medium can be realized. Project costs almost certainly will be closer to between \$814,000,000 and \$844,000,000.

A number of assumptions were made in the cost/benefit analysis that should be examined in more detail before further consideration is given to dredging of Lake Apopka. Uncertainties lie in three main areas: (1) engineering aspects of dredging, (2) sediment reuse, and (3) internal loading aspects of the remaining peat sediments after the unconsolidated floc (UCF) and consolidated floc (CF) sediments have been removed. One major uncertainty considers redistribution of UCF and CF sediments from undredged areas into dredged areas. Over the relatively long span of the project (5.9 years), redistribution is very likely and may negate much of the perceived benefits of dredging. Moreover, only 84% of Lake Apopka can be dredged with a 24 inch dredge, and some of the nearshore sediments will redistribute into the open lake after dredging has been completed. Other studies need to be conducted on the drying and handling characteristics of dried Lake Apopka sediment as well as determining its effects on plant growth before the economic value of Lake Apopka sediments can be firmly established. These studies are useful for developing more realistic reuse cost benefits; nonetheless, the upper limit market value of \$97,400,000 will not increase whatever the outcome of these studies.

Reddy, K.R., G. Bao, O.G. Olila, and D.L. Stites. 1998 (draft). Effects of chemical amendments on marsh soil chemistry and nutrient flux. Final report for Contract 96W258, submitted to St. Johns River Water Management District, Palatka, Fla.

PROJECT: Marsh Flow-Way Restoration (LA-3-301-M)

INTRODUCTION

The St. Johns River Water Management District is purchasing muck farm lands for wetland restoration as part of District aquatic ecosystem restoration programs. The initial flooding for the re-conversion of these fields to wetlands often results in the release of large amounts of soil-bound (porewater) phosphorus. The high P flux after initial flooding may result in the discharge to the adjacent water bodies of water with high phosphorus concentration and potentially exceed the loading limits for the wetland areas. It may also result in conditions conducive to the development and maintenance of low diversity wetlands that slow succession to more desirable high diversity vegetation communities and animal habitats.

One of the promising solutions of the initial nutrient flushing problem is the use of chemical amendments in immobilizing or inactivating P before it enters the water column. This approach has been reported as a sound management technique in lakes but has not been evaluated for wetlands. Laboratory studies showed that a number of chemical amendments are effective in wetlands (Ann et al. 1998). This study was conducted to evaluate the effectiveness of a few selected compounds under field conditions. The objectives of this study were to determine the influence of selected chemical amendments on (i) changes in physico-chemical properties of soils resulting from chemical amendments, (ii) dissolved nutrient concentrations of soil porewater, and resulting P flux, and (iii) effectiveness of reducing or minimizing nutrient (particularly P) flux during initial flooding of a previously farmed organic soil. The

SWIM Plan for Lake Apopka

study results will be used in conjunction with water quality data collected and analyzed by the St. Johns River Water Management District to identify any soil amendments that could effectively reduce or minimize nutrient (particularly P) flux during initial flooding of a previously farmed organic soil.

Reddy, K.R., W.F. DeBusk, and D.A. Graetz. 1991. *Nutrient dynamics in recreated marshes adjacent to Lake Apopka.* Research program manual. Submitted to St. Johns River Water Management District, Palatka, Fla. IFAS, University of Florida, Gainesville.

PROJECT: Marsh Flow-Way Restoration (LA-3-301-M)

INTRODUCTION

Several studies (Boyt et al. 1977; Fetter et al. 1978; Turner et al. 1976; Reddy et al. 1982; see review by Richardson and Davis 1987) have reported the use of freshwater wetlands (swamps and marshes) and other flooded soil systems as a possible means of reducing N and P levels of waste waters. This concept is also being evaluated as a mechanism to improve water quality in Lake Apopka. The lake water will flow through a constructed marsh allowing settlement of algal biomass and other detrital materials on the soil surface. The water will then be returned to the lake, presumably with considerable improvement in quality. By recycling the lake water through the wetlands, significant amounts of N and P should be removed form the lake basin with a resultant improvement in water quality in the lake.

In order to maximize the N and P removal rate as well as the net storage capacity of the wetlands, it is important to understand the biogeochemical processes responsible for nutrient removal. Flooded organic soil chemistry is very complex because of the interactions between organic and inorganic forms of nutrients and associated chemical and biological components. The degree of reduction in flooded organic soils can have a significant impact on labile and non-labile pools of C, N and P, and ultimately their retention/release by these soils. Although these mechanisms have been documented for many mineral flooded soils, very little or no information is available for flooded organic soils.

Nitrogen and P removal in these systems primarily occurs through physical, chemical, and biological processes in the floodwater and sediment. A significant portion of floodwater and porewater N and P can also be removed through uptake by macrophytes and algae. Rate of N and P removal by these processes in influenced by the physico-chemical conditions that exist in the floodwater and in the sediment. Some of these conditions are (1) dissolved O_2 in the water; (2) pH; (3) temperature; (4) residence time of water; (5) water depth; (6) mixing in the water column; and (7) presence of aquatic macrophytes and algae. In addition, underlying sediments can function as a sink or source of N and P to the floodwater. This depends on the interstitial N and P concentration in the sediments, and N and P regeneration rates in the sediments.

Many wetlands are effective in the removal of inorganic forms of N and P, but are poor sinks for organic forms of N and P, but are poor sinks for organic forms of N and P. Studies by Kadlec and Tilton (1978), Small (1978), Toth (1972), and Boyt et al. (1977) showed a P reduction of 95–98% when freshwater swamp and marsh systems were used to treat waste water effluents containing between 3 and 11 mg P L⁻¹, while smaller reductions of 16–60% have been reported for wetlands or flooded fields receiving drainage water containing P concentrations of \pm mg L⁻¹ (Bentley 1969; Federico et al. 1978; and Reddy et al. 1982). Depending on soil conditions and P loading, the efficiency of flooded organic soils can decrease from 90% of P removal to less than 30% within a few years (Richardson and Davis 1987).

In a laboratory study, Reddy (1983) noted that N removal rates from floodwater were controlled by the initial floodwater NH_4^+ and NO_3^- concentration rate of NH_4^+ diffusion from the sediments to the overlying water, ammonification in the sediments, NH_3^+ volatilization and nitrification at the sediment-water interface, and denitrification in the sediments. Under the conditions studied, NH_4^+ concentrations of the floodwater were in the range of 0.01–0.05 µg mL⁻¹, while NO_3^- concentrations were in the range of 0.27–0.78 µg mL⁻¹. Sediments with organic matter were found to be less effective in the removal of floodwater organic N, C and P than the sediments with calcareous clay loam.

The amount of soluble P released into floodwaters of flooded soils, lake sediments, and swamp and marsh sediments depends on the capacity of the soil or sediment to desorb or adsorb from solution, mineralization rate of organic P, and diffusion rate of P from the sediment to the overlying waters. These processes play a role in determining whether the P concentration in the interstitial and overlying water is adequate for the nutritional requirements of plants and aquatic organisms, and whether these systems can be used for removing P from the overlying waters. Inorganic P exchange rates were found to be dependent on the capacity of the sediment to adsorb or desorb P (Reddy 1983). Total P exchange rates were in the range of -1.04 to 0.34 mg P m⁻² day⁻¹.

For organic soils obtained from Lake Apopka drainage basin (Reddy and Rao 1983), ammonification occurred at a rate of 110 mg N m^{-2} day⁻¹, and NH₄⁺ flux from the anaerobic soil layer to the floodwater and aerobic soil layer was 45 mg N m^{-2} day⁻¹. The sequential N processes occurring in a flooded organic soil include: ammonification in

the anaerobic soil layer, upward diffusion of NH_4^+ from the anaerobic soil layer to the floodwater, nitrification in the floodwater, downward diffusion into the anaerobic soil layer and denitrification in the anaerobic soil layer. Loss of N due to these processes represented about 35% of the mineralized NH_4 -N in the 21-cm organic soil column. Results also showed that ammonification and NH_4^+ diffusion probably are the rate-limiting processes in N loss from a flooded organic soil.

The same study (Reddy and Rao 1983) showed that the rate of soluble P production in the anaerobic soil layer was 16 mg P m⁻² day⁻¹. Major processes occurring in the anaerobic layer were mineralization of organic P, adsorption-desorption of P, and diffusion from sediment to the overlying water. Losses of P due to these processes represented about 53% of the solubilized P in the 21-cm organic soil column. Flux measured in this study were significantly higher than those presented in an earlier study by Reddy (1983), reflecting differences in floodwater retention time, and initial P concentrations of the floodwater.

Increase in P solubility in flooded mineral soil usually has been attributed to the reduction of ferric oxyhydroxide and ferric phosphate compounds to more soluble Fe²⁺ forms and to the hydrolysis of P compounds. Increased P release in flooded organic soils is probably due to the solubilization of Fe, Al, and Ca-P. Wetlands high in mineral matter were shown to retain more P than swamps low in iron and aluminum (Richardson 1985). In alkaline mineral soils, increase in available P was not due to soil reduction of ferric phosphate, but rather to increased soil water content. Reasons for not detecting an increase in available P as the alkaline soils were reduced were due to (1) lack of reductant soluble P, and (2) control of soluble P by the calcium system. Upon flooding, organic soils undergo reduction much more rapidly than mineral soils, with redox potential (Eh) values of <-200 mV occurring within a few days after flooding. Initial slow reduction is due to the buffering of capacity of nitrate, since many organic soils have a large accumulation of nitrate under aerobic conditions. These initially high Eh values can have a significant impact on P solubility in flooded organic soils.

The sulfate concentration of Lake Apopka water is in the range of $20-30 \text{ mg L}^{-1}$. Continuous inputs of sulfate to a constructed marsh can have a significant impact on organic matter decomposition during sulfate respiration (Howarth and Teal 1979). At this time, no information is available on the significance of sulfate reduction in Florida's wetlands.

The background information presented above discusses some of the significant biogeochemical processes occurring in flooded soils. Although the soil processes are important in controlling efficiency of a constructed marsh, the reactions occurring at the root-soil interface also play a significant role in C, N and P dynamics of a wetland. For example, oxygen transport by wetlands plants can play a significant role in decomposition of organic matter and N losses as a result of nitrification-denitrification reactions (Reddy et al 1989).

The environmental quality of the Oklawaha Chain of Lakes (Fig. 1) has been a subject of concern for various state agencies, local agencies, and private citizens for more than 20 years. Progressive eutrophication has greatly reduced or eliminated many of the recreational and water quality values of the lakes. Lake Apopka, the first and largest of the chain of lakes, is also the most severely degraded.

In recognition of the problems and potential values of Lake Apopka, the Florida Legislature in 1985 passed Chapter 85-148, Laws of Florida, which funded studies aimed at determining feasible means for restoring the lake. The effort was furthered by the Surface Water Improvement and Management Act of 1987 (Chapter 87-97, Laws of Florida), which identified Lake Apopka as a priority water body in need of restoration studies. Since enactment of that legislation, diagnostic and feasibility studies have resulted in the development of the Lake Apopka Marsh Flow-Way, a project designed to restore Lake Apopka by marsh filtration of nutrient-laden lake water.

The purpose of the Marsh Flow-Way Demonstration Project (Fig. 2) is to acquire the knowledge and experience necessary to effectively design and manage the projected full-scale marsh flow-way for lake restoration. In order to optimize marsh management for cost-effective nutrient removal, it is necessary to understand the fate of nutrients that enter the marsh. The Nutrient Storage and Movement Project is designed to measure the major nutrient components in the marsh soil and vegetation, determine the rate of transformation of nutrients to and from the soil, water column and vegetation, and estimate the nutrient retention capacity of the system.

OBJECTIVES

The overall objective of the proposed research is to develop a fundamental understanding of the biogeochemistry of C, N, P and S in flooded organic soils of the proposed constructed marsh adjacent to Lake Apopka. The specific objectives are to (1) characterize organic and inorganic forms of soil C, N and P to determine the labile and non-labile pools through chemical fractionation, (2) determine nutrient retention characteristics of organic soils and the factors regulating C, N, P and S retention or release, (3) determine the C, N and P exchange between the sediment and overlying water column, (4) determine the nutrient storage/release capacity of aquatic vegetation, and (5) assess the interaction of soil properties and water management with C, N and P retention.

Reddy, K.R., M.M. Fisher, and D. Ivanoff. 1996. Resuspension and diffusive flux of nitrogen and phosphorus in a hypereutrophic lake. *J. Environ. Qual.* 25:363–371.

PROJECT: Internal Nutrient Budget (LA-1-102-D)

ABSTRACT

Bottom sediments in shallow lakes can play a major role in releasing nutrients to the overlying water column during wind induced sediment resuspension or by constant flux due to diffusion. Internal nutrient loads due to these processes may be equal to or higher than external loads. Laboratory and field experiments were conducted on Lake Apopka, a shallow, hypereutrophic subtropical lake located in central Florida. Ammonium (NH₄⁺) N and soluble reactive P (SRP) flux during sediment resuspension were measured under laboratory conditions using intact sediment cores. Ammonium N and SRP flux due solely to diffusion were assessed using in situ porewater concentrations. Average diffusive flux from sediment to the overlying water was estimated to be 25 mg NH, N m⁻² d⁻¹ and 1 mg P m⁻¹ d⁻². Resuspension fluxes of NH, and SRP were higher than diffusive flux. Soluble reactive P profiles of porewater showed distinct profile differentiation, with the surface 0 to 8 cm sediment depth acting as a Pdepletion zone, and the underlying sediment displaying steep gradients in porewater SRP. These results suggest that dissolved NH⁺ and SRP transport from the surface 8 cm of sediment was due to sediment resuspension, while below this depth, upward mobility of NH⁺ and SRP was regulated by diffusion. Although dissolved N and P flux is upwards (from sediment to water column), during extended periods (annual cycle) the lake is functioning as a net sink for N and P by transforming inorganic pools of nutrients into organic forms and depositing them on the sediment surface.

Reddy, K.R., and D.A. Graetz. 1991. *Internal nutrient budget for Lake Apopka*. Special Publication SJ91-SP6. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Internal Nutrient Budget (LA-1-102-D)

EXECUTIVE SUMMARY

Lake Apopka, with a surface area of 12,500 ha (31,000 acres), is located in Central Florida, approximately 25 km (15 miles) northwest of Orlando. The average depth of the lake is about 2 m. Currently, it is highly eutrophic with high concentrations of algal

biomass (chlorophyll *a* concentrations often exceed 100 mg m⁻³). Water quality in the lake is impacted by both external and internal sources. Historical and current external sources of pollution include discharge of excess drainage water from adjacent vegetable farms, surface and subsurface runoff from adjacent citrus groves, sewage effluent discharge from Winter Garden (this discharge has been stopped for some time), and biological nitrogen and carbon fixation.

The water quality in Lake Apopka can have a significant impact on downstream lakes in the Oklawaha River Basin, since lake water eventually flows into some of these lakes. In recognition of the problems and potential values of Lake Apopka, the Florida Legislature, in 1985, approved funds to study feasible means of restoring the lake. Part of this approval was to design a study for better understanding of the external and internal nutrient inputs to the lake, which would result in the development of a nutrient budget for the lake.

The bottom sediments in Lake Apopka are highly organic and rich in nutrients. Because of shallow water depth and the flocculent nature of these sediments, resuspension of the sediment occurs during periods of heavy winds. The release of nutrients from these sediments can cause nutrient concentrations in the water column to remain high despite reduction of external nutrient loading. The nutrients can be readily utilized by algae and other aquatic biota, thus maintaining hypereutrophic conditions in the lake.

For Lake Apopka, the pollutants of most immediate concern are phosphorus (P), nitrogen (N), and carbon (C). Phosphorus and N are essential nutrients which often limit the rate of algal primary production, the source of flocculent lake sediments. Although C, which is continually supplied through photosynthesis and removed through microbial respiration, is a major component of the flocculent organic sediment, it is not as important in eutrophication as N and P. Nevertheless, the rate of accumulation of flocculent sediments is determined by the balance between C fixation via algal photosynthesis and C mineralization through microbial respiration. Information on the C budget, then, could indicate the level of reduction of algal productivity required to cause the lake to become a net exporter of C. Quantification of these internal sources and sinks is essential for accurate prediction of the response of Lake Apopka to pollution abatement and for informed appraisal of restoration alternatives.

In recent years, it has become clear that nutrient processing by the aquatic biota and sediments of lakes can be a major factor in the determination of trophic status of the lake. To evaluate the role of C, N, and P transformations in the sediment-water column and its impact on water quality, it is critical to develop a basic understanding of these processes.

The major objectives of the research presented in this report were to:

- Characterize Lake Apopka sediments for labile and non-labile forms of nutrients
- Determine the flux of dissolved C, N, and P between sediments and the overlying water column
- Establish the relative importance of biogeochemical transformations of sedimentary forms of C, N, and P
- Determine C and N fixation in the water column
- Determine the effects of sediment mixing and resuspension on C, N, and P release into the water column

The first objective of this study was to characterize labile and non-labile forms of nutrients in Lake Apopka sediments.

The sediment profile is characterized by five different layers, based on their physical consistency. These are unconsolidated floc (UCF), consolidated floc (CF), peat (P), sand (S), clay (c), and marl (M). The UCF layer is the surface layer, with an underlying CF layer. About 95% of the sediment surface is covered with a UCF layer. During the past 20 years, the thickness of this layer has increased at a rate of 1.15 cm yr⁻¹.

Labile (dissolved) forms of nutrients in the sediment porewater account for 0.7% of C, 3.9% of N, and 6.9% of P in the sediments. Historical sedimentation rates based on ²¹⁰Pb-dating techniques were estimated to be 0.03 g cm⁻² yr⁻¹. This yields accumulation rates for C, N, and P of 91, 7.1, and 2.9 g m⁻² yr⁻¹, respectively. These values are on the same order of magnitude as those estimated by increases in the thickness of surface sediments over the past 20 years.

The second objective of this study was to determine the flux of dissolved C, N, and P between sediments and the overlying water column.

Nitrogen flux from the sediment to the overlying water column was in the range 28–40 mg N m⁻² d⁻¹. Phosphorus flux was in the range 1.7–2.7 mg P m⁻² d⁻¹. Concentration profiles of ammonium N and soluble P varied spatially, but not temporally, suggesting that the lake is at steady state. Flux of C, N, and P is governed in the UCF sediments by resuspension and in the CF sediments by diffusion and mass flow.

The third objective of this study was to establish the relative importance of biogeochemical transformations of sedimentary forms of C, N, and P.

One of the transformations of C is decomposition of organic matter. Organic matter decomposition was rapid in sediments exposed to oxygen, with about 25% of the initial C lost in one year. Under anaerobic conditions, about 6% of the initial C was lost from UCF sediments; less than 1% was lost from CF and peat sediments. The decomposition in CF and peat sediments was inhibited by an inadequate supply of electron acceptors.

A second transformation of C is adsorption and diffusion of organic acids. Soluble organic C concentrations in the water column and in the sediment porewater were approximately the same. Therefore, there is no net transport of C from the sediment to the water. The diffusion coefficients for acetic and butyric acids, intermediate products of anaerobic decomposition, were 0.46 and 0.71 cm⁻² d⁻¹. Acetic acid is more strongly adsorbed in sediment than is butyric acid.

One of the transformations of N is mineralization of organic N to ammonium. Organic N mineralization in sediments exposed to oxygen was rapid (0.6 mg N $L^{-1} d^{-1}$). Under anaerobic conditions, N mineralization rates were in the range 0.26–0.37 mg N $L^{-1} d^{-1}$.

A second transformation of N is adsorption and diffusion of ammonium N. Ammonium adsorption on sediment was stronger under aerobic conditions than anaerobic conditions. Ammonium adsorption capacity was higher in the surface sediments and decreased with depth. The diffusion coefficients for ammonium moving in the sediment profile were in the range $0.6-1.47 \text{ cm}^{-2} \text{ d}^{-1}$.

A third transformation of N is nitrification (oxidation of ammonium N to nitrate N) in sediment resuspended into the oxygenated water column. Soluble ammonium in anaerobic sediments exposed to oxygen was rapidly nitrified at a rate of 1.95 mg N $L^{-1} d^{-1}$.

A fourth transformation of N is nitrate reduction. This process can be either assimilatory producing biomass, or dissimilatory with NH_4 or N_2 being formed. Nitrate reduction rates were rapid, with denitrification (nitrate reduction to nitrous oxide and N gas) as the dominant process. Denitrification rates were in the range 1.2–2.6 mg N L⁻¹ d⁻¹.

The combined processes of nitrification and denitrification in the sediment-water column are very important in this system. Nitrification-denitrification processes were rapid in the sediment-water column, with removal rates measured up to 50 mg N m⁻² d⁻¹.

One of the transformations of P is adsorption/desorption of phosphate and diffusion of P in sediments. Soluble P decreased when anaerobic sediments were exposed to oxygen but remained constant when sediments were kept under anaerobic conditions. High equilibrium P concentrations in the sediment porewater suggest that P transport is from the sediment to the water column. In the short term, P retention in the sediment is due to

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adsorption, while over the long term, precipitation of calcium phosphates from the water column controls the porewater concentration of P.

The fourth objective of this study was to determine C and N fixation in the water column.

Carbon and N fixation in the water column is a function of light penetration and is independent of N and P concentrations in the water. This implies that N and P are not limiting the productivity of Lake Apopka. The C fixation rate was 1.9 mg C $L^{-1} d^{-1}$ assuming a 12-h photoperiod. On an areal basis, the C fixation rate is 1,400 g C m⁻² yr⁻¹. The N fixation rate was 0.16 g m⁻² yr⁻¹, suggesting that biological N fixation may not be a significant contributor to the total N budget for Lake Apopka.

The fifth objective of this study was to determine the effects of sediment mixing and resuspension on C, N, and P release into the water column.

Ammonium N release during simulated sediment resuspension of the surface 10 cm was in the range 0.4–0.5 mg cm⁻² h⁻¹. No significant release in P occurred during this sediment resuspension. Profiles of soluble P concentration in sediments suggest that sediment resuspension involves the surface 8 cm.

The results in this report provide information on the relative rates of several biogeochemical processes related to C, N, and P cycling in Lake Apopka. It is apparent from these results that Lake Apopka is very productive and dynamic in cycling nutrients. The nutrient enrichment in the water column is enhanced by sediments functioning as a steady source of soluble ammonium and P. The sediments are functioning as sinks for nitrate N and for the particulate matter deposited on the sediment surface. To quantitatively evaluate the role of sediments in the overall internal nutrient budget of the lake, it is critical that two physical processes, i.e. sediment resuspension during hydrodynamic events, and steady diffusive flux, be further evaluated.

It should be noted that the rate coefficients reported for various processes were measured under laboratory conditions. The relative rates may be different under field conditions where several environmental factors influence these processes. Future research should be focused on the biogeochemical processes functioning (1) at the sediment-water interface, especially on a micro-scale level in the surface 10 cm depth, and (2) in the water column during sedimentation of particulate dead algal cells. Since the processes functioning are dynamic in nature, they should be evaluated *in situ* on short-term intervals. The information provided in this report should be used in context with the external nutrient inputs when developing management strategies to restore Lake Apopka.

Reddy, K.R., O.G. Olila, E.M. D'Angelo, D.L. Stites, and M. Coveney. 1996. Nutrient storage and movement in the Lake Apopka Marsh, Phase III. Contract 94B271:1996. Final report submitted to St. Johns River Water Management District, Palatka, Fla. IFAS, University of Florida, Gainesville.

PROJECT: Marsh Flow-Way Restoration (LA-3-301-M)

EXECUTIVE SUMMARY

The environmental quality of the Oklawaha Chain of Lakes has been a subject of concern for various state agencies, local agencies, and private citizens for more than twenty years. Progressive eutrophication has greatly reduced or eliminated many of the recreational and water quality values of the lakes. Lake Apopka, the first and largest of the chain of lakes, is also the most severely degraded.

Lake Apopka, with a surface area of 12,500 ha (31,000 acres), is located in central Florida, approximately 25 km (15 miles) northwest of Orlando. The average depth of the lake is about 2 m. Currently, it is highly eutrophic with high concentrations of algal biomass (chlorophyll *a* concentrations often exceeds 100 μ g/L). Water quality in the lake is impacted by both external and internal nutrient sources. Historical and current external sources of pollution include: discharge of excess drainage water from adjacent vegetable farms, surface and subsurface runoff from adjacent citrus groves, sewage effluent discharge from Winter Garden (this discharge has been stopped for some time), and biological nitrogen and carbon fixation. In addition, nutrient release from bottom sediments due to wind-induced resuspension and diffusion is considered an important source to the water column.

In recognition of the problems and potential values of Lake Apopka, the Florida Legislature in 1985 passed Chapter 85-148, Laws of Florida, which funded studies aimed at determining feasible means for restoring the lake. The effort was furthered by the Surface Water Improvement and Management Act of 1987 (Chapter 87-97, Laws of Florida), which identified Lake Apopka as a priority water body in need of restoration studies. Since enactment of that legislation, diagnostic and feasibility studies have resulted in the development of the Lake Apopka Marsh Flow-Way, a project designed to restore Lake Apopka by marsh filtration of nutrient-laden lake water.

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The purpose of the Marsh Flow-way Demonstration Project is to acquire the knowledge and experience necessary to effectively design and manage the projected full-scale marsh flow-way for lake restoration. In order to optimize marsh management for costeffective nutrient removal, it is necessary to understand the fate of nutrients that enter the marsh. The Nutrient Storage and Movement Project was designed to measure the major nutrient components in the marsh soil and vegetation, determine the rate of transformation of nutrients to and from the soil, water column and vegetation, and estimate the nutrient retention capacity of the system.

The objectives of the Phase III research presented in this report were to

- Determine different P forms and their distribution as affected by drawdown, drying and re-flooding
- Evaluate the changes in organic and inorganic forms of P in the newly accreted sediments
- Develop a baseline on selected soil characteristics (C, N, and P) and compare the changes in those characteristics before and after re-flooding
- Changes in distribution of dissolved nutrients in the soil-water column following these management strategies in the constructed marsh
- Nutrient exchange rates (NER) in the soil-water column under *in situ* conditions

The first objective was to evaluate the forms and distribution of soil phosphorus as influenced by marsh drawdown, drying and reflooding.

Drawdown of the marsh increased the bulk density of surface sediments. Compacted sediments generally were higher in total P concentration than the pre-drawdown sediments. The newly accreted sediments had higher total P concentration than the native soil.

Drawdown caused a shift in sediment P distribution from less soluble to a more soluble form, as indicated by the large increase in loosely bound P (1 M KCl-extractable) concentration in the newly accreted sediments.

Drawdown also increased the reactive Fe/Al-P concentrations at the expense of labile organic P (NaOH/OP) probably due to P mineralization following exposure and drying.

The temporal shift in soil P from less soluble to a more soluble form due to drawdown may result in an initial flushing of P upon re-flooding.

The second objective was to evaluate the nutrient exchange rates between soil and water column, as influenced by marsh drawdown, drying, and reflooding.

Marsh water level and burning wetland vegetation has resulted in increased upward diffusive flux of soluble N and P from 10 and 1.3 mg/m²·day in December 1992 before marsh management.

Drawdown of water level in the South Marsh in June 1994 resulted in partial consolidation of floc sediment depth, that may extend the lifetime of the marsh for nutrient removal by this process.

The third objective of the study was to determine the changes in bioavailable P and nutrient exchange as a result of water-level drawdown and reflooding.

Measurements of floodwater dissolved reactive P (DRP) indicated that draining and soil exposure could result in large P flux to the overlying water column.

Phosphorus flux in soils drained for 6 weeks was tenfold higher (334 mg P m⁻² day⁻¹) than P flux in sols drained for 3 weeks (3 mg P m⁻² day⁻¹).

Soil exposure also resulted in an increase in bioavailable inorganic P (estimated by KCl extraction) at the expense of labile organic P pool. The KCl-P pool, initially 0.2% (control), increased to 3% and 13% of TP after 3 and 6 weeks' draining, respectively.

Results suggest that various fractions of soil P, particularly those in newly accreted materials, were highly unstable and could be released in a more available form when newly accreted soils experience stress such as exposure and drying.

Additional research is needed to develop tools which can be used to identify management strategies to improve the efficiency of marsh.

Field application of chemical amendments to reduce P release from native agricultural soils should be evaluated prior to flooding.

Nutrient storage in the belowground portion should be quantified to establish the role of vegetation.

Stability of stored nutrients in soil and floc sediment needs to be established, especially with respect to P.

Simple models should be developed as a tool to evaluate management options to improve nutrient removal efficiency of marsh.

Consideration should be given to include sedimentation ponds to reduce suspended solid loads to the marsh.

Rice, K.G., and H.F. Percival, eds. 1996. *Effects of environmental contaminants on the demographics and reproduction of Lake Apopka's alligators and other taxa*. Technical report 53. Fla. Coop. Fish and Wildlife Res. Unit, University of Florida, Gainesville.

PROJECT: Fisheries (LA-4-107-D)

ABSTRACT

Due to high nutrient and pesticide levels, Lake Apopka is considered one of the state's most polluted lakes. Lake water is frequently pumped into and from agricultural areas. Also, for years the lake was largely encircled by extensive citrus groves. In addition to agricultural chemicals, Lake Apopka receives tertiary treated sewage effluents from the municipality of Winter Garden. In 1980, a spill from the Tower Chemical Company contaminated the drainage into Gourdneck, the southwest portion of the lake.

Beginning in 1981, a major decline was observed in juvenile alligators on Lake Apopka. Meanwhile, other lakes studied in the St. Johns River drainage showed numerically stable or increasing alligator populations. Since 1984, controlled incubation of alligator eggs has demonstrated that Lake Apopka has the lowest clutch viability rates (proportion that hatch out of total eggs deposited) of any Florida alligator population examined. An analysis of alligator eggs collected in 1985 from three Florida lakes showed that eggs from Lake Apopka had significantly elevated levels of DDD, DDT, and DDE. DDT, DDE, and many other pesticides can act as hormones (chemical signals) or as inhibitors to natural hormones in the developing embryo.

In this study, we found that the total population (\geq 30 cm) of alligators on Lake Apopka decreased approximately 25% from 1980 to 1989 then increased approximately 20% through 1995 (P<0.01, $\sim R^2_{adj} = 0.80$). Juveniles (30–121 cm) decreased by almost 60% through 1989 then increased by 50% over the next 6 years (P<0.05, $\sim R^2_{adj} = 0.80$). We could detect a decrease in clutch viability of approximately 41% from 1983 to 1988 and then an increase of over 200% through 1995 (P<0.05, $\sim R^2_{adj} = 0.82$). However, clutch viability was higher on Lake Woodruff, our control area, than Lake Apopka (P<0.001, df = 103). Viability did not differ between the two lakes for animals of similar size. We estimated size distributions of adult nesting females for both areas. Lake Apopka's distribution consisted of larger animals than Lake Woodruff's. We note that clutch viability was higher for the medium-sized animals than for the very large.
Plasma sex steroid concentrations did not differ between adult females on lakes Apopka and Woodruff. Initial contaminant analyses indicated no correlation between concentrations of contaminants found in adult female abdominal fat and egg yolk. Clutch viability did not correlate to egg yolk contaminant concentrations. However, contaminant levels in maternal abdominal fat had a negative correlation (adj R^2 –0.778, P = 0.0001) to clutch viability.

Juvenile alligator females exhibited similar plasma estrogen (E) concentrations among all lakes whereas we noted that plasma testosterone (T) concentrations were significantly increased on Apopka in comparison to the other lakes. Male bass on Apopka had depressed concentrations of 11-keto-testosterone. Initial results indicate significantly higher parasite loads for bass from Lake Apopka than from the other lakes and ponds. Additionally, white blood cell counts were increased and spleen weight decreased for bass from Lake Apopka.

We noted that neonates from eggs treated with higher doses of DDE (100, 1000 mg/egg) and all doses of edstradiol exhibited elevated plasma E concentrations, but significantly reduced plasma concentrations. Thus, DDE and E treatments cause abnormal plasma hormone profiles, which result in demasculinized males. These results mimic our observations in untreated eggs collected from Lake Apopka.

Male and female juvenile alligators from Lake Griffin and Lake Jesup exhibited significantly elevated estrogen/androgen (E/A) ratios as do male alligators from Lake Apopka (F = 7.76; d.f. = 6, 467, P < 0.0001). Only males from Lake Apopka showed little relationship between body size and phallus morphometrics. Males from Lake Apopka had penis tip lengths smaller than males from any other lake, after adjustment for snout vent length.

We provide general discussion and recommendations for future research direction on Lake Apopka. Finally, we provide point-by-point conclusions at the end of this manuscript.

CONCLUSIONS

We detected an increasing trend in the juvenile population and in clutch viability on Lake Apopka since 1989. Clutch viability is lower on Lake Apopka than on the control area, Lake Woodruff. Clutch size was greater on Lake Apopka than Woodruff. However, individual egg weight was less. Clutch viability was less among the larger females. Similar-sized nesting females produced similar clutch viability rates on lakes Apopka and Woodruff. We found a difference in the shape and the mean of estimated nesting female size distributions on lakes Apopka and Woodruff. Lake Apopka's nesting females were larger on average than Lake Woodruff alligators in 1994 and 1995.

Sex steroid concentrations did not differ in adult nesting females between lakes Apopka and Woodruff, but were significantly different for juvenile animals. Similarly, juvenile alligators and adult bass on Lake Apopka had hormone concentrations significantly different from other areas.

There was little correlation between phallus size and body size in male juvenile alligators from Lake Apopka, whereas males from six other lakes showed a clear positive correlation between body size and phallus size. Circulating sex hormones (estradiol and testosterone) were different in these Apopka animals with small phalli (as well as in alligators from Lakes Jesup and Griffin), with no correlation existing between circulating T and phallus size in the Apopka animals.

Juvenile alligators captured on Lake Apopka and Lake Woodruff displayed comparable responses to acute capture stress.

We observed no correlation between environmental contaminants found in the female and those found in the egg. Contaminants in the adult female were negatively correlated with clutch viability rate.

Laboratory dosing studies of environmental contaminants, for both alligator and turtle eggs, produced animals with altered hormonal concentrations. Eggs dosed with DDE produced animals with hormone levels that corresponded to levels observed on wild animals in lakes Apopka and Woodruff.

Our data suggest two very different potential fates for alligators (and other vertebrate populations) on Lake Apopka. We could be viewing the recovery of a system and only the remnants of damage inflicted in the past by environmental contamination or other causes. On the other hand, this seeming recovery phase may end, and juvenile animals present today might not reproduce or survive. Only through continued monitoring and further experimentation can we hope to unravel this mystery.

Robinson, H. 1999. Bird report, Zellwood Drainage and Water Control District Unit 1, Unit 2, and the Zellwin Sand Farm property at Zellwood, Florida. August 15, 1998– August 14, 1999. Prepared for St. Johns River Water Management District, Palatka, Fla.

PROJECT: North Shore Restoration (LA-3-303-M)

INTRODUCTION

This is a report on the birds that visited the Zellwood Drainage District Units 1 and 2 together with the flooded portion of the Zellwin Sand Farm property, all located in Zellwood, Florida (Figure 1). This detailed summary covers the period August 15 1998 to August 14 1999. The survey is ongoing. Table G gives details of the days visited and the number of species/individuals seen. This survey involved over 1,000 hours of fieldwork.

An informal discussion was held at Zellwood on August 15, 1998, between birders and staff of the St. Johns River Water Management District. One outcome was the urgent need by all parties for detailed information on the birds using the farms. Hence the survey.

Initially, the survey concentrated on the flooded fields, but when an unexpected influx of sparrows took place the survey then included the tall herbaceous vegetated fields. In February 1999 the fields were drained and the farms closed so I didn't visit the area for nearly three weeks. I then started to explore the peripheral areas and found that there were interesting and bird-rich woodland areas that unfortunately were not covered previously in the fall. Access to the fields was granted again on April 20, 1999. The survey now included the herbaceous vegetated fields, the flooded areas on the Sand Farm, and the wooded borders.

The aim of this report is to record what I saw during the year. It is unfortunate that apart from the fall, I have been unable to get my most unusual sightings confirmed by others. I often wish that there was a designated individual who could come in to confirm some of the rather startling finds. The aim is also to identify, as far as possible, the habitat used by other species. I hope it indicates the species and numbers that might use the area, if it was either deep or shallow flooded. It also shows what may occur if the fields remain covered in herbaceous vegetation.

In addition, I conducted a breeding bird survey during the summer of 1999, and the results are included in Appendix A. I have also tried to identify all mammal, butterflies, dragonflies, damselflies, reptiles, and amphibians that I came across. Details of these are included in Appendices C–F.

Finally I have taken a brief look at some events that happened during the year and the effect that they had on the birds.

Robinson, H. 2002. Bird usage of Lake Apopka's North Shore Restoration Area. Zellwood Drainage and Water Control District Unit 1, Unit 2, and the Zellwin Sand Farm property at Zellwood, Florida. August 15, 1999–August 14, 2000. Prepared for St. Johns River Water Management District, Palatka, Fla.

