Epic Lake Restoration: Lake Apopka and the Harris Chain of Lakes

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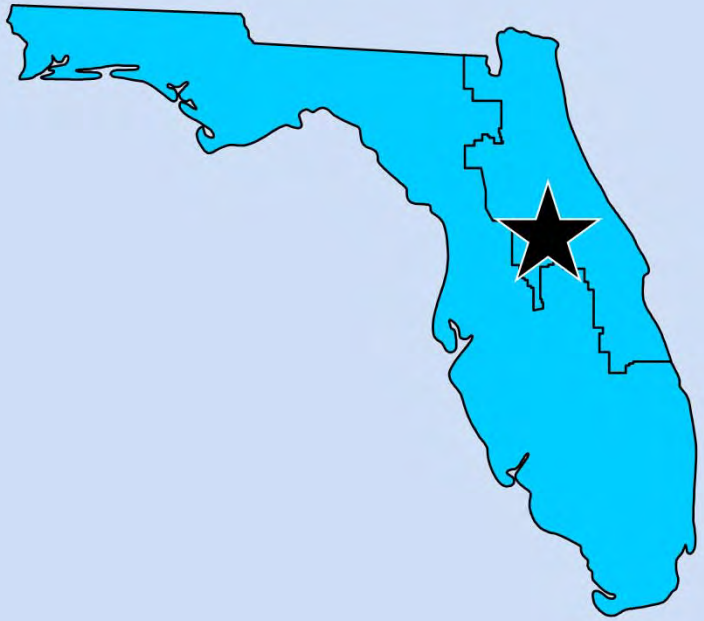
Presentation Outline

I. Geographic Orientation
II. Natural History of Lake Apopka
III. Human History of Lake Apopka
IV. Legislative Actions
V. Lake Apopka Restoration Program
VI. Harris Chain Case Study: Lake Griffin

I. Geographic Orientation

Lake Apopka: Headwaters of the Ocklawaha River Basin



Lake Apopka Restoration FSA 2012

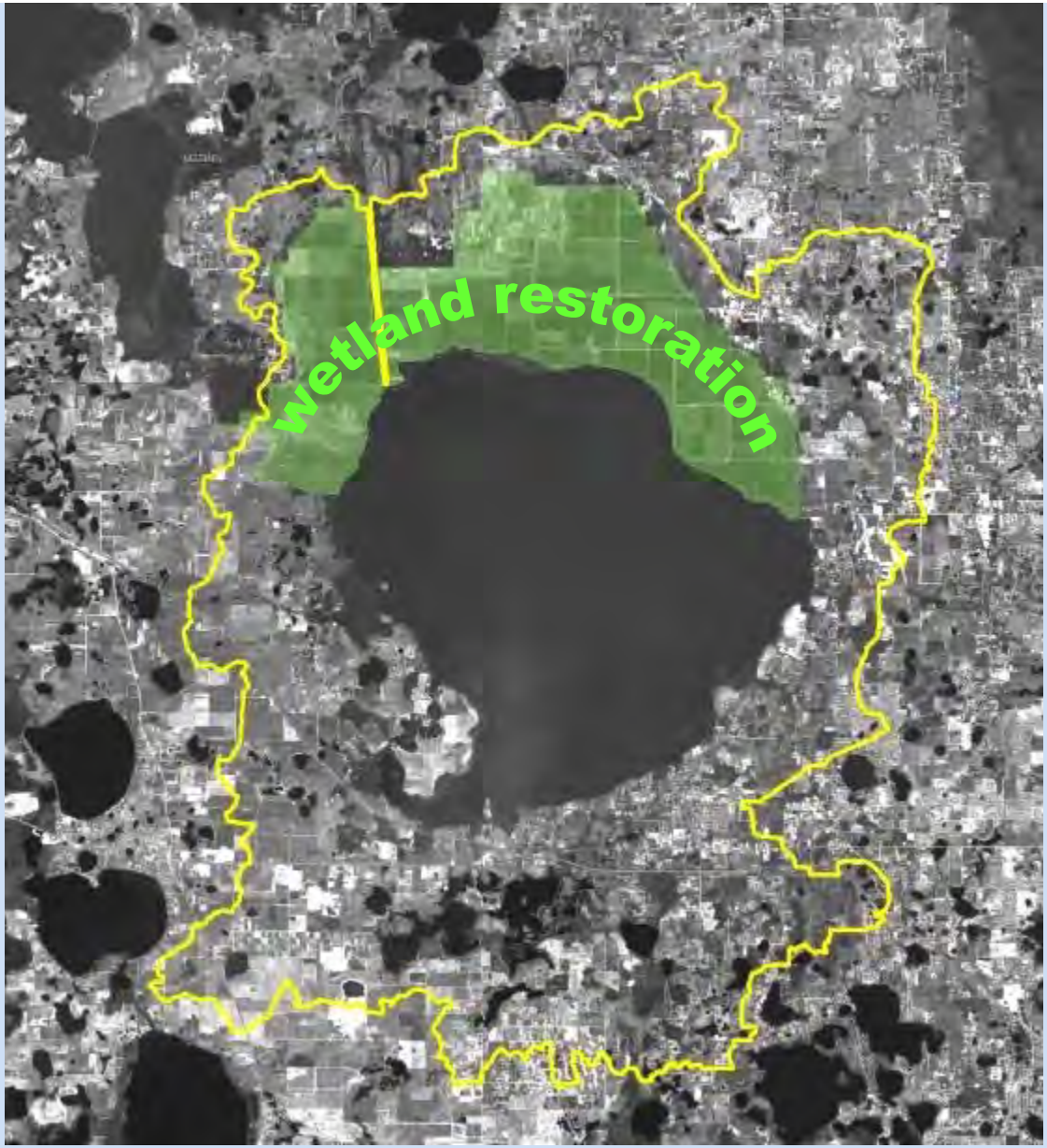
Lake Apopka and its Watershed

Watershed ~ 183 square miles

Lake ~ 48 square miles

Wetland Restoration Area

~ 30 square miles



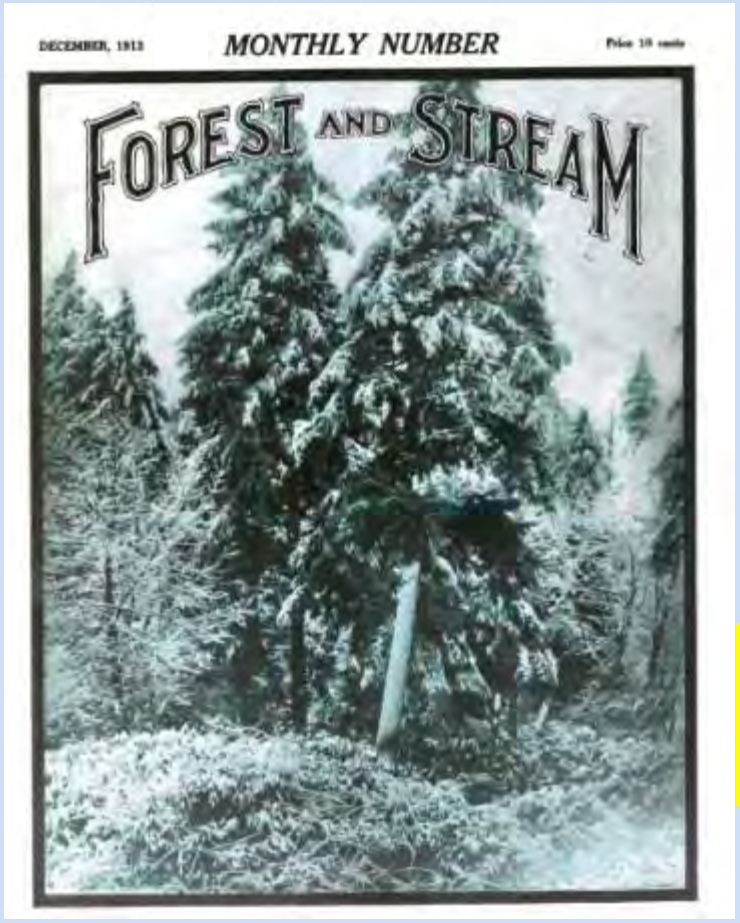
II. Natural History of Lake Apopka

Lake Apopka In the Good 'Ol Days

- Crystal clear water from rainfall and Apopka spring
- Clear water allows enough sunlight to reach lake's bottom to support abundant native submerged plants which provide critical fish and wildlife habitat
- Vast northern marsh providing abundant wetland habitat for fish and wildlife
- Minimal nutrient runoff from relatively small watershed
- Vibrant natural resource-based economy

Fishing camps lined the shores of Lake Apopka in the 1920s-50s, when the lake was known as "the large-mouth bass capital.

Forest and Stream –1913



"The best shooting and fishing in the State."

Central Florida's Original Vacation Destination

III. Human History of Lake Apopka

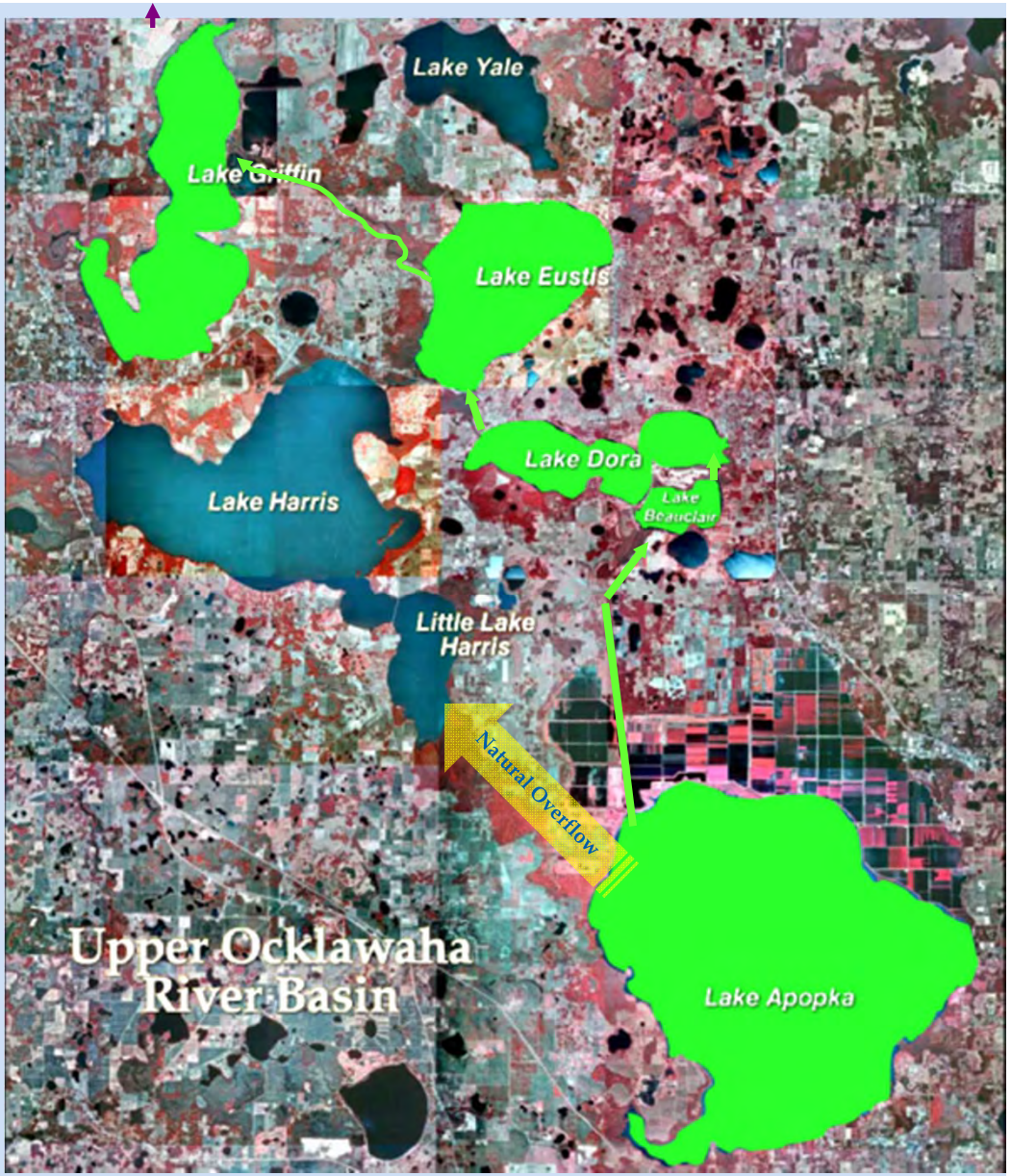
Over a Century of Impacts to the Lake Apopka Ecosystem, 1893–1920s

1893 Altered hydrology by construction of the Apopka-Beauclair Canal for transportation (citrus)

1920s Early attempts to drain Apopka's north shore marsh for Agriculture
Winter Garden begins dumping wastewater effluent into lake

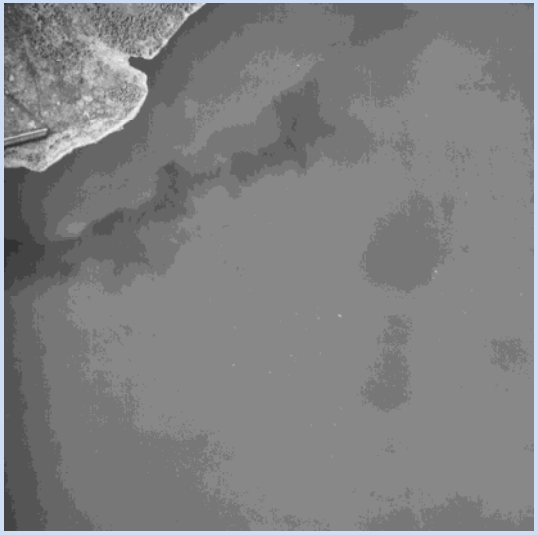
Changes to Lake Apopka's Levels and Impacts on the Ocklawaha Chain of Lakes

- Dredging of Apopka-Beauclair Canal began in 1893 and lowered lake elevation by approximately 3 feet
- Reduced lake volume by about 35%
- Changed flow direction and amounts delivered to downstream lakes



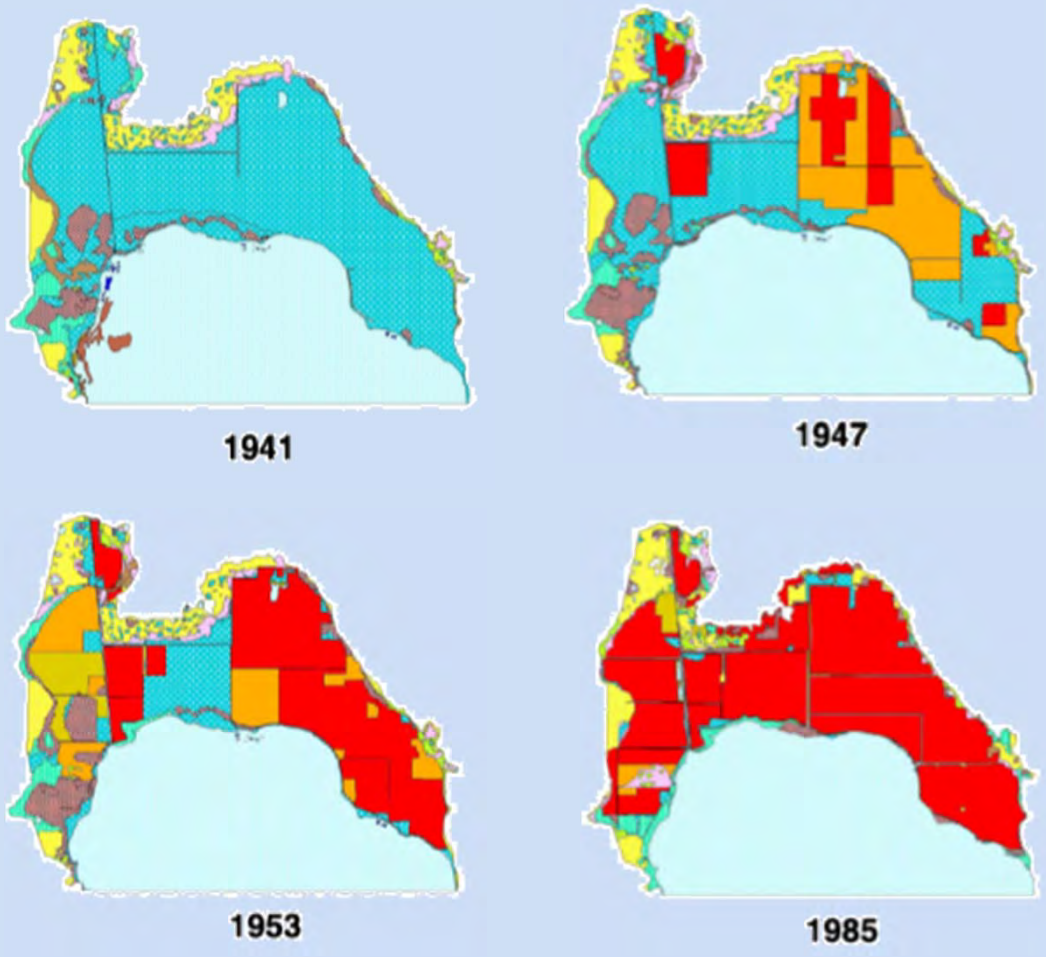
Over a Century of Impacts to the Lake Apopka Ecosystem, 1940–1980