PROJECT: North Shore Restoration (LA-3-303-M)

INTRODUCTION

This is the second report on the birds that visited the Zellwood Drainage District Units 1 and 2 together with the eastern end of the Zellwin Sand Farm Property, all located in Zellwood, Florida (Figure 1). This detailed summary covers the period from August 15, 1999, to August 14, 2000. This survey is ongoing. Table D gives details of the days site visited, the hours spent surveying and the number of species/individuals seen. This survey involved 1,207 hours of fieldwork.

The survey started in August 1998, as there was an urgent need for detailed information on the birds that visited the flooded fields. After the fields were drained in February 1999, the fields continued to be a major draw for birds. In all seasons, this area continues to surprise with many species setting new records for the State of Florida. During this year the only water has been at the Sand Farm. At times there have been areas of mud, and at other times it has been full to the banks. The area underwater is decreasing, perhaps 250 acres now against the original 300 acres. The rest of the area has been undisturbed. It has not been static as the vegetation has continued to evolve. Much of the northern and eastern areas are now clothed in some very tall, dense plant growth. There has been no significant change to the border habitats.

The actual area surveyed has varied according to season, weather conditions and from time to time, because of the work of the road system. More time has been spent in Unit 1 and the Sand Farm than in Unit 2. The extreme southern end of the area, i.e., the area south of Hooper Farms Road, received the least attention due to time constraints. I have however tried to keep to the same route seasonally in order to make the counts comparable.

The aim of this report is to record what I saw during the 12 months. I have also, where relevant, included early fall records from the first year in order that there is a full

picture of the fall migration in 2000. I have tried to identify, as far as possible, the habitat used by each species. This habitat usage is detailed in Table B. In case the reader has not seen the first report, I am including a summary of the wetland habitat usage together with my estimates of the species/numbers that would visit the flooded fields if they were either deep or shallow flooded.

In addition, I conducted a breeding bird survey during the summer of 2000. The results of this and last year's survey are included in Appendix A. I have also tried to identify all mammals, butterflies, dragonflies, damselflies, reptiles, and amphibians that I came across. Details of these, for the two years, are included in Appendices C–F.

I have provided a systematic list of the bird species seen over the two years August 15 1998–August 14, 2000. With this I have detailed the highest recorded count for each species. This is all in Table E.

Finally, I have taken a look at how the changing vegetation has effected the bird population.

Schelske, C.L. 1994. Assessing nutrient limitation in a hypereutrophic lake. *Lake Reserv. Manage*. 9(2):112.

PROJECT: Internal Nutrient Budget (LA-1-102-D)

Abstract

Nutrient limitation in Lake Apopka, a hypereutrophic lake in north central Florida, was assessed with nutrient enrichment bioassays, dilution bioassays, and chemical measurements in an 18-month study. Results of nutrient enrichment bioassays with natural phytoplankton assemblages showed that phytoplankton were nitrogen limited in 18 of 19 monthly assays. Phosphorus was the limiting nutrient in one experiment. These results are consistent with chemical measurements. Phosphorus limitation was not expected because average total phosphorus is approximately 200 μ g P/L. In addition, phytoplankton store excess phosphorus as polyphosphate. Nitrogen was limiting because combined inorganic nitrogen is low (<50 μ g/L) compared to chlorophyll *a* that ranged from 50 to 200 μ g/L. Because algal biomass was high, dilution experiments were conducted to determine the effect of nutrient reduction on phytoplankton growth. A dilution series of lake water and simulated lake water containing no nitrogen and phosphorus was used to test the effects of nutrient reduction in 2 x 2 factorial experiments with nitrogen and phosphorus. In these

experiments, the importance of nitrogen limitation decreased with increasing dilution of simulated lake water. Algal growth was nitrogen limited in undiluted lake water, but at high dilution, algal growth was colimited by nitrogen and phosphorus. These dilution experiments provide guidelines on the amount of phosphorus removal needed to achieve specific reductions in algal biomass.

Schelske, C.L. 1997. *Sediment and phosphorus deposition in Lake Apopka*. Special Publication SJ97-SP21. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Internal Nutrient Budget (LA-1-102-D)

EXECUTIVE SUMMARY

Sediment studies in Lake Apopka were undertaken with two major objectives. The first was characterization and determination of the origins of the flocculent and consolidated sediment layers. This objective is important because the origin of sediments is presumed to have changed abruptly in 1947 when the lake primary producer community shifted from macrophyte dominance to phytoplankton dominance. Several independent approaches were employed to characterize sediments and determine their origin. The second major objective was to estimate lake-basin sedimentation of mass, organic matter, total phosphorus (TP), and non-apatite inorganic phosphorus (NAIP) after 1947 and also for shorter periods after 1947 when phytoplankton became the dominant primary producer. To meet these objectives, a high quality data set for 46 survey and 8 historic cores was collected (see Appendices B and C). Historic cores were ²¹⁰Pb dated to provide a chronology of historic changes in sediment and nutrient deposition. Stratigraphic feature in historic and survey cores were correlated as a means of obtaining time-dependent markers in the undated survey cores. Data from the survey cores arranged on an equal area grid were equally weighted in developing basinwide estimates.

Highly organic, flocculent sediments produced during the phytoplankton phase were hypothesized to be lower in dry weight fraction and with a lower total carbon/total nitrogen (TC/TN) ratio than sediments produced during the macrophyte phase. This difference was expected because macrophytes require structural organic carbon to grow upright. This structural carbon is degraded slowly compared to more labile forms in phytoplankton; thus a higher TC/TN ratio is found in sediments produced during the macrophyte phase. A stratigraphic marker of this type was used to determine the thickness of flocculent sediments at historic and survey stations.

Several stratigraphic markers were used to infer the change from macrophyte to phytoplankton dominance in the lake. The ratio of TC/TN, fraction dry weight, and TP concentration provided stratigraphic evidence that flocculent sediments were produced as by-products of autotrophic metabolism during the recent, 50-year period of phytoplankton dominance. These variables, which were analyzed in all cores, were used to establish the thickness of flocculent sediments. That flocculent sediments were produced during the planktonic phase was verified with additional analyses, including the chemical measurement of diatom silica and analysis of diatom microfossils.

Highly organic sediments such as those found in Lake Apopka are not common in some geographic areas, but are characteristic of many Florida lakes (Brenner and Binford 1988). Lake Apopka forms the headwaters of the Ocklawaha River and receives relatively small inputs of allochthonous organic matter from its small drainage area, headwater spring and rainfall. Lake Apopka, therefore, may differ from many Florida lakes in that a high proportion of its sedimentary organic matter has been formed historically from organic matter produced photosynthetically in the lake, either from the macrophyte community during the macrophyte phase or from phytoplankton community during the phytoplankton phase. Results presented here provide many lines of evidence for the two different sources of sedimentary organic carbon in Lake Apopka.

Data on diatom microfossils provide additional support for criteria used in stratigraphic zonation. Three distinct assemblages were present in the diatoms identified from LA9-95, a historic core collected in 1995. These included (1) a diverse assemblage dominated by benthic taxa (*Amphora ovalis, Cyclotella stelligera, Cymbella* sp., *Pinnularia* sp., *and Nitzschia* sp.) that was found below the zone of flocculent sediments, (2) an assemblage dominated by *Aulacoseira italica, Pseudostaurosira brevistriata, Staurosirella pinnata,* and *Staurosira construens* found at the bottom of the zone of flocculent sediments, and (3) an assemblage comprised of 75–80% *A. italica* in the uppermost zone of flocculent sediments was approximately an order of magnitude less than the overlying assemblage.

Data on microfossil diatoms provide evidence that water transparency changed markedly in a few decades. Water transparency inferred from the diatom assemblage present during the macrophyte phase indicates high water transparency such that benthic algae grew on the lake bottom. By contrast, the meroplanktonic diatom, *A. italica* now is the dominant diatom in the lake because it can survive in the aphotic environment on the lake bottom. Decreased transparency is attributed to increases in phytoplankton standing crop and other factors. Increased standing crop of phytoplankton is one of the consequences of nutrient enrichment.

The ratio of planktonic to benthic (P/B) diatoms also provides evidence that the primary producer community shifted from macrophytes to phytoplankton at the time when flocculent sediments were first deposited. *A. italica* is the major phytoplankton species in the lake presently; therefore, the P/B ratio is highest in the upper 15 cm where this species is dominant (75–80% of the assemblage). The P/B ratio increases upcore as does the concentration of TP. True benthic species will be replaced by other forms if water transparency decreases as the result of increased standing crops of phytoplankton or other factors. These data indicate that the changes in the lake's primary producer community since the 1940s and earlier were driven by increased nutrient loading.

Establishing the thickness of flocculent sediments at survey stations allowed the calculation of inventories (storage) of mass, organic matter, TP, and NAIP at each station. The thickness of flocculent sediments varied greatly among the 46 survey cores and ranged from 1 to 136 cm. Flocculent sediments were highly organic averaging 63% of sediment mass. Storage of sediment mass and TP also varied among stations. This variability can be illustrated by noting the <5% of the total storage of TP was found at the 10 stations with the lowest storage and that 63% of the TP storage was found at the 15 stations with the highest storage. This variability does not affect estimates of basinwide storage which are based on equal areal weighting for each station.

Variability in sediment deposition over the lake basin is attributed to the dynamics of sedimentation that focus sediments at high sedimentation sites. Sediments that are focused at high deposition sites have in part been transported from other areas of the lake that are subject to sediment resuspension. Stations with high sedimentation rates are characterized as depositional sites. These sites preserve the paleolimnological record and must be identified to infer historical conditions in the lake. Stations with low sedimentation, transitional, or no-depositional sites were in the central part of the lake where the effects of wind action on sediment resuspension would be greatest.

Resuspension of sediments was evaluated as a potential source of phosphorus to the water column. An amount equivalent to approximately 400 μ g TP/L in the water mass is present in the upper 5 cm of sediment and an amount equivalent to 1200 μ g TP/L is present in the upper 10 cm. Concentrations as large as 400 μ g TP/L are found very rarely during monitoring of the lake. These calculated amounts, therefore, are undoubtedly overestimates of the amount that might be resuspended at any one time, particularly because sediments are not likely to be resuspended over the entire lake bottom during most storm events and because some areas in the center of the lake which are subjected to the greatest effects of wave action have thin layers of flocculent sediments.

Conventional models of dating sediments with ²¹⁰Pb could not be used in Lake Apopka because the construction of dikes in the 1940s reduced the area of the lake basin. This reduction in surface area of the lake invalidates the assumption in models that ²¹⁰Pb flux to the sediments is constant over time. A hybrid model which adjusted ages so that the zone of flocculent sediments was 50 yr old was used to date flocculent sediments. During this time period, the flux of ²¹⁰Pb can be assumed to be constant. Ages and sedimentation rates calculated from the hybrid model indicated that sedimentation rate increased at least 2.1-fold and total phosphorus accumulation rate (TPAR) increased from 3.3-fold in the last 50 years. These results were then used to estimate the change in TP sedimentation over time.

Flocculent sediments were highly organic, averaging 63% organic matter measured as loss on ignition (LOI); therefore, sedimentation accumulation and mass sedimentation rate (MSR) are determined largely by organic matter. This characteristic is important in evaluating the ²¹⁰Pb chronology. A mean 2.1-fold increase in MSR in 50 yr was found using the hybrid model. This 2.1-fold increase can be attributed to an increase in organic matter production by phytoplankton in 50 years because sediments are highly organic. Increased production and sedimentation of organic matter over time can then be used to partly explain the relatively flat excess ²¹⁰Ph profiles. An increase in phytoplankton production is one of the expected consequences of increased phosphorus loading to the system that is inferred from historic increases in TP storage in the sediments.

Several lines of evidence, including TPAR obtained from ²¹⁰Pb dating, indicate that whole-basin rates of TP storage increased during the planktonic phase, approximately the last 50 yr. Average rates of TP storage for the period of phytoplankton dominance were estimated to be 45,000 kg yr⁻¹. This is slightly smaller than 49,100 kg yr⁻¹, an estimate by Brezonik et al. (1978) for net TP deposition (storage) in 1977. Average rates of deposition were 61.6% larger in the last 10 years and about 50% smaller during the first 10 years of phytoplankton dominance if the rate of TP accumulation increased 4-fold at a logarithmic rate during the 50-yr period of phytoplankton dominance.

The high abundance of meroplanktonic algae in near-surface sediments and storage of phosphorus by this algal community may be one of the factors contributing to artificially high MSR and TPAR at the tops of sediment cores. Data from LA9-95 show that *A. italica* has the greatest relative abundance in the upper 15 cm. The uptake and storage of phosphorus by meroplankton is a biogeochemical process that may account for the relatively large storage of phosphorus in recent sediments. Polyphosphate stored in these cells may be a significant phosphorus sink.

Estimated whole-basin inventories (storage) of organic matter in the last 50 yr are reasonable compared to estimated organic matter production by phytoplankton. Data on annual phytoplankton production in the lake are limited; however, organic matter sedimented in the past 50 yr is on the order of 10% of estimated phytoplankton production. This comparison indicates that calculated storage of organic matter closely approximates storage evaluated independently. This comparison and comparable estimates of TP sedimentation by Brezonik et al. (1978) and the present investigation validate data obtained in the present investigation. The whole-basin inventory of TP in flocculent sediments was 2.25 x 10^{6} kg (2,250 metric tons). This inventory which accumulated in 50 yr is 54 times larger than the present inventory of TP in the water column. These data indicate that residence time of phosphorus in the water column is short, on the order of one year. This calculation undoubtedly underestimates recent rates of TP sedimentation in the lake which have increased historically. These data show that the sediments are a significant sink for phosphorus.

The present investigation provides data to quantify phosphorus storage in sediments and to demonstrate that phosphorus loading and sedimentation have increased since 1947 during the planktonic phase of the lake. Data from the investigation are used to show that phosphorus storage has increased at least 3-fold in the last 50 yr based on decadal comparisons and as much as 4-fold if annual rates are compared. Changes in the assemblage composition of diatom microfossils in flocculent sediments also provide additional evidence that phosphorus loading has increased markedly in the past 50 yr.

Schelske, C.L., F.J. Aldridge, and H.J. Carrick. 1992. *Phytoplankton-nutrient interactions in Lake Apopka*. Special Publication SJ92-SP9. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Phytoplankton-Nutrient Interactions (LA-4-104-D)

EXECUTIVE SUMMARY

Phytoplankton-nutrient interactions in Lake Apopka were studied under an agreement between the St. Johns River Water Management District and the University of Florida. The study was instituted because Lake Apopka contains high concentrations of total phosphorus, and excessive algal (phytoplankton) growth has been identified as the prime symptom of eutrophication in this lake. High standing crops of phytoplankton are the result of excessive phosphorus loading and contribute to low light penetration in the water column. Studies on this shallow, hypereutrophic lake were conducted from December 1989 to November 1991. Results are presented in five chapters.

INTRODUCTION (CHAPTER 1)

Chapter 1 presents the purpose and scope of the report including a literature review on previous environmental conditions and management activities. The literature review includes discussion of the dramatic environmental changes that occurred in 1947 when the lake changed from a clear-water, macrophyte-dominated system to a turbid, phytoplankton-dominated system.

PHYTOPLANKTON PRODUCTION AND AMBIENT LAKE CONDITIONS (CHAPTER 2)

Results of a sampling program conducted from February 1990 to July 1991 are presented. Data collected twice-monthly include photosynthetically active radiation (PAR), water column light extinction, Secchi disc transparency, water temperature, dissolved oxygen, and chlorophyll *a*. This chapter also includes monthly measurements of phytoplankton productivity.

Except for water temperature and lake level, no distinct seasonal patterns were found in the parameters measured during the study. Seasonal patterns, if present, are obscured by large between-sampling differences in data collected twice-monthly. We obtained evidence that phytoplankton dynamics in this shallow lake are controlled by short-term dynamics in environmental processes. Algae and other materials that have settled to the bottom may be resuspended by wind-generated turbulence and periodically comprise a large fraction of measured phytoplankton and total suspended solids.

The high standing crops of phytoplankton are a major factor causing high turbidity in the lake. Measurements of Secchi disc transparency showed that the limit of visibility in the water ranged from 6–14 inches. Large ranges in other variables were found including K_t or light extinction (3.1–12.8 m⁻¹), water temperature (17.0–32.5°C), chlorophyll (44–217 mg m⁻³), maximum gross primary productivity (133–1149 mg C m⁻³ h⁻¹), and areal gross primary production (116–568 mg C m⁻² h⁻¹).

Although twice-monthly sampling is not adequate to characterize the short-term variation in phytoplankton dynamics in Lake Apopka, our results are valid to describe average conditions in the lake. These results provide an important database on which management decisions can be based and from which the results of management decisions can be assessed.

NUTRIENT ENRICHMENT BIOASSAYS (CHAPTER 3)

Results of monthly bioassays for nitrogen (N) and phosphorus (P) nutrient limitation are presented. The experimental approach was based on measuring responses of the algal community to nutrient enrichments of N, P, or N+P compared to non-enriched controls. Experiments were run in the laboratory under controlled light and temperature conditions using the natural phytoplankton assemblages present in the lake at the time water was collected. Comparison of experiments conducted in Lake Apopka with those conducted in the laboratory showed no statistically significant difference in response.

We conducted 20 experiments at approximately monthly intervals from December 1989 to July 1991 to determine if N or P was the primary limiting nutrient or a secondary limiting nutrient. Results from these experiments indicated that N was the primary limiting nutrient in 19 of the 20 experiments and that P was the primary limiting nutrient only once. Secondary P limitation was found in only 5 of the 19 experiments in which responses to N+P were statistically greater than the response to N alone.

We conclude that N is the primary limiting nutrient because the water of Lake Apopka generally contains large supplies of phosphorus that can be utilized for phytoplankton growth when the water is enriched with N. We also conclude that N limitation in Lake Apopka is the result of excessive P loading to the lake and that P supplies must be reduced to reduce standing crops of algae.

NUTRIENT-DILUTION BIOASSAYS (CHAPTER 4)

Chapter 4 presents results of bioassays for nitrogen (N) and phosphorus (P) nutrient limitation that were combined with dilution experiments. These studies are called nutrient-dilution bioassays because the experiments utilized nutrient enrichment with N, P, and N+P in combination with dilution of lake water to determine the effect of reduced nutrient supplies on phytoplankton growth and production. Lake water was diluted from 5% to 95% in these experiments. Effects of nutrient reduction must be known to predict or assess the impact of reduced nutrient loading on phytoplankton production and other ecosystem processes.

Although complex interactions characterized these experiments, results provide insight on the relative roles of N and P in establishing and maintaining the present hypereutrophic conditions in Lake Apopka. Most of the phosphorus occurs in phytoplankton, and a large portion is stored in phytoplankton as polyphosphates. This finding is important because the stored polyphosphate in phytoplankton can be used for growth in the absence of phosphorus in the water. Phytoplankton in the lake, therefore, are generally N-limited because of phosphorus storage in phytoplankton cells.

Clear evidence for reduction of biomass with dilution was obtained only in N treatments because N enrichment allowed the utilization of stored phosphorus for phytoplankton growth and eventually caused phytoplankton to be P-limited.

In general for treatments other than N enrichment, the biomass yield increased with dilution. This effect was most dramatic with the combined treatment of N+P, but was also evident in the control and P treatments. The unexpected increase in phytoplankton growth with dilution possibly can be attributed to one or more of the following factors: dilution increases the supply of nutrients for the diluted phytoplankton, zooplankton grazing on phytoplankton is relieved with dilution, artificial diluents like MIS may contain substances that enhance growth either directly or indirectly, allelopathic substances (growth-inhibiting compounds) may have been diluted, and light attenuation was reduced by dilution.

The cellular content of stored phosphorus in algae increased with dilution more than 3-fold. In the present marsh restoration project, increased P-storage capacity with dilution may aid in the removal of P from Lake Apopka by (1) removing available P more swiftly in waters that have been diluted with effluent from the marsh and (2) decreasing the internal P load by producing more P-rich particles to be deposited in the wetland. The relative effectiveness of this internal "P-pump," in concert with P removal by the wetland, requires additional experimentation in order to assess its role in the net export of P from Lake Apopka.

INDICATORS OF NUTRIENT STATUS (CHAPTER 5)

Nutrient enrichment bioassays (NEB) appear to be the most reliable indicator of nutrient limitation to phytoplankton in Lake Apopka. In addition to NEB, physiological indicators of N and P limitation can be used to provide an independent validation. For indices to be used as predictive tools of phytoplankton nutrient status, they need to be calibrated in parallel with NEB for phytoplankton assemblages of varying nutrient deficiency. The most appropriate methods for this are HEP (hot-water extractable phosphorus) storage or P-uptake for evaluation of P-limitation and N-uptake to corroborate N-limitation. All three of these assays are non-hazardous (avoid the use of harsh chemicals), simple to conduct (experimentation duration <24 h), and do not require any specialized equipment (e.g., radioisotopes) other than that used to measure basic water chemistry.

Routine chemical measurement of dissolved inorganic nitrogen in the water can be used to determine if phytoplankton are N-limited. The nutrient status of phytoplankton relative to N is not complicated by N storage in phytoplankton cells.

Schelske, C.L., M.F. Coveney, F.J. Aldridge, W.F. Kenney, and J.E. Cable. 1999. Wind or nutrients: Historic development of hypereutrophy in Lake Apopka, Florida. T. Berman, ed. In Proceedings from the Kinneret Symposium on Limnology and Lake Management 2000+, September 6–11, 1999, Tiberias, Israel.

PROJECT: Phytoplankton-Nutrient Interactions (LA-4-104-D)

ABSTRACT

Lake Apopka is a large (125 km°) , shallow (mean depth = 1.63 m), polymictic, hypereutrophic lake located 25 km north of Orlando, Florida. Before 1947, the macrophyte-dominated lake was characterized by clear water and a highly prized sports fishery. A switch in the primary producer community from macrophyte dominance to phytoplankton dominance has been attributed to a hurricane in 1947 that uprooted the submersed macrophytes. Paleolimnological data, however, show that phosphorus (P) loading increased before the switch. We propose shading by increased growth of phytoplankton stimulated by P enrichment as an alternative mechanism for the switch. Other workers have used records of storm tracks over Florida to rule out wind effects from the 1947 hurricane as the primary cause for the switch. Principal sources of P loading before the 1940s were from sewage discharge and citrus farming and processing. In the 1940s, P loading increased after 80 km² of adjacent sawgrass (Cladium jamaicense) wetlands were diked and drained so fertile histosols (muck soils) could be used for high-intensity agriculture. Eventually muck farm agriculture provided 85% of the areal total phosphorus (TP) loading, approximately 400 mg m² yr². Inferences from the paleolimnological record show that phytoplankton production and sedimentation of organic compounds derived largely from phytoplankton increased several fold during the phytoplankton phase in response to accelerated P loading. Phytoplankton and meroplankton that are resuspended during wind events and their by-products are presently the major components of light attenuation. Resuspension of meroplankton that assimilate nutrients in an aphotic benthic environment is an important factor in phytoplankton dynamics. Interactions of wind, nutrients, and light are important in maintaining the present hypereutrophic condition and its associated aphotic benthic environment. Management programs are underway to reduce P loading and increase water clarity and restore submersed macrophytes. Our paleolimnological results show that TP sedimentation is at least 360 mg m^{-2} yr⁻¹. TP residence time in the

water based on this TP sedimentation rate is 0.93 yr, which indicates sediments are an important P sink. Decreases in nutrient loading and the role of biological sinks that may affect or accelerate the response to reduced TP loading are discussed in an evaluation of current restoration strategies.

Schelske, C.L., and W.F. Kenney. 2001. Model erroneously predicts failure for restoration of Lake Apopka, a hypereutrophic, subtropical lake. *Hydrobiologia* 448:1–5.

PROJECT: Restoration Monitoring (LA-6-803-S)

ABSTRACT

A recent paper (Bachmann et al. 1999) based on analysis of literature data predicts failure for restoration plans implemented by the St. Johns River Water Management District (SJRWMD) for Lake Apopka, a large (125 km²), shallow (mean depth = 1.63 m), polymictic lake in central Florida. A marsh flow-way designed to remove particulates from inflowing water from Lake Apopka as a means to improve downstream and lake-water quality is part of the restoration plan. According to Bachmann et al. (1999) restoration "will be ineffective in removing particles from the lake" and fail because estimated time for removal of 2.21 million tons of historic sediments in a constructed marsh flow-way is 329 yr. This inadvertently proposed mining hypothesis given as a condition for successful restoration is based on questionable assumptions, i.e., removing all the historic sediments deposited over a 50-yr period with the flow-way and exporting concurrent sedimentation while historic sediments are being removed. These questionable assumptions are used in an erroneous, discontinuous model of sediment dynamics that does not justify the alternate approach for restoration of Lake Apopka suggested in their paper.

Schiffer, D.M. 1994. Quality of water and bottom sediments, and nutrient and dissolved-solids loads in the Apopka-Beauclair Canal, Lake County, Florida 1986–90. Water-Resources Investigations Report 93-4103. Tallahassee, Fla.: U.S. Geological Survey.

PROJECT: External Nutrient Budget (LA-1-101-D)

ABSTRACT

The water entering Lake Beauclair, in the Ocklawaha River chain of lakes in central Florida, has high concentrations of the nutrients nitrogen and phosphorus. Major sources of the nutrients entering Lake Beauclair are Lake Apopka outflow and drainage from farming operations adjacent to the Apopka-Beauclair Canal. The U.S. Geological Survey began a study in 1986 to determine the relative contribution of nutrient loads from these two sources.

Two flow and water quality monitoring sites were established to obtain data needed to calculate loads leaving Lake Apopka and at a control structure (the Apopka-Beauclair Canal lock and dam) between the two lakes. Water samples were collected at those sites biweekly for analysis of major ions during 4 years of the study. The study, which was originally scheduled to end in 1989, was extended to 1991 to provide an additional 2 years of data collection at a constriction built at the lake-outflow gaging site. Prior to 1988, discharge could not be gaged at the site because of low velocities. The constriction increased velocities in the canal and made it possible to gage discharge at the site. Regression analysis of discharge data collected at the gaged sites indicated that 64% of the variation in discharge at the lake-outflow site is explained by discharge at the lock and dam, and other hydrologic variables (rainfall, water-surface slope) explained 8% of the variation.

The quality of water in the Apopka-Beauclair Canal is relatively uniform during periods between storms. Analysis of water samples collected 1 to 2 days after storms, however, indicated that water quality is much more variable during these periods because of the effects of farm inflow (to the canal) at both the lake outflow and lock-and-dam sites. Sand, silt, and clay account for most of the native materials in the bed sediments of the canal, but muck (the highly organic fraction of the bottom sediments characterized by a high water content) and organic material are deposited downstream from Lake Apopka to a distance of about 0.5 mile (the location of the lake-outflow site). Higher median concentrations of carbon, and nitrogen and phosphorus species (except ammonia nitrogen) were measured in bottom sediments at the lake-outflow site than at the lockand-dam site, an indication that much of the nutrient load leaving the lake is not being transported downstream to Lake Beauclair.

Nutrient and dissolved-solids loads were computed for the two monitoring sites based on daily mean discharge and water-quality data linearly interpolated between samples. Loads at the lock and dam were fairly constant (a reflection of the controlled discharge at the site) except during periods of increased discharge (when gates were opened). Loads at the lake-outflow site were much more variable (a reflection of the more variable discharge at that site). An alternative approach for determining the relative nutrient-load concentration was derived using water-quality data for both locations and discharge data for the lock and dam. This approach involved the computation of a "canal-effective load," which is a measure of the effect on the total load measured at the lock and dam from farm activities along the canal and physical and chemical processes occurring in the canal between the two monitored sites. The canal-effective load represents the net increase (or decrease) in load at the lock and dam, above (or below) the load that would have been received from Lake Apopka if there were no farm discharge to the canal.

The maximum monthly nitrate-plus-nitrite nitrogen load at the lock and dam during the study was 41 tons in April 1987, and the maximum monthly canal-effective nitrate-plus-nitrite nitrogen load was 6.44 tons in September 1988. The canal-effective total nitrogen load generally was less than 10% of the total nitrogen load at the lock and dam. The annual phosphorus load ranged from 33 tons in the 1987 water year to 9.1 tons in the 1990 water year; canal-effective phosphorus load accounted for 11.4% of the annual phosphorus load in 1987 and 33% in 1990.

Much of the constituent load transported through the lock and dam on the Apopka-Beauclair Canal was transported during periods of high discharge. In April 1987, when discharges were as high as 589 cubic feet per second, loads transported through the lock and dam accounted for 59% of the ammonia-plus-organic nitrogen load, 61% of the total nitrogen load, 59% of the phosphorus load, 51% of the total organic carbon load, and 47% of the dissolved-solids load transported during the 1987 water year.

The canal-effective nitrogen load accounted for less than 10% of the total nitrogen load at the lock and dam, but most of the total phosphorus load was attributable to the canal-effective load. In December 1987 and January 1990, 69 and 73% of the total phosphorus load, respectively, was due to the canal-effective load. During the summer months of 1989, both load calculation methods indicated large inflows to the canal. In June and July 1989, 50% and 60%, respectively, of the total phosphorus load was attributable to the canal-effective load.

Load computations using the canal-effective load approach indicated that, with the exception of phosphorus, nutrient and dissolved-solids loads due to farm activity along the canal account for 10% or less of the total load at the Apopka-Beauclair Canal lock and dam.

Schramm, H.L., Jr., and L.L. Pugh. 1996. Gizzard shad stock estimate for Lake Apopka, Florida. Contract 95W121. Miss. Coop. Fish and Wildlife Res. Unit. Submitted to St. Johns River Water Management District, Palatka, Fla.

PROJECT: Rough Fish Harvesting (LA-3-302-M)

EXECUTIVE SUMMARY

Gizzard shad (*Dorosoma cepedianum*) have achieved a large biomass in Lake Apopka, Florida. Removal of a large portion of this biomass will remove significant amounts of phosphorus in this highly eutrophic lake and help create conditions more conducive for establishing desirable sportfish populations. Under the direction of the St. Johns River Water Management District, 281, 198 kg of gizzard shad were commercially removed from Lake Apopka in 1995 by gill nets. Evaluation of this restoration method requires determining the proportion of the total gizzard shad population harvested. This report provides population estimates of gizzard shad prior to harvest and evaluates methods used to produce the population estimates.

Population estimates were calculated by change-in-composition, depletion (Leslie estimate), and Baranov's catch equation methods. Input data for these calculations included harvest and fishing effort for the duration of the commercial fishery (16 January 5-April 1995); age, length, weight, and gender of fish in experimental gill net (6.4–12.7 cm square mesh) samples collected before and after the commercial fishery and monthly during the commercial fishery; and length data from commercial gill net catches during August–November 1995. Age was determined by analysis of sagittal otoliths obtained from the sampled fish. Validation of otoliths for aging gizzard shad was constrained by lack of otoliths collected throughout the year; however, marginal increment analysis of otoliths collected during January–June suggested otoliths provided accurate ages of gizzard shad in Lake Apopka. We assumed the ages of gizzard shad assigned by otolith analysis were accurate and used these ages in population estimation calculations.

The changes-in-composition method estimated the population of Lake Apopka gizzard shad was 1,618,354 fish (95% confidence limits [CL] = 1,441,597 and 1,795,111 fish) weighing 657,537 kg (95% CL = 585,721 and 729,354 kg). This estimate excludes the segment of the population too small to be effectively sampled by the experimental gill nets (<280 mm).

The depletion method estimated the population was 1,505,811 fish (95% CL = 2,925,094 and 4,969,049 fish) weighing 2, 195,874 kg (95% CL = 1,656,481 and 2,813,972 kg). This estimate is for fish longer than 280 mm and age 1 or older. Expanding the estimate to

the entire population resulted in an estimated 12,041,034 fish weighing 2,911,809 kg. This estimate equate to a standing crop of 233 kg/hectare, which is lower than expected for hypertrophic Lake Apopka.

Population estimates from the change-in-composition method and the catch equation method both provided estimates with reasonable and relatively narrow confidence limits. Although the catch equation method resulted in a population estimate more than twice the estimate obtained by the change-in-composition method, both estimates must be considered equally reliable based on similarly narrow confidence limits. Both methods are subject to errors in measurement of input parameters obtained at the beginning and end of the harvest period.

A total of 281, 198 kg and an estimated 402,493 gizzard shad were harvested from Lake Apopka during January–April 1995. This harvest was 25% and 9% of the number of harvestable fish estimated by the change-in-composition and catch equation methods, respectively; and 43% and 11% of the weight of harvestable fish estimated by the change-in-composition and catch equation methods, respectively.

Future estimation of Lake Apopka gizzard shad should use the change-in-composition and catch equation methods. Both methods are subject to errors in measurement of input parameters obtained at the beginning and end of the harvest period. The reliability of future population estimates can be increased by greater harvest; complete subsampling of landings to measure length, weight, gender, and age of at least 300 fish during each month of the commercial fishery; and measuring length, weight, gender, and age of at least 300 fish from experimental gill net samples collected immediately before and after the commercial harvest program. Future interpretation of population estimates by these two methods should consider trends in population estimates and sensitivity analyses for variation in input parameters should be performed.

Schramm, H.L., Jr., and L.L. Pugh. 1997. *Gizzard shad stock estimate for Lake Apopka, Florida 1995.* Special Publication SJ97-SP10. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Rough Fish Harvesting (LA-3-302-M)

EXECUTIVE SUMMARY

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phosphorus in this highly eutrophic lake and help create conditions more conducive for establishing desirable sportfish populations. Under the direction of the St. Johns River Water Management District, 281, 198 kg of gizzard shad were commercially removed from Lake Apopka in 1995 by gill nets. Evaluation of this restoration method requires determining the proportion of the total gizzard shad population harvested. This report provides population estimates of gizzard shad prior to harvest and evaluates methods used to produce the population estimates.

Population estimates were calculated by change-in-composition, depletion (Leslie estimate), and Baranov's catch equation methods. Input data for these calculations included harvest and fishing effort for the duration of the commercial fishery (16 January – 5 April 1995); age, length, weight, and gender of fish in experimental gill net (6.4–12.7 cm square mesh) samples collected before and after the commercial fishery and monthly during the commercial fishery; and fish length and weight data from commercial gill net catches during August–November 1995. Age was determined by analysis of sagittal otoliths obtained from the sampled fish. Validation of otoliths for aging gizzard shad was constrained by lack of otoliths collected throughout the year; however, marginal increment analysis of otoliths collected during January–June suggested otoliths provided accurate ages of gizzard shad in Lake Apopka. We assumed the ages of gizzard shad assigned by otolith analysis were accurate and used these ages in population estimation calculations.

The change-in-composition method estimated the population of Lake Apopka gizzard shad was 1,618,354 fish (955 confidence limits [CL] = 1,441,597 and 1,795,111 fish weighing 657,537 kg (95% CL = 585,721 and 729,354 kg). This estimate excludes the segment of the population too small to be effectively sampled by the experimental gill nets (,280 mm).

The depletion method estimated the population was 1,505,811 fish (95% CL = 903,490 and 18,390,461 fish) weighing 928,634 kg (95% CL = 557,182 and 11,341,397 kg). This estimate is for gizzard shad longer than 300 mm. Although similar to the change-in-composition estimate, the precision of the estimate was low. The variation in catch rates and relatively low harvest reduced the reliability of this estimate.

The catch equation method estimated the population was 3,877,582 fish (95% CL = 2,925,094 and 4,969,049 fish) weighing 2, 195,874 kg (95% CL = 1,656,481 and 2,813,972 kg). This estimate is for fish longer than 280 mm and age 1 or older. Expanding the estimate to the entire population resulted in an estimated 12,041,034 fish weighing 2,911,809 kg. This estimate equates to a standing crop of 233 kg/hectare, which is lower than expected for hypereutrophic Lake Apopka.

Population estimates from the change-in-composition method and the catch equation method both provided estimates with reasonable and relatively narrow confidence limits. Although the catch equation method resulted in a population estimate more than twice the estimate obtained by the change-in-composition method, both estimates must be considered equally reliable based on similarly narrow confidence limits. Both methods are subject to errors in measurement of input parameters obtained at the beginning and end of the harvest period.

A total of 281, 198 kg and an estimated 402,493 gizzard shad were harvested from Lake Apopka during January–April 1995. This harvest was 25% and 9% of the number of harvestable fish estimated by the change-in-composition and catch equation methods, respectively; and 43% and 11% of the weight of harvestable fish estimated by the change-in-composition and catch equation methods, respectively.

Future estimation of Lake Apopka gizzard shad should use the change-in-composition and catch equation methods. Both methods are subject to errors in measurement of input parameters obtained at the beginning and end of the harvest period. The reliability of future population estimates can be increased by greater harvest; complete subsampling of landings to measure length, weight, gender, and age of at least 300 fish during each month of the commercial fishery; and measuring length, weight, gender, and age of at least 300 fish from experimental gill net samples collected immediately before and after the commercial harvest program. Future interpretation of population estimates by these two methods should consider trends in population estimates and sensitivity analyses for variation in input parameters should be performed.