1941	Creation of Zellwood Drainage and Water Control District. Levee construction and wetland drainage leading to decades of muck farm agriculture and substantial nutrient pollution
1940s	Farms began applying pesticides
1947	First algal bloom appears on Lake Apopka during spring
1952	Water control structure built on Apopka-Beauclair Canal, water levels were stabilized
1980	Tower Chemical spill of organochlorine products into Apopka (ongoing cleanup as a Super Fund Site)



Farm Development on Lake Apopka's North Shore 1941–1985

- Shallow marsh
- Shrub swamp
- Hardwood swamp
- Wet prairie
- Muck farm in prep
- Muck farm

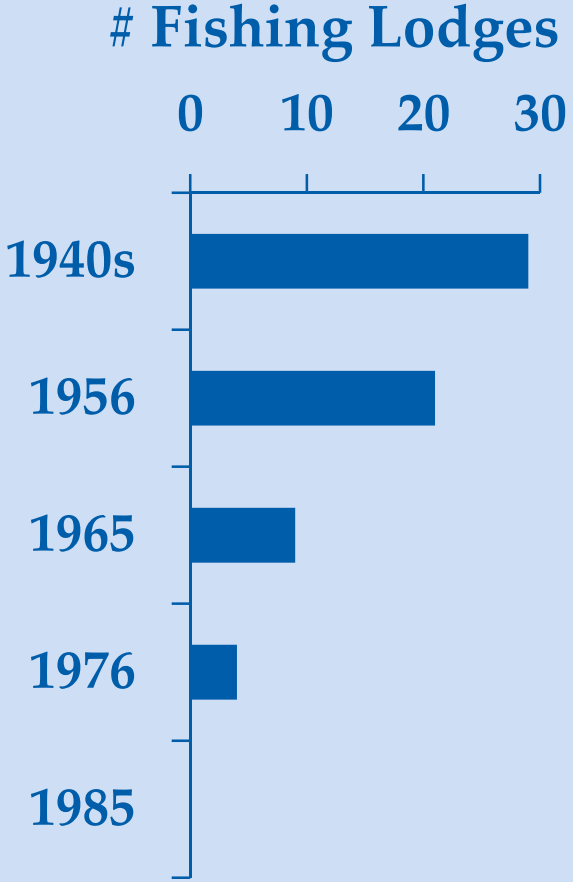


Intensive Agriculture

- Three crops per year
- Nutrient-rich water pumped back into Lake Apopka

Agricultural Discharges (Zellwood)

Economic Impact: Sportfishing and Fishing Lodge Economy Collapses



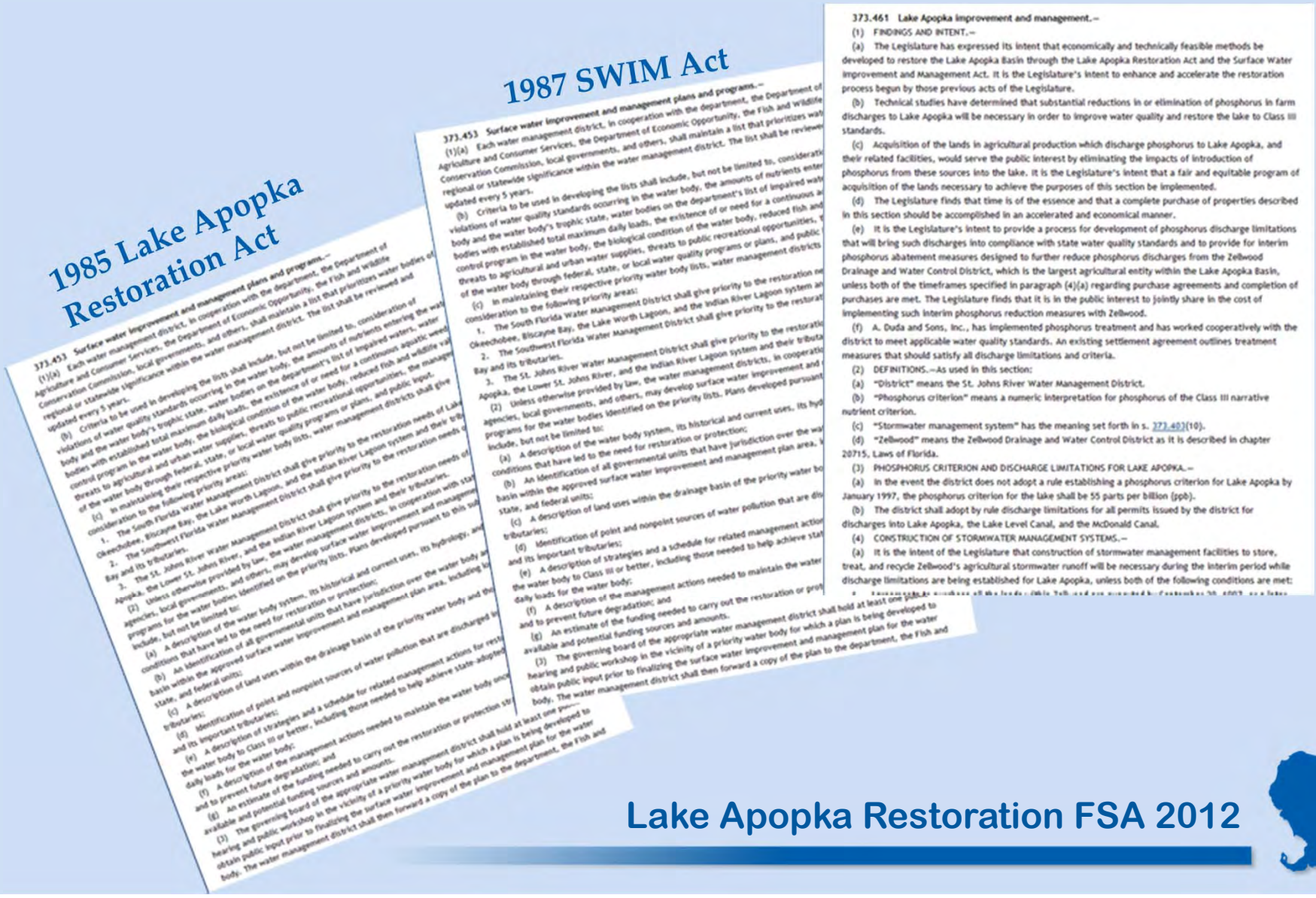
Time for Legislative Action

IV. Legislative Action

1996 Lake Apopka Restoration Act

1987 SWIM Act

1985 Lake Apopka Restoration Act



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) 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.

(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) 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).

(b) 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 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:

373.453 Surface water improvement and management plans and programs.—

(1)(a) Each water management district, in cooperation with the department, the Department of Agriculture and Consumer Services, the Department of Economic Opportunity, the Fish and Wildlife Conservation Commission, local governments, and others, shall maintain a list that prioritizes water bodies of regional or statewide significance within the water management district. The list shall be reviewed and updated every 5 years.

(b) Criteria to be used in developing the lists shall include, but 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, water bodies on the department's list of impaired waters, water bodies with established total maximum daily loads, the existence of or need for a continuous aquatic weed control program in the water body, the biological condition of the water body, reduced fish and wildlife values, threats to agricultural and urban water supplies, threats to public recreational opportunities, threats to the water body through federal, state, or local water quality programs or plans, and public input.

(c) In maintaining their respective priority water body lists, water management districts shall give consideration to the following priority areas:

1. The South Florida Water Management District shall give priority to the restoration needs of Lake Okeechobee, Biscayne Bay, the Lake Worth Lagoon, and the Indian River Lagoon system and their tributaries.

2. The Southwest Florida 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.

3. 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) Unless otherwise provided by law, the water management districts, in cooperation with state agencies, local governments, and others, may develop surface water improvement and management plan programs for the water bodies identified on the priority lists. Plans developed pursuant to this subsection include, but not be limited to:

(a) A description of the water body system, its historical and current uses, its hydrology, and conditions that have led to the need for restoration or protection;

(b) An identification of all governmental units that have jurisdiction over the water body and the basin within the approved surface water improvement and management plan area, including local, state, and federal units;

(c) A description of land uses within the drainage basin of the priority water body and its tributaries;

(d) Identification of point and nonpoint sources of water pollution that are discharged to the water body and its important tributaries;

(e) A description of strategies and a schedule for related management actions needed to help achieve state adopted daily loads for the water body;

(f) A description of the management actions needed to maintain the water body and to prevent future degradation; and

(g) An estimate of the funding needed to carry out the restoration or protection strategies and available and potential funding sources and amounts.

(3) The governing board of the appropriate water management district shall hold at least one public hearing and public workshop in the vicinity of a priority water body for which a plan is being developed to obtain public input prior to finalizing the surface water improvement and management plan for the water body. The water management district shall then forward a copy of the plan to the department, the Fish and

First Major Legislative Direction

- **1985 Lake Apopka Restoration Act**
  - District directed to develop Restoration Plan
    - To be based on diagnostic and feasibility studies
  - Established Lake Apopka Restoration Council
    - Seven Citizen Appointees by the Governor
    - Florida Department of Environmental Regulation
    - Florida Game and Fresh Water Fish Commission
    - St. Johns River Water Management District
    - Orange County
    - Lake County

Second Major Legislative Direction

- **1987 Surface Water Improvement and Management (SWIM) Act**
  - Identified Lake Apopka as one of only six priority water bodies in Florida
  - Established goals
    - Improve water quality to Class III standards
    - Restore habitat for native plants, fish and wildlife
    - Enhance aesthetic and recreational experiences
    - Increase tourism and other economic benefits
    - Expressed legislative intent to develop "economically and technically feasible methods" to restore the lake
- **1988-1990 Program and Land Acquisition Appropriations**
  - $15 million (total)

Third Major Legislative Direction

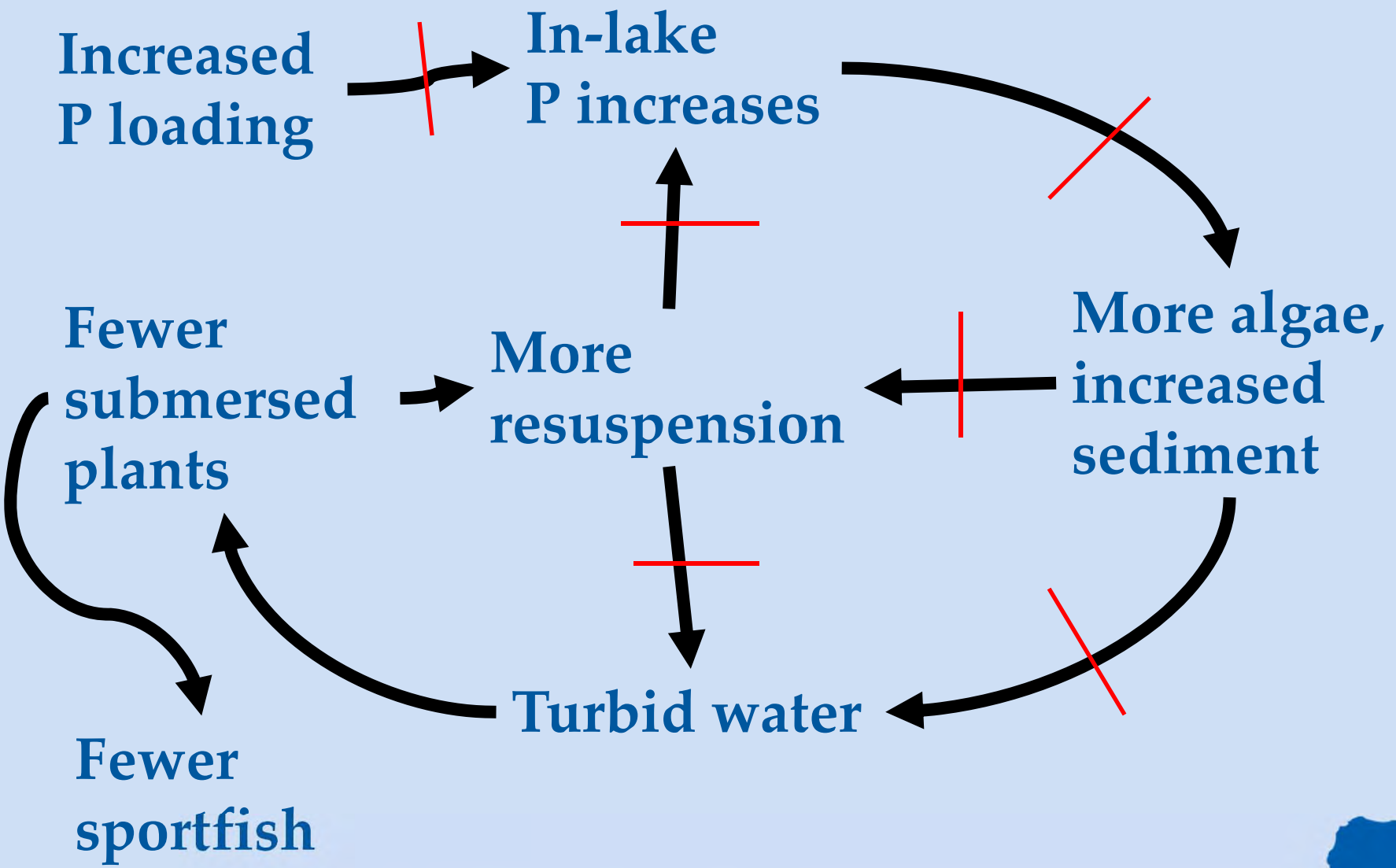
- **1996 Lake Apopka Restoration Act**
  - "Substantial reductions in or elimination of phosphorus in farm discharges" are necessary to restore the lake.
  - "Acquisition of the lands in agricultural production which discharge phosphorus to Lake Apopka… would serve the public interest."
  - If the District does not adopt a phosphorus criterion, "the phosphorus criterion for the lake shall be 55 parts per billion."
  - $20 million appropriated for farm buyout
- **1997 and 1999 Legislative Appropriations for Farm Buyout**
  - 1997 — $45 million
  - 1999 — $11 million
- **NRCS Farm Buyout Support**
  - $18.5 million

V. Lake Apopka Restoration Program

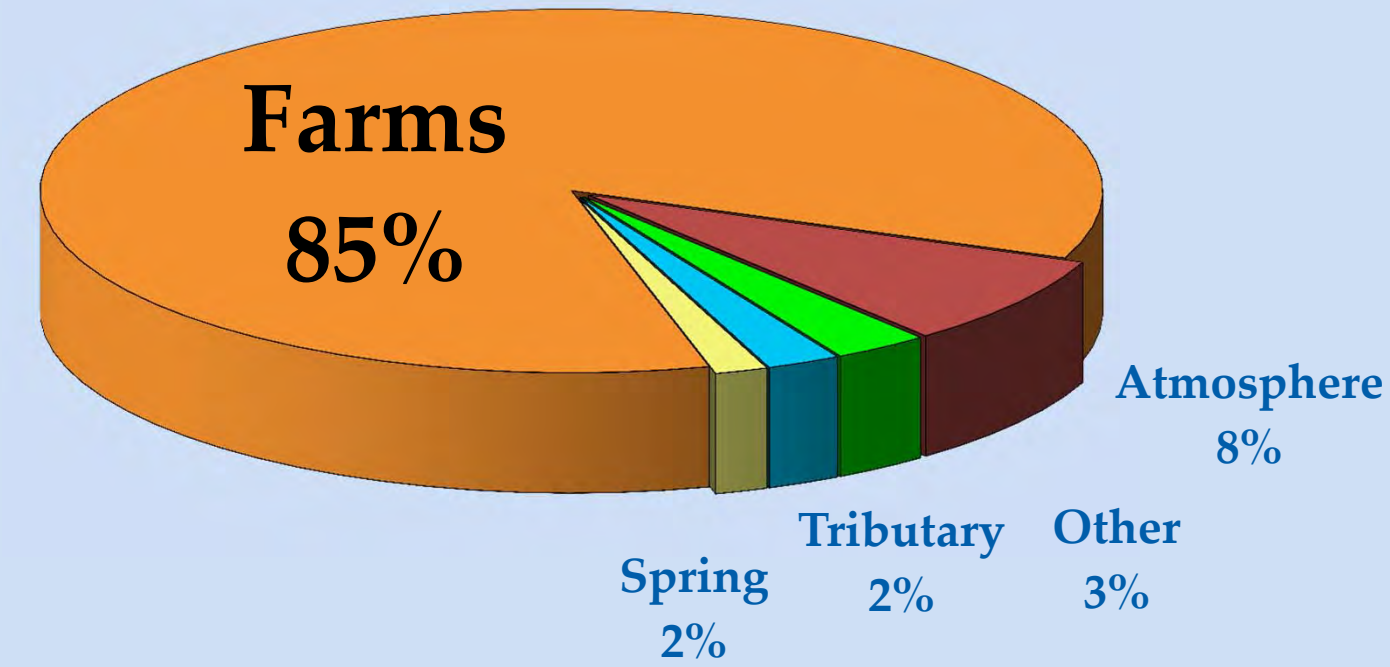
Diagnostic and Feasibility Studies were the Basis for the Restoration Program

- Diagnostic studies – What causes the degraded condition of the lake?
- Feasibility studies – What approaches can cost-effectively deal with the causes of degradation?