Schramm, H.L., Jr., and L.L. Pugh. 1997. *Gizzard shad stock estimate for Lake Apopka, Florida 1996.* Special Publication SJ97-SP11. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Rough Fish Harvesting (LA-3-302-M)

EXECUTIVE SUMMARY

Gizzard shad (*Dorosoma cepedianum*) have achieved a large biomass in Lake Apopka, Florida. Removal of a large portion of this biomass will remove significant amounts of phosphorus in this highly eutrophic lake and help create conditions more conducive for establishing desirable sportfish populations. Under the direction of the St. Johns River Water Management District, 249,748 kg of gizzard shad were commercially removed from Lake Apopka in during March–May 1996. Evaluation of this restoration method requires determining the proportion of the total gizzard shad population harvested. This report provides population estimates of gizzard shad prior to harvest and evaluates methods used to produce the population estimates.

Population estimates were calculated by change-in-composition, depletion (Leslie estimate), and Baranov's catch equation methods. Input data for these calculations included harvest and fishing effort for the duration of the commercial fishery (7 March-23 May 1996); age, length, weight, and gender of fish in experimental gill net (6.4–12.7 cm square mesh) samples collected before and after the commercial fishery and monthly during the commercial fishery; and fish length and weight data from commercial gill net catches during January–May 1996. Age was determined by analysis of sagittal otoliths obtained from the sampled fish. Validation of otoliths for aging gizzard shad was constrained by lack of otoliths collected throughout the year; however, marginal increment analysis of otoliths collected during January–June suggested otoliths provided accurate ages of gizzard shad in Lake Apopka. We assumed the ages of gizzard shad assigned by otolith analysis were accurate and used these ages in population estimation calculations.

The change-in-composition method estimated the population of Lake Apopka gizzard shad age-1 and older in February 1996 was 726,228 fish (95% confidence limits [CL] = 718,706 and 733,750 fish) weighing 245,683 kg (95% CL = 243,138 and 248,228 kg). The estimate for the total population (all ages) was 2,0 19,268 fish weighing 458,129 kg.

The depletion method estimated the population of age-1 gizzard shad in February 1996 was 899,681 fish (95% CL = 732,753 and 1,288,907 fish) weighing 375,527 kg (95% CL = 305,851 and 537,990 kg). The depletion method estimated the total population was 2,200, 192 weighing 589,201 kg.

The catch equation method estimated the population of age-1 gizzard shad in January 1995 was 2,073,744 fish (95% CL = 1,947,327 and 2,204,113 fish) weighing 1,174,361 kg (95% CL = 1,102,771 and 1,248,189 kg). Expanding the estimate to the entire population resulted in an estimated 6,455,109 fish weighing 1,917,002 kg.

We consider all three methods appropriate for the population estimated and the data available. Therefore, the best estimate of the total gizzard shad population is 2,0 19,268–6,455,109 fish weighing 458,129–1,917,002 kg. This estimate equates to a density of 162–518 fish/hectare and a biomass of 37–154 kg/hectare which is lower than expected for hypertrophic Lake Apopka.

In January–April 1995, the subsidized commercial fishery harvested 281, 198 kg of gizzard shad; estimated exploitation rates, based on three population estimates for

January 1995 were 24–43%. During March–May 1996, the subsidized commercial fishery harvested 249,748 kg of gizzard shad; this harvest amount was 67–102% of the estimated harvestable population weight in February 1996.

While the comparison with other biomass estimates and high exploitation rates suggest the population estimates are low, several population variables support high exploitation rate and, hence, relatively small population size. First, gizzard shad in Lake Apopka had rapid growth rate and recruited to the commercial fishery at age-1; new recruits are a large portion of the commercial landings. Second, high exploitation rates are expected to result in overfishing. The lower estimated population in 1996 than in 1995 (Schramm and Pugh 1996), and the decline in mean weight of fish in each age class from February 1996 to May 1996 indicate overfishing occurred.

We conclude that the population estimates provided in this report are reasonable. Based on these estimates, the harvest of gizzard shad during 1995 and 1996 substantially reduced the Lake Apopka gizzard shad population.

Segal, D.S., and C.D. Pollman. 1991. Assessment of potential sediment contamination for the restoration of Lake Apopka. Special Publication SJ91-SP8. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Internal Nutrient Budget (LA-1-102-D)

EXECUTIVE SUMMARY

Lake Apopka forms the headwaters of the Oklawaha chain of lakes, eutrophic to hypereutrophic water bodies located in central Florida approximately 25 km northwest of Orlando. Once a popular resort area noted for its game fishing, Lake Apopka is now ranked as the seventeenth-most eutrophic lake in Florida. This condition results largely from direct backpumping of nutrient-enriched irrigation water from muck farms on the northern shores of the lake into Lake Apopka and from past sewage treatment practices by the City of Winter Garden. The St. Johns River Water Management District (SJRWMD) has been charged by the Florida state legislature to assess the feasibility of restoring Lake Apopka to Class III water quality standards (Chapter 17-3, *F.A.C.*). Priority issues in the restoration program outlined by the SJRWMD in the Lake Apopka Surface Water Improvement and Management (SWIM) Plan include poor water quality and excessive accumulation of flocculent organic sediments. Dredging nutrient-rich sediments from Lake Apopka and reuse of the dried muck has been suggested as a restoration technique. The newly initiated marsh flow-way project uses a restored 950-acre wetland to filter water from the lake, which will result in substantial deposition of lake sediments in the restored wetland. Artificial barriers to stabilize the sediment, reduce nutrient release, and improve plant habitat are also being considered as possible tools in lake restoration. A survey of levels and potential toxic effects of substances in Lake Apopka sediments was necessary to support these and other projects. This contamination assessment is especially important if dredged sediments are reused, such as for soil amendments, as a cost-recovery method for dredging.

The goals of this project were the following:

- 1. To analyze sediment samples from two depths at ten locations in Lake Apopka for the 152 elements and compounds on the EPA Target Compound List
- 2. To tabulate the analytical results
- 3. To determine the potential toxic and deleterious effects of those elements or compounds on lake biota, fisheries, and other recreational uses of the lake

An extensive literature search revealed a large number of lake water toxicity studies, which focused primarily on chronic and acute effects. In contrast, the availability of similar guidelines or criteria for sediment-associated toxicity was much more limited, and criteria were available only for the Great Lakes, Canada, and Wisconsin. Because these criteria were developed for northern temperate systems, their applicability to Lake Apopka is uncertain. Therefore, for this survey, when contaminant concentrations exceeded both the north-temperate sediment criteria and the reported EPA threshold for toxicity in water, the contaminant was considered potentially toxic to the lake's biota.

Comparison of contaminant concentrations in bulk sediments with toxicity criteria developed for lake water generally provides a very conservative analysis. Sediment concentrations reflect not only the dissolved free forms, but also forms that are chemically bound to sediment particles, which often renders them less toxic. These comparisons should serve to identify potential contamination problems, but may also exaggerate actual toxicity risks.

In Lake Apopka sediments, 13 of the 152 elements and compounds occurred in sufficiently high concentrations to warrant detailed examination. Based on these comparisons, copper and lead appear to pose the greatest threat of toxicity to Lake Apopka. Concentrations of arsenic and selenium exceed both the sediment threshold criteria and chronic aquatic threshold criteria but not the acute aquatic threshold criteria, and hence may be toxic to the lake's biota. Sediment concentrations of barium, beryllium, chromium, and zinc suggest potential toxicity as well, although the evidence for toxicity is less well established because of the lack of aquatic toxicity studies (barium, beryllium) or because levels in the sediments compared across media (sediments and water) did not consistently exceed established criteria (zinc and chromium). Concentrations of nickel are below established threshold criteria. Toxicity threshold data for vanadium, acetone, and benzoic acid were insufficient to determine the potential toxicity of these contaminants in Lake Apopka.

Although elevated levels of some elements and compounds appear to occur in Lake Apopka sediments, it is difficult to assess the effects these contaminants will have on the lake's biota because of the complex interactions that occur in biological systems. For example, the toxicity of many elements declines in hard water. The relatively high water hardness in Lake Apopka sediments should ameliorate potential toxic effects of these elements. However, because of the debilitating health effects that some contaminants cause, combined with the desire to restore Lake Apopka to a healthy sport fishery lake, it is suggested that further consideration be given to those elements and compounds that exceeded both sediment and lake water threshold criteria values.

Sheng, P., X. Meng, and S. Schofield. 1994. Assessment of hydrodynamic conditions in Lake Apopka. Vol. I. Analysis of wind data from Lake Apopka and Orlando Airport. Final report for St. Johns River Water Management District, Palatka, Fla. University of Florida, Gainesville.

PROJECT: Hydrodynamic Survey (LA-4-109-D)

INTRODUCTION

Lake Apopka is a large (31,000 acres), shallow (mean depth 5.4 ft) hypereutrophic lake located approximately 30 miles northwest of Orlando, Fla. Through the SWIM program, the St. Johns River Water Management District (SJRWMD) is creating a 5,000-acre marsh flow-way on former agricultural lands on the NW shore of Lake Apopka. The flow-way will recirculate Lake Apopka water to remove solids and nutrients by filtration. Through 1-2 intakes located on the eastern side of the marsh, lake water is drawn into the marsh, while subsequently the marsh water is discharged from the northern end near the entrance to the Apopka-Beauclair Canal (ABC). To effectively utilize the marsh, it is desirable to minimize hydraulic short-circuiting, a condition which occurs when most of the discharge water is quickly drawn into the intakes. To minimize the hydraulic short-circuiting of discharge water, it is essential to quantify the flow patterns in Lake Apopka during a variety of meteorological conditions.

Among the various meteorological conditions, wind forces play the dominant role in affecting Lake Apopka's flow patterns. Thus, in order to be able to quantitatively assess the probability of hydraulic short-circuiting, it would be useful to understand the wind field patterns at Lake Apopka.

CONCLUSIONS

1. Lake Apopka is located in the middle of the Florida Peninsula, where the weather conditions are influenced by the air flows over the Atlantic Ocean and Gulf of Mexico, cold air from the north and warm air from the south. The weather conditions in this area are very unstable due to such a complicated air flow environment, and vary from year to year.

2. The wind speed ranges at Orlando Airport are obviously very different from those at Lake Apopka. These differences should be mainly resulted from the totally different surrounding environments at these two sites, which would also affect the turbulence structure of the wind field, and in turn affect the wind forces over the lake. Therefore, it would be inappropriate to use the wind data at Orlando Airport as a substitute for the wind conditions at Lake Apopka.

3. Generally, N/NE and S/SW wind prevail over Lake Apopka on yearly and monthly bases.

4. From the wind roses, we can tell that the extent to which N/NE and S/SW prevail is quite limited due to (1). To decide the optimal location and to design the intake and discharge points for the flow-way to minimize hydraulic short-circuiting, the chance of occurrence of wind in each direction should be equally considered.

Sheng, P., and S. Schofield. 1994. Assessment of hydrodynamic conditions in Lake Apopka. Vol. II, Bathymetric surveys of the northwest section of Lake Apopka. Final report prepared for St. Johns River Water Management District, Palatka, Fla. University of Florida, Gainesville.

PROJECT: Hydrodynamic Survey (LA-4-109-D)

Abstract

The northwest section of Lake Apopka was surveyed during December 1992. A bathymetric survey grid was laid out to obtain fine resolution (200 ft) contour spacing along the northwest area of the lake, encompassing approximately 10 square miles. The survey was conducted using a microwave positioning system for positioning and an Innerspace depth sounder. The depths were corrected for a lake level of 66 ft (MSL). Results of the 1992 survey are summarized in Part A of this volume.

Results of the 1992 bathymetric survey were used in the three-dimensional model simulation of wind-driven circulation in Lake Apopka (Sheng and Meng 1994, Vol. V of the report series). Results of the model simulations suggested that a 50 ft grid resolution is needed to more accurately represent the flow and dye dispersion in the northwest section of Lake Apopka. Hence, a finer resolution (50 ft) bathymetric survey was conducted over a 0.843 square mile area in the northwest section of the lake during February 1994. Results of the 1994 survey are presented in Part B of this volume.

Sheng, P., and S. Schofield. 1994. Assessment of hydrodynamic conditions in Lake Apopka. Vol. III, Lake Apopka 1992 field data report. Final report prepared for St. Johns River Water Management District, Palatka, Fla. University of Florida, Gainesville.

PROJECT: Hydrodynamic Survey (LA-4-109-D)

ABSTRACT

A field study on the hydrodynamics of Lake Apopka was conducted in August and September 1992. Various meteorological and hydrodynamic instruments were mounted on three instrument towers located in the northwest, central, and southeast sections of the lake. Comprehensive data at the Center Tower and Southeast Tower were successfully collected over a 14-day period. The Northwest Tower malfunctioned most of the time due primarily to the damages incurred by lightning strikes during the first week of deployment, except during several 3-day periods. Results of the data analysis showed that diurnal wind variation associated with lake breeze generated significant seiche oscillation and currents (up to 10 cm/s) in the lake. Diurnal temperature fluctuation was found to be significant at all the stations, although vertical temperature stratification was not significant. The flow data are used for numerical simulation as described in Vol. V of the report. Significant temporal variation in suspended sediment concentration (100–400 mg/L) was also found. Sheng, P., S. Schofield, X. Meng, and K. Ellins. 1994. Assessment of hydrodynamic conditions in Lake Apopka. Vol. IV, Dispersion of discharge water from the Apopka-Beauclair Canal into Lake Apopka. Final report prepared for St. Johns River Water Management District, Palatka, Fla. University of Florida, Gainesville.

PROJECT: Hydrodynamic Survey (LA-4-109-D)

ABSTRACT

As part of the study entitled "Assessment of Hydrodynamic Conditions in Lake Apopka" funded by the St. Johns River Water Management District, a tracer study was conducted by the Coastal and Oceanographic Engineering Department of the University of Florida to track the discharge from the Apopka-Beauclair Canal to Lake Apopka.

On January 27 1993, 25 pounds of Rhodamine-WT dye was injected into the Apopka-Beauclair Canal in the northwest quadrant of Lake Apopka during a weather event exhibiting northerly winds. The canal discharge was at approximately 100 cfs, 50% of full capacity. The dye was tracked with a fluorometer mounted on a boat from 15:30 until 17:24. At the same time, aerial photographs were taken from an airplane flying at 3500 ft altitude between 14:50 and 16:56. In addition to the Rhodamine dye, SF_{6} was also injected into the Apopka-Beauclair Canal and water samples were collected from the boat. Results from the fluorometer readings, aerial photographs, and analysis of SF. samples all revealed consistent dispersion patterns of the discharge water: an initial southward movement and a subsequent eastward movement of the discharge plume, which contained a large amount of mud. The discharge water did not reach the water intake on the west shore during the course of the study period, although there was some westward movement of the mud and dye plume. Model simulations suggested that finer resolution bathymetry and numerical grid could lead to improved model results. A finer (50-ft) resolution bathymetric survey was conducted in February 1994 and its results were used in the refined model simulation for investigating the potential of short circuiting.

Sheng, P., S. Schofield, X. Meng, and K. Ellins. 1994. Assessment of hydrodynamic conditions in Lake Apopka. Vol. V, A three-dimensional hydrodynamic numerical model of wind-driven circulation in Lake Apopka (LAHM3D): Theory, Model documentation, user's manual and model simulation. Final report prepared for St. Johns River Water Management District, Palatka, Fla. University of Florida, Gainesville.

PROJECT: Hydrodynamic Survey (LA-4-109-D)

INTRODUCTION

This report details the development, calibration, and validation of LAHM3D model (Lake Apopka Hydrodynamic Model-3D), which is a numerical model for calculating three-dimensional unsteady flow in Lake Apopka. Given proper boundary and initial conditions, geometry and bathymetry of a water body, the model is able to calculate the three-dimensional, time-dependent distributions of flow velocity (u, v, w), temperature (T), density (ρ), and dissolved species concentration (c) in Lake Apopka.

CONCLUSIONS

LAHM3D model has been developed to simulate the wind-driven circulations in Lake Apopka. Results of a two-day model calibration and an eight-day model validation are quite reasonable, based on comparison between simulated and measured currents. Pending further improvement, the model can be used to provide detailed 3-D circulation patterns in Lake Apopka over long time periods as well as over transient events of short durations.

The "irregularity" in the measured data at the Southeast Tower suggests the significant influence by abrupt bathymetric variation and hence, the need for finer-resolution bathymetric data to accurately represent the abrupt depth variation for a successful model simulation. Future study should also measure the water level in the lake so that model simulation of water level can be validated. Despite our effort, we did not obtain good data at the Northwest Tower. Tracer study, as opposed to in-situ mooring, could be used to obtain circulation patterns there.

The LAHM3D model could be further enhanced to include the following:

SWIM Plan for Lake Apopka

- A moving boundary (flooding-drying) algorithm to simulate the movement of shoreline during severe storm conditions
- A vegetation canopy model to parameterize the effect of vegetation on circulation in the marsh area
- A 3-D sediment transport model to allow the simulation of movement of fine sediments in various parts of Lake Apopka
- A 3-D water quality model to allow estimation of nutrient budget of Lake Apopka for better lake management

Shireman, J.V., and K.K. Opuszynski. 1992. *Ichthyofaunal reconstruction for the management of phytoplankton*. Special Publication SJ92-SP4. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Ichthyofaunal Reconstruction (LA-4-206-F)

EXECUTIVE SUMMARY

Experimental ponds were used to test the hypothesis that bighead carp, a filter-feeding fish, could improve water quality and reduce the excessive growth of nuisance algae in Lake Apopka. Six experimental ponds were built adjacent to the lake and received water from Lake Apopka. Four ponds were stocked with bighead carp. Two ponds were not stocked and used as control ponds.

Out of 16 physics-chemical parameters measured, seven were significantly different between Lake Apopka and the ponds. Secchi disk visibility was greatest in the ponds, along with higher values of specific conductance. Total alkalinity in the fish stocked ponds was higher than in the lake, but no difference was found between the control ponds and the lake. Total nitrogen, total phosphorus, total chlorophyll *a*, and filtered chlorophyll *a* were higher in the lake.

No differences in plankton abundance were found between the lake and the control ponds for blue-green algae (*Botryococcus braunii*), total algae number, rotifers, copepods, and total zooplankton number groups. These parameter values, however, were significantly lower in the ponds stocked with bighead carp than in the lake. It suggests that bighead carp exerted some effect on the pond ecosystem, but this effect was not large enough to cause significant differences between the stocked and unstocked ponds. The algal community in the ponds and lake was characterized by an extreme dominance of blue-green algae, reduced number of total algal species, and a clear dominance by several algal species (*Spirulina lesissuna, Lyngbya contorta, L. limnetica, L.*

lagerheinii and *Microsystis incerta*). A large green algae (*Botryococcus Braunii*), despite low numerical occurrence, constituted an important component of the algal biomass (more than 45% at the lake intake site and more than 25% in the ponds, based on chlorophyll *a* determination). Bighead carp fed selectively on *B. braunii*, which comprised 66–70% of the volume and 50–60% of the dry weight of the fish food. Bighead carp did not reduce algal numbers in the ponds but did decrease the ratio of blue-green/green species in the pond algal community. Using the data collected in this study, we calculated that a biomass of 750 kg/ha of bighead carp would be needed to cause a significant reduction in *B. braunii* abundance in Lake Apopka within eight days. This biomass was not achieved during the study due to the slow growth and high mortality of stocked fish and the short experimental time period. The small size of the fish also contributed to their inability to reduce the algal biomass.

Shumate, B.C., C.L. Schelske, T.L. Crisman, and W.F. Kenney. 2002. Response of the cladoceran community to trophic state change in Lake Apopka, Florida. *Journal of Paleolimnology* 27:71–77.

PROJECT: Phytoplankton-Nutrient Interactions (LA-4-104-D)

ABSTRACT

A paleolimnological evaluation of cladoceran microfossils was initiated to study limnological changes in Lake Apopka, a large (125 kg^2) , shallow (mean depth = 1.6 m), warm, polymictic lake in central Florida. The lake switched from macrophytes to algal dominance in the late 1940s, creating a Sediment Discontinuity Layer (SDL) that can be visually used to separate sediments derived from macrophytes and phytoplankton. Cladoceran microfossils were enumerated as a means of corroborating extant eutrophication data from the sediment record. Inferences about the timing and trajectory of eutrophication were made using the cladoceran-based paleoreconstruction. The cladoceran community of Lake Apopka began to change abruptly in both total abundance and relative% abundance just before the lake shifted from macrophytes to algal dominance. Alo affinis, a mud-vegetation associated cladoceran, disappeared before the SDL was formed. Plankton and benthic species also began to increase below the SDL, indicating an increase in production of both planktonic and benthic species. Chydorus cf. spaericus, an indicator of nutrient loading, increased relative to all other cladocerans beginning in the layer below the SDL and continuing upcore. Changes in the transitional sediment layer formed before the lake switched to phytoplankton dominance, including an increase in total phosphorus concentration, suggest a more gradual eutrophication process than previously reported. Data from this

SWIM Plan for Lake Apopka

study supported conclusions from other paleolimnological studies that suggested anthropogenic phosphorus loading was the key factor in the euthrophication of Lake Apopka.

St. Johns River Water Management District. 1999. Wetland hydraulic investigation project, Lake Apopka test channel status report. Technical memorandum 38. Palatka, Fla.

PROJECT: Marsh Flow-Way Restoration (LA-3-301-M)

OBJECTIVE:

The objective of this study is to investigate the relationship between vegetation characteristics and flow resistance in shallow wetlands with emergent vegetation. The focal point of the study is the selection of an appropriate methodology, including a set of vegetation parameters, enabling the formulation of a relationship between vegetation, and flow characteristics in a wetland environment. The vegetation characteristics considered include type of vegetation, vegetation density, stem diameter, stem height, percent cover, and leaf area. Flow characteristics considered include flow depth, flow velocity, and flow resistance as quantified by Manning's roughness coefficient.

St. Johns River Water Management District. 2000. District water management plan. Palatka, Fla.

PROJECT: District Water Management Plan (LA-6-501-M)

EXECUTIVE SUMMARY

All five water management districts (WMDs) are required to prepare district water management plans (DWMPs) and update them every five years. The first update of the St. Johns River Water Management District (SJRWMD) DWMP is summarized in this document.

DWMPs provide long-range guidance for WMD activities and present a compilation of water resource information that forms the basis for water management. SJRWMD's DWMP sets direction for the District's strategic plans, fiscal plans, and other planning efforts.

The overall goal for the DWMPs and activities of all the WMDs is stated in the Water Resources element of the State Comprehensive Plan (Chapter 187, *FS*) as follows:

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

The format of the DWMPs was developed through the cooperative efforts of the five WMDs and the Department of Environmental Protection (DEP). Each plan provides goals, issues, objectives, and strategies for each of the four WMD areas of responsibility (AORs):

- Water supply
- Flood protection and floodplain management
- Natural systems

The state's goal for water resources is realized through the individual district goals for each AOR. Issues in the SJRWMD plan were identified in resource assessments and a series of workshops held in 14 counties for local government staff, elected officials and the public. The issues will be addressed through implementation of DWMP strategies over the next five years. Progress will be tracked using measures specific to each district's particular programs in addition to a set of state performance measures developed by the WMDs, DEP and the Governor's Office.

Maps portraying the results of the resource assessments can be found in the complete plan, which also contains general information on the SJRWMD such as its natural resources, population and land use and an overview of each of its ten major watersheds. This summary document presents the goal, issues, objectives, strategies, and performance measures for each AOR and also issues, strategies and performance measures specific to each watershed.

St. Johns River Water Management District. 2001 (draft). Lake Apopka marsh flow-way plan for initial operation and pesticide monitoring and exposure management. Palatka, Fla.

PROJECT: Marsh Flow-Way Restoration (LA-3-301-M)

SUMMARY

Reduction in P loading is a primary component of the Lake Apopka Restoration Program and the restoration efforts for the downstream Ocklawaha Chain of Lakes. Ongoing drainage of the MFW site discharges a fraction of labile P to Lake Apopka. The labile pool of P in the soils increases while the site is dry, which may result in even greater discharges of P when the MFW finally starts operation. The restoration of Lake Apopka and downstream lakes in the Ocklawaha Chain of Lakes (e.g., Beauclair, Dora, and Eustis) will be delayed by not operating the MFW.

Not operating the MFW not only slows restoration of Lake Apopka but also does not completely remove the risks from soil pesticide residues. While dry, the soils remain exposed to terrestrial wildlife. The soil thresholds (Exponent 2000) discussed in this plan and in a previous risk analysis by ATRA (1997) suggest that OCPs do not pose an acute toxicity threat to wildlife, but may pose a long-term sub-lethal risk. During operation, the residual OCP concentration in the soils of the MFW create limited sublethal risk for wildlife; but these risks appear to be low. This is supported by the observation that when the MFW Demonstration Project was in operation from 1990 to 1997, no bird deaths or sick birds were observed at the site. The former fields north of Phase I, which are the locations for future MFW phases, have been flooded since 1994 to reduce soil oxidation and mineralization. No deaths of birds have been observed in any of these areas as well. Moreover, in the MFW, there will be minimal exposure to the existing contaminated soils due to the rapid accrual of new sediment, dense vegetation within the cells, and the biodegradation of the OCPs under anaerobic conditions.

Although the chronic risks to wildlife appear low, the District will implement a monitoring and management program to track OCP levels in soils and biota to ensure that the realized risks are indeed low. District personnel will be at the MFW regularly for monitoring and maintenance and will be able to act quickly and effectively if problems do arise. If problems develop, the MFW's pumps and water control structures will allow changes in water levels or flows to be rapidly implemented. The information gathered as part of the OCP monitoring effort for the MFW will be available to guide restoration efforts at the NSRA and other wetlands.

Restoration of Lake Apopka will yield substantial ecological and economic benefits. Initiation of operation of Phase I of the MFW is a critical step towards realizing these benefits. Operation of Phase I also provides a means of rapidly reducing the risks to wildlife posed by OCPs in the farmed soils. For these reasons, it appears prudent to initiate operation of Phase I as described in this document. Stenberg, J.R., D.L. Day, and G.R. Best. 1991. Development of natural vegetation in the Lake Apopka Marsh Flow-Way Demonstration Project: Phase I—Baseline conditions, fall 1990. Special Publication SJ91-SP11. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Marsh Flow-Way Restoration (LA-3-301-M)

EXECUTIVE SUMMARY

The objective of this paper is to present the results of a study of the baseline vegetation conditions in the Apopka Marsh Demonstration Project. Data collected during this study will provide a pre-flooding reference point for comparison with future evaluations as the marsh develops.

For the purposes of this report, discussion of the marsh is divided into two sections the north and south marshes. This division not only differentiates the two sites by land use history, but also separates the marshes into the inflow marsh (south marsh) and outflow marsh (north marsh). Historically, the north marsh has been farmed for the longest time (1950–1988). The south marsh has been intermittently farmed since about 1965.

A sampling grid containing permanent community and temporary biomass sampling plots was established in the fall of 1990 along a downstream gradient from the lake water inlet to the outflow pumps. Also, a 600 m transect was established from near the inlet downstream along the flow direction to provide higher resolution measurements. Sampling intensity was 0.014% of the total marsh area.

Data collected consisted of plant species composition, percentage cover, height, density, phenology, and water depth. Aboveground vegetation was clipped at ground level from one plot per sampling node. Belowground biomass was sampled at grid points near the inlet to determine preliminary estimates of belowground biomass averages and variation. Soil cores were collected and placed in a greenhouse under a moist soil treatment to determine the composition of the soil seed bank.

Sixty-four plant species were found. Each plant species was categorized according to its wetland affinity. The categories were as follows:

• Obligate Hydrophyte—found in wetlands >99% of the time

- Facultative-Wetland—usually found in wetlands 67–99% of the time
- Facultative—found in wetlands 34-66% of the time
- Facultative-Upland—occasionally found in wetlands 1–33% of the time
- Upland—seldom found in wetlands <1% of the time

The proportions of species by wetland affinities were: obligate hydrophyte (51%), facultative-wetland (24%), facultative (16%), facultative-upland (8%), and upland (2%). The north marsh was dominated by dogfennel (Eupatotiwn capillifolium) stands separated by grass and herb fringed canals. The south marsh was a complex aggregate of wetland and marginal wetland plants, including, dayflower (Commelina diffusa), water primrose (Ludwigia octovalvis), smartweed (Polygonum punctatum), arrowhead (Sagittafia lancifolia), and cattail (Typha latifolia). Vegetative co-dominance within both the north and south marshes was shared by six species. The occurrence of common south marsh plants in the north can be attributed to the exploitation of occasional patches and canal edges. Mean above ground biomass estimates ranged from 191 g/m_{e} to 1,807 g/m². No strong gradient pattern along the east-west axis of the marshes was observed for total aboveground biomass. A comparison of mean biomass vs. mean cover revealed a pattern in which cover peaked at about 900 g/m² biomass, thus reducing the utility of mean cover as a predictor of mean biomass. Mean belowground estimates ranged from 116 g/m² to 342 g/m². A correlation analysis revealed no relationship between aboveground and belowground biomass. This may result from the nature of root distribution within the study area. Also, within plot variation of belowground biomass was very high. In future studies, a larger sample size will be needed to minimize the sample variation problem.

Stenberg, J., M. Clark, and R. Conrow. 1997. Development of natural and planted vegetation and wildlife use in the Lake Apopka Marsh Flow-Way Demonstration Project: 1990–1994. Special Publication SJ98-SP4. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Marsh Flow-Way Restoration (LA-3-301-M)

EXECUTIVE SUMMARY

This report describes the results of a study of the early successional characteristics of plant and wildlife communities developing on the Lake Apopka Marsh Flow-Way Demonstration Project. The study was conducted to gain an understanding of possible biological community development patterns that might be expected on former agriculture lands undergoing restoration to wetland by the St. Johns River Water
Management District. The study was conducted during the time period September 1990 to March 1994.

The Lake Apopka Marsh Flow-Way Demonstration Project was located along the northwest shore of Lake Apopka (28°40' N latitude/80°39' W longitude), approximately 40 km northwest of Orlando, Florida. Prior to large-scale anthropogenic disturbance, the site probably had been a sawgrass and shrub wetland. A sawgrass and shrub wetland was inferred from observing aerial photographs taken during 1940. During the 1940s and 1950s, conversion to agricultural use on the site, as well as, in the remaining Apopka Marsh was completed. The site was farmed until its purchase by the St. Johns River Water Management District in 1989. The flow-way project became operational and was flooded during November 1990. Flooding continued nearly uninterrupted through the end of the survey period (March 1994). Water level drawdowns occurred during June–August 1991 and spring 1993.

At the initiation of the flow-way project, four distinct vegetation communities were present on the site. The eastern half of the southern flow-way cell (south marsh) contained a shallow emergent marsh with prominent species including, cattail (*Typha latifolia*), smartweed (*Polygonum punctatum*), pickerel weed (*Pontederia cordata*), arrowhead (*Sagittaria lancifolia*), water primrose (*Ludwigia* spp.), and southern waterhemp (*Amaranthus australis*). The western half of the southern cell (south marsh) was covered by an expanse of panic grass (*Panicum dichotomiflorum*) and water primrose (*Ludwigia* spp.) The northern cell (north marsh) contrasted sharply with that of the south. Most of the northern cell was covered by a continuous community of dogfennel (*Eupatorium capilifolium*). A narrow swath (~400m x 600m) adjacent to the western perimeter road was dominated by St. Augustine grass (*Stenatophrum secondatum*).

Soil on the site was predominantly histosol with varying thickness. Shallowest organic soil depths were observed in the northeastern corner of the southern cell. A soil consisting of silts and clays was observed below less than 10 cm of histosol. With time, and the continual action of Lake Apopka phytoplankton sedimentation, an unconsolidated flocculent layer with greatest depths of about 35 cm was observed in the eastern south cell.

The study was conducted using a multi-faceted approach. To test plant community successional patterns and the potential for manipulating these successional patterns sample plots and transects were established in the unmanipulated marsh (Natural Succession Transects) and in three areas containing planted, seeded, or mulched plots (Experimental Planting Sites).

Transects containing evenly spaced clusters (nodes) of plots (four $1-m^2$ plots per cluster; three permanent, one temporary biomass clip plot) were regularly distributed across the marsh. Four transects (32 plots per transect) were placed perpendicular to the marsh water flow path in each of the north (600 m long) and south (450 m long) marshes (number of plots = 256). A ninth transect (610 m long) was placed parallel to the flow path at a point beginning near the south marsh lake water inlet and extending west. The ninth transect increased the total number of plots to 296.

Within the Experimental Planting Sites, sample plots were placed in each of the treatments. Within each of the small treatment plots (15x15m for planted, seeded, and mulched; 18 by 18 m for control plots) a single 1 m² was established. The larger Mixed Species plots (24 by 24 m) received two 1 m² sample plots.

Three different types of data were gathered from the sample plots. Species composition and structure (percent cover, density, and height) data were taken from all of the 1 m² plots (Experimental Planting Sites and Natural Succession Transects). Also, an overall estimate was made of species composition and cover percentage from each entire treatment plot in the Experimental Planting Sites.

Vegetative biomass was clipped and collected from one plot per cluster along the Natural Succession Transects. Live biomass (separated into species) and dead biomass (all species combined) were dried and weighed. Ground biomass subsamples were submitted to the Soil Science Department, University of Florida, for tissue nutrient analysis.

Phenological patterns were measured in all treatments to determine if dynamics in flower and fruit production could be detected. These measurements were taken at the same time as structure and composition measurements. Measurements consisted of estimating the proportion of canopy in a sample plot containing flowers, immature fruit, and/or mature fruit. A canopy index was developed in which estimates were based on the canopy in one-third canopy increments.

The effects of moisture on seed germination was tested in a growth chamber with seeds of wetland plant species placed under two moisture treatments (saturated and flooded).

A seed trapping study was conducted to determine if seed flow into and out of the Experimental Planting Sites was occurring. To accomplish this task, seed traps were constructed from PVC pipe and 1x1 mm mesh fiberglass screen and placed along the upstream and downstream edges of two Experimental Planting Sites. Four traps per edge were placed. The traps were retrieved and replaced with clean traps monthly, four times. In the greenhouse, the water-borne traps were emptied into a germination pan

and incubated under a twice daily automatically timed mist irrigation. Germination trials were run for two months per trap sample. Seedlings were identified to the species level and counted. Plants that could be identified were grown to a size allowing identification. A collection of reference plants were maintained to allow identification of some species. The air-borne traps were surveyed and seeds were identified to species and counted.

The potential impact on succession by the soil seed bank was estimated by measuring seed germination from soils collected from the Natural Succession Transects, Experimental Planting Site-Control Plots, and Experimental Planting Site-Mulch Plots in November 1991 and 1992. Soils were collected using 10cm diameter by 20cm long PVC corers, returned to greenhouse and placed under two soil moisture treatments (moist and 3–4 cm flooded). Seedlings were identified to species and counted.

Clonal recruitment was estimated by marking eight individual rhizomes per species per planting site of arrowhead, cattail, bulrush, and pickerel weed in May 1992, then returning in May 1993 and measuring the distance grown and the distance to the nearest competitor. This experiment was conducted in the three Experimental Planting Sites.

Avian species were featured in a baseline study of wildlife utilization of the early successional marsh ecosystem. Birds were observed using two methods. First, a fixed width transect survey was conducted using the established vegetation transects. The transect width was approximated to be 35m wide on either side of the transect centerline. Birds observed or heard within this corridor were identified to species and counted. A second method used involved slowly driving around the marsh perimeters and observing birds. In addition to the flow-way marshes, observations were taken from the unmanaged marsh adjacent to and north of the south marsh, and the agricultural fields adjacent to and north of the north marsh. Again, birds were identified to species and counted. For comparison, these observations were converted into bird numbers per hectare.

Evaluation of the Experimental Planting Sites revealed that the Mixed species planting treatment provided a diverse, cattail resistant vegetative community. In contrast, the mulched and seeded treatments provided a favorable environment for cattail invasion. The single species planted treatments varied in establishment and expansion success and resistance to cattail. Spikerush (*Eleocharis interstincta*), pickerel weed, arrowhead, and giant bulrush (*Scirpus californicus*) tended to establish quickly and resist cattail. Giant bulrush also was resistant to invasion by pennywort (*Hydrocotyle ranunculoides* and *H. umbellata*). Pennywort was a dominant mat-forming species throughout the marsh, with the most dense coverages occurring in disturbed areas (e.g., Experimental

Planting Site) and areas without dense overstory canopy. The canopy of giant bulrush was no more dense than other areas containing pennywort, yet was resistant to invasion by pennywort. Bulrush established quickly, covering the entire plot. Bulrush resisted cattail invasion during the study period. But its coverage of live biomass declined after two years, potentially increasing its invisibility by cattail. Maidencane (*Panicum hemitomon*) established slowly, did not cover the plot and was easily invaded by cattail.