Diagnostic Studies pointed to Phosphorus pollution as the primary cause of degradation



The Diagnostic Studies also Showed that the Phosphorus Pollution was Largely from Farm Discharges

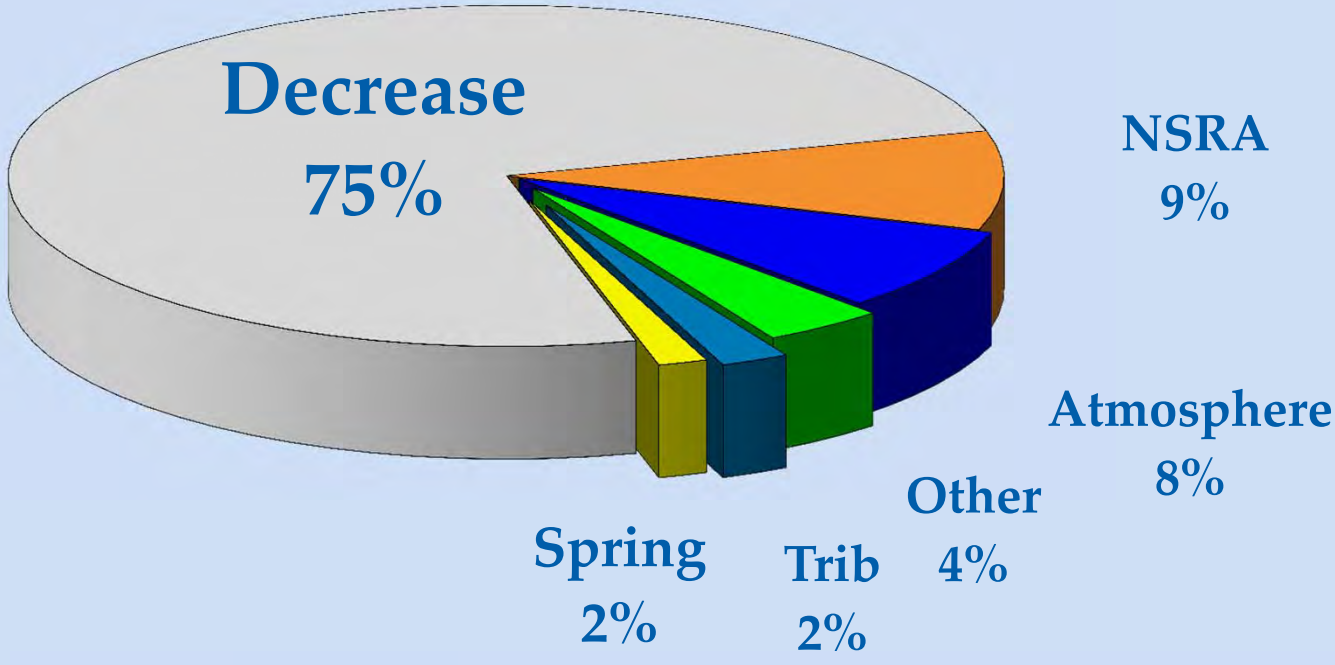


A Large Reduction in Phosphorus Loading was Necessary to Meet the TMDL

Apopka's phosphorus load

During farming 137,569 lbs.

Restoration goal 35,054 lbs.



The Restoration Program

- Phosphorus management
  - Reduce phosphorus loading to the lake to meet the TMDL – largely, farm loading
  - Remove available phosphorus from the lake and reduce phosphorus recycling – using cost-effective technologies
- Adaptive management
  - Monitoring – water quality, biology
  - Invasive aquatic weed control

Feasibility Studies of Potential Technology

- **Reduce phosphorus loading**
  - Retention and treatment of farms
  - Cessation of farming; reflooding; wetland re-creation
- **Phosphorus removal**
  - Growing and harvesting waterhyacinths
  - Wetland filtration (marsh flow-way)
  - Harvesting of gizzard shad
- **Reduce phosphorus recycling**
  - Alum treatment
  - Enhancing microbial decomposition
  - Dredging
  - Harvesting of gizzard shad

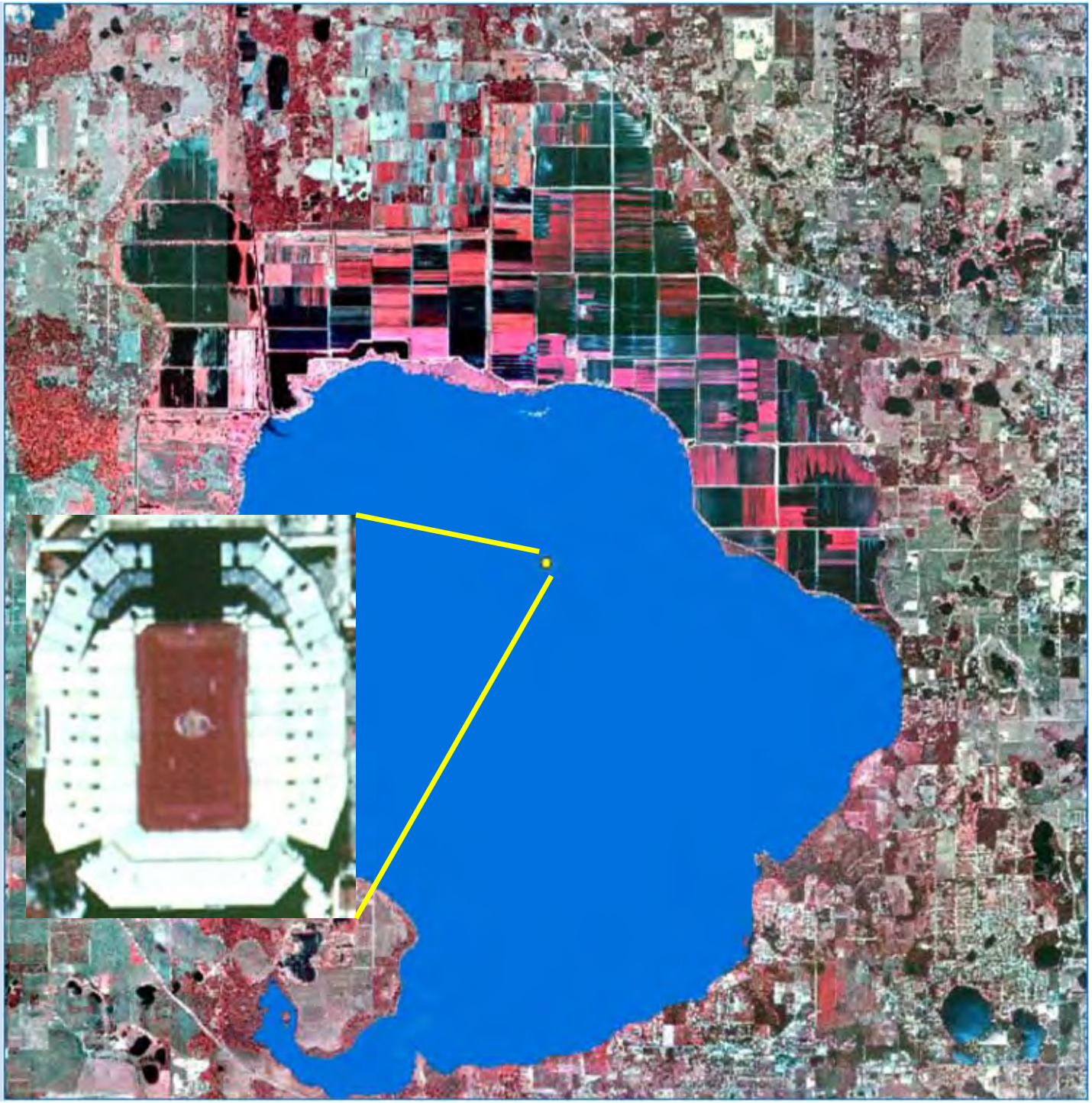
Feasibility Studies of Potential Technology

- **Decrease algal density by changing trophic structure**
  - Introduction of algae-eating fish
  - Harvesting of gizzard shad
- **Reduce or consolidating muck sediments**
  - Dredging
  - Lake level drawdown
- **Increase aquatic and emergent plant abundance**
  - Lake level drawdown
  - Planting behind wave barriers

The suitability of these technologies was affected by the large size of the system

Lake Area ~ 48 mile^2

NSRA ~ 30 mile^2



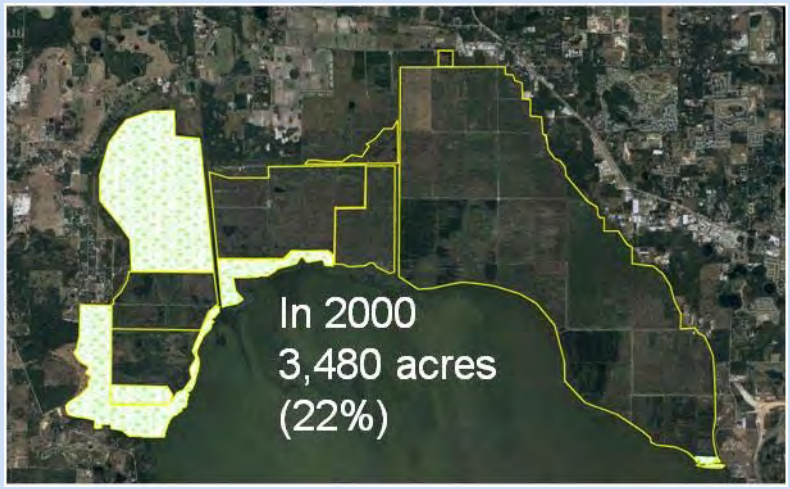
The restoration plan is based on the findings of the feasibility studies

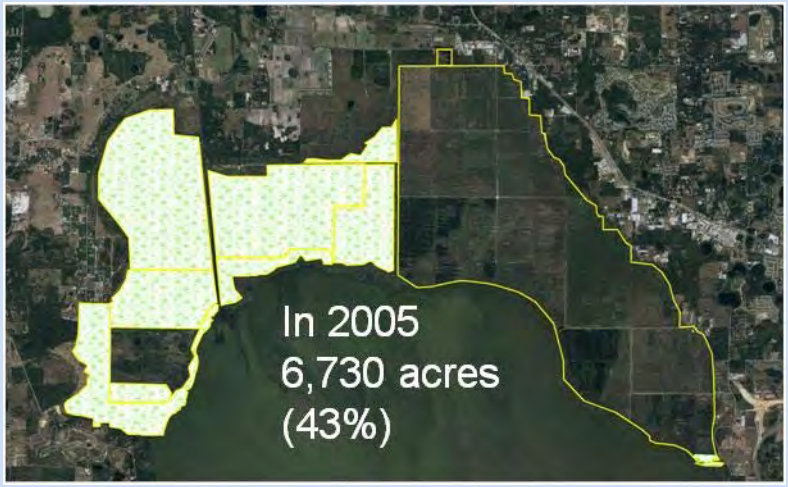
Technology	Logistically Feasible?	Effective?	Estimated or Actual Cost
Treatment of discharge water	Yes	Yes	NA
Conversion of farms to wetlands	Yes	Yes	$116 million
Growing and harvesting hyacinths	No	NA	NA
Wetland filtration	Yes	Yes	$13.2 million
Harvesting shad	Yes	Yes	$5.9 million
Lake level drawdown	Yes	Uncertain	$0.4 –23 million
Alum treatment of lake	Yes	Uncertain	$16.8 million
Microbial enhancement	Yes	No	NA
Whole-lake dredging	Yes	Yes, after load reduction	$800 million
Introducing algae-eating fish	Yes	No	NA
Planting behind barriers	Yes	Yes	0.7 M

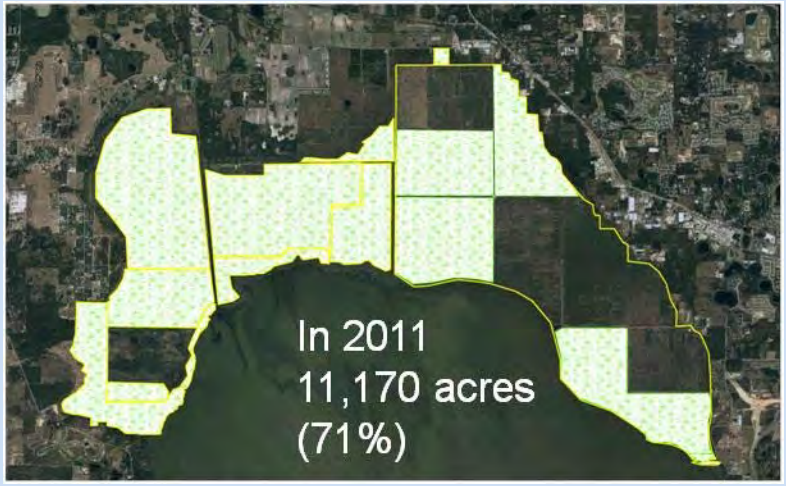
The Phosphorus Management Program

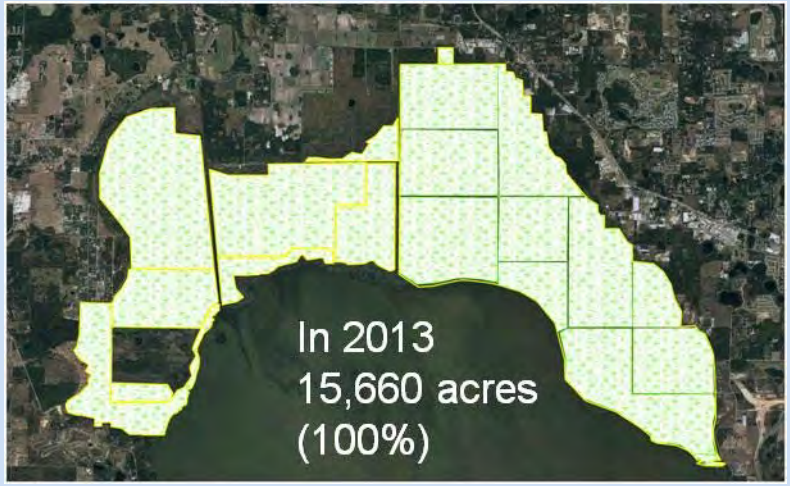
- Reduce phosphorus loading from the former farms
  - Conversion of farms to wetlands
  - Reflood and manage water levels
  - Treat soils with alum residual to bind phosphorus
  - Treat necessary discharges with alum
- Reduce phosphorus recycling by harvesting gizzard shad
- Remove available phosphorus from the lake
  - Harvest gizzard shad
  - Operate the marsh flow-way

The Restoration Program – 1. Reduce phosphorus loading through wetland re-creation on former farms










Lake Apopka North Shore Infrastructure and Flooding
Legend
Pump discharge to lake
Gravity inflow from lake
Main canal structure
Main canal/flow pattern
cfs=cubic feet per second
Sandfarm
2013
Main Zellwood pump
66 cfs
2011
2011
30 cfs
80 cfs
30 cfs
2002–03
2008
Apopka - Beauclair Canal
Duda pump
55 cfs
East Pond
West Pond
I-8
5 cfs
2013
2013
High water pump
124 cfs
City of Apopka
Reuse (up to 7 cfs)
I-9
25 cfs
2009
2013
Lake Apopka
Emergency pump
21 cfs
2009
I-11
15 cfs
I-12
15 cfs
Lake Apopka Restoration FSA 2012

In order to safely flood the former farms, we needed to mitigate the high concentrations of pesticides in the soils. Several options were evaluated.