Floating mats developed in the Experimental Planting Sites. The pickerel weed planted treatment floated completely, while the giant bulrush treatment and giant flag (*Thalia geniculata*) (Mixed Species Planting treatment) remained firmly rooted. The remaining treatment plots floated at different times during the duration of the study.

Successional patterns along the Natural Succession Transects tended to consist of the initial vegetative community senescing after flooding followed by a period of shallow open water with patches of vegetation developing, increasing in size and eventually coelescing into continuous hydrophytic plant community. Dominant plants in the hydrophytic plant community tended to be cattail (*Typha domingensis* and *T. latifolia*), pennywort, pickerel weed, arrowhead, alligator weed (*Alternanthera philoxeroides*), coastalplain willow (*Salix caroliniana*), and water primrose (*Ludwigia peruviana*). Less prominent species with potential for dominance included *Polygonum densiflorum* and *Bidens laevis*. Structure and composition, and biomass measurements revealed shifts in dominance by the successional plant community during the study period.

Extensive floating mats developed along the Natural Succession Transects, as well as in the Experimental Planting Sites. Biomass measurements provided some evidence for one of the means of floating mat development. In the southeastern marsh, rhizomes were found growing up into the water column. Biomass measurements tracked this pattern over time. This strategy was found with cattail, arrowhead, and pickerel weed. These suspended roots and rhizomes seemed effective at trapping phytoplankton sediments from the inflowing lake water. The utilization of the water column by roots and rhizomes preferentially to the deeper sediments (See belowground biomass measurements) led to a shift of buoyant biomass into the water column. Assuming that decomposing organic matter increased gas production, trapping of sediments, and deposition of dead leaves contributed additional buoyant biomass. Finally, the coupling of the increase in buoyant biomass over time and the sediments' agricultural history led to floating mat formation. Floating mats affected the marsh in a number of ways. They increased the area of substrate available for seed germination and seedling establishment. Finally, floating mats moved around with the wind and scoured grounded or rooted vegetation patches leading to newly floating mats.

Results of the seed flooding experiment were often different from that of published reports. Germination rates tended to be lower than expected. This probably resulted from the absence of critical germination cues such as light and heat environment. An extensive literature review of seed germination by species found in the seed bank, seed dispersal, and vegetation studies was provided to reduce an information shortfall.

Water borne seed dispersal differences between "inflows" and "outflows" to the Experimental Planting Areas were not detected. This pattern may have resulted because the dense cover of plant species such as pennywort may have limited the movement of seed in flowing water or stopped water altogether. A measurement of water flow in the north marsh planting site was less than the detection limit of the flow sensor (1.5 cm s⁻¹). Seed germination by pennywort from traps located in pennywort communities was commonly observed, suggesting that the plant species nearest the seed traps would provide the greatest measurable contribution. Air borne seed traps captured a preponderance of cattail seeds (0–65.3 seeds trap-1). A single broomsedge (*Andropogon* spp.) seed was the only species other than cattail captured in air-borne seed traps. Seeds that we expected to capture, but did not, included more *Andropogon* spp., *Baccharis* spp., *Eupatorium* spp., and *Mikania scandens*.

Seed bank measurements revealed a seed bank species community similar to other freshwater marshes. The seed bank consisted of a community containing annual or biennial species (47%), generalist species (84%), and graminoids and herbs (95%). The seed bank tended to contain a larger, generally unrelated flora (24–52 species) than that of the established vegetation community (12–38 species).

The greenhouse soil moisture experiment revealed that shallow flooding (4 cm depth) reduced seed germination from the seed bank. Under moist soil conditions, seed germination from the Mulch treatment was greater than from the Natural Succession Transects and the Control Treatment, while the Natural Succession Transects and Control Treatment were somewhat similar. No differences among field treatments were found when soils were maintained under flooded soil conditions. Cattail tended to germinate at greater rates under flooded conditions than moist.

Clonal measurements provided insights into the competitive success of cattail in comparison with other rhizomatous species. Cattail grew at a greater rate (0.043–0.162 cm^{-d}) than bulrush (0.012–0.073 cm^{-d}), arrowhead (0.03–0.038 cm^{-d}), and pickerel weed (0.013–0.028 cm^{-d}). The competitive success of cattail can also be explained by its growth pattern in addition to its rapid growth. Cattail tended to grow three rhizomes from a culm. As each rhizome approached 1–2 m long it produced a leaf producing culm. Then, each culm grew an additional three rhizomes. In contrast, the competing species, pickerel weed and arrowhead, tended to produce a single long dense rhizome.

As expected the marsh contained a wetland adapted avian community. No detectable differences in avian species similarity patterns were measured among the treatments. The south marsh tended to have fewer birds than the north marsh. Blackbirds tended to be the most common bird in the south marsh. The prevalence of blackbirds can be attributed to coverage by cattail. The north marsh had slightly greater densities among more taxa than the south marsh. We detected minimal temporal differences in total bird density in the south marsh while the north tended to be increasing during the sample period.

In summary, the Lake Apopka Marsh Flow-Way Demonstration Project was characterized as an early successional freshwater marsh ecosystem. Vegetation measurements taken along Natural Succession Transects revealed an ecosystem rapidly filling open space as predicted by successional models of Eugene Odum. Insights into dominance by cattail in this succession may be found with a number of factors. High nutrient loading is related to cattail dominance. The disturbed soil environment brought on by agricultural practices reduced the density of plant species, in both the seed bank and established vegetation that could compete with cattail. Cattail was found to successfully germinate under shallow flooding conditions. Field observations revealed that cattail was capable of growing under completely inundated conditions. The clonal growth measurements revealed that rhizome growth rates of cattail were much greater than those of pickerel weed and arrowhead. In addition, large-scale cattail rhizome structural architecture, consisting of three rhizomes per culm growing and establishing a culm having three rhizomes each, was more competitive than the single rhizome plan of the various other species in the ecosystem. But assemblages of competitive species, if planted at a favorable density, were capable of competing and becoming established. The Experimental Planting Sites revealed that establishment of pickerel weed, arrowhead, giant bulrush, spikerush, or a mixture of the above species and giant flag, early in ecosystem succession could help establish invasion resistant vegetation communities. Unsuccessful planted species included: maidencane, bulrush, and sawgrass. Wildlife observations revealed that increasing numbers of wetland bird species were using the marsh over time.

Stenberg, J.R., and M.W. Clark. 1998. Monitoring of natural and planted vegetation in the Lake Apopka marsh flow-way restoration project, August 1993–March 1995. Special Publication SJ98-SP17. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Marsh Flow-Way Restoration (LA-3-301-M)

EXECUTIVE SUMMARY

The objective of this project was to continue measurements of ecosystem succession in the Lake Apopka Marsh Flow-Way Demonstration Project and to initiate measurements in the Full Marsh. Earlier ecosystem succession studies (November 1990–February 1993) had revealed a pattern of increasing coverage by a few highly competitive plant species. To provide a more complete assessment of ecosystem development on the site, a second phase of the study was implemented from August 1993 to March 1995. An early part of the second phase of the Demonstration Project (August 1993–September 1994) has been reported in Stenberg, Clark, and Conrow (1997). Development of Natural and Planted Vegetation and Wildlife Use in the Lake Apopka Marsh Flow-Way Demonstration Project: 1990–1994, Special Publication SJ98-SP4. This report will include previously reported and final sample results. The report will focus on vegetation cover dynamics (Demonstration and Full Marshes), floating vegetation mats (Demonstration Marsh), and drawdown and fire (Demonstration Marsh).

Measurements from Demonstration Marsh experimental planting sites revealed patterns of continuing resistance to invasion of cattail (*Typha domingensis* and *T. latifolia*) by the most competitive species, *Pontederia cordata* and *Sagittaria lancifolia*, and decline of a number of planted target species. Measurements on Demonstration Marsh natural succession transects revealed that cattail species continued to maintain the greatest areal coverage in the marsh. Under conditions of an expanding cattail community in the "ambient" environment, resistance or aquiescence to invasion in the planted community revealed the competitive capabilities of planted target species.

During the monitoring phase, a number of planted communities continued large-scale senescence. Included in this group were spikerush (*Eleocharis interstincta*) and bulrush (*Scirpus validus*). This event was unexpected because the two species were surviving successfully during the early years of the project. It is likely that the two species experience a natural senescence after an initial growth period. Softstem bulrush peaked about one year after planting (August 1991–1992) then slowly declined until its decline accelerated after August 1993. In contrast, *Eleocharis interstincta* reached maximum cover after one year, then began a decline in August 1993. The senescent period will probably be followed by regrowth from remaining viable rhizomes if the species are not excluded by cattail. In this marsh it is likely that the target species would be replaced by cattail during a senescent period. *Hydrocotyle ranunculoides* became more prominent as an invader into experimental planting sites. More plots were found with *Hydrocotyle ranunculoides* coverages over 50% in March 1995 than in March 1994.

Vegetation biomass measurements provided information about the structure and successional state of the Demonstration Marsh. Total aboveground biomass ranged

dynamically around 500–1,000 g m⁻². Belowground biomass continued to decline in the south marsh as roots and rhizomes shifted to floating vegetation mats. Floating vegetation mat biomass increased from 827 g m⁻² (August 1993) to 989 g m⁻² (September 1994). More south marsh transects contained floating mat biomass in September 1994 (three transects) than in previous samples (one transect for August 1993 and March 1994). The north marsh had a slowly increasing belowground biomass until March 1994 followed by a decline in September 1994. Floating mat biomass also increased in the north marsh (647 g m⁻² in August 1993 to 877 g m⁻² September 1994).

In spring 1994, a drawdown in the north and south marshes was followed by an increase in coverage of species that were common during the initial phase of the project and were found in the seed bank. These species included *Cyperus odoratus, Ludwigia leptocarpa, Panicum dichotomiflorum,* and *Polygonum punctatum.* A summer 1994 prescribed burn in the south marsh was followed by reduced biomass and cover of the more prominent species *Hydrocotyle ranunculoides* and cattail (*Typha domingensis* and *T. latifolia*).

Water depth measurements revealed that at least 73% of natural succession transect sample plots contained floating vegetation mats, while 55% of experimental planting sites were floating. Floating mats didn't float up without an intermediate stage. About 30% of planting site plots contained vegetation mats partially suspended in the water column. About 27% of natural succession plots were partially suspended. Floating vegetation mats hinlet was greater than at the outlet weir.

The most distinctive feature of the Full Marsh was its rapid colonization by cattail. In addition, it was invaded by the armyworm caterpillar (*Simyra henrici*). Herbivory by the caterpillar appeared to increase the cover of dead cattail biomass in the August 1994 sample. The lack of cattail in Full Marsh flow-way cell G seemed related to water depth being greater than its adaptive limit and possibly to distance from a substantial seed source.

Stites, D.L., M. Coveney, L. Battoe, E. Lowe, and V. Hoge. 2001 (draft). An external phosphorus budget for Lake Apopka. Technical memorandum. St. Johns River Water Management District, Palatka, Fla.

PROJECT: External Nutrient Budget (LA-1-101-D)

EXECUTIVE SUMMARY

An external phosphorus budget (external inputs to and outputs from the lake water) was calculated for the six calendar years from January 1989 through December 1994. During the first two years of the project, all sources and sinks, including rainfall, spring discharges, groundwater seepage, stormwater runoff, surface water inflows and outflows, tributary discharges, industrial and municipal point sources, agricultural discharges, and lake water quality were quantified. The following four years of data collection were less intense, and the effort focused on ambient water quality, atmospheric deposition, pump discharges, industrial and municipal point sources, and the Apopka-Beauclair Canal. Other sources and sinks were calculated using information developed in the first two years of the project.

Hydrologic inputs were dominated by rainfall, agricultural pumping, and spring discharges, in that order. The discharges from the muck farms north of Lake Apopka were the primary sources of external phosphorus loading to Lake Apopka, followed by atmospheric deposition, tributary discharges, and Apopka (Gourdneck) Spring. Phosphorus left the lake principally (more than 90%) through the Apopka-Beauclair Canal, with the rest of the losses resulting from lateral and downward seepage, and water withdrawn from the lake by farming operations.

Three drainage areas comprise the area east of the Apopka-Beauclair Canal. The Zellwood Drainage and Water Control District (ZDWCD) and Jem Farm (owned and operated by A. Duda & Sons) are separated by Lake Level Canal (LLC). Zellwin Sand Farm (ZSF), located immediately north of the ZDWCD and Jem Farm, discharges into LLC along with ZDWCD. West of the Apopka-Beauclair Canal, farm discharges were calculated for two separate fields: Franks Farm C (FFP) and Clay Island (DPK). ZDWCD (3,521 hectare) accounted for 64% of the farmed area. Jem Farm (1,035 ha), the fields west of the Apopka-Beauclair Canal (396 ha), and ZSF (587 ha) comprised the rest of the farmed area.

Annual loads of 114, 62, 44, 38, 17, and 44 metric tons (t) were calculated for 1989 through 1994, respectively. Phosphorus from farm discharges accounted for 70–89% of the total annual inflow of phosphorus to Lake Apopka (depending on the year). Annual volume-weighted total phosphorus (TP) concentration in the discharges varied between approximately 0.74 mg/L (1990) and 1.08 mg/L (1991). Changing water management practices as a result of the Consent Order Agreement significantly reduced the loading from Jem Farm. Undocumented changes to the internal drainage system of ZDWCD in 1991 may also have reduced their discharges. Discharges to Lake Level Canal from individual pumps on the ZDWCD were not monitored as part of the project in 1989 or 1990. Thus it is not possible to define effects of changes in water management made

prior to the monitoring begun by the farmers in 1992. The reduction in farm phosphorus discharges after 1991 was primarily the result of reduction in loading from Jem Farm, as a result of a lower volume of discharge.

The next most important source of phosphorus to the lake was rainfall, which contributed an average of 5.0 t TP per year over the six years. Apopka Spring and the tributaries each contributed approximately 1.4 t TP annually. All other sources (Winter Garden Pollution Control Facility, Scotts Hyponex Corporation Peat Mine, stormwater runoff, and seepage into the lake) contributed 1.7 t TP/yr combined.

Losses of TP from the lake, primarily through the Apopka-Beauclair Canal, accounted for less than 20% of the inputs, with the exception of 1993 (66%) and 1994 (49%). Discharge volumes through the canal were relatively low during 1989 through 1993 (an average of 3,471 ha-m/year) compared to an average of 7,051 ha-m/year calculated from long-term records of discharge from the Apopka-Beauclair Lock and Dam. The average annual export of 9.95 TP from the Apopka-Beauclair Canal recorded in this study may be below the long-term average as a result. Net storage declined similarly to the decline in annual loading. Between 8 and 122 t of TP (depending on the year) remained in the lake each year. The lowest net annual storage of 8.4 t occurred in 1993.

Stout, I.J., and R. Clerico. 2000. Rodent population study in the North Shore Restoration Area, Part 1 (survey of rodents near Lake Apopka). Special Publication SJ2000-SP2. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: North Shore Restoration (LA-3-303-M)

EXECUTIVE SUMMARY

Eight small mammal trapping grids were established by stratified random placement within the 5,592-hectare (ha) Lake Apopka North Shore Restoration Area. Each grid was designed to sample approximately 0.5 ha with 49 Sherman traps spaced at 10-meter intervals. Traps were opened for two successive days at approximately five-day intervals for a total of eight days during November and December 1999. Limited trapping with Sherman live traps was conducted on transects and in farm buildings. A total of 3,456 trap nights were registered and 1,319 individuals of three species were captured. About 70% of the rodent captures were cotton rats (*Sigmodon hispidus*). Two hundred and thirty-four house mice (*Mus musculus*) were marked with numbered monel ear-tags and released at the point of capture. All house mouse captures were

marked on the grids. House mice were also ear-tagged on one trapping transect. The third species of rodent captured in the live traps was the rice rat (*Oryzomys palustric*).

Captures per trap night was used as a standard metric to compare grids and relative abundance of species among grids. Capture success was very high due to the extraordinary numbers of cotton rats present in the abandoned muck farms. Capture success of house mice was much lower than for cotton rats. Nonetheless, markrecapture success was fairly poor for tagged house mice and may suggest a large pool of individuals from which the live-trapped samples were derived. Alternatively, a negative trap response on the part of tagged individuals may explain the low recapture success.

High spatial variation in rodent abundance was observed. Food supply, vegetative cover, predators, and interactions among the rodents may have contributed to this variation. During the period of study, reproduction was essentially halted. Lactating female house mice were not observed. Male house mice were not observed to be in reproductive condition. Some evidence of reproduction was observed in December 1999 when a single pregnant house mouse was captured.

One possible explanation for the high number of rodents may be the occurrence of two successive mild winters in 1997 and 1998. Food and cover may have been sufficient to allow the local rodent population to outpace the normal limiting factors, for example, local predators and self-regulating mechanisms. Additional work is ongoing and will be presented in a future report.

Stout, I.J., R. Clerico, and K.B. Clanton. 2001. Rodent population study in the North Shore Restoration Area, Part II (survey of rodents near Lake Apopka). Special Publication SJ2001-SP1. Palatka, Fla.: St. Johns River Water Management District.

Project: North Shore Restoration (LA-3-303-M)

EXECUTIVE SUMMARY

Eight small mammal trapping grids were established by stratified random placement within the 3,238-hectare North Shore Restoration Area (NSRA). Each grid was designed to sample approximately 0.5 hectare, with 49 Sherman traps spaced at 10-meter intervals. During phase I, traps were opened for two successive days at approximately five-day intervals for a total of eight days during November and December 1999. Limited trapping with Sherman live traps was conducted on transects and in farm buildings. A total of 3,456 trap nights were registered and 1,319 rodents were captured. About 70% of the rodent captures were cotton rats (*Sigmodon hispidus*). Two hundred and thirty-four house mice (*Mus musculus*) were marked with numbered monel ear-tags and released at the point of capture. All house mouse captures were marked on the grids. House mice were also ear-tagged on one trapping transect. The third species of rodent captured in the live traps was the rice rat (*Oryzomys palustric*).

Captures per trap night was used as a standard metric to compare grids and relative abundance of species among grids. Capture success was very high due to the extraordinary numbers of cotton rats present on the NSRA during phases I and II. Capture success of house mice was much lower than for cotton rats. Nonetheless, markrecapture estimates suggested that modest to very high densities of house mice were present in 1999. Recapture success was fairly poor for tagged house mice and may suggest a large pool of individuals from which the live-trapped samples were derived. Alternatively, a negative trap response on the part of tagged individuals may explain the low recapture success.

High spatial variation in rodent abundance was observed. Food supply, vegetative cover, predators, and interactions among the rodents may have contributed to this variation. During phase I, reproduction was essentially halted. Lactating female house mice were not observed. Male house mice were not observed to be in reproductive condition. Some evidence of reproduction was observed in December when a single pregnant house mouse was captured.

Numbers of house mice trapped during phase II were modest. House mice were present in the NSRA during the period from March through August 2000. However trap success was very low in all months in the NSRA and in the adjacent uplands. Removal of cotton rats on two of the grids in the NSRA did not result in more captures of house mice. Efforts to document the movement of house mice across the interface between the NSRA and the adjacent uplands proved unsuccessful. The failure of the removal studies to demonstrate the presence of house mice beyond those numbers observed in the controls supports the view that house mice numbers were depressed in 2000 relative to the levels observed in 1999. In addition, no evidence of house mouse dispersal was obtained.

One possible explanation for the high number of rodents in 1999 may be the occurrence of two successive mild winters in 1997 and 1998. Food and cover may have been sufficient to allow the local rodent population to outpace the normal limiting factors, for example, local predators and self-regulating mechanisms. The drought conditions at the NSRA during the first six months of 2000 resulted in an obvious reduction in plant growth and cover. The apparent lack of population growth by house mice during 2000 was correlated with low rainfall conditions. At the population level, the lack of food and cover is the most likely proximal explanation for the low numbers of house mice observed during 2000.

Future years may bring a resurgence of house mouse populations. Some limited monitoring may be prudent when higher than normal rainfall patterns coincide with frost-free winters. Control measures should be limited to the reduction of habitat along the eastern boundary of the NSRA.

Thomas, C.C. 1991. *Rough fish market survey final report*. Special Publication SJ91-SP2. Palatka, Fla.: St. Johns River Water Management District.

PROJECT: Trophic Structure Manipulation (LA-4-207-F)

SUMMARY

This survey found that the current market for whole fresh or frozen gizzard shad is limited to local use as a trap bait for the commercial blue-crab fishery. The current exvessel price paid for whole shad is about \$0.05 per pound. A survey of eastern seaboard and gulf states showed that little potential exists for increased demand for a whole fresh or frozen gizzard shad product.

The domestic and international market potential for food source components derived from gizzard shad is favorable. Canned and fresh deboned gizzard shad fish flesh products developed as part of this project tested well and show good future market potential. Markets also appear favorable for shad "roe" and "gizzards" as specialty items. It is estimated that development of a food source component market would increase the ex-vessel price for gizzard shad to about \$0.15 to \$0.20 per pound. Further development of food source components is recommended.

The current and future market potential for industrial products derived from gizzard shad is limited. Large supplies of competitive industrial fish species are currently available at prices of about \$0.03 per pound. It would be difficult for gizzard shad to compete in established fish meal and pet food markets. Any potential for market development of gizzard shad as a fertilizer would require location of processing facilities near the source of fish. One industrial application, which shows some market potential, is the development of a shelf-stable pelletized commercial trap bait made from gizzard shad whole fish or waste. Establishment of this market would require additional product development work.

This information is being used to evaluate current and potential markets for gizzard shad. Development of markets for harvested fish could establish the feasibility of a Lake Apopka restoration method by rough fish removal, which could be supported primarily from revenue generated by the sale of harvested gizzard shad. This report concludes that the current value of gizzard shad is too low for unsubsidized harvest; however, the potential for development of food products from this fish is positive, and such development could increase the value of gizzard shad to a level where subsidizing the harvest would not be required.

APPENDIX I—CONSENT ORDERS

The following documents were reproduced from scanned images utilizing optical character recognition technology. Every effort was made to ensure that these are accurate reproductions of the original documents, but in some cases, the documents may appear different from the original forms.

1.	St. Johns River Water Management District v. A. Duda and Sons, Inc., Consent Order
2.	In Re: A. Duda and Sons, Inc., Amendment to Consent Order
3.	A. Duda and Sons, Inc. vs. St. Johns River Water Management District, Settlement Agreement
4.	Consent Order between St. Johns River Water Management District and Zellwood Drainage and Water Control District
5.	In Re: Consent Order between St. Johns River Water Management District and Zellwood Drainage and Water Control District, Agreement for Modification of Consent Order
6.	In Re: Consent Order between St. Johns River Water Management District and Zellwood Drainage and Water Control District, Second Agreement for Modification of Consent Order
7.	In Re: Consent Order between St. Johns River Water Management District and Zellwood Drainage and Water Control District, Third Agreement for Modification of Consent Order
8.	In Re: Consent Order between St. Johns River Water Management District and Zellwood Drainage and Water Control District, Fourth Agreement for Modification of Consent Order
9.	In Re: Consent Order between St. Johns River Water Management District and Zellwood Drainage and Water Control District, Fifth Agreement for Modification of Consent Order

SWIM Plan for Lake Apopka

10.	In Re: Consent Order between St. Johns River Water Management District and Zellwood Drainage and Water Control District, Seventh Agreement for Modification of Consent Order	.609
11.	In Re: Consent Order between St. Johns River Water Management District and Zellwood Drainage and Water Control District, Eighth Agreement for Modificat of Consent Order	ion .615

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT, Complainant,

V. A. DUDA AND SONS, INC., Respondent. FILE OF RECORD NO. 88-637

CONSENT ORDER

Pursuant to the provisions of Sections 403.121(2), 373.129, and 120.57(3), <u>Florida</u> <u>Statutes</u>, and <u>Florida Administrative Code</u> Subsection 17-103.110(3), this Consent Order is made and entered into between the St. Johns River Water Management District (District) and A. Duda and Sons, Inc. (Duda).

The District finds and the Duda does not contest the following:

1. The District is an administrative agency within the State of Florida having the power and duty to control and prohibit pollution of Florida's water resources in accordance with Chapter 373 and Chapter 403, <u>Florida Statutes</u>, and the regulations promulgated thereunder. The District has jurisdiction over the matters addressed in this Consent Order.

2. Duda is a corporation authorized under the laws of the State of Florida and having offices at 1975 W. S. R. 426, Oviedo, Florida 32765.

3. Duda owns or controls property located at Sections 33, 24, 25, 26, Township 20 South, Range 26 East; Sections 1, 2, 3, 4, 10, 11, 12, 14, 15, 22, 23, Township 21 South, Range 26 East; Sections 5, 6, 7, 8, Township 21 South, Range 27 East; Sections 31, 32, Township 20 South, Range 27 East, Orange and Lake Counties, Florida.

4. Duda conducts agricultural operations on the above mentioned property. In carrying out these activities, Duda applies or causes to be applied fertilizers (organic and inorganic) and pesticides, irrigates and floods all or portions of the property at various times, and pumps excess waters to Lake Apopka and the Apopka-Beauclair Canal.

5. The farming operations referred to in paragraph 4 above have caused effluent to be discharged into Lake Apopka and the Apopka-Beauclair Canal (the Canal), which

the District contends have contributed to the degradation of Lake Apopka and the water bodies downstream of Lake Apopka.

6. Lake Apopka is classified as a Class III water body, as that class is established at <u>Florida Administrative Code</u> Section 17-3.081. Lake Apopka is part of the Oklawaha River Basin Chain of lakes. Water quality in Lake Apopka has, over the last 40 years, deteriorated to the detriment of uses of the lake for recreation, and for propagation and maintenance of a well-balanced population of fish. This deterioration can be attributed to several factors to including the natural process of eutrophication, to past meteorological events, to the alteration of natural lake level cycles by construction of a lake level control structure, to rough fish and hyacinth control practices, to discharges of domestic wastewater, to discharges of industrial wastestreams of various types, and to discharges from a number and variety of different agricultural operations. Because of conditions resulting from these contributors, the lake no longer consistently nor uniformly conforms to the use criteria for Class III waters as stated at <u>Florida</u> Administrative Code Section 17-3.081.

7. The Florida Department of Environmental Regulation on April 12, 1982, issued to the Central Florida Agricultural Institute a permit (No. IT48-47962) for the temporary operation of a pollution source (T.O.P.), pursuant to Florida Statutes Section 403.088. The T.O.P. was designed in part to facilitate the development and implementation of comprehensive and effective pollution control methods for protecting Lake Apopka and associated downstream water bodies. The Central Florida Agricultural Institute was an unincorporated association of farmers whose operations were located in and around Lake Apopka, in which Duda was included. The permit required monitoring of the discharges from the various farms included in the Central Florida Agricultural Institute in accordance with a program prepared by a consultant entitled Central Florida Agricultural Institute Proposed Monitoring Program, December 1981, and contained a compliance schedule ultimately requiring "construction" by April 1, 1987. The final report of Duda's consultant indicated that, with respect to Duda, recommended improvements including (1) installation of a stage recording device in the recycle ponds; (2) expansion of the smaller flow-through pond, in addition to planting with certain aquatic vegetation, and (3) installation of an improved effluent distribution system in the larger flow-through pond. In spite of the issuance of the T.O.P. and the report of Duda's consultant, the District contends that no comprehensive and effective pollution control methods for protecting Lake Apopka and associated downstream water bodies have been developed which might qualify Duda for an operation permit.

8. Duda, in recognition of the need to address the deteriorated water quality condition of Lake Apopka, and in order to respond to water quality concerns expressed by the Department of Environmental Regulation and by the District, proposes herein a

major restructuring of the surface water control system contained within its operation at Lake Apopka which is designed to significantly reduce the volumes of water discharged to Lake Apopka and the Canal and to improve the quality of any waters discharged from its system.

9. Duda agrees that the discharge from its agricultural operation into Lake Apopka may be subject to the requirements for one of several permit programs administered by the District.

10. The District contends that the discharge from Duda's agricultural operation on Lake Apopka without first being subject to a valid operating permit is a violation of <u>Florida Administrative Code</u> Chapter 17-4.

11. The District contends that the discharge from Duda's agricultural operation on Lake Apopka causes or contributes to violations of <u>Florida Administrative</u> Code Sections 17-3.061 and 17-3.121.

12. Duda shall, for the farm east of the Apopka-Beauclair Canal, implement the following construction activities and time schedule:

A. Within one hundred eighty (180) days of the effective date of this Consent Order, Duda shall submit to the District six (6) copies of drawings, signed and sealed by a professional engineer registered in the State of Florida, showing a redesigned drainage system, a retention/detention pond or ponds with a minimum surface area of 256 acres, pump stations, and other water management structures. The drawings shall substantially conform to Exhibit A, and must be a plan view and also show cross sections, giving invert elevations of pumps, elevations of outfall structures from ponds, elevations of top of dike of detention/retention ponds, and bottom elevations of detention/retention ponds. These drawings will be part of a Management and Storage of Surface Waters (MSSW) permit application pursuant to Chapter 40C-4, Florida Administrative Code, for construction and operation of the ponds and redesigned drainage systems. Concurrent with the submittal of the redesign of the drainage system, Duda shall submit an operation plan for the proposed drainage system. Duda shall maximize the use of water from the detention/retention ponds for irrigation purposes. The construction plans shall include a real time rain gauge and stage recorder which shall be installed next to the outfall structures for each pond and the outfall structures shall be a fixed crest weir in nature set at a predetermined elevation. Duda shall have sixty (60) days to fully respond to any requests for additional information, should such a request be necessary. To minimize the chances that additional information will be requested following submission of the redesign plan, District and Duda agree to meet as needed prior to actual submission of the redesign plan;

B. In conjunction with or in advance of the submission of its MSSW permit application, Duda may submit to the District a general design plan for the redesigned drainage system which is to be permitted. The District staff may authorize commencement of construction on certain portions of the redesigned system prior to issuance of the MSSW permit, but such authorization must be in writing, approved by the Executive Director, and no construction may commence by Duda pursuant to this section until such written authorization is obtained.

C. Within one hundred twenty (120) days from issuance of an MSSW permit by the Distict, Duda shall commence construction of the detention/retention and redesigned drainage system;

D. Within eighteen (18) months of commencement of Duda shall have completed construction of the redesigned drainage system and the detention/retention ponds;

E. With sixty (60) days after the completion of the construction of the detention/retention ponds and the redesigned drainage system, Duda shall have the professional engineer of record certify that the construction is complete, built as shown in the plans and is operational;

13. Duda shall conduct a study to determine optimal water use efficiency the goal of which shall be to reduce to the maximum extent feasible and, if possible, eliminate withdrawals of water from Lake Apopka. Said study shall be submitted within one (1) year after certification of the constructed system. This shall not affect any action which the District may take in regard to Duda's CUP application which is presently pending before the District.

14. Duda shall conduct and complete within two years of the issuance of the MSSW, a water quality study with the purpose to devise and implement a monitoring plan and investigate additional strategies which would enable Duda to further reduce nutrient loading to Lake Apopka and other affected water bodies resulting from Duda's farming activities.

15. The District is presently conducting studies which will result in a nutrient budget for Lake Apopka. As a result of these studies, nutrient limitations may be placed upon Duda and other dischargers into the lake.

16. Duda shall, before the date of certification of the constructed drainage system by the engineer of record, apply for an obtain a temporary operating permit pursuant to <u>Florida Administrative Code</u> Section 17-4.250. Said application shall contain as a necessary part thereof the results and recommendations of the study required under paragraph 14 above. Said temporary operating permit issued by District shall be issued for a term of five (5) years. Prior to the expiration date of the T.O.P., Duda shall apply for an operating permit pursuant to the requirements of <u>Florida Administrative Code</u> Chapter 17-4. The District shall, based on external and internal nutrient budget studies to be conducted by the District, and data supplied by Duda pursuant to studies required under paragraph 14 above, evaluate the assimilative capacity of the lake and apply either performance standards or water quality based limitations which have been promulgated by rule and incorporate into said operating permit such standards or limitations.

17. Duda and District acknowledge the District seeks to purchase Duda's property west of the Canal in connection with the Lake Apopka Marsh Flow Way Restoration Project, and that therefore construction on Duda's property west of the Canal shall not be necessary at this time. In the event the property is not purchased on or before October 1, 1989, the District and Duda shall enter into negotiations regarding construction requirements west of the Canal.

18. Within thirty (30) days of the effective date of this Consent Order, Duda shall consult with either the U.S.D.A. Soil Conservation Service or the appropriate local soil and water conservation district, organized pursuant to Chapter 582, Florida Statutes, with respect to the conduct of site assessments using the most recent "Guide for Determining Agricultural Best Management Practices" published jointly by the U.S. Environmental Protection Agency, Region IV, Atlanta, Georgia, and the U.S.D.A. Soil Conservation Service, Gainesville, Florida, as well as appropriate Technical Guides of the Soil Conservation Service and develop in coordination with that agency an Agricultural Conservation Plan for all the farm lands under the control of Duda on Lake Apopka. A copy of the Agricultural Conservation Plan shall be prepared and shall be submitted to the District by Duda following review by the agency. These plans shall be submitted to the District, within one (1) year of the effective date of this Consent Order. Within eighteen (18) months from the effective date of this Consent Order, the approved plan shall be implemented. Duda shall, on a quarterly basis from the effective date of this Consent Order, notify the District in writing of the status of the plans and the anticipated date of submittal of the approved Agricultural Conservation Plan. The quarterly reports shall be due within thirty (30) days after the end of the quarter.

19. Duda shall, within sixty (60) days of the effective date of this Consent Order, have a professional engineer registered in the State of Florida, develop for Duda's use and submit to the District six (6) copies of a field calibrated water discharge pump curve for each pump that discharges directly or indirectly to surface waters of the State so that

accurate pumping quantities can be determined. Within forty-five (45) days of the effective date of this Consent Order, Duda shall install on all such pumps an accurate means to determine the water volume pumped.

20. Duda shall maintain accurate pumping records showing hours pumped, gallons pumped, and the time the pump started and stopped. Duda shall maintain accurate daily rainfall data. Duda shall maintain records of daily water levels via recording staff gauges in the detention/retention ponds. Six (6) copies of these records shall be submitted to the District on a quarterly basis from the effective date of this Consent Order within thirty (30) days of the end of the quarter.

21. Duda shall, within thirty (30) days of completion of construction of the redesigned system, implement a monitoring program to sample its discharges to Lake Apopka and associated water bodies, based upon a water quality study to be commenced within thirty (30) days of the effective date of this Consent Order. During the period between the effective date of this Consent Order and the date the redesigned drainage system becomes operational, Duda shall implement an interim monitoring program to sample its discharge to Lake Apopka. The interim monitoring program shall provide the following: Duda shall sample the first pump event at each pump station following the effective date of this Consent Order and every tenth pump event at each pump station thereafter. Each event shall be sampled every other hour and contaminant content for the event determined on the following three subsamples: the first sample collected after the discharge period has started, half way through the discharge period, and at the end before the discharge is stopped. The parameters to be sampled are Total Kjeldahl Nitrogen (TKN), Nitrate + Nitrate Nitrogen (N0, + N0, N), Ammonia -Nitrogen (NH₃-N), Total Phosphorous (TP), temperature, Biochemical Oxygen Demand (BOD) (5 day), Total Suspended Solids (TSS), Total Organic Carbon, (TOC), Turbidity, Specific Conductivity, field pH, Dissolved Oxygen (DO), orthophosphorus and those Pesticides / Herbicides listed at F.A.C. 17-3.121(20) which have actually been applied to the area being drained by the pump being sampled prior to the pump event and since the last previous sample collected at said pump. Duda may use the results of the District's sampling programs for part or all of the required monitoring if the required method and parameters are sampled by the District. Duda is responsible for notifying the District that sampling done by someone other than Duda is going to be relied upon by Duda.

22. Within forty-five (45) days of the effective date of this Consent Order, Duda shall submit to the District six (6) copies of a proposed Quality Assurance Project Plan (QAPP). The QAPP shall apply to all sampling and the analysis required by this Consent Order. The QAPP shall be prepared in accordance with the requirements set forth in the document titled :DER Guidelines for Preparing Quality Assurance Plans

DER-QA-001/85, January 30, 1986". A copy of the document is available upon request from the District. A QAPP is required for all persons collecting or analyzing samples. The District reserves the right to reject all results submitted by Duda which are not in accordance with <u>Florida Administrative Code</u> Section 17-4.246.

23. The District shall review the proposed QAPP, and if the District determines that QAPP does not adequately address quality assurance as required by Paragraph 18, the District shall notify Duda in writing of the deficiencies. Duda shall then have twenty-one (21) days from receipt of the District's written notification to resubmit the proposed QAPP addressing the deficiencies noted by the District.