Description	Cost per acre
Mix or bury surface soils with cleaner deep soils	$2,700
Mound the soils and cap with clay	$9,400
Cap with clay	$24,370
Bury in lined reservoir with clay cap	$65,000
Transfer contaminated soils to landfill	$118,500

The Restoration Program – 2. Reduce recycling of phosphorus in the lake by large-scale harvesting of gizzard shad

- Between 2003–2007, the average annual harvest was about 1.3 million pounds
- Now the annual harvest is lower — 2011 estimated at about 650,000 pounds
- Public-private partnership — partly funded by private profits
- Directly supports private-sector jobs

Removing 1 million pounds of gizzard shad reduces phosphorus recycling by about 17,500 pounds and removes 7,000 pounds of phosphorus

The Restoration Program – 3. Remove available phosphorus via wetland filtration of lake water (the 655-acre flow-way)

Marsh Flow-Way: 2003-2011

- Treated 3.1 volumes of the lake
- Removed
  - 43,500 lbs. phosphorus
  - 1.5 million lbs. nitrogen
  - 73 million lbs. suspended sediment

The restoration program was designed to manage phosphorus to elicit a sequence of beneficial effects

1. Reduce phosphorus loading and recycling

2. Lower phosphorus concentrations

3. Lower levels of algae (Phytoplankton)

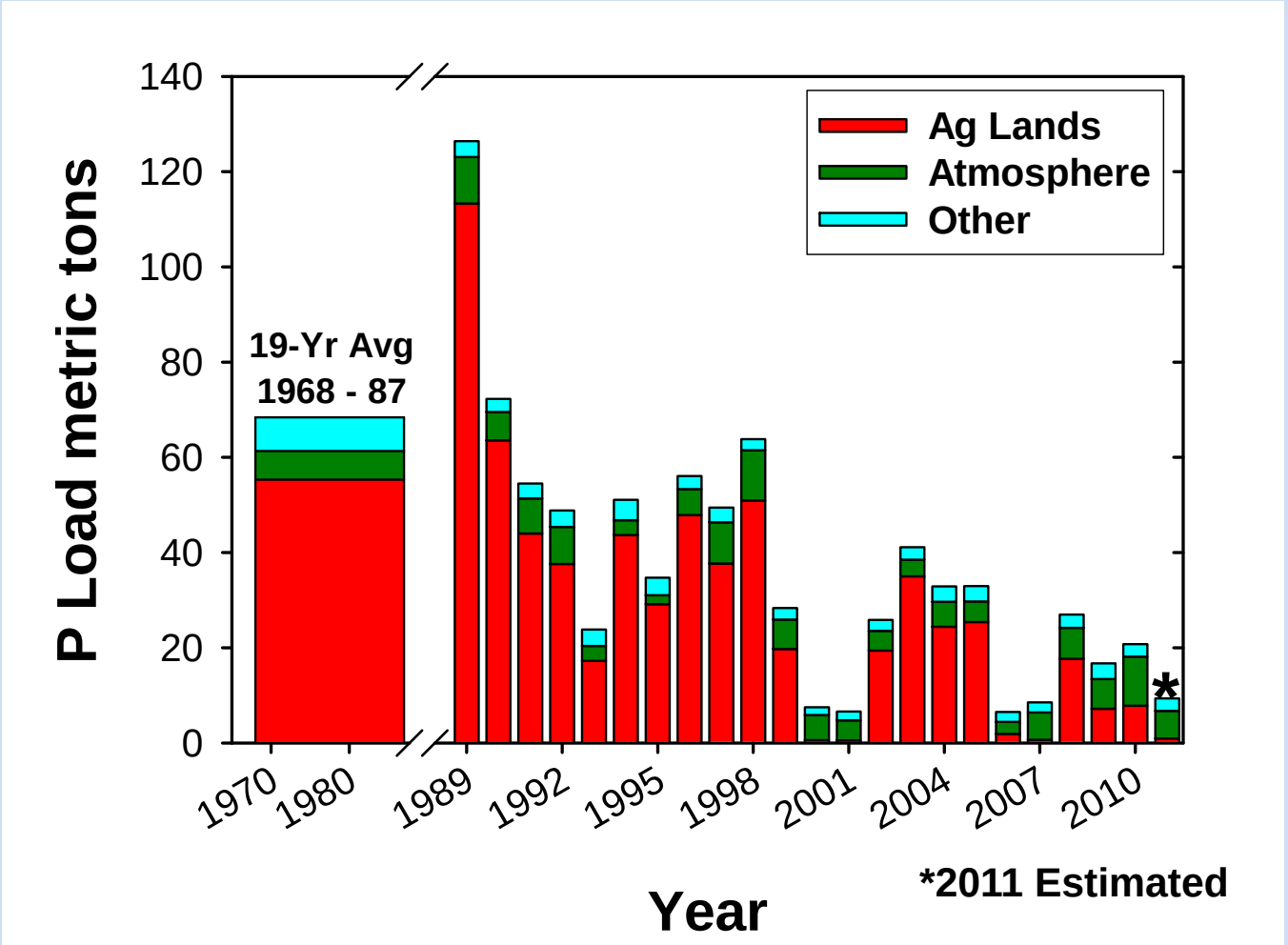
4. Higher water transparency

5. Expansion of aquatic vegetation (habitat)

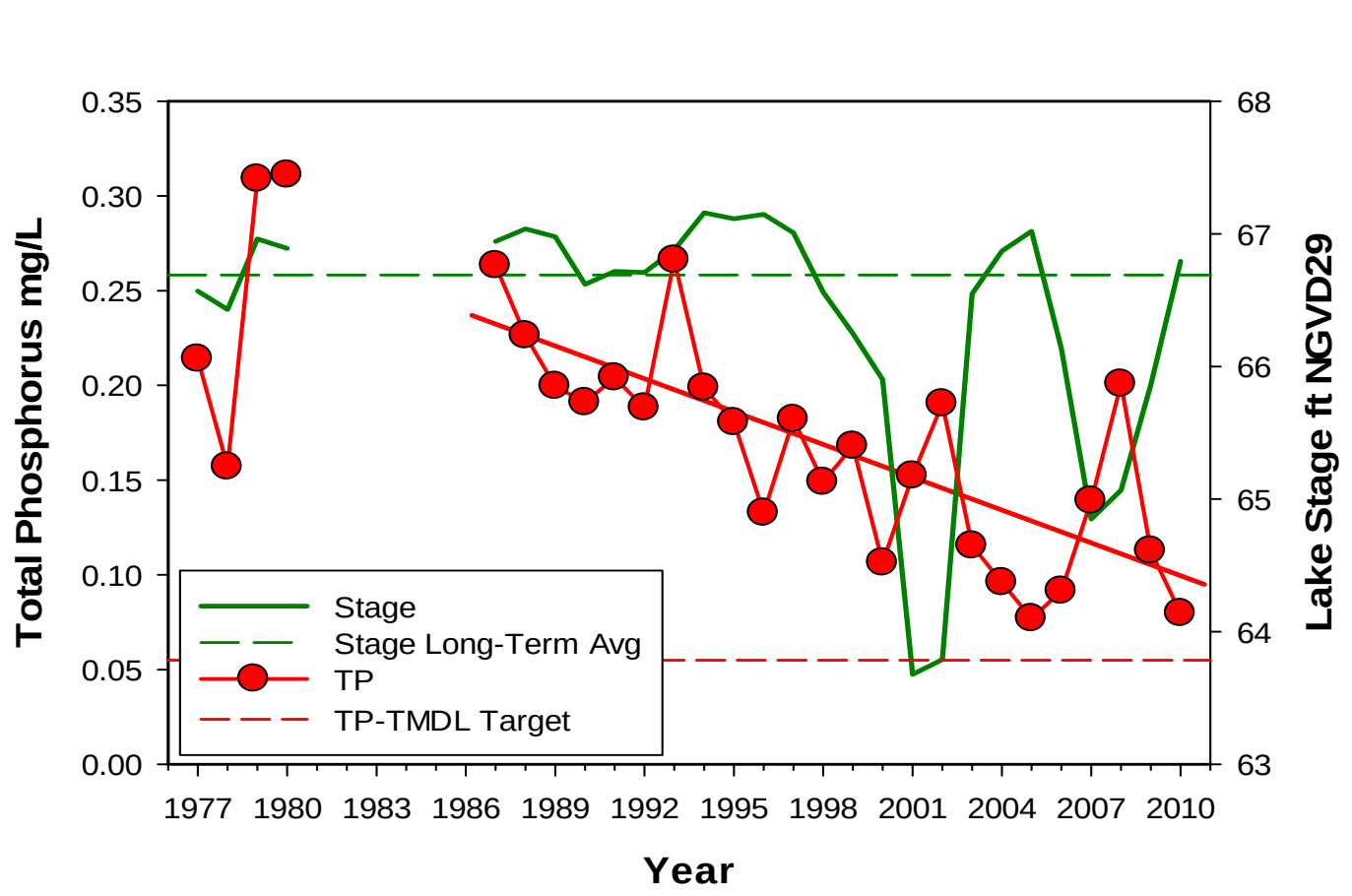
6. Increased game fish populations

Because wetland restoration is the key strategy for reducing phosphorus loading, there are substantial ancillary benefits for fish and wildlife.