24. If the District determines, upon review of the resubmitted QAPP, that it still contains deficiencies the District shall again notify Duda in writing of any of its recommended modifications. This shall continue until the District determines their QAPP is acceptable. The QAPP shall become effective and shall be implemented upon receipt by Duda of the District's written notification of the District's approval of the QAPP. Duda shall incorporate all recommended modifications identified by the District.

25. Duda shall provide, on a quarterly basis from the effective date of this Consent Order, a list of pesticides listed in Section 17-3.121(20), <u>Florida Administrative Code</u>, (general and restricted use), used on the farm for the preceding quarter. The list must be received by the District: within thirty (30) days of the next quarter. The information submitted pursuant to this paragraph is considered trade secrets and shall be kept confidential by the district pursuant to Sec. 403.73 <u>Fla. Statutes</u>.

26. Duda shall maintain all pumps, control structures, riser boards, pipes, flapper gates, and any other structures in good working condition to control backflow.

27. Duda shall commence all necessary repairs within thirty (30) days of discovery. Duda shall notify the District, in writing, within five (5) days after the repairs have been completed, as to what repairs have been made, unless for good cause shown said notice cannot be made within five (5) days. If more than five (5) days will be needed, Duda will notify the District.

28. Duda shall have the responsibility to assure that the pumps on site are only utilized in accordance with this Consent Order or other District permit.

29. Duda shall allow authorized representatives of the District and DER access to the property at reasonable times for the purpose of determining compliance with this Consent Order and the rules and regulations of the District, and monitoring.

30. The District hereby expressly reserves the right to initiate appropriate legal action to prevent or prohibit future violations of applicable statutes or the rules promulgated thereunder.

31. The District, for and in consideration of the complete and timely performance by Duda of the obligations agreed to in this Consent Order, hereby waives its right to seek judicial imposition of damages, or civil or criminal penalties for alleged violations outlined in this Consent Order. Duda waives its right to an administrative hearing on the terms of this Consent order under Section 120.57, <u>Florida Statutes</u>, and its right to appeal this Consent Order pursuant to Section 120.68, <u>Florida Statutes</u>.

32. Entry of this Consent Order does not relieve Duda of the need to comply with applicable federal, state, or local laws, regulations, or ordinances, including Chapter 40C-3(?), <u>Florida Administrative Code</u>. The entry of this Consent order does not abrogate the rights of the substantially affected persons who are not parties to this order, pursuant to Chapter 120, <u>Florida Statutes</u>.

33. The terms and conditions set forth in this Consent order may be enforced in a court of competent jurisdiction pursuant to Sections 120.69 and 403.121, <u>Florida</u> <u>Statutes</u>. Failure to comply with the terms of this Consent order shall constitute a violation of Section 403.161(l)(b), <u>Florida Statutes</u>.

34. No modification of the terms of this Consent Order shall be effective until reduced to writing and executed by both Duda and the District. The terms of this Consent Order will have been violated should Duda's redesign plan be determined to be not in compliance with the terms and conditions of this consent order. This Consent Order will terminate should Duda be issued a T.O.P. or an operation permit.

35. All reports, plans, or data required by this Consent order to be submitted to the District should be sent to:

Mr. Jeffrey Elledge, Director Department of Resource Management St. Johns River Water Management District Post Office Box 1429 Palatka, FL 32078-1429

36. Duda shall publish, at its expense within twenty-one (21) days of the date that this Consent order has been signed by all parties, in the legal ad section of a newspaper of general circulation in both Lake and Orange Counties, Florida, the following notice:

NOTICE OF PROPOSED AGENCY ACTION

The St. Johns River Water Management District gives notice of proposed agency action of entering into a Consent order with A. Duda and Sons, Inc. The Consent Order addresses the construction of retention ponds to hold the runoff from storm events before discharging to Water of the State.

The Consent Order is available for public inspection during normal business hours, 8:00 a.m. to 5:00 p.m., Monday through Friday, except legal holidays, at the St. Johns River Water Management District, Post office Box 1429, Palatka, Florida 32078-1429.

Persons whose substantial interests are affected by the above proposed agency action have a right pursuant to Section 120.57, <u>Florida Statutes</u>, to petition for administrative determination (hearing) on the proposed action. The petition must conform to the requirements of <u>Florida Administrative Code</u> Rule 28-5, and must be filed (received) with the St. Johns River Water Management District, Office of Legal Services, Port Office Box 1429, Palatka, Florida 32078-1429, within fourteen (14) days of publication of this notice. Failure to file a petition within the 14 days constitutes a waiver of any right such person has to an administrative determination (hearing), pursuant to Section 120.57, <u>Florida Statutes</u>.

If a petition is filed, the administrative hearing process is designed to formulate agency action. Accordingly, the District's final action may be different from the proposed agency action. Persons whose substantial interests will be affected by any decision of the District have a right to intervene in the proceeding. A petition for intervention must be filed pursuant to Model Rule 28-5.207, <u>Florida</u> <u>Administrative Code</u>, at least five (5) days before the final hearing and be filed with the Hearing Officer if one has been assigned at the Division of Administrative Hearings, Department of Administration, The Oakland Building, 2009 Apalachee Parkway, Tallahassee, Florida 32399-1500. If no Hearing Officer has been assigned, the petition is to be filed with the St. Johns River Water Management District, Office of Legal Services, Post Office Box 1429, Palatka, Florida 32078-1429. Failure to petition to intervene within the allowed time frame constitutes a waiver of any right such person has to an administrative determination (hearing) under Section 120.57, <u>Florida Statutes</u>.

Duda shall provide proof of publication to the District within fourteen (14) days of this notice.

37. This Consent Order shall take effect upon the date of filing and acknowledgement by the Clerk of the District unless a Petition for Administrative Hearing is filed in accordance with Chapter 120, <u>Florida Statutes</u>, and it shall constitute final agency action by the District pursuant to Section 120.69, <u>Florida Statutes</u>, and <u>Florida Administrative Code</u> Subsection 17103.110(3). Upon the timely filing of a petition, this Consent Order will not be effective until further order of the District.

37. The provisions of this Consent Order shall apply to and be binding upon the parties, their officers, directors, agents, servants, employees, successors, and assigns and all persons, firms and corporations acting under, through or for them and upon those persons, firms and corporations in active concert or participation with them.

DONE AND ORDERED this <u>16th</u> day of <u>June</u>, 1988, in Palatka, Putnam County, Florida.

FOR RESPONDENT: A. DUDA AND SONS, INC.

<u>June 16, 1988</u> date BY:_____

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

<u>June 16, 1988</u> date BY:

JOHN L. MINTON CHAIRMAN, GOVERNING BOARD

RENDERED this <u>21st</u> day of <u>June</u>, 1988.

St. Johns River Water Management District 538

FILING AND ACKNOWLEDGMENT TO 120.52 (9) Florida Stautes with the designated District Clerk, receipt of which is herebyacknowledged.

RUTH D. HEDSTROM DISTRICT CLERK

A. DUDA & SONS, INC.

WATER BUDGET

April 1988

Prepared by: APPLIED TECHNOLOGY AND MANAGEMENT, INC. 502 NW 75[™] STREET, SUITE 95 GAINESVILLE FLORIDA 32607 (904) 375-8700

Exhibit A

BACKGROUND

A. Duda and Sons, Inc. (Duda) owns and operates Lake Jem Farm, located on the northern shore of Lake Apopka in Central Florida approximately 15 miles northwest of Orlando (see Figure 1). It consists of approximately 2940 acres of muck (organic soil) bounded by dikes and situated on the east side of the Apopka-Beauclair Canal.

Duda conducts agricultural operations on the property. In carrying out these activities, Duda applies or caused to be applied fertilizers (organic and inorganic) and pesticides, irrigates and floods portions of the property at various times, and pumps excess waters to Lake Apopka and the Apopka-Beauclair Canal.

In addition to Lake Jem Farm, Lake Apopka is bordered by other muck farms to the north, and by citrus groves to the east, south and west. The city of Winter Garden lies on the lake's south-eastern shore.

Lake Apopka is classified as a Class III water body, as defined in Florida Administrative Code Section 17-3.081. Water quality in Lake Apopka has, over the last forty years, deteriorated to the detriment of uses of the lake for recreation, and for propagation and maintenance of a well-balanced population of fish. This deterioration can be attributed in part to the natural process of eutrophication, to past meteorological events, to the alteration of natural lake level cycles by construction of a lake level control structure, to rough fish and hyacinth control practices, to discharge of domestic wastewater, to discharges of industrial wastestreams of various types, and to discharges from a number and variety of different agricultural operations. Because of conditions resulting from these contributors, the lake no longer consistently nor uniformly conforms to the use criteria for Class III waters as stated in Florida Administrative Code Section 17-3.081.

The Florida Department of Environmental Regulation on April 12, 1982, issued to the Central Florida Agricultural Institute a permit (No. IT48-47962) for the temporary operation of a pollution source, pursuant to Florida Statutes Section 403.088. The Central Florida Agricultural Institute was an unincorporated association of farmers whose operations were located in and around Lake Apopka, in which Duda was included. The permit required monitoring of the discharges from the various farms included in the Central Florida Agricultural Institute (CFAI) in accordance with a program prepared by a consultant entitled





Central Florida Agricultural Institute Proposed Monitoring Program, December 1981, and contained a compliance schedule ultimately requiring "construction" by April 1, 1987. The final report of the consultant indicated that, with respect to Duda, recommended improvements including: (1) installation of a stage recording device in the recycle ponds; (2) expansion of the smaller flow-through pond, in addition to planting with certain aquatic vegetation; and (3) installation of an improved effluent distribution system in the larger flow through pond. Subsequent discussions between the Department of Environmental Regulation and Duda indicated that the Department would not deem the improvements sufficient under Florida Statutes Section 403.088. The District and the Florida Department of Environmental Regulation, on January 4, 1986, entered into an "Operating Agreement Concerning Stormwater Discharge Regulation and Dredge and Fill Regulation" by which the Department agreed to take such steps necessary to delegate to the District, inter alia, industrial discharge facilities, except for those relating to solid, hazardous, domestic or industrial waste facilities.

Duda, in order to respond to water quality concerns expressed by the Department of Environmental Regulation and by the District, proposed a major restructuring of the surface water control system contained within its operation at Lake Apopka which would be designed to significantly reduce the volumes of water discharged to Lake Apopka and the Canal.

The system will incorporate ponds for management, retention and/or detention of stormwater, and for reduction of water inputs to the operation so as to provide for a significant reduction in the volume of discharges from Duda's property.

As a first step in the restructuring of the surface water management system Duda retained Applied Technology and Management, Inc. (ATM) in December 1987 to conduct a water balance study to determine appropriate system parameters to minimize, to the degree technologically and economically feasible, discharge volumes to Lake Apopka.

CROP AND LAND USE DATA

Table I summarizes the crop and land use data for the site. This information was developed based on farm records and interviews with the farm managers. It is an estimate of present practices and future intentions, however changes may occur with time as market demands and crop production technologies change.

The total farm acreage consists of all land within the main dike with the exclusion of an existing 40 acre flow through pond. While the existing pond is within the main dike it has no significant effect on the functioning of the water management system and was not included in the analysis of the existing system.

There are 2350 acres of farmed land at the site and 590 acres of "other" land which includes the farm canals, ditches and laterals, office, shop and processing areas, roads, and farm labor living area.

Table 1 also shows an estimate of the timing and acreage of field flooding during the year. This activity would typically begin in May, peak in July and end in October.

					Crop	o/Land U	se (acre	s)				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Carrots	860	940	810	580	260	0	0	06	430	290	1050	1280
Celery	10	170	350	480	360	130	0	50	200	240	190	80
Corn	0	0	06	770	1040	260	0	110	370	260	0	0
Leaf	210	270	170	120	40	0	0	10	10	10	180	170
Sod	350	350	350	350	350	350	350	350	350	350	350	350
Total Cropped Land	1430	1730	1770	2300	2050	740	350	610	1360	1650	1770	1830
Non-Cropped Land												
Flooded	0	0	0	0	200	1450	1600	1040	400	140	0	0
Not Flooded	920	620	580	50	100	160	400	700	590	560	580	520
Total	920	620	580	50	300	1610	2000	1740	066	700	580	520
Total Farmable Land	2350	2350	2350	2350	2350	2350	2350	2350	2350	2350	2350	2350
Other Lands	590	590	590	590	590	590	590	590	590	590	590	590
Total Land	2940	2940	2940	2940	2940	2940	2940	2940	2940	2940	2940	2940

1. Summary of Existing Crop and Land Use Practices

is: Applied Technology and Management, Inc., 1988 A. Duda and Sons, Inc., 1988 Appendix I

HYDROLOGIC INPUTS AND OUTPUTS

Three hydrologic components affecting the water management system operation are rainfall, evaporation, evapotranspiration and seepage from the lake to the farm. This section presents the assumptions and values of these parameters used in the analysis. Based on a review of regional geology, leakance to deeper lithologic zones was assumed to be negligible.

Table 2 presents the average annual rainfall, evaporation and potential evapotranspiration rates used in the water balance by month. Rainfall data was taken from a summary prepared by the District (1986) for Clermont. Potential evapotranspiration was taken from Smajstrla, et al. (1984) for Orlando and is based on the Penman method using 25 years of data. Annual lake evaporation was determined from Visher and Hughes (1975) and distributed over the year in the same ratios as the distribution of potential evapotranspiration.

Table 3 presents the average crop and surface coefficients used to estimate actual evaporation and evapotranspiration rates for the site. The corn and sod coefficients are based on data presented in Jones, et al. (1984). The flooded land coefficient is the ratio of annual pan evaporation to annual potential evapotranspiration. The remaining land use coefficients were estimated based on soil type, length of cropping season and the Soil Conservation Service seasonal consumptive use crop coefficients as listed in Technical Release 21 (SCS, 1970). Table 4 presents the estimated actual evaporation and evapotranspiration rates used in the water balance.

Table 5 presents an analysis of the remaining hydrologic component, seepage. An estimate of hydraulic conductivity was obtained from District staff who have collected preliminary data from an ongoing project at Lake Apopka with a data collection site at the Lake Jem farm. Flow path length and thickness were also determined with District data from the same site. This data was used in Darcy's equation, to determine flow per unit length and total seepage flow into the farm on a monthly basis. Average monthly water levels were determined for Lake Apopka at Winter Garden for the period 1960 through 1984 and 1986 for input to Darcy's equation. The existing average annual seepage into the farm from the surrounding water bodies is approximately 3566 acrefeet under existing conditions.

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (inches)	2.27	2.91	3.15	2.71	3.82	7.12	7.83	7.18	6.53	2.99	1.67	2.25	50.43
Lake Evaporation (inches)	2.32	2.80	4.19	5.09	5.69	5.09	5.17	4.9	4.3	3.61	2.7	2.15	48.01
Potential Evaporation (inches)	2.71	3.33	4.60	5.62	6.28	5.85	5.85	5.31	4.64	4.01	3.03	2.5	53.73

Table 2. Rainfall, Evaporation, and Evapotranspiration for Project Location

Sources: Applied Technology and Management, Inc. 1988 St. Johns River Water Management District, 1986 Visher and Hughes, 1975 Smajstrla, et al., 1984

Table 3. Land Use Evaporation and Evapotranspiration Coefficients

Land Use	Coefficient
Carrots	0.85
Celery	0.85
Corn	0.9
Leaf	0.8
Sod	0.9
Flooded Non-cropped Land	1.3
Non-flooded Non-cropped Land	0.75
Other Lands	0.5

Sources: Applied Technology and Management, Inc., 1988 Jones, et al., 1984

				Estii	mated Ev	aporatior	n or Evap	otranspira	ation (inch	nes)			
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Carrots	2.30	2.83	3.91	4.78	5.34	4.97	4.97	4.51	3.94	3.41	2.58	2.13	45.67
Celery	2.30	2.83	3.91	4.78	5.34	4.97	4.97	4.51	3.94	3.41	2.58	2.13	45.67
Corn	2.44	3.00	4.14	5.06	5.65	5.27	5.27	4.78	4.18	3.61	2.73	2.25	48.36
Leaf	2.17	2.66	3.68	4.50	5.02	4.68	4.68	4.25	3.71	3.21	2.42	2.00	42.98
Sod	2.44	3.00	4.14	5.06	5.65	5.27	5.27	4.78	4.18	3.61	2.73	2.25	48.36
Flooded, Non-cropped Land	3.52	4.33	5.98	7.31	8.16	7.60	7.60	6.90	6.03	5.21	3.94	3.25	69.85
Non-Flooded Non- Cropped Land	2.03	2.50	3.45	4.22	4.71	4.39	4.39	3.98	3.48	3.01	2.27	1.88	40.30
Existing Water Management Ponds	2.32	2.80	4.19	5.09	5.69	5.09	5.17	4.90	4.30	3.61	2.70	2.15	48.01
Other Lands	1.36	1.67	2.30	2.81	3.14	2.93	2.93	2.66	2.32	2.01	1.52	1.25	26.87

St. Johns River Water Management District

Table 4. Summary of Estimated Evaporation and Evaporation Rates

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Source: Applied Technology and Management, Inc., 1988

SWIM Plan for Lake Apopka
~	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Total
L 66.7 66.8	66.8		66.8	66.6	66.2	66.1	66.0	66.4	66.7	66.7	66.6	66.6	66.5	
L 62.5 62.5	62.5		62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	
13.8 13.8	13.8		13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	
105.0 105.0	105.0		105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	
15.0 15.0	15.0		15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	
8.2 8.5	8.5		8.5	8.1	7.3	7.1	7.3	7.7	8.2	8.3	8.0	8.0	7.9	
53,600 53,600 5	53,600 5	2	3,600	53,600	53,600	23,600	53,600	53,600	53,600	53,600	53,600	53,600	53,600	
440,690 454,430 45	454,430 45	4	57,600	433,300	392,080	381,510	389,970	413,220	440,690	444,920	431,180	429,070	425,722	5,534,382
d 10.12 10.43	10.43		10.51	9.95	9.00	8.76	8.95	9.49	10.12	10.21	9.90	9.85	9.77	127.00
no 314 292	292		326	298	279	263	278	294	304	317	297	305	297	3,566
-			1											

Table 5. Steady State Seepage Through the Berm

Source: Applied Technology and Management, Inc. 1988

EXISTING SYSTEM

This section presents the discharge characteristics of the existing site water management system. Table 6 presents the estimated flow rates of the pump stations on the farm, taken from the CFAI Water Quality Monitoring Report (Post, Buckley, Schuh & Jernigan, Inc., 1985). The pump station locations are shown in Plate 1.

Hours of operation were recorded by Duda for each pump station for the period 1985 through 1987. These values were multiplied by the appropriate flow rate from Table 6 to obtain the estimated monthly flows shown in Table 7. The resulting average annual discharge volume for this period was 5351.3 million gallons which is equivalent to an average continuous discharge rate of 22.7 cfs or a depth of approximately 67 inches per year over the 2940 acres.

Based on available rainfall data at Clermont the period 1985 through 1987 was near normal (within 5%) on an annual basis, as shown in Table 8. Therefore the average discharge, as determined from the three years of record, was used as the condition against which to compare the performance of subsequent proposed designs.

	Flow Rate	
Pump	(gpm)	(cfs)
D-1	40000	89.1
D-5	15000	33.4
D-6	27000	60.2
D-7	15000	33.4
D-8	27000	60.2
D-9	27000	60.2
D-10	27000	60.2
D-11	10000	22.3
Total Capacity	188000	418.9

Table 6. Drainage Pump Flow Rates

Sources: A. Duda & Sons, Inc., 1988 Post, Buckley, Schuh & Jernigan, Inc., 1985

Table 7	. Estimat	ed month	ly flows.												
1986	D-1	81.6	0.0	0.0	0.0	0.0	0.0	6.0	0.0 0	0.0	0.0	0.0	0.0	81.6	6.8
	D-5	41.4	0.0	0.0	0.0	0.0	0.0	99.2	0.0	0.0	0.0	69.8	0.0	210.4	17.5
	D-6	46.2	8.1	26.9	39.7	94.9	48.7	5.3	50.3	134.8	21.1	83.1	132.1	691.1	57.6
	D-7	87.6	85.0	84.9	71.2	74.1	139.7	171.9	134.3	69.3	81.2	117.9	62.1	1179.4	98.3
	D-8	136.3	175.0	70.6	67.1	99.5	112.5	151.3	130.2	20.0	42.8	23.5	missing	1028.9	85.7
	6-D	75.0	0.0	0.0	0.0	16.7	0.0	0.0	87.5	112.4	154.2	65.5	91.6	603.0	50.2
	D-10	79.7	24.3	45.8	85.0	220.3	301.6	162.3	104.2	107.0	56.9	71.4	39.1	1297.7	108.1
	D-11	22.3	13.5	11.5	27.0	33.6	27.1	15.0	48.0	13.4	11.6	65.0	24.2	312.2	26.0
	Total	570.1	305.9	239.7	290.0	539.2	629.6	605.1	554.6	456.9	367.8	496.2	349.2		
1987	D-1	0.0	0.0	156.2	172.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	329.0	27.4
	D-5	0.0	0.0	69.3	192.6	23.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	285.4	23.8
	D-6	51.9	99.1	161.1	0.0	22.7	0.0	missing	0.0	0.0	0.0	110.6	161.1	606.5	50.5
	D-7	86.9	86.6	136.8	0.0	51.3	144.5	188.3	144.9	164.0	127.8	161.3	36.9	1329.3	110.8
	D-8	44.3	41.0	77.0	38.9	84.9	27.8	230.9	24.8	21.7	0.0	0.0	0.0	591.1	49.3
	0-0	62.0	76.8	180.1	87.7	45.6	108.7	230.9	159. 1	119.1	125.1	206.4	95.7	1497.0	124.8
	D-10	93.2	128.8	131.2	117.0	33.1	50.2	102.2	227.7	151.5	157.7	149.9	52.4	1394.9	116.2
	D - 11	13.8	4.8	13.4	198.6	112.4	0.0	24.9	45.2	23.7	7.2	33.1	7.3	484.4	40.4
	Total	352.1	437.6	925.2	807.6	373.5	331.2	1.777	601.7	479.9	417.8	661.3	353.4		
Sources	: A. Duda	& Sons, In	c., 1988												

Notes: Average annual discharge volume 5351.3 million gallons Applied Technology and Management, Inc., 1988 Average continuous discharge rate = 22.7cft

SWIM Plan for Lake Apopka

	Monthly Rainfall (inches)			
Month	Average	1985	1986	1987
January	2.27	1.40	9.41	**
February	2.91	1.07	1.89	3.17
March	3.15	2.64	3.56	12.4
April	2.71	0.96	0.72	0.52
May	3.82	3.16	0.92	3.4
June	7.12	11.63	8.69	3.88
July	7.83	7.89	5.69	3.68*
August	7.18	8.56	8.15	3.14
September	6.53	7.18	4.03	
October	2.99	2.94	1.68	
November	1.67	0.3	1.39	
December	2.25	2.91	2.45	
Total	50.43	50.64	48.58	26.51
Percent of Normal	100.4%		96.3%	98.6%

Table 8. Average and 1985 through 1988 Monthly Rainfall at Clermont

Sources: NOAA, 1987

Applied Technology and Management, Inc., 1988 Notes: *One to nine daily values missing **More than ten daily values missing

FARM HYDROLOGY AND WATER BALANCE ANALYSIS

Based on the previously defined rainfall, evaporation, evapo-transpiration and seepage values the following observations can be made:

- 1. In an average year rainfall will exceed evapotranspiration resulting in an average-net gain to the farm system.
- 2. The farm is lower than the surrounding lake and canal levels. The dike material allows a significant volume of water into the farm (28.8% of the rainfall contribution), adding to the management problem.
- 3. Because it is, on the average, a net gaining system, regular discharges will be required to maintain an economic and productive farm operation.
- 4. One method of reducing discharges to the lake is to reduce the amount of withdrawal from the lake by use of a multi-purpose drainage detention and water supply pond.

Therefore to assess the proposed surface water management systems a monthly water budget analysis was performed. The analysis divided the water management system into two cells; a field water balance and a pond water balance.

Two systems were evaluated; (1) a 125 acre pond in the southwest portion of the site which would incorporate the existing 40 acre pond (System 1), and (2) a 256 acre pond comprising the 125 acre pond of System I and an additional 131 acre pond north of, but contiguous to, the existing farm (System 2) (see Figure 2).

The water budgets for the proposed systems are presented in Tables 9 and 10. Based on this water budget modeling System 1 will produce a 65% reduction in the average annual discharge volume when compared to Table 7. System 2 will reduce the discharge by another 4% to 69%.



Table 9. Summary of Estimated Monthly Water Budget, Average Conditions, Proposed 125 Acre System

Water Volume (acre-feet)

	Jan	Feb	Mar	Apr	May	Jun	Jut	Aug	Sep	Oct	Nov	Dec	Total
FIELD WATER BALANCE					•)					
Rainfall	540	723	782	673	949	1768	1944	1783	1622	743	415	559	12500
Evapotranspiration	482	629	877	1111	1293	1445	1460	1210	959	790	576	475	11305
Seepage Volume	298	278	309	284	265	250	264	279	288	301	282	290	3388
Required Flood Volume	0	0	0	0	287	1796	216	0	0	0	0	0	2299
Water Excess or Deficit	356	372	215	-154	-366	-1223	533	853	951	254	121	373	
Total Farm Inlet Volume	0	0	0	154	366	1223	0	0	0	0	0	0	1744
Rainfall Pumpage	356	372	215	0	0	0	533	853	951	254	121	373	4027
Flood Pumpage	0	0	0	0	0	0	805	920	374	201	0	0	2299
Total Pumpage	356	372	215	0	0	0	1338	1773	1324	455	121	373	6327
POND WATER BALANCE													
Initial Pond Storage	625	625	625	625	446	60	0	625	625	625	625	625	
Rainfall	24	30	33 33	28	40	74	82	75	68	31	17	23	525
Evaporation	24	29	44	53	59	53	54	51	45	38	28	22	500
Total Farm Inlet Volume	0	0	0	154	366	1223	0	0	0	0	0	0	1744
Total Farm Pumpage	356	372	215	0	0	0	1338	1773	1324	455	121	373	6321
Water Excess or Deficit	981	966	829	446	60	-1142	1365	2421	1972	1073	736	666	
Lake Inlet Volume	0	0	0	0	0	1142	0	0	0	0	0	0	1142
Discharge Volume	356	373	204	0	0	0	740	1796	1347	448	≡	374	5750
Average Monthly Discharge Rate (cfs)	5.8	6.7	3.3	0.0	0.0	0.0	12.0	29.2	22.6	7.3	1.9	6.1	
Final Pond Storage	625	625	625	446	60	0	625	625	625	625	625	625	
Source: Applied Technology and	d Manage	ment, Inc.,	1988										
Notes: Average annual water	excess	= 7.9 cubi	c feet/seco	pu									
Flooding	g Depth	= 20.2 mo = 1.5 feet	licol y cal										
Por	nd Area	= 5 leet = 125 acre	SS										

Table 10. St	ummary of E	stimate	d Month	ıly Wateı	r Budget	, Averaç	je Conditi	ions, Pro	posed 2	56 Acre	System			
			S	/ater Vol	lume (ac	sre-feet)								
EIEL D WATE	R RALANCE	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall		540	754	817	703	066	1846	2030	1861	1693	775	433	583	13026
Evapotranspi	iration	475	651	910	1150	1334	1471	1486	1241	991	818	597	492	11617
Seepage Vol	ume	282	262	292	268	251	236	249	264	272	284	267	274	3201
Required Flo	od Volume	0	0	0	0	275	1721	206	0	0	0	0	0	2203
Water Exces	s or Deficit	346	366	1.99	-179	-369	-1110	586	885	974	242	102	365	
Total Farm Ir	nlet Volume	0	0	0	179	369	1110	0	0	0	0	0	0	1658
Rainfall Pum	page	346	366	199	0	0	0	586	885	974	242	102	365	4066
Flood Pumps	ige	0	0	0	0	0	0	771	881	358	193	0	0	2203
Total Pumpa	ge	346	366	199	0	0	0	1357	1766	1332	435	102	365	6268
POND WATE	ER BALANCE													
Initial Pond S	storage	1280	1280	1280	1280	1050	641	0	1280	1280	1280	1280	1280	
Rainfall	I	48	62	67	58	81	152	167	153	139	64	36	48	1076
Evaporation		49	60	89	108	121	109	110	104	92	77	58	46	1024
Total Farm Ir	nlet Volume	0	0	0	179	369	1110	0	0	0	0	0	0	1658
Total Farm P	umpage	346	366	199	0	0	0	1357	1766	1332	435	102	365	6268
Water Exces	s or Deficit	1625	1648	1457	1050	641	-425	1414	3094	2660	1702	1360	1647	
Lake Inlet Vo	lume	0	0	0	0	0	425	0	0	0	0	0	0	425
Discharge Vo	olume	345	368	177	0	0	0	134	1814	1380	422	80	367	5087
Average Mor Discharge Ra	ithly ate (cfs)	5.6	6.6	2.9	0.0	0.0	0.0	2.2	29.5	23.2	6.9	1.3	6.0	
Final Pond S	torage	1280	1280	1280	1050	641	0	1280	1280	1280	1280	1280	1280	
ource: Applied Te	chnology and N	lanageme	∋nt, Inc., 1	988										
otes: Avera	ige annual wate	r excess	= 7.0 cu = 19 6 ii	Ibic feet/se	scond									
	Floodir Por PC	ng Depth nd Depth nd Area	= 1.5 fe = 5 feet = 256 a	et cres										

NUTRIENT LOADING

The goal of the water balance analysis was to find a technically and economically feasible means of reducing discharges to the lake based on the assumption that reducing the discharge would also reduce the loading. An additional reduction in the loading rates would also be experienced based on the biological and physical treatment afforded by a water management pond. Biological treatment would occur as nutrients are taken up by aquatic vegetation. Physical treatment would occur as a result of the settling of suspended material.

The CFAI Water Quality Monitoring study was reviewed to determine values of selected water quality parameters of concern at Lake Apopka. Table 11 presents a summary of the mean concentration of three water quality parameters reported in the CFAI Water Quality Monitoring study. Total Nitrogen (TN) and Total Phosphorus (TP) were selected because of the potential impact of these nutrients on algal growth and the present trophic status of the lake. Total Suspended Solids (TSS) are of interest because of the impact on the potential treatment technology. Settling ponds will have a significant impact on improving discharge water quality for nutrients bound up in the sediments.

Table 11 shows that with some type of pond system (either recirculation or flowthrough) the average TN level is about 64.8% of the direct discharge system. Similarly, average pond discharge TP and TSS levels are 44.7% and 62.1% respectively, of the direct discharge system.

Table 12 shows the loading reduction, expressed as a percent of initial, or existing loading, with increasing pond size for Systems 1 and 2. The results show that the greatest portion of the reduction in loading is due to a decrease in flow by use of a pond system. The implementation of System 1 reduces the loading to 35% of the initial level. If "credit" is given for loading reduction due to the biological and settling action of the pond, the Total Nitrogen, Total Phosphorus, and Total Suspended Solids, will be reduced to 22.7%, 15.7%, and 21.8% of the initial levels respectively. The table also shows the reductions for System 2 which is an average of 2.75% lower than that for System 1.

Table 11. Summary of Selected Water Quality Parameters from CFAI Report

	Mean Effluent Qu	ality by Para	meter (mg/1)		
System Type	Station	Total Nitrogen	Total Phosphorus	Total Su Sol Average	spended ids n
Without Pond	ZDWCD-2	5.91	1.31	60.5	6
With Pond	ZDWCD-1	5.50	0.97	52.5	11
With Pond	DP-1	4.50	0.96	21.0	11
With Pond	DP-4	1.27	0.24	22.0	8
With Pond	FP-2	6.10	0.24	77.3	9
With Pond	LP-1	1.79	0.52	15.0	13
Pond Average		3.83	0.59	37.6	
Percent Drop With Pond			64.8%	44.7%	62.1%

Sources: Applied Technology and Management, Inc., 1988 Post, Buckley, Schuh & Jernigan, Inc., 1986

Notes: Total Nitrogen and Total Phosphorus from PBS&J Table 4-1. Total Suspended Solids calculated by ATM from PBS&J Addendum B.

Table 12. Reduction in Loading Relative to Existing Condition

	Annı F	ual Discharo Pond Size	ge	I	Percent of Ini	tial Loading	
System	(acres)	(ac-ft)	(Mgal.)	Flow Only	TN	TP	TSS
Existing	0	16,424	5,351.3	100.0%	100.0%	100.0%	100.0%
System 1	125	5,750	1,873.5	35.0%	22.7%	15.7%	21.8%
System 2	256	5,087	1,657.5	31.0%	20.1%	13.9%	19.2%

Source: Applied Technology and Management, Inc., 1988

Notes: 1. Existing system flow based on 1985-87pump records. 2. Total Nitrogen loading reduction based on a reduction in TN to

64.8% from 5.91 mg/l to 3.83 mg/l.

3. Total Phosphorus loading reduction based on a reduction in TP to

44.7% from 1.31 mg/1 to 0.586 mg/l. 4. Total Suspended Solids loading reduction based on a reduction in TSS to 62.1% from 60.5 mg/1 to 37.6 mg/1.

PROPOSED ACTION

Given the goal of reducing loading to Lake Apopka by reducing discharges, the average annual discharge volume can be significantly reduced by adding on site storage capacity. In order to provide sufficient storage capacity, and thereby reduce their drainage to the lake, Duda proposed the construction of a 85 acre pond in the southwest corner of the site, which when combined with the existing 40 acre pond will provide a total of 125 acres of detention and water supply pond.

This pond would result in approximately a two-thirds reduction in the average annual discharge to Lake Apopka. Additional water treatment through biological and physical action would increase the nutrient loading reduction to approximately 75% to 85% depending upon the parameter of interest. Additional pond area does not significantly increase the loading reduction.

SWIM Plan for Lake Apopka

APPLIED TECHNOLOGY AND MANAGEMENT. INC. 502 N.W. 75 STREET. SUITE 95 GAINESVILLE. FLORIDA 32607 TELEPHONE: (904) 375-8700

April 25, 1988

Mr. Jeff Elledge, P.E. Director, Resource Management St. Johns River Water Management District Highway 100 West Palatka, FL 32077

RE: Lake Jem Farm; Operation of Ponds During Stormwater Discharge

Dear Jeff:

The purpose of this letter is to review the operation of the proposed stormwater management ponds for the Lake Jem Farm under design conditions. The analysis was based on the following design criteria and assumptions:

1. The design storm was the 10 year 24 hour event (7.5 inches). The design stormwater detention volume is the first inch of runoff.

2. The discharge structures were rectangular weirs (C = 3.2) with a water quality Vnotch device for bleed down of the first inch of runoff. Several types of structures could be used to meet the objectives. The final structure type will be selected in coordination with the farm operations manager after the site specific topography is developed.

3. The structures were designed to detain and bleed down the first one-half of the stormwater retention volume in no less than 60 hours.

4. Other than direct rainfall on the pond surface

inflow to each pond was from pump discharges. The maximum inflow rate will be the maximum combined pump capacity into that pond plus the rainfall rate on the pond.

5. Pumping rates to each pond were based on the total pump capacity presented in the April 4, 1988 submittal, pro-rated by the ratio of each ponds area to the total pond area of 256 acres.

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6. Maximum head on each discharge structure was limited to 0.5 foot above the top of the water quality bleed down device.

7. For conceptual modeling purposes the datum in each pond (elevation zero) is assumed to be the bottom invert of the V-notch. After detailed site specific topography is obtained the actual structures can be designed referenced to mean sea level.

8. The ponds are assumed to be ful1 (at elevation zero) at the beginning of the storm.

The discharge structures were designed based on this information. Tables 1 and 2 show the discharge structure specifications for Ponds One and Two respectively. Tables 3 and 4 present the discharge hydrographs for the ponds showing a peak head at 13 hours of 1.58 feet above the V-notch invert. The peak discharge from Pond One was 275.1 cfs and that for Pond Two is 288.3 cfs.

These results show that the design storm and detention volumes can be provided within approximately 1.5 feet of temporary storage above the discharge elevation. If you have any further questions or comments on the enclosed information please call me.

Sincerely,

John C. Good, Agricultural Engineer APPLIED TECHNOLOGY AND MANAGEMENT, INC.

Attachments

xc: Jack Malloy Mike Lane Craig Bromby Table 1. Design of Discharge Structure for Pond OneParameterUnitsValue

Total Farm Drainage Area acres2855.0Total Pond Areaacres256.0Total Pump Capacitycfs418.9

FIELD RUNOFF Drainage Area to Pond acres 1394.0 Volume of 1 inch runoff acre-feet 116.2

POND RUNOFFPond Areaacres125.0Volume of 1 inch runoffacre-feet10.4

STORAGE DEPTHTotal Runoff Volumeacre-feetStorage Depthfeet1.0

STORMWATER STRUCTURE DESIGN Average Discharge cfs 12.8 Depth of V-notch feet 1.0 Angle of Notch degrees 107.1 Top Width feet 10.0

WEIR DESIGN

Maximum Allowable Rise feet0.5Weir Coefficient--1.2Peak Flowcfs204.5Weir Lengthfeet180.8

Source: Applied Technology and Management, Inc. 1988

Design of Discharge Structure for Pond Two Table 2. Units Value Parameter Total farm Drainage Area acres 2855.0 Total Pond Area acres 256.0 **Total Pump Capacity** cfs 418.9 FIELD RUNOFF Drainage Area to Pond acres 1461.0 Volume of 1 inch runoff acre-feet 121.7 POND RUNOFF Pond Area acres 131.0 Volume of 1 inch runoff acre-feet 10.9 STORAGE DEPTH **Total Runoff Volume** acre-feet 132.7 Storage Depth feet 1.0 STORMWATER STRUCTURE DESIGN Average Discharge cfs 13.4 Depth of V-notch 1.0 feet Angle of Notch degrees 158.2 Top Width feet 10.5 WEIR DESIGN Maximum Allowable Rise feet 0.5 Weir Coefficient --3.2 Peak Flow cfs 214.4 Weir Length feet 189.5

Source : Applied Technology and Management, Inc., 1988

SWIM Plan for Lake Apopka

Table 3. Lake Jem Pond 1 Discharge

SUBWATERSHED NAME	=	Pond 1
TOTAL AREA	=	125.0 ACRES
SOIL STORAGE CAPACITY	=	0.00 INCHES
CURVE NIJM13ER	=	100.0
TIME OF CONCENTRATION	=	0.00 HOURS
RETURN FREQUENCY	=	10 YEARS
RAINFALL DURATION	=	24 HOURS
TOTAL RAINFALL DEPTH	=	7.50 INCHES

TIME	RAINFAL	L STAGE	RUNOFF	INFLOW	PUMP-	DISCHA	RGE
(HR)	(IN)	(CFS)	(CFS)		(CFS)	(CFS)	(FT)
()	0.00	0.00	0.0	0.0	0.0	0.0	ò.00
	2.00	0.19	11.3	204.5	0.0	0.0	0.10
	4.00	0.41	13.2	210.5	0.0	1.2	0.39
	6.00	0.67	17.0	204.5	0.0	2.7	0.54
	8.00	1.01	22.7	204.5	0.0	7.9	0.83
	10.00	1.51	37.8	204.5	0.0	38.6	1.12
	12.00	4.55	565.3	204.5	0.0	210.3	1.48
	13 0O	5.68	71.8	204.5	0.0	275.1	1.58
	14.00	6.05	41.6	204.5	0.0	267.7	1.56
	16.00	6.53	24.6	204.5	0.0	248.1	1.53
	18.00	6.85	17.0	204.5	0.0	234.6	1.51
	20.00	7.11	15.1	204.5	0.0	226.8	1.50
	22.00	7.32	13.2	204.5	0.0	221.7	1.49
	24.00	7.50	9.5	204.5	0.0	218.4	1.49
	26.00	7.50	0.0	204.5	0.0	210.8	1.48
	28.00	7.50	0.0	204.5	0.0	207.3	1.47
	30.00	7.50	0.0	204.5	0.0	205.7	1.47
	32.00	7.50	0.0	204.5	0.0	205.1	1.47
	34.00	7.50	0.0	204.5	0.0	204.8	1.47
36.0O	7.50	0.0	204.5	0.0	204.6	1.47	
38.00	7.50	0.0	204.5	0.0	204.6	1.47	
40.00	7.50	0.0	204.5	0.0	204.6	1.47	
60.00	7.50	0.0	0.0	0.0	15.1	1.03	
80.00	7.50	0.0	0.0	0.0	9.1	0.08	

FLOW ROUTING SUMMARY MAXIMUM STAGE WAS 1.50 FEET AT 13.00 HOURS MAXIMUM DISCHARGE WAS 275.1 CFS AT 13.00 HOURS Table 4. Lake Jem Pond 2 Discharge

SUBWATERSHED NAME	=	Pond
TOTAL AREA	=	131.0 ACRES
SOIL STORAGE CAPACITY	=	0.00 INCHES
CURVE NUMBER		= 100.0
TIME OF CONCENTRATION	=	0.00 HOURS
[RETURN FREQUENCY	=	10 YEARS
RAINFALL DURATION	=	24 HOURS
TOTAL RAINFALL DEPTH	=	7.50 INCHES

TIME	RAINFALL SATAGE	RUNOFF		INFLOW	PUMP- OUT	DISCHARGE	
(HR)	(IN)	(CFS)	(CFS)		(CFS)	(CFS)	(FT)
. ,	0.00	0.00	0.0	0.0	0.0	0.0	0.00
	2.00	0.19	11.9	214.3	0.0	0.0	0.10
	4.00	0.41	13.9	214.3	0.0	1.2	0.39
	6.00	0.67	17.8	214.3	0.0	2.8	0.54
	8.00	1.01	23.8	214.3	0.0	8.3	0.83
	10.00	1.51	39.6	214.3	0.0	40.4	1.12
	12.00	4.55	592.4	214.3	0.0	220.4	1.48
	13.00	5.68	75.3	214.3	0.0	288.3	1.58
	14.00	6.05	43.6	214.3	0.0	280.5	1.56
	16.00	6.53	25.8	214.3	0.0	260.0	1.53
	18.00	6.85	17.8	214.3	0.0	245.9	1.51
	20.00	7.11	15.9	214.3	0.0	237.7	1.50
	22.00	7.32	13.9	214.3	0.0	232.3	1.49
	24.00	7.50	9.9	214.3	0.0	228.8	1.49
	26.00	7.50	0.0	214.3	0.0	220.9	1.48
	28.00	7.50	0.0	214.3	0.0	217.2	1.47
	30.00	7.50	0.0	214.3	0.0	215.6	1.47
	32.00	7.50	0.0	214.3	0.0	214.9	1.47
	34.00	7.50	0.0	214.3	0.0	214.6	1.47
	36.00	7.50	0.0	214.3	0.0	214.4	1.47
	38.00	7.50	0.0	214.3	0.0	214.4	1.47
	40.00	7.50	0.0	214.3	0.0	214.4	1.47
	60.00	7.50	0.0	0.0	0.0	1.5.9	1.03
	80.00	7.50	0.0	0.0	0.0	9.5	0.88

FLOW ROUTING SUMMARY MAXIMUM STAGE WAS 1.58 FEET AT 13.00 HOURS MAXIMUM DISCHARGE WAS 288.3 CFS AT 13.00 HOURS

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

IN RE:

A. DUDA & SONS, INC. BREVARD COUNTY, FLORIDA FILE OF RECORD NO. 93-1343

AMENDMENT TO CONSENT ORDER

This Amendment to the Consent Order rendered on (DATE) is intended to modify paragraph 17 of the original Consent Order. The requirements of that paragraph do not reflect the current situation in which the Respondent finds himself.

The Consent Order was originally agreed upon and entered into assuming that the Respondent would construct a reservoir in a certain location. Since that time, Respondent has determined that it would be more suitable to place the reservoir in a different location, and has modification of its permit application accordingly. Staff will recommend issuance of MSSW permit no. 4-005-0435, including the change in location of the reservoir, at the December Governing Board meeting. A copy of the original Consent Order is attached as exhibit 1 to this Amendment. The Consent Order is therefore amended as follows:

1. Paragraphs 1-15, Findings of Fact and Conclusions of Law, shall remain in full force and effect as set forth in the original Consent Order.

2. Paragraph 17, Corrective Action, shall be amended to allow the Respondent to construct the detention pond as per plans received by the District on August 9, 1993, and amended by plans

received on September 1 and 29, 1993. Construction must be completed in accordance with the terms of permit no. 4-009-0435, and no later than May 13, 1994.

3. Paragraphs 16, and 18-33 shall remain in full force and effect as set forth in the original Consent Order.

A. DUDA & SONS, INC. Nov. 23, 1993 (DATE)

By J. R. Maloy Corp. Vice Pres.

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT 12/8/93 (DATE)

By: Patricia T. Harden, Chair GOVERNING BOARD

RENDERED this 9^{TH} day OF DECEMBER, 1993. PATRICIA C. SCHULTZ District Clerk ST. JOHNS RIVER WATER MANAGEMENT DISTRICT A. DUDA AND SONS, INC. Petitioner,

DOAH Case No. 94-6578RP

VS. SJRWMD FOR No. 94-1556

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT,

Respondent.

SETTLEMENT AGREEMENT

Whereas, A. Duda and Sons, Inc. (hereinafter "Duda"), the Petitioner herein, has filed its petition seeking a determination of the invalidity of certain administrative rules proposed for adoption by Respondent, St. Johns River water Management District (hereinafter "District") specifically, Chapter 40C-61, Fla. Admin. Code, "Works of the District Basins"; and

Whereas, compliance with the provisions of the proposed Chapter 40C-61, Fla. Admin. Code, would require Duda to make certain modifications to its agricultural surface water management system which was previously permitted by the District pursuant to management and storage of surface waters (MSSW) permit number 4-095-0309M; and Whereas,these modifications to Duda's existing agricultural surface water management system must enable Duda to export and dispose of certain amounts of treated stormwater from its existing system to off-site areas; and

Whereas, Duda has already willingly invested substantial resources in complying with the District's rule requirements for agricultural surface water management systems (Chapter 40C-44, Fla. Admin. Code); and

Whereas, the District has determined that a joint effort between Duda and the District for the purpose of enabling Duda to meet the additional requirements of Chapter 40C-61, Fla. Admin. Code is both equitable and in the best interest of the ultimate restoration of Lake Apopka;

Therefore, the following is agreed to and stipulated by the undersigned parties: 1. Duda will, within the timeframes contained in Chapter 40C-61, Fla. Admin. Code, submit to the District an application for such permits as are necessary to comply with the performance standards contained therein.

2. Duda's permit application will propose a system capable of exporting excess water from its existing stormwater management ponds, including an operation plan detailing the peak rates of flow to be removed from the existing ponds, maximum durations of peak flow, and a regulation schedule for water levels in the stormwater management ponds. Excess water, for purposes of this agreement, is that amount of water which must be exported to provide reasonable assurance of compliance with the performance standards contained in Chapter 40C-61, Fla.

Admin. Code and which cannot feasibly be stored in Duda's existing stormwater management ponds or otherwise be used or disposed of on the lands owned or controlled by Duda without discharging same to Lake Apopka or any tributaries

thereof. Although the exportation of excess water should reduce Duda's discharges to Lake Apopka, the operation plan shall allow Duda to continue periodic discharges to lake Apopka.

3. Duda will continue to maximize use of its existing

stormwater management ponds and surface water management system for storage, treatment and agricultural irrigation purposes, in accordance with the terms and conditions contained in its existing District-issued permits. The rate and frequency of removal of excess water will be provided for and controlled by the operation plan to be included as part of Duda's permit application. The operation plan, upon approval by the District, will be appended to the permit and will be a condition thereof.

4. Duda will continue to employ appropriate management practices, as described in the Soil Conservation Service Conservation Plan prepared for Duda's Lake Gem Farm, to reduce phosphorus loads to the stormwater management ponds.

5. Duda does not presently own or control land or facilities capable of storing or disposing of its excess water without discharging same to Lake Apopka or one of its tributaries. The District does own lands in the immediate vicinity of Duda's farming operations wherein it can store or dispose of Duda's excess water without discharging same to Lake Apopka or on which it can otherwise treat said water sufficiently to allow it to meet the standards contained in Chapter 40C-61, Fla. Admin. Code.

6. The District will accept Duda's excess water at the rate and with the frequency specified in the approved operation plan referred to in paragraphs 2 and 3 above. 7. Certain infrastructure, including water control structure(s) and work(s) will need to be constructed and installed in order to enable Duda to export its excess water to the District's property. Duda will install, operate and maintain a pump located immediately west of its stormwater management ponds and east of the Apopka-Beauclair Canal, and such pump shall be capable of moving the volume of water specified in the permit at the rates and with the frequencies necessary to comply with the operation plan to be included in the permit. The pump must be designed and operated to withdraw water from the stormwater management pond and export water based on a minimum nineteen (19) feet static head and fifty-one (51) feet friction head, at seventy-five (75) per cent pump efficiency.

8. The District will install, operate and maintain such conveyance facilities, including pipe capable of receiving water in the volumes and with the rates of flow specified in the operation plan, as are necessary to convey Duda's excess water from the pump to be installed in accordance with paragraph 7 above to the District's property west of the Apopka-Beauclair Canal.

9. Duda will grant to the District such easements, licenses or other real property rights as are necessary to install and maintain the conveyance facilities referred to in paragraph 8 above, for the purpose of conveying Duda's excess water from its pump, across the Apopka-Beauclair Canal, to the District's property west of the canal.

10. The District will consult with Duda regarding the location and placement on Duda's property of any conveyance facilities which it must construct in order to meet the terms of this agreement, as well as the location and construction method to be used to traverse the Apopka-Beauclair Canal, with the purpose of minimizing any costs or impacts to Duda's agricultural operations. However, the District will make the final determination of where the conveyance facilities to be constructed by it are to be placed, as well as the final determination of the location and method of traversing the Apopka-Beauclair Canal.

11. Compliance with the terms of this settlement agreement will provide reasonable assurance to the District that Duda's discharge meets the requirements of Chapter 40C61, Fla. Admin Code, and will thereby entitle Duda to issuance of a permit pursuant to that Chapter. In compliance with Chapter 120, Fla. Stat., after review of Duda's application and a determination of its compliance with the terms of this settlement agreement, the District staff will issue a Notice of Intended Agency Action recommending issuance of a permit in accordance with Chapter 40C-61, Fla. Admin. Code, and thereafter, subject to the rights of third parties to file petitions for administrative hearings with regard to said notice, the Governing Board will approve the permit.

12. Within five (5) days of approval of this settlement agreement by the District Governing Board, Duda will file with the Division of Administrative Hearings a notice of voluntary dismissal, with prejudice, of its pending Petition For Administrative Determination of Invalidity of Proposed Rules, bearing the above DOAH case number. Duda further covenants that it will not initiate any challenges to Chapter 40C-61, as currently published, in any future action brought pursuant to Section 120.56, Fla. Stat. 13. Performance of the obligations set forth in this agreement are not contingent on the outcome of any proceedings brought by any parties other than Duda for the determination of the invalidity of Chapter 40C-61, Fla. Admin. Code. Should the presently published version of Chapter 40C-61, Fla. Admin. Code be found to be invalid, both Duda and the District will continue to perform the obligations contained herein. Any permit modification necessary to carry out the terms of this agreement would then be processed through the District's MSSW rule(40C-4, Fla. Admin. Code) or its Agricultural Surface Water Management System rule (40C-44) Fla. Admin Code). 14. Proposed subsection 40C-61.040(2), Fla. Admin. Code, provides for the submission of applications for permits pursuant to the chapter to the District within one year of the effective date of Chapter 40C-61, Fla. Admin. Code. Proposed subsection 40C-61.040(3), Fla. Admin. Code, provides that dischargers requiring permits be in compliance with the nutrient limitations contained therein for the calendar year ending December 31, 2001. Duda will submit its application within the time period provided for in the proposed rule provided the currently published version becomes effective. Should the currently published version of the proposed rule not become effective by June 30, 1995,

Duda will submit an application to modify its existing MSSW permit to fulfill the requirements of this settlement agreement no later than June 30, 1996.

15. Irrespective of the compliance date stated in proposed subsection 40C-61.040(3), within 90 days of receiving written notification from the District that it has completed the conveyance facilities referred to in paragraph 8 above and is ready to receive Duda's excess water, Duda will have the pump referred to in paragraph 7 above in place, connected to the District's conveyance facilities, and operating in accordance with its operation plan. Should the District fail to so notify Duda within 90 days of the compliance date set forth in subsection 40C-61.040(3), Duda's time for compliance with the proposed rule and with this agreement shall be extended by a commensurate number of days until such notice is received from the District.

16. This settlement agreement shall, upon execution by Duda and approval by the District's Governing Board, constitute a final administrative order of the District and may be enforced as such by either of the parties hereto.

17. This settlement agreement shall take effect upon rendition by the District Clerk, which shall follow full execution by the parties hereto, unless a petition for administrative hearing is filed on a timely basis with regard to it, in which case it will become effective immediately upon entry of a Final Order of the Governing Board approving same following any formal administrative hearing.

18. The provisions of this settlement agreement shall apply to and be binding upon the parties, their officers, directors, agents, servants, employees, successors and assigns, and all persons, firms or corporations acting under, through or for them and upon those persons, firms or corporations in active concert or participation with them.

A. Duda and Sons, Inc. December 19, 1994 Date

By: Ferdinand S. Duda, President

St. Johns River Water Management District

12/14/94 Date By: Patricia Harden Governing Board Chair

Rendered this 30 day of December, 1994 Patricia Schultz District Clerk

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT IN RE: CONSENT ORDER BETWEEN ST. JOHNS RIVER WATER MANAGEMENT DISTRICT AND ZELLWOOD DRAINAGE AND WATER CONTROL DISTRICT

FILE OF RECORD NO. 88-636

CONSENT ORDER

The parties hereto, ST. JOHNS RIVER WATER MANAGEMENT DISTRICT, hereinafter referred to as "St. Johns", and ZELLWOOD DRAINAGE AND WATER CONTROL DISTRICT, hereinafter referred to as "ZELLWOOD" for the purpose of resolving certain issues and proceedings presently pending between them, do hereby voluntarily enter into this CONSENT ORDER and agree to the following:

1. St. Johns is am administrative agency within the State of Florida having the certain authority to regulate pollution of Florida's water resources in accordance with Chapters 373 and 403, and the regulations promulgated thereunder, to the extent stated in Paragraph 17101.040(4)(i) and Subparagraph 17-101.040(11)(a)3, <u>Florida Administrative Code</u>.

2. Zellwood is a water control district created pursuant to Chapter 20714, <u>Laws of Florida</u>, 1941, in Orange County, Florida. Zellwood is empowered to drain, reclaim, improve, and make fit for cultivation the lands described in paragraph 3. Furthermore, Zellwood is empowered in Chapter 20714 to protect those lands from the effects of water, to control the water levels within the drainage district, to discharge waters to Lake Apopka, and to provide facilities for the irrigation of lands therein for agricultural and sanitary purposes. The total area of the District is approximately 8,700 acres. Zellwood consists of two units separated by the McDonald Canal. Unit 1 consists of approximately 2,900 acres, and Unit 2 consists of approximately 5,800 acres.

3. Zellwood is located on the northeast corner of Lake Apopka in Sections 2, 3, 4, 5, 8, 9, 10, 11, 12, 13, 14, 15, 23, and 24, Township 21 South, Range 27 East; Sections 7, 18, 19, and 30, Township 21 South, Range 28 East, Orange County, Florida. In carrying out its duties, Zellwood has caused and from time to time causes seepage water, flood waters, irrigation water, and rainfall to be discharged into Lake Apopka.

4. Lake Apopka, pursuant to Section 17-3.081, <u>Florida Administrative Code</u>, has been classified as a Class III water body. Lake Apopka is a part of the Oklawaha River Basin chain of lakes. Lake Apopka does not meet the water quality standards established in Rule 17-3, <u>Florida Administrative Code</u>, for Class III waterbodies.

5. Although the parties disagree as to the technical and economic feasibility of restoration of Lake Apopka to Class III standards, it will likely be necessary to reduce the amount of phosphorus being introduced into Lake Apopka. The waters discharged to Lake Apopka by Zellwood are required to meet the duly established state water

quality standards for the lake, however, compliance by Zellwood with the terms of this Consent Order shall constitute, during the term of this Consent Order, full compliance with all state water quality standards and effluent limitations.

6. For the purposes of voluntarily reducing the amount of nutrients being discharged to Lake Apopka by Zellwood and by the end of the term of this agreement fully complying with the duly established water quality standards for discharges to the lake, in the context of subparagraph F. below, Zellwood must perform the following acts within the time schedule specified herein:

A. Within 180 days of this Consent Order, Zellwood shall submit to St. Johns six (6) copies of drawings, signed and sealed by a professional engineer registered in the State of Florida, showing a modified water management system, a seepage interceptor system designed to intercept water seeping under the dike separating Zellwood's muck farmlands from Lake Apopka, and pumping the seepage water back into Lake Apopka. The drawings shall substantially conform to Exhibit A and must be a plan view and also show cross sections, giving number, capacity and location of pumps, invert elevations of pumps, elevations of outfall structures from ditches, elevations of top of dikes or ditches, and bottom elevations of ditches. Concurrent with the submittal of the redesign of the modified water management system. St. Johns shall have twenty-one (21) days to review and make recommendations pursuant to subparagraph P. below.

B. In. conjunction with or in advance of the submission of the information required by paragraph 6.A. above, Zellwood may submit to St. Johns a general design plan for the modified water management system. St. Johns may agree to commencement of construction on certain portions of the redesigned system prior to submission of the redesign drawings required by paragraph 6.A. above, but such authorization must be in writing, approved by the Executive Director.

C. No later than December 1, 1989, Zellwood shall commence construction of the interceptor system and modified water management system.

D. No later than May 1, 1991, Zellwood shall have completed construction of the modified water management system and the interceptor system.

E. Within sixty (60) days after the completion of construction of the interceptor system and the modified water management system, Zellwood shall have the professional engineer of record certify that the construction is complete, substantially as shown in the plans, and is operational.

F. The parties agree that St. Johns may recommend modifications to the design of the interceptor system and that Zellwood shall in good faith consider such

recommendations; provided, however, that the concept of this Consent Order is to impose performance standards and not design standards, and St. Johns, therefore, is not required to permit or approve the design of the interceptor system and modified water management system before Zellwood may construct it except insofar as is stated herein.

7. Concurrent with the activities described in paragraph 6 above, Zellwood shall conduct further water quality studies the purpose of identifying additional treatment and management strategies which, in conjunction with the facilities Zellwood has agreed to construct, have the potential to further reduce nutrient loading beyond the specific limitations set forth in paragraphs 9 and 10 below. As a minimum the study shall examine-and address water use and management practices, fertilization practices, flooding practices for insect control, feasibility of available technologies for phosphorus removal as each of these relate to the Zellwood farms operation. Simultaneously with the submission of the drawings required under paragraph 6.A., Zellwood shall present a study plan for said studies to St. Johns for review and comment. St. Johns shall complete its review and submit any comments to Zellwood within forty-five (45) days of receipt of the study plan. Zellwood will consider in good faith the comments of St. Johns, but no formal approval will be necessary. The study must be initiated no later than 30 days thereafter and completed no later than July 1, 1992 and the results thereof submitted to St. Johns no later than 60 days thereafter.

8. Also concurrent with the activities described in paragraphs 6 and 7 above, Zellwood shall conduct a water balance study for the purpose of developing a water budget for the system. In connection therewith, Zellwood shall do the following:

A. Within one hundred and eighty (180) days of the effective date of this Consent Order, the minimum data collection stations must be installed: 1.Seepage monitoring data collection stations:

Three (3) stations in levee along Lake Apopka to monitor seepage under and through the levee;

Two (2) stations in levee along Lake Level Canal to monitor seepage under and through the levee;

Two (2) stations along the northeast boundary of Zellwood Farms to monitor seepage into the farm from upland areas; and Two (2) stations within Zellwood Farms.

Zellwood must consult in good faith with St. Johns regarding the location and design of seepage collection stations prior to installation.

2. Surface monitoring data collection stations; water level reading and/or staff gauges at the following locations to monitor surface inflow:

Culvert in SCL right-of-way, approximately one (1) mile south of Clear Water Lake. Culvert at road at nursery, west of Clear Water Lake; and Culvert at Mud Lake.

B. As soon as the data collection facilities are installed, Zellwood must begin to collect data at those sites. Data are to be collected weekly in seepage wells. Data will be collected monthly and during six storm events samplings per year at the culverts. Water in the seepage interceptor system will be sampled at four sites placed so as to capture significant spatial variation according to the following regime (1) biweekly for nutrients (total phosphorus, orthophosphate, total kjeldahl nitrogen, ammonia, nitrate + nitrite) and field parameters (pH, dissolved oxygen, temperature, and conductivity), (2) monthly, for Biological oxygen Demand (5 day), total suspended solids, and turbidity. After one year of monitoring if no violations of Section 17-3, Florida Administrative Code are found for Biological Oxygen Demand (5 day), total suspended solids and turbidity, sampling for these parameters may be deleted. After one year of monitoring, if the coefficient of variation for any nutrient parameter is less than or equal to 15%, that parameter may be sampled monthly. Raw data will be submitted to St. Johns quarterly after commencement of data collection. Zellwood must also keep records of crops, including date of planting and harvest, crop types, and acreage of planting, which shall be submitted to St. Johns annually commencing December 31, 1990. Crop records are considered trade secrets and shall be kept confidential by St. Johns pursuant to Section 403.73, Florida Statutes.

C. The data specified herein shall be collected continuously for the life of this Consent Order.

D. The study results must include a monthly water budget calculation for the farm to account for all water inflows and outflows based on, but not limited to, the data collected as required in this Consent Order, and data collected by St. Johns for the Lake Apopka Nutrient Study. These calculations shall also be submitted at the end of the first and second year.

9. The modified water management system described in Exhibit A must be capable upon operation of reducing Zellwood's net discharge of total phosphorus into Lake Apopka to 54,000 pounds of phosphorus. For purposes of this Consent Order, net phosphorus discharge will be calculated as the gross phosphorus discharge (the sum of all phosphorus discharges to the lake) minus the phosphorus received by the interceptor system (volume pumped by the interceptor system pumps X average concentration of phosphorus in the lake water) and the phosphorus received by surface water intakes from the lake (intake volume X average concentration of phosphorus in lake water). Data will be collected as described elsewhere in this Consent Order which will determine the effectiveness of the system in meeting this phosphorus limitation. If, after one (1) year of monitoring, data shows that the system does not meet a net loading limitation of 54,000 pounds total net phosphorus per year with adjustment for yearly variations in rainfall and groundwater levels to be adjusted as follows:

(a) RAINFALL—Allowable net phosphorus loading will be adjusted in direct proportion for each year from normal rainfall as determined by NOAA procedures.

(b) GROUNDWATER—Allowable net phosphorus loading will be adjusted in direct proportion each year for variation in the normal groundwater seepage. Methods including siting and number of wells for monitoring and calculating upwelling seepage shall be consistent With U.S.G.S. standards.

Zellwood shall, within sixty (60) days of notification of this fact, submit to St. Johns a plan for additional treatment methods or facilities including retention, if necessary, to reach this limitation. St. Johns shall have thirty (30) days to review and comment upon the plan submitted. Zellwood shall consider St. Johns' recommendations in good faith but no approval is required for said plan. Zellwood shall complete such improvements as are necessary to implement the plan no later than six (6) months thereafter.

10. For the fifth year of this Consent Order and each year thereafter following the execution of this Consent Order, Zellwood shall further reduce the number of net pounds of phosphorus discharged to Lake Apopka to 40,675 pounds of total phosphorus per year. If, after one year of monitoring, data shows that the system does not meet a net loading limitation of 40,675 pounds of total phosphorus per year, taking into account rainfall and groundwater effects as set forth in paragraph 9 above, Zellwood shall, within sixty (60) days of notification of this fact, submit to St. Johns a plan for additional treatment methods or facilities, including retention, if necessary to reach this limitation. St. Johns shall have thirty (30) days to review and comment upon the plan submitted. Zellwood shall consider St. Johns' recommendations in good faith but no approval is required for said plan. Zellwood shall complete such improvements as are necessary to implement the plan no later than six (6) months thereafter.

11. St. Johns is presently conducting studies directed toward development of a nutrient budget for Lake Apopka. Upon completion of this study, the data derived therefrom will likely be used to establish a wasteload allocation for nutrients for Lake Apopka. By executing this Consent Order, notwithstanding any Other requirement in this Consent order, Zellwood does not waive any legal right it may have, including without limitation, the right to challenge any wasteload allocation subsequently adopted that imposes more stringent discharge limitations on Zellwood than those set forth in paragraphs 9 and 10 above. Neither does Zellwood, by executing this Consent Order, waive any right it may have to seek other established forms of administrative relief from discharge standards which are more stringent than those set forth in paragraphs 9 and 10 above and if such relief is sought, it shall be diligently pursued. If standards are adopted and upheld for Lake Apopka which require more stringent limitations on discharges than those established in paragraphs 9 and 10 above, Zellwood will take such reasonable steps as are necessary to be in the position to meet such wasteload allocation as of 12:00 a.m. on the final day of this order or two years after the standards are adopted and upheld, whichever is longer.

12. The parties hereto have discussed the desire of St. Johns to purchase farmlands within Zellwood for inclusion in future Lake Apopka restoration projects. Recognizing the fact that Zellwood cannot commit individually owned farmlands for

sale, it is the intent of Zellwood to meet with and negotiate the voluntary sale of farmlands and associated businesses within Zellwood to St. Johns, if fair compensation can be agreed upon therefore. If is determined that additional land is needed by Zellwood in order to meet water quality standards which require discharge limitations which are more stringent than those established by paragraph 10 above, then St. Johns will make available to Zellwood reasonable amounts of any land it owns within or contiguous to Zellwood for the purpose of establishing such retention and water reuse facilities as are necessary in order to enable Zellwood to increase its total phosphorus reduction capabilities sufficiently to reduce its total phosphorus discharge from the levels described in paragraph 10 above to such levels as are established by the process described in paragraph 11 above when and if such stricter standards become applicable to Zellwood. Zellwood will compensate St. Johns on the basis of the fair-market reasonable rental value of the land utilized, to be determined based upon the assumption that the highest and best use is the manner in which the property is actually used (i.e. retention facilities, treatment marsh, etc.). Rental value shall be determined by an independent real property appraiser who shall be jointly selected by the parties.

13. If St. Johns does not own any real property within or contiguous to Zellwood at the time it is determined, if it is determined, that Zellwood must, as a result of establishment of a wasteload allocation for Lake Apopka, meet discharge standards as established in paragraph 11 above, St. Johns will acquire and if St. Johns is unable Zellwood will acquire such lands as are reasonably necessary to construct such retention and water reuse facilities as are necessary in order to meet such standards. St. Johns will hold title to such lands as are acquired, although each of the parties hereto shall contribute fifty percent (50%) of the cost of acquiring such lands. Zellwood shall be responsible for any capital costs incurred in connection with making said land suitable for treatment or storage purposes. In return, Zellwood shall be permanently permitted to utilize said lands for treatment and storage for as long as such facilities are necessary to meet state water quality standards.

14. In the event St. Johns determines it is necessary to acquire all lands within Zellwood after lands were acquired pursuant to paragraph 13. and Zellwood has not used those lands for at least ten (10) years for treatment and/or reuse, St. Johns shall reimburse Zellwood for the amount it contributed for acquisition less 10% for each year of use by Zellwood. Any values determined under this paragraph shall only apply to this paragraph.

15. Zellwood's obligation upon expiration of this Consent Order to meet any waste load allocation of less than 40,675, net pounds of total phosphorus per year shall be expressly conditioned upon St. Johns' prompt performance of its duty to participate in the acquisition of any necessary lands as set forth in paragraph 13 above. Should St. Johns' failure or delay in performing such duty result without fault by Zellwood in Zellwood's failure to meet such waste load allocation upon expiration of this Consent Order, then Zellwood shall not be deemed to be in violation of applicable water quality standards for nutrients until St. Johns shall have performed such duty and a reasonable time shall have Passed for construction of the necessary works on the acquired lands.

16. Zellwood shall, within thirty (30) days of the effective date of this Consent Order, have a professional engineer registered in the State of Florida, commence development for Zellwood's use the following: (a) a field calibrated water discharge pump curve in accordance with procedures of the Hydraulic Institute or other agreed to standards for each pump, including seepage pumps, that discharges directly or indirectly to surface waters of the State so that accurate pumping quantities can be determined and (b) discharge rating curves pursuant to agreed to standards for all proposed gate openings to be used at each inlet structure for the purpose of determining flow rates based on upstream and downstream water levels. Within one hundred and eighty (180) days of the effective date of this Consent Order, Zellwood shall have implemented an accurate means to determine the water volume used for irrigation and volume discharged. Raw data will be provided to St. Johns as collected on a monthly basis.

17. Zellwood shall maintain accurate pumping records showing hours pumped, gallons pumped, and the time the pump started and stopped. Zellwood shall maintain accurate hydrologic data including records of daily withdrawals from intake structures. Raw data shall be submitted quarterly to St. Johns.

18. Zellwood shall, within sixty (60) days after submittal to St. Johns of a Quality Assurance Plan, implement a monitoring program to sample its discharges to Lake Apopka and associated waterbodies. The monitoring program shall provide the following: Zellwood shall sample the first pump event at each pump station following the effective date of this Consent Order and every tenth pump event at each pump station thereafter. Each event shall be sampled as follows: the first sample collected after the discharge period has started, half way through the discharge period, and at the end before the discharge is stopped. The parameters to be sampled are Total Kjeldahl Nitrogen (TKN) Storet No. 625, Nitrate + Nitrate - Nitrogen (NO₂ + NO₃N) Storet No. 630, Ammonia - Nitrogen (NH₃,-N) Storet No. 610, Total -Phosphorous (TP) Storet No. 665, temperature Storet No. 10, Biochemical Oxygen Demand (BOD) (5 day) Storet No. 310, Total Suspended Solids (TSS) Storet No. 530, Total Organic Carbon (TOC) Storet No. 680, Turbidity Storet No. 82079, Specific Conductivity Storet No. 95, field pH Storet No. 400, Dissolved oxygen (DO) Storet No. 300, Orthophosphorus Storet No. 70507 and those Pesticides /Herbicides listed at Section 173.121(20) Florida Administrative Code, which have actually been applied to the area being serviced by the pump being sampled prior to the pump event and since the last previous sample collected at said pump. If after one year of sampling, data does not indicate significant differences between samples, they may be composited. If, after one year's sampling, any pesticide/herbicide is not detected, Zellwood may eliminate it from the list of parameters to be tested for in this paragraph. As to any other parameters except

phosphorus, St. Johns' Executive Director may waive the requirement of data collection in the event Zellwood demonstrates consistent compliance with water quality standards. Zellwood may use the results of St. Johns' sampling programs for part or all of the required monitoring if the required method and parameters are sampled by St. Johns. Zellwood is responsible for notifying the St. Johns that sampling done by someone other than Zellwood is going to be relied upon by Zellwood.

19. Within ninety (90) days after completion of the system described in paragraph 6.A. above, Zellwood shall submit to the St. Johns six (6) copies of a Quality Assurance Plan (QAP). The QAP shall apply to all sampling and the analysis required by this Consent Order. The QAP shall be prepared in accordance with the requirements set forth in the document entitled: "DER Guidelines for Preparing Quality Assurance Plans DER-QA-001/85, January 30, 1986". Any sampling done prior to submission of the QAP shall be done pursuant to the above-referenced guidelines.

20. Zellwood shall develop, on an annual basis from the effective date of this Consent Order, a list of types and amounts of pesticides listed in Subsection 17-3.121(20), <u>Florida Administrative Code</u>, (general and restricted use) used on the farms for the preceding year. The list must be submitted annually to St. Johns. The information submitted pursuant to this paragraph is considered trade secrets and shall be kept confidential by St. Johns pursuant to Section 403.73, <u>Florida Statutes</u>.

21. Zellwood shall maintain all pumps control structures, riser boards, pipes, gates, and any other structures in good working condition.

22. Zellwood shall allow authorized representatives of St. Johns access to the property at reasonable times for the purpose of determining compliance with this Consent Order and the rules and regulations administered by St. Johns and for monitoring.

23. St. Johns hereby expressly reserves the right to initiate appropriate legal action to prevent or prohibit future violations of applicable statutes or the rules promulgated thereunder not addressed by this Consent Order.

24. Entry of this Consent Order does not relieve Zellwood of the need to comply with applicable federal, state or local laws, regulations, or ordinances. The entry of this Consent Order does not abrogate the rights of substantially affected persons who are not parties to this Consent Order, pursuant to Chapter 120, <u>Florida Statutes</u>.

25. The terms and conditions set forth in this Consent Order may be enforced in a court of competent jurisdiction pursuant to Sections 120.69, 403.121, and 373-129, <u>Florida Statut</u>es. Failure to comply with the term of this Consent Order, including the specific discharge limitations set forth herein, shall constitute a violation or Section 40-3.161(1)(b) <u>Florida Statutes</u>. Zellwood, by executing this Consent Order, does not waive any defenses it may have including the illegality of the imposition of civil penalties against governmental entitles in the event enforcement of this Consent Order becomes necessary. 26. Time is of the essence in this Consent Order. If Zellwood is prevented from meeting a deadline or requirement specified in this Consent Order due to the Court having jurisdiction over the Plan of Reclamation or any condemnation proceedings, or due to acts of third parties, acts of God or other events which are beyond the control of the parties, so long as Zellwood is acting with due diligence, the time for meeting the deadline or requirement shall be extended by the number of days of the unavoidable delay.

27. No modification of the term of this Consent Order shall be effective until reduced to writing and executed by both Zellwood and St. Johns. A11 reports, plans, or data required by this Consent Order to be submitted to St. Johns should be sent to:

Director, Department of Resource Management St. Johns River Water Management District Post Office Box 1429 Palatka, Florida 32078-1429

29. Zellwood shall publish, at their expense within twenty one (21) days of the date that this Consent Order has been signed by all parties, in the legal ad section of a newspaper of general

circulation in Orange County, Florida, the following notice:

NOTICE OF PROPOSED AGENCY ACTION

The St. Johns River Water Management District gives notice of proposed agency action of entering into an Order with Zellwood Drainage and Water Control District. The Consent Order addresses the construction of interceptor ditches to reduce the amount of nutrient laden water being discharged to Waters of the State.

The Consent Order is available for public inspection during normal business hours, 8:00 a.m. to 5:00 p.m., Monday through Friday, except legal holidays, at the St. Johns River Water Management District, Post Office Box 1429, Palatka, Florida 32078-1429. Persons whose substantial interests are affected by the above proposed agency action have a right, pursuant to Section 120.57, <u>Florida Statutes</u>, to petition for administrative determination (hearing) on the proposed action. The petition must conform to the requirements of <u>Florida Administrative Code</u> Rule 28-5, and must be filed (received) with the St. Johns River Water Management District, Office of Legal Services, Post Office Box 1429, Palatka, Florida 32078-1429, within fourteen (14) days of publication of

this notice. Failure to file a petition within the 14 days constitutes a waiver of any right such person has to an administrative determination (hearing) pursuant to Section 120.57, <u>Florida Statutes</u>.

If a petition is filed, the administrative hearing process is designed to formulate agency action. Accordingly, the District's final agency action may be different from the proposed agency action. Persons whose substantial interests will be affected by any decision of the District have a right to intervene in the proceeding. A petition for intervention must be filed pursuant to Model Rule 28-5.207, <u>Florida Administrative</u> <u>Code</u> at least five (5) days before the final hearing and be filed with the Hearing Officer if one has been assigned at the Division of Administrative Hearings, Department of Administration, The DeSoto Building, 1230 Apalachee Parkway, Tallahassee, Florida 32399-1550. If no Hearing Officer has been assigned, the petition is to be filed with the St. Johns River Water Management District, Office of Legal Services, Post Office Box 1429, Palatka, Florida 32078-1429. Failure to petition to intervene within the allowed time frame constitutes a waiver of any right such person has to an administrative determination (hearing) under Section 120.57, <u>Florida Statutes</u>. Zellwood shall provide proof of publication to the District within fourteen (14) days of this notice.

30. This Consent Order shall take effect upon the date of filing and acknowledgement by the Clerk of St. Johns unless a Petition for Administrative Hearing is filed in accordance with Chapter 120, <u>Florida Statutes</u> and it shall constitute final agency action by St. Johns pursuant to section 120.69, <u>Florida Statutes</u>, and Subsection 17-103.110(3), <u>Florida Administrative Code</u>. Upon the timely filing of a petition, this Consent Order will not be effective until further order of this District.

31. The provisions of this Consent Order shall apply to and be binding upon the parties hereto, their officers, directors, agents, servants, employees, successors, and assigns and all persons, firms and corporations acting under, through, or for them and upon those persons, firms, and corporations in active concert or participation with them.

32. Upon full execution of this Consent Order, each of the parties will voluntarily dismiss, without prejudice, the lawsuits which each has brought against the other and which are presently pending in the Circuit Court of the Seventh Judicial Circuit, in and for Putnam County, Florida (Case Nos. 88-5545-CA-J and 88-6225CA-J). Each party will bear its own attorney's fees and costs for those actions. Full execution of this Consent Order shall also resolve all issues related to harmful impacts to water quality and quantity in Lake Apopka by Zellwood in the consumptive use permitting case which is presently being litigated before the Division of Administrative Hearings (DOAH Case No. 85-0813). St. Johns shall issue to Zellwood its consumptive use permit for an annual allocation of not less than 10.9 billion gallons within 60 days after approval of this Consent Order.

33. This Consent Order shall be for a term of ten (10) years, commencing on the date of full execution by each of the parties and ending on midnight of the last day of the tenth year thereafter. DONE AND ORDERED this 15th day of May, 1989, at Palatka, Florida. FOR RESPONDENT: ZELLWOOD DRAINAGE AND WATER CONTROL DISTRICT 940 North Highland Avenue Orlando, Florida 32803

<u>May 15, 1989</u> DATE

FOR COMPLAINANT: ST. JOHNS RIVER WATER MANAGEMENT DISTRICT Post Office Box 1429 Palatka, Florida. 32078-1429 5/10/89 DATE BY: H. R. Clonts, Jr. ITS:Pres.: Bd. of Supervisors

BY: JOHN L. MINTON CHAIRMAN

RENDERED this 16th day of May, 1989. RUTH D. STUART DISTRICT CLERK FILING AND ACKNOWLEDGMENT FILED, on this date. pursuant to 120.52(9) Florida Statutes, with the designated District Clerk, receipt of which is hereby acknowledged.

Ruth Stuart	5/16/89
Clerk	Date

Exhibit B PARSONS BRINKERHOFF CORE & STORRIE, INC. TASK ORDER NO. 1 SERVICES FOR SCREENING EVALUATION OF POTENTIAL RAPID INFILTRATION BASIN SITES FOR THE ZELLWOOD DRAINAGE & WATER CONTROL DISTRICT

SCOPE OF WORK AND BUDGET

The work to be performed under this scope of work will be provided by Parsons Brinckerhoff Gore & Storrie, Inc. (PBG&S) to the Zellwood Drainage & Water Control District (ZDWCD). This scope of work is for a screening evaluation of potential rapid infiltration basin (RIB) sites for disposal of up to 5 mgd of surface water from the ZDWCD. The screening evaluation is intended to examine limited information on the surficial aquifer geology and hydrology of individual geology sites to define a priority sequence which can assist in the selection of sites for more detailed subsequent investigation. The evaluation will be carried out at a level of effort consistent with the screening nature of the assessment and as limited by the available time and budget. SERVIVES TO BE PERFORMED BY PBG&S

The following services are to be performed by PBG&S under this Task Order: 1. PBG&S staff will review near-surface geologic characteristics of the area within which the candidate sites are located. This review will be based on information from: SCS soils maps and U.S. Geological Survey (USGS) Quadrangle maps.

2. Based on information described in Item 1, PBG&S staff will recommend general areas within which the ZDWCD staff will seek candidate sites which might be available for sale.

3. Once the ZDWCD staff have identified candidate sites which may be available in the preferred areas identified under Item 2, PSG&S staff will make a field visit to the candidate sites. PBG&S staff will attend a meeting with ZDWCD staff to select a short list of up to ten (10) sites for screening level geological investigation, and will recommend the geological investigations to be performed on the short listed candidate sites.

4. PBG&S staff will attend a meeting with SJRWMD staff to discuss the analyses of lake characteristic to be performed by the SJRWMD. The purpose of this meeting wi11 be to ensure that mutually compatible analytic approaches are used by PBG&S and the SJRWMD.

5. PBG&S staff will review the information from the screening geologic investigations of the candidate sites and from the SJRWMD lake analysis to verify whether any further analysis appears to be warranted.

6. PBG&S staff will attend a meeting with staff from the ZDWCD and the SJRWMD to review the information from Items 1 through 5. Based on the information

presented at this meeting, the ZDWCD will decide whether PBG&S should continue with Items 7 through 9 below.

7. If the ZDWCD decides that further analysis of the suitability of one or more of the candidate sites appear to be justified, PBG&S staff will perform a further review of regional geologic characteristics based on the information described in Item 1, USGS and SJRWMD data on Floridan aquifer potentiometric elevations, available USGS publications on the geology of the area and well logs and Consumptive Use Permit (CUP) information to be provided by the SJRWMD.

8. Based on the regional geologic review performed under Item 5, the lake analyses to be performed by the SJRWMD as described below, and the geologic investigations performed on the candidated sites, PBG&S will define the apparent priority of further investigation and analysis of candidate sites. PBG&S will deliver to the ZDWCD three (3) copies of a letter report presenting the recommended priorities for further investigations.

9. PBG&S staff will attend a meeting with the ZDWCD and SJRWMD staffs to present their findings under this Task Order, and to discuss any further work to be undertaked.

DATA AND SERVICES TO BE FURNISHED BY THE SJRWMD

The following data and services are to be provided by the SJRWMD:

1. The SJRWMD will attend a meeting with PBG&S staff to agree on the technical approach to be used by the SJRWMD in performing the work described in item 2 below.

2. The SJRWMD will perform an analysis of the hydrology and hydraulics of Clear Water Lake and of the chain of lakes which includes Heiniger Lake, Sheppard Lake, Marshall Lake, Lake Fuller and Lake Semmes. This analysis will include information on the historical fluctuations of water levels in these lakes, the 100 yr floodplain elevation (if defined), an estimated water budget for the lakes, elevations and hydraulic conveyance capacities of hydraullic structures between the lakes (including the outfall by which water can overflow from the lake system back to ZDWCD property), property and structures within the floodplain of the lake system, and the preferred range of water elevations in the lakes for rehabilitation of the lake system.

3. If the ZDWCD authorizes PBG&S to perform Items 7 through 9 of the "Services to be Performed by PBG&S", the SJRWMD will provide PBG&S with all data in their files which may be useful to assist with PBG&S's work under this Task Order. These data will include geologic logs and CUP'S issued within two miles of any candidate site. The SJRWMD will also provide all data in their files relating to water table and Floridan aquifer potentiometric elevations within two miles of any candidate site.

DATA AND SERVICES TO BE FURNISHED BY THE ZDWCD The ZDWCD will provide the following data and services:

1. The ZDWCD will research the availability of land for sale in the preferred areas identified by PBG&S. Once the survey of available properties is complete, the ZDCWD will meet with PBG&S staff to discuss the candidate sites and select those for which screening level geological investigation will be performed. (Typical investigation of a small site would involve a deep standard penetration test, extraction of Shelby tube samples from several depths for laboratory testing of vertical hydraulic conductivity, and installation and slug testing of a piezometer).

2. Once the candidate sites and the geological investigations to be performed have been agreed, the ZDWCD will contract with geotechnical consultant to perform the required investigations.

3. The ZDWCD will coordinate the activities of the ZDWCD, PBG&S, the SJRWMD and the selected geotechnical consultant. The results of the geotechnical consultant's investigations will be documented in a report to the ZDWCD. A copy of this report will be provided to PBG&S.

4. After the meeting described in Item 6 of the "Services to be Performed by PBG&S", the ZDWCD will provide PBG&S a written introduction to proceed or not to proceed with the work described in Items 7 through 9 of the "Services to be Performed by PBG&S".

SCHEDULE

The meetings between the ZDWCD, PBG&S and the SJRWMD will be scheduled by the ZDWCD at times mutually agreed by the participants.

Within seven (7) weeks of the ZDWCD issuing PBG&S with a written notice to proceed with the project, the following items will be performed: Items 1 through 4 of the "Services to be Performed by PBG&S", Items 1 and 2 of the "Data and Services to be Furnished by the SJRWMD", and Items 1 through 3 of the "Data and Services to be Furnished by the ZDWCD". Within eight (8) weeks of the ZDWCD issuing PBG&S with a written notice to proceed with this project, PBG&S will complete Item 6 of the "Services to be Performed by PBG&S".

If the ZDWCD decides to proceed with items 7 through 9 of the "Services to be Performed by PBG&S", within seven (7) days of the ZDWCD's notice to continue with the project the SJRWMD will provide to PBG&S the information described in Item 3 of the "Data and Services to be Furnished by the SJRWMD". PBG&S will provide a draft final report documenting our analysis performed under this Task Order within four (4) weeks after receiving written notice to proceed with Items 7 through 9 of the "Serviced to be Performed by PBG&S".
METHOD OF PAYMENT

The ZDWCD will compensate PBG&S for the services described in this scope of work using the <u>hourly rate plus direct expenses</u> method. PBG&S will perform Item 1 through 6 of the "Services to be Performed by PBG&S with an upset limit of \$7,300.00 which will not be exceeded without the prior approval of the ZDWCD. If the ZDWCD decides to proceed with all the work described in the "Services to be Performed by PBG&S", PBG&S will perform the work with a total upset limit of \$13,300.00 which will not be exceeded without the prior approval of the ZDWCD.

APPROVAL: Zellwood Drainage & Water Control District Signature: Name & Title: Date:

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT IN RE: CONSENT ORDER BETWEEN ST. JOHNS RIVER WATER MANAGEMENT DISTRICT AND ZELLWOOD DRAINAGE AND WATER CONTROL DISTRICT

FILE OF RECORD NO. 88-636

AGREEMENT FOR MODIFICATION OF CONSENT ORDER

The parties hereto, Zellwood Drainage and Water Control District (hereinafter "Zellwood"), and the St. Johns River Water Management District (hereinafter "St. Johns"), executed a Consent Order on May 15, 1989, which addresses certain water quantity and water quality issues with regard to farming activities conducted within Zellwood's borders. Implementation of the Consent Order was delayed until August 14, 1991 due to a petition for administrative hearing that was filed with regard to the Consent Order, the hearing on that petition, and subsequent appeals of the Final Order which resolved the issues raised by the petition.

Since August 14, 1991, each of the parties hereto have proceeded in good faith toward meeting all requirements of the Consent Order in a timely manner. The next critical deadline by which an action must be completed is July 31, 1993, by which construction of the seepage interceptor system, described in Paragraph 6(A) of the Consent Order must be completed. The parties hereto have, however, engaged in discussions about an alternative method of phosphorus reduction, specifically, an upland disposal system, which may prove to be more effective in reducing phosphorus loading to Lake Apopka than the seepage interceptor system, while at the same time providing additional groundwater recharge.

Although Zellwood is not required to install an upland disposal system in lieu of the seepage interceptor system specified in the Consent Order, it is willing to explore the feasibility of same. In order for the parties hereto to evaluate the financial, technical and environmental feasibility of an upland disposal system as a substitute for the seepage interceptor system, a temporary extension of certain deadlines contained in the Consent Order would be required in order to insure that Zellwood is not penalized for any good faith exploration of conversion to an upland disposal system.

THEREFORE, the parties agree and stipulate to the following modifications of the existing Consent Order, a copy of which is attached hereto as Exhibit A.:

1. Due to the delay in implementation of the Consent Order described above, Paragraph 6(D) thereof would require Zellwood to complete construction of the seepage interceptor system by July 31, 1993. This deadline is hereby extended for a period not to exceed ninety (90) days, as provided in paragraph two, plus the number of days that transpire between approval by the Governing Board of St. Johns of this modification and the expiration of the point of entry for any parties whose substantial interests may be affected by this agreement. Expiration of the point of entry shall be established by the publication date for the notice to the public of St. Johns' intent to approve this modification to the Consent Order.

2. Zellwood, on its own behalf and on behalf of its consultant, and St. Johns agree to complete the tasks described in Task Order 1 entitled "Services for Screening Evaluation of Potential Rapid Infiltration Basin Sites for the Zellwood Drainage District", provided that Zellwood executes Task Order No. 1 within three (3) days after the expiration of the point of entry for any parties whose substantial interests may be affected by this Modification Agreement.

3. Paragraphs 9 and 10 of the Consent Order set the phosphorous loading limitations which Zellwood is required to achieve. The commencement of the loading limitations in Paragraphs 9 and 10 shall be extended by the same amount of time as is described in Paragraph one (1) above. However, this modification shall not extend any other terms of the Consent Order.

4. Should Zellwood elect to cease further analysis and evaluation of an upland disposal alternative after completion of Task No. 6 as described in the attached Exhibit B under the heading, "Services To Be Performed By PBG&S" prior to the expiration of the ninety (90) day extension provided for in paragraphs 1 and 3 above, then said extensions shall immediately expire, and the time period for performing the duties provided for in Paragraphs 6(D), 9 and 10 of the Consent Order shall immediately be restarted.

5. This modification agreement is contingent upon no petitions for administrative proceedings being filed with regard to it. Should any third party file a timely request for administrative hearing on this agreement, then the agreement shall become voidable at the option of either of the parties and, if voided by either of the parties the terms of the Consent Order shall continue in place, without modification.

6. It is recognized that a complete evaluation of the financial, technical and environmental feasibility of converting to upland disposal could take longer than the period provided for herein. It is further recognized that should an upland disposal system prove feasible, further agreements would be necessary between the parties to establish specifications for the system, financing and final design for the system, as well as time for construction of the system. Any subsequent agreement which would further modify the Consent Order must be in writing and fully executed by each of the parties. Any such agreement would be subject to public notice and an opportunity provided to petition for administrative hearing by any substantially affected party.

7. Except as provided for herein, all terms and conditions of the Consent Order remain in full force and effect.

SWIM Plan for Lake Apopka

This Modification to Consent Order was executed by the parties on the date indicated below and thereafter rendered by the Clerk of St. Johns on the date so indicated. Zellwood Drainage and Water Control District

940 North Highland Ave. Orlando, Florida 32803

3/12/93 Date

By: Glenn R. Rogers President, Bd. of Supervisors

St. Johns River Water Management District P.O. Box 1429 Palatka, Florida 32178-1429

3/10/93 Date

> By: Joe E. Hill, Chairman Governing Board

Rendered this 11th day of March 1993. Patricia C. Schultz District Clerk ST. JOHNS RIVER WATER MANAGEMENT DISTRICT IN RE: CONSENT ORDER BETWEEN ST. JOHNS RIVER WATER MANAGEMENT DISTRICT AND ZELLWOOD DRAINAGE AND WATER CONTROL DISTRICT SECOND AGREEMENT FOR

MODIFICATION OF CONSENT ORDER

File of Record No. 88-636

The parties hereto, Zellwood Drainage and Water Control District (hereinafter "Zellwood") and the St. Johns River Water Management District (hereinafter "St. Johns"), entered into an Agreement for Modification of Consent Order which was rendered on March 11, 1993. This agreement modified certain portions of a Consent Order between the parties which was rendered on May 16, 1989. A copy of the Consent Order is attached hereto as Exhibit No. 1 and a copy of the Agreement for Modification of Consent Order is attached hereto as Exhibit No. 2.

Exhibit No. 2 describes a process and a timetable by which the parties hereto would explore the feasibility of substituting construction of an upland disposal system in lieu of the seepage interceptor system described in Exhibit No. 1. Substantially all of the tasks described in Exhibit No. 2 and the attachments thereto have been completed. As a result of the work done pursuant to Exhibit No. 2, the parties have determined that further technical, work must be accomplished in order to finally determine the feasibility of going forward with the upland disposal alternative. This will require further extension of certain time deadlines contained in the Consent Order and the modification thereto.

THEREFORE, the parties agree and stipulate to the following second modification to the existing Consent Order:

1. The current deadline for completion of construction of the seepage interceptor system is November 19, 1993, as established by the first modification of the Consent Order. The construction deadline is hereby extended for a period not to exceed 90 days, plus the number of days that transpire between approval by the St. Johns Governing Board of this second modification and the expiration of the point of entry for any parties whose substantial interest may be affected by this agreement. Expiration of the point of entry shall be established by the publication date for the 14 days notice to the public of St. Johns' intent to approve this second modification to the Consent Order. This 90 day extension shall begin to run immediately after the 14 day notice period.

2. Zellwood, on its own behalf, and on behalf of its consultant, and St. Johns agree to complete the tasks described in the Task Order attached hereto as Exhibit No. 3, provided that Zellwood executes, Exhibit No. 3 within three (3) days after the expiration of the point of entry, as described in paragraph 1 above, for any parties whose substantial interests may be affected by this modification agreement.

3. St. Johns, with the assistance of Zellwood, agrees to complete the tasks described in the Scope of Work for the Site Specific Hydraulic Loading Test, a copy a which is attached as Exhibit No. 4, within the 90 day extension period allowed herein.

4. Paragraphs 9 and 10 of the Consent Order, as modified by Exhibit No. 2, set the phosphorous loading limitations which Zellwood is required to achieve. The commencement of the loading limitations in Paragraphs 9 and 10, as modified by Exhibit No. 2 shall be extended by the same amount of time as is described in Paragraph 1 above. However, this modification shall not extend any other terms of the Consent Order.

5. It is recognized that substantial progress has been made to evaluate the technical feasibility of converting to an upland disposal system and that the hydraulic loading tests described in paragraphs 2 and 3 above will provide key information to finally determine the feasibility of the upland disposal alternative. The initial review has indicated that the upland disposal system may have much greater costs than originally envisioned and further feasibility evaluations will depend on the availability of funding to accomplish same.

6. This second modification agreement is contingent upon no petitions for administrative proceedings being filed with regard to it. Should any third party file a timely request for administrative hearing on this agreement, then the agreement shall become voidable at the option of either of the parties and, if voided by either of the parties the terms of the original Consent Order, as amended by the first modification agreement, shall continue in place.

7. It is recognized that a complete evaluation of the financial, technical and environmental feasibility of converting to upland disposal could take longer than the period provided for herein. It is further recognized that should an upland disposal system prove feasible, further agreements would be necessary between the parties to establish specifications for the system, funding and final design for the system, as well as time for construction of the system. Any subsequent agreement would be subject to public notice and opportunity provided to petition for administrative hearing by any substantially affected party

8. Except as provided for herein, all terms and conditions of the Consent Order, as previously modified, remain in full force and effect.

This Second Agreement for Modification of Consent Order was executed by the parties on the date indicated below and thereafter rendered by the Clerk of St. Johns on the date so indicated.

Zellwood Drainage and Water Control District

Board of Supervisors

Glenn Rogers, President

St. Johns River Water Management District

Joe E. Hill, Chairman Governing Board

<u>6/16/93</u> Date <u>6/9/93</u> Date

Rendered this 28th day of June, 1993 Patricia C. Schultz District Clerk ST. JOHNS RIVER WATER MANAGEMENT DISTRICT IN RE:

CONSENT ORDER BETWEEN ST. JOHNS RIVER WATER MANAGEMENT DISTRICT AND ZELLWOOD DRAINAGE AND WATER CONTROL DISTRICT THIRD AGREEMENT FOR MODIFICATION OF CONSENT ORDER

File of Record No. 88-636

The parties hereto, Zellwood Drainage and Water Control District (hereinafter "Zellwood") and the St. Johns River Water Management District (hereinafter "St. Johns"), entered into an Modification of Consent Order which was rendered on March 11, 1993. This agreement modified certain portions of a Consent Order between the parties which was rendered on May 16. 1989. A second modification agreement between the patties was rendered on June 28, 1993. The Consent Order together with the two modifications thereto are hereby incorporated herein by reference. The first and second modifications to the consent order describe a process and a timetable by which the parties hereto would explore the feasibility of substituting construction of an upland disposal system in lieu of the seepage interceptor system described in the original Consent Order. Substantially all of the field work necessary for the feasibility study has been done, however, additional analysis of the data derived from the field work is necessary before a final conclusion regarding feasibility can be reached. Completion of the feasibility analysis will require further extension of certain time deadlines contained in the Consent Order and the modification thereto. THEREFORE, the parties agree and stipulate to the following third modification to the existing Consent Order:

1. The current deadline for completion of construction of the seepage interceptor system is March 9, 1994, as established by the second modification of the Consent Order. The construction deadline is hereby extended for a period not to exceed 60 days, from the date this modification agreement is rendered by the St. Johns District Clerk.

2. Zellwood, on its own behalf, and on behalf of its consultant, and St. Johns agree to complete the feasibility analysis as described in the first and second modification agreements and the attachments thereto.

3. Paragraphs 9 and 10 of the Consent Order, as modified by the first and second modification agreements set the phosphorous loading limitations which Zellwood is required to achieve. The commencement of the loading limitations in Paragraphs 9 and 10, as modified by the second modification agreement, shall be extended by the same amount of time as is described in Paragraph 1 above. However, this modification shall not extend any other terms of the Consent Order.

4. It is recognized that substantial progress has been made to evaluate the technical feasibility of converting to an upland disposal system and the feasibility analysis described in paragraph 2 above will provide key information to finally determine the feasibility of the upland disposal alternative. The initial review has indicated that the upland disposal system may have much greater costs than originally envisioned and further pursuit of this alternative will depend on the availability of funding to accomplish same.

5. This third modification agreement is contingent upon no petitions for administrative proceedings being filed with regard to it. Should any third party file a timely request for administrative hearing on this agreement, then the agreement shall become voidable at the option of either of the parties and, if voided by either of the parties the terms of the original Consent Order, as amended by the first and second modification agreements, shall continue in place.

6. It is recognized that a complete evaluation of all of the financial, technical and environmental feasibility of converting to upland disposal could take longer than the period provided for herein. It is further recognized that should an upland disposal system prove feasible, further agreements would be necessary between the parties to establish specifications for the system, funding and final design for the system, as well as time for construction of the system. Any subsequent agreement would be subject to public notice and opportunity provided to petition for administrative hearing by any substantially affected party.

7. Except as provided for herein, all terms and conditions of the Consent Order, as previously modified, remain in full force and effect.

This Third Agreement for Modification of Consent Order was executed by the parties on the date indicated below and thereafter rendered by the Clerk of St. Johns on the date so indicated.

Zellwood Drainage and Water Control District	St. Johns River Water Management District
Glenn Rogers, President	Joe E. Hill, Chairman
Board of Supervisors	Governing Board
9/14/93	<u>9/8/93</u>
Date	Date
Rendered this 20 th day of Septem	ber, 1993
Patricia C. Schultz	
District Clerk	

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

IN RE:

CONSENT ORDER BETWEEN ST. JOHNS RIVER WATER MANAGEMENT DISTRICT AND F ZELLWOOD DRAINAGE AND WATER CONTROL DISTRICT FOURTH AGREEMENT FOR MODIFICATION OF CONSENT ORDER

File of Record No. 88-636

The parties hereto, Zellwood Drainage and Water Control District (hereinafter Zellwood) and the St. Johns River Water Management District (hereinafter St. Johns), entered into an Agreement for Modification of Consent Order which was rendered on March 11, 1993. This agreement modified certain portions of a Consent Order between the parties which was rendered on May 16, 1989. Subsequently, a second modification agreement between the parties hereto was rendered on June 28, 1993, and a third modification agreement between the parties hereto was rendered on September 20, 1993. The original Consent Order together with the three modifications thereof are hereby incorporated by reference herein.

The first, second and third modification agreements describe a process and a timetable by which the parties would explore the feasibility of substituting construction of an upland disposal system in lieu of the seepage interceptor system described in the original Consent Order. This feasibility study has now been completed and it concludes that it is technically feasible to dispose of up to five million gallons of farm runoff water through upland rapid infiltration basins in the vicinity of Zellwood.

Having determined the technical feasibility of an upland disposal system, the next immediate step toward creating such a system at this location is the creation of a conceptual engineering design for it. If the parties are to continue to explore this alternative for reducing the amount of phosphorus discharged to Lake Apopka, a further extension of certain deadlines contained in the Consent Order, as modified, is necessary in order to generate a conceptual engineering design. Each of the parties hereto does, in fact, desire to take this next step in the process.

In addition, the parties hereto have examined certain of the monitoring requirements contained in the original Consent Order and have determined that some can be modified to improve the data derived from monitoring and also to reduce some of the burdens associated with the monitoring.

Therefore, the parties agree and stipulate to the following fourth modification to the original Consent Order:

1. The current deadline for completion of construction of the seepage interceptor system is May 8, 1994, as established by the third modification of the Consent Order. The construction deadline is hereby extended for a period not to exceed 270 days from the date this modification agreement is rendered by the St. Johns District Clerk. 2. Zellwood, by and through its employees, agents and consultants, and St. Johns agree to complete the conceptual design process set forth in the attached Exhibits "A" and "B". The various tasks outlined in Exhibit A will be Zellwood's responsibility and the tasks outlined in Exhibit B will be St. Johns' responsibility. Each party will be responsible for performing its assigned tasks within the time frames specified in Exhibits A and B. This time schedule and the extension granted in paragraph 1 above are calculated to allow the design process to be completed in time for the parties hereto to evaluate and act on any further steps beyond the design phase by the date of the August, 1994 meeting of the St. Johns Governing Board.

3. Paragraphs 9 and 10 of the original Consent Order, as modified by the first, second and third modification agreements, set the phosphorus loading limitations which Zellwood is required to achieve. The commencement of the loading limitations in Paragraphs 9 and 10, as modified by the third modification agreement, shall be extended by the same amount of time as is described in paragraph 1 above. However, this modification shall not extend any other terms of the original Consent Order.

4. With the completion of the technical feasibility determination, substantial progress has been made toward possible implementation of an upland disposal system for Zellwood. Completion of the conceptual design will be a further step toward this potential alternative. The parties recognize that further progress toward actual implementation of an upland disposal system will depend on the availability of funding for same.

5. It is recognized that a complete evaluation of all of the financial, technical and environmental requirements of converting to upland disposal could take longer than the period provided for herein. It is further recognized that after a conceptual design is completed for an upland disposal system at this location, moving toward implementation of the system would require further agreements to provide for final design of and funding for the system. Any subsequent agreement would be subject to public notice and opportunity provided to petition for administrative hearing by any substantially affected party.

6. Effective January 1, 1994, the monitoring requirements described in paragraph 8 of the original Consent Order shall be eliminated, and the following monitoring and reporting requirements will apply in place thereof:

(a) The final 1993 monthly water budget calculation, as described in paragraph 8(D), must be submitted by March 30, 1994.

Water discharged from the seepage interception system, if constructed, must be sampled monthly at each pump for total phosphorus. Sampling results must be submitted to the District quarterly, within 30 days of the end of the previous calendar quarter.

(c)Zellwood must record crops grown, including date of planting and harvest, crop types, and acreage of planting. Aggregated crop records must be submitted to the District annually, within 30 days of the end of the previous year.

(d) The data specified in sections (b) and (c) above shall be collected for the life of the Consent Order.

7. Effective January 1, 1994, the monitoring requirements described in paragraph 18 of the original Consent Order shall be eliminated, and the following monitoring and reporting requirements will apply:

(a) Zellwood shall implement a monitoring program to sample its discharges to Lake Apopka and associated water bodies. The monitoring program shall consist of composite sampling of every pump event at pump stations PS1 and PS2, and discrete monthly sampling of pump stations P3, P4 and P9, if operated. Samples shall be collected at the pump station inlet and analyzed for Total Phosphorus. Composited samples shall be collected 15 minutes after initiation of a sample event, and every four hours thereafter until the end of the sample event, using a nonrefrigerated autosampler and acidified sample bottles. Composited samples must be removed biweekly and transported to the analytical laboratory. Pump events at pump stations P3, P4, and P9 must be sampled monthly, If no pumps were operated within a pump station during a particular month, no sample is required for that month. An acid-preserved, discrete sample shall be collected 15 minutes after the initiation of a sample event, and transported to the analytical laboratory with the biweekly composite sample. If the discharge from any pump station exceeds 5% of the total volume discharged on an annual basis, Zellwood will implement a program to monitor each pump event at that particular pump station for total phosphorus, through manual or automated means. Samples must be submitted to a laboratory, certified by the Department of Health and Rehabilitative Services, for analysis within 28 days of initial sample collection. Sample results must be submitted to the District quarterly, within 30 days after the end of each calendar quarter.

(b) Zellwood must submit a revised quality assurance plan for District approval by December 15, 1993.

8. This fourth modification agreement is contingent upon no petitions for administrative proceedings being filed with regard to it. Should any third party file a timely request for administrative hearing on this agreement, then the agreement shall become voidable at the option of either of the parties and, if voided by either of the parties, the terms of the original Consent Order, as amended by the first, second and third modification agreements, shall continue in place.

9. Except as provided herein, all terms and conditions of the original Consent Order, as previously modified, remain in full force and effect. This Fourth Agreement for Modification of Consent Order was executed by the parties on the date indicated below and thereafter rendered by the Clerk of St. Johns on the date so indicated .

Zellwood Drainage and Water Control District St. Johns River Water Management District

Glenn Rogers, President Board of Supervisor <u>11/15/93</u> Patricia Harden, Chair Governing Board <u>11/10/93</u>

Rendered this 17th day of November, 1993 Patricia C. Schultz District Clerk PARSONS BRINCKERHOFF GORE & STORRIE, INC. TASK ORDER NO. 3 SERVICES FOR CAPACITY ASSESSMENT AND CONCEPTUAL DESIGN OF A POTENTIAL RAPID INFILTRATION BASIN SITE FOR THE ZELLWOOD DRAINAGE & WATER CONTROL DISTRICT

SCOPE OF WORK, SCHEDULE AND BUDGET

The work to be performed under this scope of work will be provided by Parsons Brinckerhoff Gore & Storrie, Inc. (PBG&S) to the Zellwood Drainage & Water Control District (ZDWCD). This scope of work is for further evaluation of the potential recharge capacity of the properties to the east, southeast and west of Lower Lake Doe and Lake Witherington. Based on the evaluation results, PBG&S will make recommendations to the ZDWCD on the suitability of this site for development of an infiltration system for disposal of stormwater from the ZDWCD. If the site appears to have adequate capacity, PBG&S will make recommendations on the conceptual design of an appropriate infiltration system. PBG&S will also provide information to assist the ZDWCD to develop preliminary cost estimates for construction and operation of the system. SERVICES TO BE PERFORMED BY PBG&S

The following services are to be performed by PBG&S under this Task Order: <u>1. Hydrogeologic Investigation</u>

1.1 PBG&S staff will select locations for additional borings to be used for correlation with the ground penetrating radar (GPR) surveys obtained by the ZDWCD. PBG&S staff will interpret additional GPR surveys to be obtained by the ZDWCD from the property to the east and southeast of Lower Doe Lake and Lake Witherington.

1.2 PBG&S staff will select a location for a load test cell further uphill from the load test cell which was used under Task Order 2. The location will be selected to provide information on the degree of confinement in the uphill zone which was unaffected by the previous load test. PBG&S will develop a plan for installation of piezometers around the test cell.

1.3 PBG&S staff will provide ZDWCD staff with guidance on performance of the load test, and will interpret the load test result.

2. Groundwater Modeling

2.1 PBG&S will coordinate with the SJRWMD staff in their assessment of long-term fluctuations in the potentiometric, surface of the Floridan aquifer in response to rainfall fluctuations and changes in net recharge caused by development. This analysis will be used to derive a projected baseline range of Floridan potentiometric, values, to be used in modeling projections of the capacity of the proposed RIB sites.

2.2 Based on the work performed under Task Orders 1 and 2, and on the data from items 1a through 2a above, PBG&S will set up a groundwater flow model grid to represent the hydrologic system of the preferred potential RIB sites around Lower Lake Doe and Lake Witherington.

2.3 PBG&S will calibrate the groundwater flow model to the extent feasible with the available data.

2.4 PBG&S will use the calibrated groundwater flow model to assess the best locations for RIBs on the proposed property, and to estimate the maximum practically achievable steady-state RIB capacity. PBG&S will also use the model to estimate the post-loading recovery rates for the proposed RIBs, to assist in assessment of a practical operating system for the facilities.

2.5 PBG&S will perform a sensitivity analysis of the groundwater flow model to assess the uncertainty in the projected RIB system capacity due to the limited available calibration data. (Note. Calibration data are limited because portions of the surficial aquifer system are completely unsaturated under natural conditions. Therefore there are no background data available showing water levels under natural recharge conditions to provide a calibration condition for the groundwater flow model).

2.6 PBG&S staff will review the results of the phosphorus adsorption capacity testing performed by the SJRWMD. Based on these results and consultation with the SJRWMD over water quality control aspects of the SJRWMD surface water management plan, PBG&S will advise the ZDWCD whether numerical phosphorus transport modeling appears necessary. If phosphorus transport modeling is required, PBG&S will provide the ZDWCD with an amendment to this scope of work and budget to cover the additional work.

3. Conceptual Design of a Surface Water Control System

3.1 PBG&S will coordinate with the SJRWMD staff who will perform the analysis for conceptual design of a surface water control system for the Lake Doe/Lake Witherington chain of lakes. PBG&S will share information with the SJRWMD so that the surface water analysis and the groundwater modeling are compatible with each other.

4. Conceptual Design of a RIB System

4.1 PBG&S will develop a conceptual design for a RIB system to be built on the proposed infiltration site(s). The conceptual design will include RIB cell locations and general geometry, including bottom elevation, berm heights and overflow control structure elevation. The conceptual design will also include a flow distribution and

control system to distribute flows between the various RIB cells. The conceptual design will provide schematic figures, but will not include engineering design drawings.
4.2 PBG&S will develop a preliminary RIB operating plan which will include recommendations on groundwater and surface water monitoring required to assist in decisions on operational distribution of flows between RIBs.

5. Conceptual Design of a Water Conveyance System

5.1 PBG&S will coordinate with the ZDWCD Staff who will provide a conceptual design for the conveyance system to collect surface water from the ZDWCD and pump it to the proposed RIB site(s). PBG&S will share information with the ZDWCD so that the conveyance system, the RIB distribution system and operating plan are compatible with each other.

6. Preliminary Cost Estimates for Construction and Operation

6.1 PBG&S will assist the ZDWCD to develop preliminary cost estimates for design and construction of the proposed RIB system. PBG&S will provide the ZDWCD with preliminary estimates of the amount of earth moving which will be required, typical costs for construction of the proposed flow distribution system between the RIBs, the cost of groundwater monitor wells, the cost of any proposed water quality sampling, and the expected frequency of maintenance activities such as mowing RIB berms and disking RIB bottoms.

7. Coordination, Communication and Final Report

7.1 PBG&S will perform routine project coordination with the staffs of the ZDWCD and the SJRWMD. The project coordination will include attendance at up to ten (10) meetings, of which at least five (5) will be held either at PBG&S's offices or at the SJRWMD offices in Orlando.

7.2 PBG&S will provide the ZDWCD with a report documenting the additional hydrogeologic investigations, the groundwater modeling, and the conceptual RIB system design.

DATA AND SERVICES TO BE FURNISHED BY THE SJRWMD The following data and services are to be provided by the SJRWMD: <u>1. Hydrogeologic Investigation</u>

1.1 SJRWMD staff will attend a meeting with PBG&S staff to discuss the additional investigations of the lakes south of Lake Witherington which will be performed by the SJRWMD. These investigations may include borings designed to provide additional

information on the hydrogeologic conditions below these lakes to assist the SJRWMD to estimate their potential leakage to the Floridan aquifer. The SJRWMD will estimate of potential leakage rates by comparing the borings to those made adjacent to the load test in Lake Witherington.

1.2 The SJRWMD will provide phosphorus adsorption capacity testing on representative soil samples from the proposed RIB site(s). The testing will be designed to provide both total adsorption capacity, and adsorption rate coefficient, suitable for modeling phosphorus transport from the infiltration basins.

2. Conceptual Design of a Surface Water Control System

2.1 The SJRWMD will provide a conceptual design for a surface water control system for the Lake Doe/Lake Witherington chain of lakes. The control system will be designed to ensure that the RIB system does not increase the risk of flooding during wet weather on properties adjacent to the chain of lakes. The conceptual design will include provision for appropriate control structures between lakes, with sufficient storm conveyance capacity to prevent flooding by conveying excess wet weather flows out of the chain of lakes. The conveyance system will include an ultimate discharge structure which will either convey the flood waters back to the ZDWCD or to Lake Apopka. The choice of discharge destination will depend on technical feasibility and cost-effectiveness.

2.2 The SJRWMD conceptual surface water control system design will include consideration of any necessary alterations to the vegetation which has invaded the dry lake bottoms, and preferred operating levels for the lakes. The plan will also address the potential water quality impacts of rehydrating the desiccated muck soils in the lake bottoms,

2.3 The SJRWMD conceptual surface water control system design will include a plan for any necessary routine monitoring and operational control activities.

3. Preliminary Cost Estimates for Final Design, Construction and Operation

3.1 The SJRWMD will provide the ZDWCD with preliminary estimates of the costs for final design, construction and operation of the surface water control system.

4. Coordination and Communication and Final Report

4.1 The SJRWMD will assist PBG&S and the staff of the ZDWCD in normal project coordination activities. The project coordination will include attendance at up to ten (10) meetings, of which at least five (5) will be held either at PBG&S's offices or at the SJRWMD offices in Orlando.

4.2 The SJRWMD will provide the ZDWCD with a written report documenting the conceptual design of the surface water control system, and the plan for its operational monitoring and control. The report will also present the preliminary cost estimates described in item 3.1 immediately above.

DATA AND SERVICES TO BE FURNISHED BY THE ZDWCD The ZDWCD will provide the following data and services: <u>1. Hydrogeologic Investigation</u>

1.1 The ZDWCD will obtain the services of a qualified contractor or agency to provide GPR scans of the hillside to the east and southeast of Lake Witherington. The contractor or agency will also extend the existing GPR survey on the west side of Lower Lake Doe and Lake Witherington. The locations for GPR transects will be selected through consultation with PBG&S.

1.2 Once the second upland load test location has been selected, the ZDWCD will construct a test cell in the selected location. The ZDWCD will obtain the services of a qualified contractor or agency to install piezometers and obtain soil samples around the test cell at locations and depths specified by PBG&S. The ZDWCD will survey the tops of the piezometer casings to a relative accuracy of \pm 0.01 ft.

1.3 The ZDWCD (with assistance from the SJRWMD) will provide a pump and conveyance system to discharge water from a Floridan aquifer well into the test cell at a flow rate up to 250 gpm. The flow rate shall be adjustable (eg. through use of a throttle valve), and flows will be metered using a totalizing flow meter. The test cell will be provided with a float control to maintain ponded water elevations within a selected operating range by switching the pump on and off.

1.4 The ZDWCD will monitor the test flows daily, and will record the daily flow volumes supplied to the test cell. ZDWCD staff will monitor water levels in the piezometers around the test cell and the elevation of any water ponded in the test cell. The ZDWCD will maintain a record of daily rainfall during the load test.

2. Conceptual Design of a Flow Conveyance System

2.1 The ZDWCD will provide a conceptual design for a flow conveyance system to collect and store surface waters from thee ZDWCD and pump then to the proposed infiltration site(s) for distribution to the RIBs. The conceptual design of the conveyance system will include collections ditches, a storage pond, pumping facilities, piping from the ZDWCD to the proposed site(s), and a flow control system.

3. Preliminary Cost Estimates for Final Design, Construction and Operation

3.1 The ZDWCD will prepare cost estimates of the total costs for final design, land purchase, and construction and operation of the surface water infiltration system. The cost estimates will be based on the information provided by PBG&S and the SJRWMD supplemented by additional information provided by the ZDWCD.

4. Coordination and Communication

4.1 The ZDWCD will assist PBG&S and the staff of the SJRWMD in normal project coordination activities. The project coordination will include attendance at up to ten (10) meetings, of which at least five (5) will be held either at PBG&S's offices or at the SJRWMD offices in Orlando.

SCHEDULE

The meetings between the ZDWCD, PBG&S and the SJRWMD will be scheduled by the ZDWCD at times mutually agreed by the participants.

The GPR investigation and the additional borings in the upland areas and lake bottoms will be completed within four (4) weeks of project start-up.

The duration of the load tests will depend on the water level response which is observed in the test piezometers. The tests may run for up to three (3) months. Provided that the load test is completed within eleven (11) weeks of project start-up, PBG&S will complete interpretation of the load test results and set-up of the groundwater flow model within fourteen (14) weeks of project start-up. PBG&S and SJRWMD staffs will then attend a meeting with the ZDWCD to review the additional information and decide if further analysis is warranted.

If further analysis is approved by the ZDWCD, PBG&S will proceed with calibration of the groundwater model and assessment of the available capacity of the proposed RIB system. The SJRWMD will proceed in parallel with PBG&S to perform the conceptual design of the surface water management system (this information will be incorporated into the groundwater model). The SJRWMD will complete analysis of the surface water system within eight (8) weeks of the notice from the ZDWCD to PBG&S to proceed with this portion of the project. PBG&S will complete the groundwater capacity modeling within four (4) weeks after receiving the SJRWMD's analysis and conceptual design of the surface water system.

Once the capacity analysis of the proposed RIB system is completed, PBG&S will met with the ZDWCD and the SJRWMD to discuss the results. If the capacity is high enough to warrant further preliminary design work, the ZDWCD will authorize PBG&S to proceed with the final phase of this Task Order If so authorized by the ZDWCD, PBG&S will proceed with conceptual design of the RIB system. The conceptual design and associated preliminary cost estimates will be completed within eight (8) weeks of the ZDWCD's authorization to proceed. Within the same time period, the SJRWMD will provide the preliminary cost estimates associated with the surface water control system, and the ZDWCD will proceed with conceptual design of the surface water conveyance system from the ZDWCD to the proposed RIB site(s).

PBG&S will provide the ZDWCD with a written report documenting PBG&S's work under this Task Order within ten (10) weeks of the ZDWCD's authorization to proceed with the conceptual design and cost estimates for the RIB system.

If the load test can be completed within eleven (11) weeks from project start-up, the project is scheduled to be completed in thirty three (33) weeks.

METHOD OF PAYMENT

The ZDWCD will compensate PBG&S for the services described in this scope of work using the <u>hourly rate plus direct expenses</u> method. The hourly rates for personnel utilized in the performance of this Task Order, including overhead factors and operating margin, shall be as follows;

Personnel Category	<u>Rate (\$/ nr)</u>	
Principal Engineer/Geologist/Scientist		95 - 120
Senior Manager/Engineer/Geologist/Scientist		65 - 95
Project Engineer/Geologist/Scientist		50 - 70
Staff Engineer/Geologist/Scientist		40 - 55
Project Administrator		40 - 50
Secretary		20 - 30

PBG&S will perform the "Services to be Performed by PBG&S" with an upset limit of \$_____ which will not be exceeded without the prior approval of the ZDWCD. APPROVAL: Zellwood Drainage & Water Control District Signature: Name & Title: Date: Conceptual Design of Surface water Management Plan Scope of Work

This scope of work is for development of a conceptual surface water management plan for a portion of the Zellwood Chain of Lakes (from Lower Lake Doe to SR 437). Services to be performed by the District

The following tasks will be performed by the District:

1. District staff will evaluate hydraulic constraints and flood elevations within the specified portion of the chain of lakes. If appropriate, District staff will develop a conveyance and routing model. District staff will recommend a conceptual water management strategy, which will include control elevations and structures, if necessary.

2. District staff will examine the relationship between rainfall and Floridan aquifer levels to assist in evaluating the long-term response of the chain of lakes to additional hydrologic inputs.

3. District staff will determine desired wetland hydroperiods within the specified portion of the chain of lakes.

4. District staff will develop a water quality management strategy for the specified portion of the chain of lakes if appropriate, limited water quality sampling will be performed. The phosphorus adsorption capacity of the proposed Rapid Infiltration Basin site will be tested and evaluated.

5. District staff will continue to cooperate with Zellwood in performing the RIB conceptual design study, where staff time and equipment allow.

6. District staff, with the approval of Zellwood, will periodically provide updates to Zellwood and their consultant regarding the District's evaluation. The District will provide copies of the results of the phosphorus adsorption analysis to Zellwood.

7. District staff will provide a written report to Zellwood.

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT IN RE:

CONSENT ORDER BETWEEN ST. JOHNS RIVER WATER MANAGEMENT DISTRICT AND ZELLWOOD DRAINAGE AND WATER CONTROL DISTRICT FIFTH AGREEMENT FOR MODIFICATION OF CONSENT ORDER

File of Record No. 88-636

The parties hereto, Zellwood Drainage and Water Control District (hereinafter Zellwood), and the St. Johns River Water Management District (hereinafter St. Johns), entered into an Agreement for Modification of Consent Order which was rendered on March 11, 1993. This agreement modified certain portions of a Consent Order between the parties which was rendered on May 16, 1989. Subsequently, a second modification agreement between the parties hereto was rendered on June 28, 1993, a third modification agreement between the parties hereto was rendered on September 20, 1993, and a fourth modification agreement between the parties hereto was rendered on September 20, 1993. The original Consent Order together with the four modifications thereof are hereby incorporated by reference herein.

The first, second, third, and fourth modification agreements describe a process and a timetable by which the parties would explore the feasibility of substituting construction of an upland disposal system in lieu of the seepage interceptor system described in the original Consent Order. This feasibility study has now been completed and it concludes that it is technically feasible to dispose of up to five million gallons of farm runoff water through upland rapid infiltration basins in the vicinity of Zellwood.

Having determined the technical feasibility of an upland disposal system, the next immediate step toward creating such a system at this location is the creation of a conceptual engineering design for it. Although a conceptual engineering design has largely been completed, there is still some additional analysis which must be completed before further consideration of pursuing and upland disposal alternative may go forward. An additional extension of certain deadlines contained in the Consent Order, as modified, is necessary in order to complete the analysis of the conceptual engineering design.

Therefore, the parties agree and stipulate to the following fourth modification to the original Consent Order:

1. The current deadline for completion of construction of the seepage interceptor system is February 2, 1995, as established by the fourth modification of the Consent Order. The construction deadline is hereby extended for a period not to exceed 91 days from the date this modification agreement is rendered by the St. Johns District Clerk.

2. Zellwood, by and through its employees, agents and consultants, and St. Johns agree to complete the conceptual design process set forth in the fourth modification

agreement. This time schedule and the extension granted in paragraph 1 above are calculated to allow the design process to be completed in time for the parties hereto to evaluate and act on any further steps beyond the design phase by the date of the November, 1994 meeting of the St. Johns Governing Board.

3. Paragraphs 9 and 10 of the original Consent Order, as modified by the first, second third and fourth modification agreements, set the phosphorus loading limitations which Zellwood is required to achieve. The commencement of the loading limitations in Paragraphs 9 and 10, as modified by the fourth modification agreement, shall be extended by the same amount of time as is described in paragraph 1 above. However, this modification shall not extend any other terms of the original Consent Order.

4. With the completion of the technical feasibility determination, substantial progress has been made toward possible implementation of an upland disposal system for Zellwood. Completion of the conceptual design will be a further step toward this potential alternative. The parties recognize that further progress toward actual implementation of an upland disposal system will depend on the availability of funding for same.

5. It is recognized that a complete evaluation of all of the financial, technical and environmental requirements of converting to upland disposal could take longer than the period provided for herein. It is further recognized that after a conceptual design is completed for an upland disposal system at this location, moving toward implementation of the system would require further agreements to provide for final design of and funding for the system. Any subsequent agreement would be subject to public notice and opportunity provided to petition for administrative hearing by any substantially affected party.

6. This fifth modification agreement is contingent upon no petitions for administrative proceedings being filed with regard to it. Should any third party file a timely request for administrative hearing on this agreement, then the agreement shall become voidable at the option of either of the parties and, if voided by either of the parties, the terms of the original Consent Order, as amended by the first, second third and fourth modification agreements, shall continue in place.

9. Except as provided herein, all terms and conditions of the original Consent Order, as previously modified, remain in full force and effect.

SWIM Plan for Lake Apopka

This Fifth Agreement for Modification of Consent Order was executed by the parties on the date indicated below and thereafter rendered by the Clerk of St. Johns on the date so indicated.

Zellwood Drainage and Water Control District

Glenn Rogers, President Board of Supervisors St. Johns River Water Management District

Patricia Harden, Chair Governing Board

<u>8/18/94</u> Date <u>8/10/94</u> Date

Rendered this 23rd day of August, 1994 Patricia C. Schultz District Clerk

F.O.R. No. 88-636

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT IN RE: CONSENT ORDER BETWEEN ST. JOHNS RIVER WATER MANAGEMENT DISTRICT AND ZELLWOOD DRAINAGE AND WATER CONTROL DISTRICT SEVENTH AGREEMENT FOR MODIFICATION OF CONSENT ORDER

The parties hereto, Zellwood Drainage and Water Control District (hereinafter "Zellwood"), and the St. Johns River Water Management District (hereinafter "St. Johns") entered into a Consent Order which was rendered by St. Johns on May 16, 1989, and bears the above File of Record number. Said Consent Order addresses regulation of Zellwood's discharge of water to Lake Apopka in connection with the agricultural activities conducted within Zellwood's borders. There have been six previous agreements for modification of the Consent Order.

The first through fifth modifications of the Consent Order extended certain deadlines therein while the parties explored the feasibility of substituting an upland disposal system, designed to dispose of portions of the water Zellwood currently discharges to Lake Apopka, for the seepage interceptor system provided for in Paragraph 6(A) of the Consent Order. The sixth modification to the Consent Order further extended certain deadlines in the Consent Order for the purpose of the parties exploring the feasibility of substituting an alum injection system for the seepage interceptor system. Based on the feasibility evaluation performed for Zellwood by its consultant, Environmental Research & Design, Inc. (ERD), the inclusion of an alum injection system as a component of Zellwood's overall strategies to reduce or render phosphorus discharges less available to Lake Apopka, is feasible. The parties have, as a consequence of this study, mutually agreed to the installation and further evaluation of an alum injection system by Zellwood in accordance with the terms and limitations set forth herein. Therefore, the parties do hereby agree and stipulate to the following seventh modification to the existing Consent Order:

1. The provisions of Paragraph 6 of the original Consent Order as it describes and relates to the construction of a seepage interceptor system, designed for the purpose of intercepting water seeping under Zellwood's dike and then pumping it back into Lake Apopka, are hereby eliminated.

2. As a substitute for construction and operation of the seepage interceptor system, Zellwood will construct and operate an alum injection system at its Pump Station No. 2, or additional pumps as determined by the study described in Paragraph 5 below, in a manner projected to reduce the orthophosphate loads from Zellwood's Pump Station No. 2 by the equivalent of 80% on a flow-weighted annual average basis beginning in calendar year 1997. The operational criteria shall be determined based on the study described in paragraph 5 below. The system will be constructed in accordance with the plans and specifications submitted to St. Johns on March 8, 1995 and April 11, 1995, which include an operation and maintenance plan. Any significant deviation from the plan must be agreed upon in writing by both parties prior thereto.

3. The parties hereto recognize that the treatment efficiencies obtained in the field tests performed by Zellwood's consultant in January, 1995, do not necessarily represent the full range of operational conditions Zellwood encounters over a year, either in terms of volumes of water to be treated at various times of the year or in terms of phosphorus concentrations contained in the water. The alum dosage rate and injection method necessary to achieve the equivalent of an 80% treatment efficiency for orthophosphate at Pump Station No. 2, on a flow-weighted annual average basis, are likely dependent on these variables. The parties agree that operation of the alum injection system described in the March 8, 1995 and April 11, 1995, plans submitted to St. Johns which are referred to in Paragraph 2 above, for a minimum period of one year will be necessary in order to determine a dosage rate of alum and operational conditions necessary for Zellwood to achieve the equivalent of an 80% treatment efficiency at Pump Station No. 2 on a flow-weighted annual average basis, if such an efficiency can be achieved. If the results of the study described in Paragraph 4 below indicate that it is not feasible to reduce orthophosphate loads by the equivalent of 80% on a flowweighted annual averacre basis, Zellwood and St. Johns staff will discuss appropriate amendments to the Consent Order with the Governing Board.

4. Zellwood must construct and install the alum injection system described in the March 8, 1995 and April 11, 1995, plans submitted to St. Johns and have same operational by July 15, 1995. For a minimum period of one year following commencement of operation of the system Zellwood will study and evaluate the operational criteria necessary for the system to achieve the performance standard outlined in Paragraph 5 below. This study must conform to the following specifications:

(a) The percentage reduction in orthophosphate load will be calculated based on samples collected before alum treatment and after alum treatment, as described in Paragraph 6(a) below;

(b) The study must include an evaluation of dosage rates, including seasonal or rainfall adjusted rates, alterations to the injection method or location, and installation of injection systems on additional pump stations;

(c) The results of the study must be submitted to St. Johns by September 30, 1996.

5. Using the data collected in the study and the results of the operational effectiveness data described in Paragraph 11 (a) below, Zellwood must provide St. Johns with information giving reasonable assurance that for the remainder of the Consent Order, orthophosphate loads will be reduced by the equivalent of 80% on an flow-weighted, annual average basis, versus orthophosphate loading at Pump Station No. 2 prior to treatment by the alum injection system, with said assurance being based

on 90% statistical confidence level. In determining, whether reasonable assurance exists, St. Johns will consider mitigating information, such as an adjusted alum dosage rate which achieved the desired percentage reduction, applied to an equivalent pump event. Following such a demonstration, St. Johns' staff will approve operational criteria, based on the results of the study referred to in Paragraph 5 above, which must be implemented by January 1, 1997. If Zellwood substantially alters historical pumping patterns to the extent that reasonable assurance is no longer provided that the alum injection system will achieve the equivalent of an 80% treatment efficiency at Pump Station No. 2 on a flow-weighted annual average basis, St. Johns staff will reevaluate, and if necessary, modify the operational criteria.

6. The following monitoring regime shall be instituted at Pump Station No. 2 for the purposes of evaluating the performance of the alum injection system and shall substitute for the monitoring required for Pump Station No. 2 by the Fourth Agreement for Modification of the Consent Order. Data collected pursuant to this paragraph must be submitted to St. Johns quarterly:

(a) Zellwood must sample every other pump event for total phosphorus and orthophosphate. Samples must be collected immediately upstream of the alum injection point (prior to alum injection or mixing with alum) and in the pipe at the discharge point (after alum injection, but prior to discharge to lake Apopka). A pump event is defined as the cumulative pumping per day from 8:00 A.M. to 7:59 A.M. If more than one sample is taken from a pump event requiring sampling, the samples shall be combined for a single analysis. During pumping days in which a sample is not required to be taken, Zellwood may turn off the automatic sampler. Samples must be collected at least 30 minutes after the pump event has started. Orthophosphate samples must be collected and analyzed according to EPA methods (preserved by cooling to less than 4 degrees centigrade and analysis within 48 hours) by a laboratory appropriately certified by the Department of Health and Rehabilitative Services. Samples collected by the refrigerated automatic sampler after 12:01 P.M. on Friday through Monday at 8:00 A.M. must be submitted to the analytical laboratory before 12:01 P.M. on that Monday. If the samples are not analyzed within the timeframes specified by EPA, that fact must be noted and specified in the quarterly data report;

(b) A modified quality assurance plan must be submitted by Zellwood to St. Johns staff for approval which incorporates the changes outlined herein to their monitoring program. Said modified plan must be submitted to St. Johns by June 15, 1995; (c) Zellwood must record pump hours daily;

(d) Zellwood must record the volume of alum injected weekly and calculate dosage rates based on alum volume and pump discharge volume. During the study period described in Paragraph 5 above, Zellwood must record the volume of alum injected per pump event. The volume of alum added must be recorded using a totalizing flow meter; (e) After each year of sampling, St. Johns will evaluate the sampling results and determine if a lower sampling frequency is warranted, based on the variability of the data. St. Johns will also evaluate the reliability and feasibility of additional sampling of weekend orthophosphate samples not analyzed within EPA timeframes.

7. It is also necessary to institute certain in-lake monitoring procedures in Lake Apopka to evaluate any impact associated with the discharge of alum to the lake. The following requirements relate to in-lake monitoring:

(a) Zellwood must retain a qualified consultant to monitor and report the visual depth of floc annually, based on sediment cores collected at distances of 150 yards and 250 yards, respectively, from the fuel tanks north of Pump Station No. 2, on a transect perpendicular to Zellwood's levee;

(b) Zellwood must measure sediment total aluminum concentrations annually (mg/kg) dry weight) at a depth of 0-6 inches and 6-12 inches from the sediment/water interface, with an initial sample collected prior to operation of the alum injection system. Cores must be collected at distances 150 yards and 250 yards, respectively, from the fuel tanks north of Pump Station No. 2, on a transect perpendicular to Zellwood's levee;

(c) Zellwood must monitor benthic macroinvertebrates to evaluate species composition and abundance at a sample station located at a distance of 150 yards from the fuel tanks north of Pump Station No. 2, on a transect perpendicular to Zellwood's levee, and at a minimum distance of 25 feet north of the cattail fringe. Samples must be collected annually, prior to operation of the alum injection system, and during the second calendar quarter thereafter. If a substantial decline in species composition or abundance is documented at the sample station which may be reasonably attributed to alum injection, based on data obtained pursuant to subparagraphs (a) or (b) above, Zellwood must submit a proposal for additional monitoring of benthic macroinvertebrates to St. Johns' staff for approval;

(d) St. Johns will incorporate sampling and analysis for dissolved aluminum water column into the existing Lake Apopka monitoring program.

8. Zellwood's consultant will perform two additional jar tests with samples collected between July 15, and August 30, 1995, to evaluate the rate of orthophosphate removal, using the methodology described in Section 2.2 of the report, entitled "Evaluation of the Feasibility of Alum Treatment for Pumped Agricultural Discharges At the Zellwood Water Control District", dated January, 1995.

9. Should St. Johns choose to monitor the effectiveness of the alum injection system or the quality of discharge to Lake Apopka, Zellwood shall provide space and electrical service adjacent to Zellwood's sampling equipment appropriate for St. Johns' automatic samplers and access by St. Johns' staff. In no event, however, shall Zellwood be required to provide electrical service where none exists, unless scheduled for installation in connection with the plans submitted to St. Johns on March 8, 1995 and April 11, 1995.

10. Should pH levels less than 6.0 s.u. be measured at the point of discharge from Pump Station No. 2 to Lake Apopka, Zellwood shall immediately cease operation of the alum injection system, report the event to St. Johns' Resource Management Department staff, and take such measures as are necessary to resume operation of the alum injection system in a manner which will not cause pH levels to drop below 6.0 s.u. If pH levels less than 6.0 s.u. are measured on three or more occasions per calendar year, Zellwood shall make appropriate modifications to the system to prevent pH levels from falling below that level which shall include installation of a continuous pH monitoring system at the point of discharge to Lake Apopka with an automatic cut-off switch to inactivate the alum injection system at pH levels below 6.0 s.u.

11. In addition to the quarterly data reports required by the current Order, Zellwood shall submit the following information to St. Johns:

(a) An annual report describing the operational effectiveness and maintenance of the alum injection system. The annual report shall include a tabulation of operational hours, down-time hours and recommended modifications, if necessary, to increase operational effectiveness. Recommendations shall be implemented by Zellwood after consultation with St. Johns' staff;

(b) An annual summary report on the alum injection system, which includes the information required to be collected or calculated under Paragraphs 4 through 7 above;

(c) All rainfall records submitted to St. Johns quarterly.

12. For the calendar year commencing January 1, 1996, and for any yearthereafter during which Zellwood operates the alum injection system in accordance with the Consent Order as modified herein, Zellwood's net discharge of total phosphorus to Lake Apopka from all discharge points combined shall not exceed 54,000 pounds per calendar year, with adjustments for rainfall and groundwater as detailed in Paragraph 9 of the original Consent Order.

13. If after operating the alum injection system for the one year study period outlined in Paragraph 4 above, Zellwood is unable to develop operational criteria which will enable it to provide St. Johns with reasonable assurance that it can reduce orthophosphate levels in the discharge as outlined in Paragraph 5 above, Zellwood's net discharge of total phosphor-us to Lake Apopka from all discharge points shall not exceed 54,000 pounds per calendar year with adjustments for rainfall and groundwater as specified in Paragraph 9 of the original Consent Order and in accordance with the timeframes established by it and subsequent modifications of the Consent Order. If Zellwood elects not to operate the alum injection system, the net discharge of total phosphorus to Lake Apopka from all discharge points shall not exceed 40,675 pounds per year, with adjustments for rainfall and groundwater as incorporatated by reference in Paragraph 10 of the original Consent Order and in accordance with the time frames and limitations established by Paragraph 10 of the original Consent Order and subsequent modifications. Should this occur the monitoring conditions for Pump Station No. 2 as outlined in the Fourth Agreement for Modification of Consent Order must immediately be reinstated.

14. St. Johns' approval of an alum injection system to meet the requirements of the Consent Order does not imply that St. Johns will approve the method or design specified in this agreement for compliance with proposed rule chapter 40C-61, Fla. Admin. Code. Continuation after the expiration of this Consent Order of an alum injection system by Zellwood for the purpose of phosphorus abatement will require Zellwood to provide St. Johns with reasonable assurance that said system meets any applicable permitting requirements in place at that time.

15. Except as specifically addressed herein, or in any of the previous 6 modifications to the original Consent Order, all terms and conditions of the original Consent Order, as amended, remain in full force and effect.

Zellwood Drainage and Water
Control DistrictSt. Johns River Water
Management DistrictGlenn Rogers, President,
Board of SupervisorsPatricia Harden, Chair
Governing Board<u>4-18-95</u>
Date<u>4/12/95</u>
DateRendered this 21st day of April, 19951995

Patricia C. Schultz District Clerk ST. JOHNS RIVER WATER MANAGEMENT DISTRICT IN RE:

CONSENT ORDER BETWEEN ST. JOHNS RIVER WATER MANAGEMENT DISTRICT AND ZELLWOOD DRAINAGE AND WATER CONTROL DISTRICT

F.O.R. No. 88-636

EIGHTH AGREEMENT FOR MODIFICATION OF CONSENT ORDER

The parties hereto, Zellwood Drainage and Water Control District (hereinafter "Zellwood"), and the St. Johns River Water Management District (hereinafter "St. Johns") entered into a Consent Order which was rendered by St. Johns on May 16, 1989, and bears the above File of Record (F.O.R.) number. Said Consent Order addresses regulation of Zellwood's discharge of water to Lake Apopka in connection with the agricultural activities conducted within Zellwood's borders. There have been seven previous agreements for modification of the Consent Order.

The first through fifth modifications of the Consent Order extended certain deadlines therein while the parties explored the feasibility of substituting an upland disposal system, designed to dispose of portions of the water Zellwood currently discharges to Lake Apopka, for the seepage interceptor system provided for in Paragraph 6(A) of the Consent Order. The sixth modification to the Consent Order further extended certain deadlines in the Consent Order for the purpose of the parties exploring the feasibility of substituting an alum injection system for the seepage interceptor system. The seventh modification required construction of the alum injection system and monitoring for a period of one year to determine long-term operational criteria. Monitoring results have not conclusively provided sufficient data to specify long-term operational criteria. As a result, the parties mutually agree to the terms and limitations set forth herein. Therefore, the parties do hereby agree and stipulate to the following eighth modification to the existing Consent Order:

1. Zellwood will continue to operate an alum injection system constructed in accordance with the plans and specifications submitted to St. Johns on March 8, 1995, and April 11, 1995, at its Pump Station No. 2, in a manner projected to reduce the dissolved orthophosphate loads from Zellwood's Pump Station No. 2 by the equivalent of 80% on a flow-weighted annual average basis beginning April 1, 1997. Zellwood shall operate this alum injection system at a dosage rate of 15 mg/l for the period from April 1, 1997, to April 1, 1998.

2. Based on the results of the monitoring required by Paragraphs 4 and 5 below, Zellwood will continue to evaluate the long-term operational criteria necessary

for the system to achieve the performance standard outlined in Paragraph 3 below. This evaluation must conform to the following specifications:

(a) The percentage reduction in dissolved orthophosphate load will be calculated based on samples collected before alum treatment and after alum treatment, as described in Paragraph 4(a) below;

(b) The dosage rates must be evaluated, including seasonal or rainfall adjusted rates,

(c) The results of the operation and monitoring must be submitted to St. Johns by May 15, 1998, and each year thereafter.

3. Using the monitoring data and the results of the operational effectiveness data described in Paragraph 5(a) below, Zellwood must continue to provide St. Johns with information giving reasonable assurance that for the remainder of the term of the Consent Order, dissolved orthophosphate loads will be reduced by the equivalent of 80% on an flow-weighted, annual average basis, versus orthophosphate loading at Pump Station No. 2 prior to treatment by the alum injection system, with said assurance being based on 90% statistical confidence level. In determining whether reasonable assurance exists, St. Johns will consider mitigating information, such as an adjusted alum dosage rate which achieved the desired percentage reduction, applied to an equivalent pump event. Following submission of the information required by Paragraph 2(c), Zellwood and St. Johns' staff will develop long-term operational criteria, which must be implemented by July 1, 1998, and which shall remain in effect until the expiration of this Consent Order, or operation of the stormwater treatment facility required by Section 373.461, F.S., whichever first occurs. Notwithstanding any other requirement in this paragraph, Zellwood shall maintain a minimum dosage rate of 15 mg/I until the operational criteria are developed and implemented. If Zellwood substantially alters historical pumping patterns to the extent that reasonable assurance is no longer provided that the alum injection system will achieve the equivalent of an 80% treatment efficiency at Pump Station No. 2 on a flowweighted annual average basis, St. Johns staff will reevaluate, and if necessary, modify the long-term operational criteria.

4. The following monitoring regime shall be maintained at Pump Station No. 2 for the purposes of evaluating the performance of the alum injection system and shall substitute for the monitoring required for Pump Station No. 2 by the Fourth Agreement for Modification of the Consent Order. Data collected pursuant to this paragraph must be submitted to St. Johns quarterly:

(a) During any calendar week that Zellwood pumps, Zellwood must sample at least one pump event for total phosphorus and dissolved orthophosphate prior to alum addition and dissolved orthophosphate after alum addition. Samples must be collected immediately upstream of the alum injection point (prior to alum injection or mixing with alum) and in the pipe at the discharge point (after alum injection, but prior to discharge to Lake Apopka). A pump event is defined as the cumulative pumping per day from 8:00 A.M. to 7:59 A.M. If more than one sample is taken from a pump event requiring sampling, the samples shall be combined for a single analysis. During pumping days in which a sample is not required to be taken, Zellwood may turn off the automatic sampler. Samples must be collected at least 30 minutes after the pump event has started. Dissolved orthophosphate samples must be collected and analyzed according to EPA methods (preserved by cooling to less than 4 degrees centigrade and analysis within 48 hours) by a laboratory appropriately certified by the Department of Health and Rehabilitative Services. Samples collected by the refrigerated Automatic sampler after 12:01 P.M. on Friday through Monday at 8:00 A.M. must be

submitted to the analytical laboratory before 12:01 P.M. on that Monday. If the samples are not analyzed within the timeframes specified by EPA, that fact must be noted and specified in the quarterly data report;

(b) Zellwood must record pump hours daily;

(c) Zellwood must record the volume of alum injected weekly and calculate dosage rates based on alum volume and pump discharge volume. Zellwood must record the volume of alum injected per pump event. The volume of alum added must be recorded using a totalizing flow meter;

(d) After each year of sampling, St. Johns staff will evaluate the sampling results and determine if a lower sampling frequency is warranted, based on the variability of the data. Approval of a lower sampling frequency shall not require amendment of this Consent Order.

5. In addition to the quarterly data reports required by the current Consent Order, Zellwood shall submit the following information to St. Johns:

(a) Annual reports describing the operational effectiveness and maintenance of the alum injection system. The annual report shall include a tabulation of operational hours, down-time hours and recommended modification, if necessary, to increase operational effectiveness. Recommendations shall be implemented by Zellwood after consultation with St. Johns' staff;

(b) An annual summary report on the alum injection system, which includes the information required to be collected or calculated under Paragraphs 2 through .4 above;

(c) All rainfall records submitted to St. Johns quarterly.

6. Monitoring for total phosphorus at pumps P3, P4 and P9, as required by paragraph 7 of the Fourth Agreement for Modification of Cosent Order is suspended due to their infrequent use. The District shall assume total phosphorus concentrations are 1.0 mg/l, 1.5 mg/I and 0.9 mg/I at pumps P3, P4 and P9, respectively, when calculating discharge of total phosphorus into Lake Apopka. Total phosphorus monitoring must be reinstated at pumps P3, P4 and P9 if the combined discharge from those pumps exceeds 7% of the total volume discharged off-site during a calendar year. Total phosphorus monitoring shall be reinstated at pump P9 upon operation of the

stormwater treatment facility referenced in Section 373.461, Florida Statutes, unless discharge from P9 is routed through such stormwater treatment facility.

7. If after operating the alum injection system as outlined in Paragraph 1 above, Zellwood is unable to develop operational criteria which will enable it to provide St. Johns with reasonable assurance that it can reduce dissolved orthophosphate levels in the discharge as outlined in Paragraph 3 above, Zellwood's net discharge of total phosphorus to Lake Apopka from all discharge points shall not exceed 54,000 pounds per calendar year with adjustments for rainfall and groundwater as specified in Paragraph 9 of the original Consent Order and in accordance with the timeframes established by it and subsequent modifications of the Consent Order. If Zellwood elects not to operate the alum injection system, the net discharge of total phosphorus to Lake Apopka from all discharge points shall not exceed 40,675 pounds per year, with adjustments for rainfall and groundwater as incorporated by reference in Paragraph 10 of the original Consent Order and in accordance with the time frames and limitations established by Paragraph 10 of the original Consent Order and subsequent modifications. Should this occur, the monitoring conditions for Pump Station No. 2 as outlined in the Fourth Agreement for Modification of Consent Order must immediately be reinstated.

9. St. Johns' approval of an alum injection system to meet the requirements of the Consent Order does not imply that St. Johns will approve the method or design specified in this agreement for compliance with any rule adopted to implement Section 373.461,Florida Statutes. Continuation after the expiration of this Consent Order of an alum injection system by Zellwood for the purpose of phosphorus abatement will require Zellwood to provide St. Johns with reasonable assurance that said system meets any applicable permitting requirements in place at that time. 10. Except as specifically addressed herein, or in any of the previous seven modifications to the original Consent Order, all terms and conditions of the original Consent Order, as amended, remain in full force and effect.

Zellwood Drainage and Water Control District	St. Johns River Water Management District
Glenn Rogers, President	William Segal, Chair
Board of Supervisors	Governing Board
3-25-97	3/18/97
Date	Date
Rendered this 20 th day of March. 1997.	
Sandra L. Bertram	
Asst. District Clerk	

St. Johns River Water Management District 618