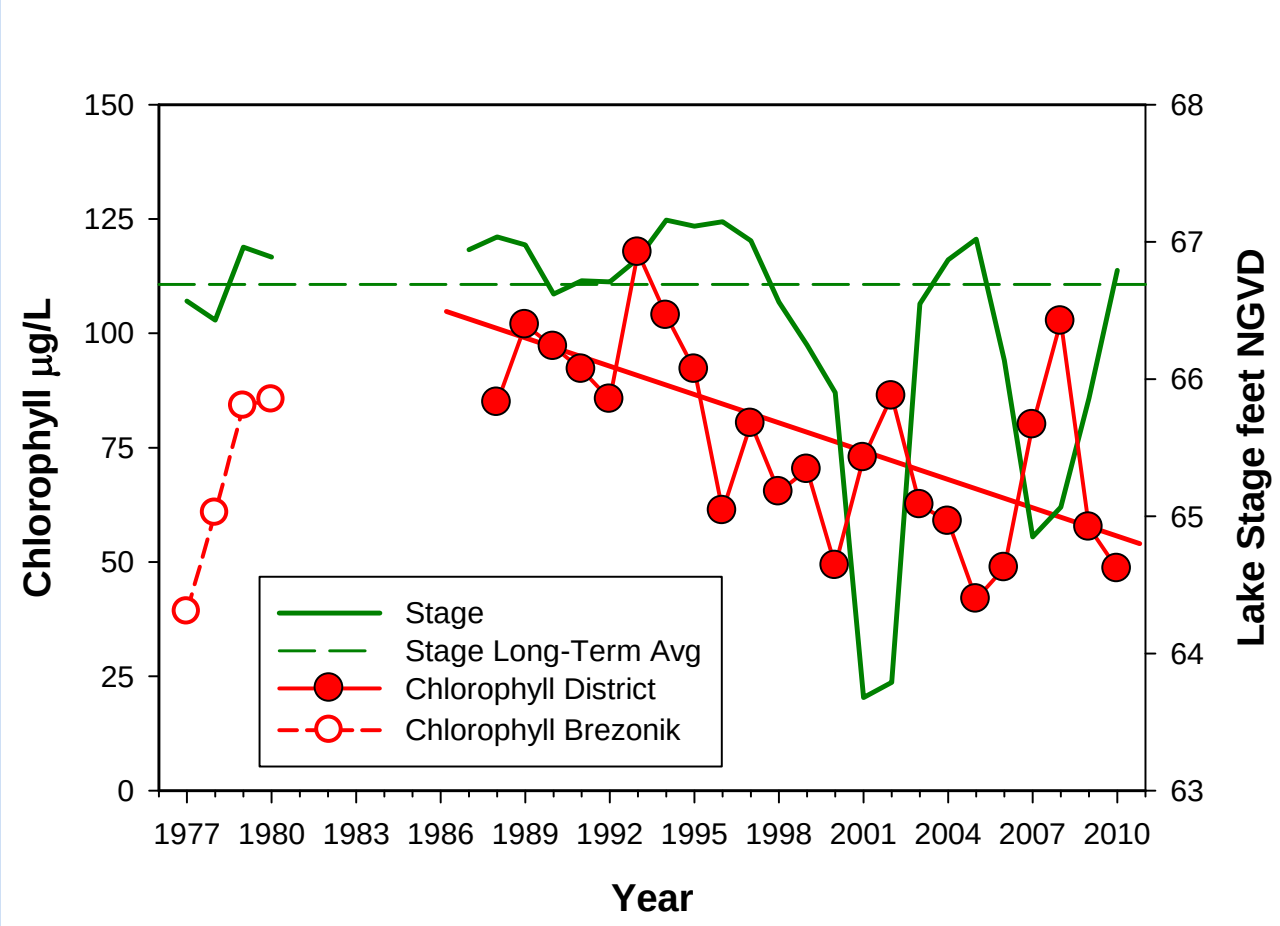
1. Reduce Phosphorus Loading – Progress has Been Substantial



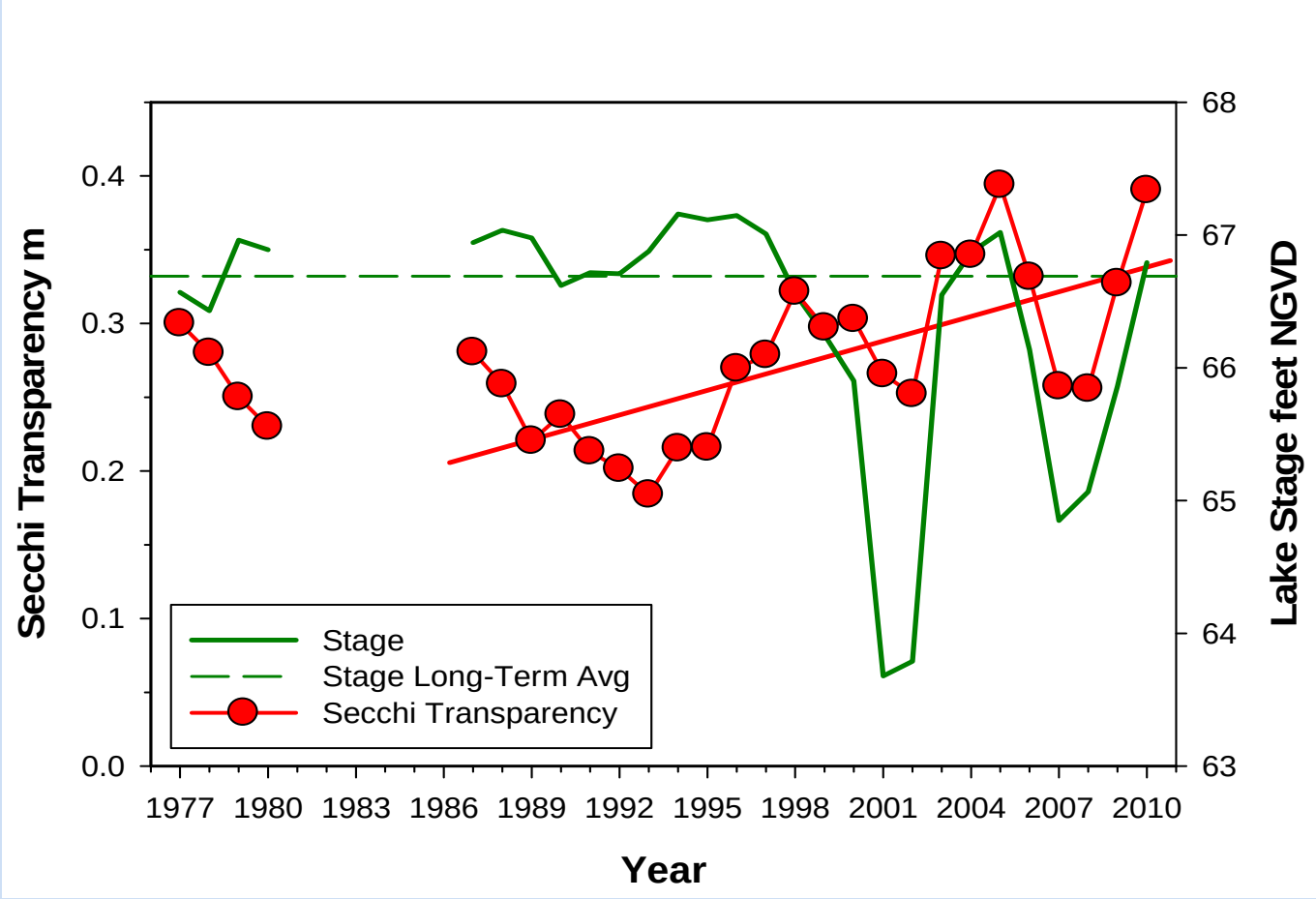
2. Lower Phosphorus Concentration – Concentrations have decreased



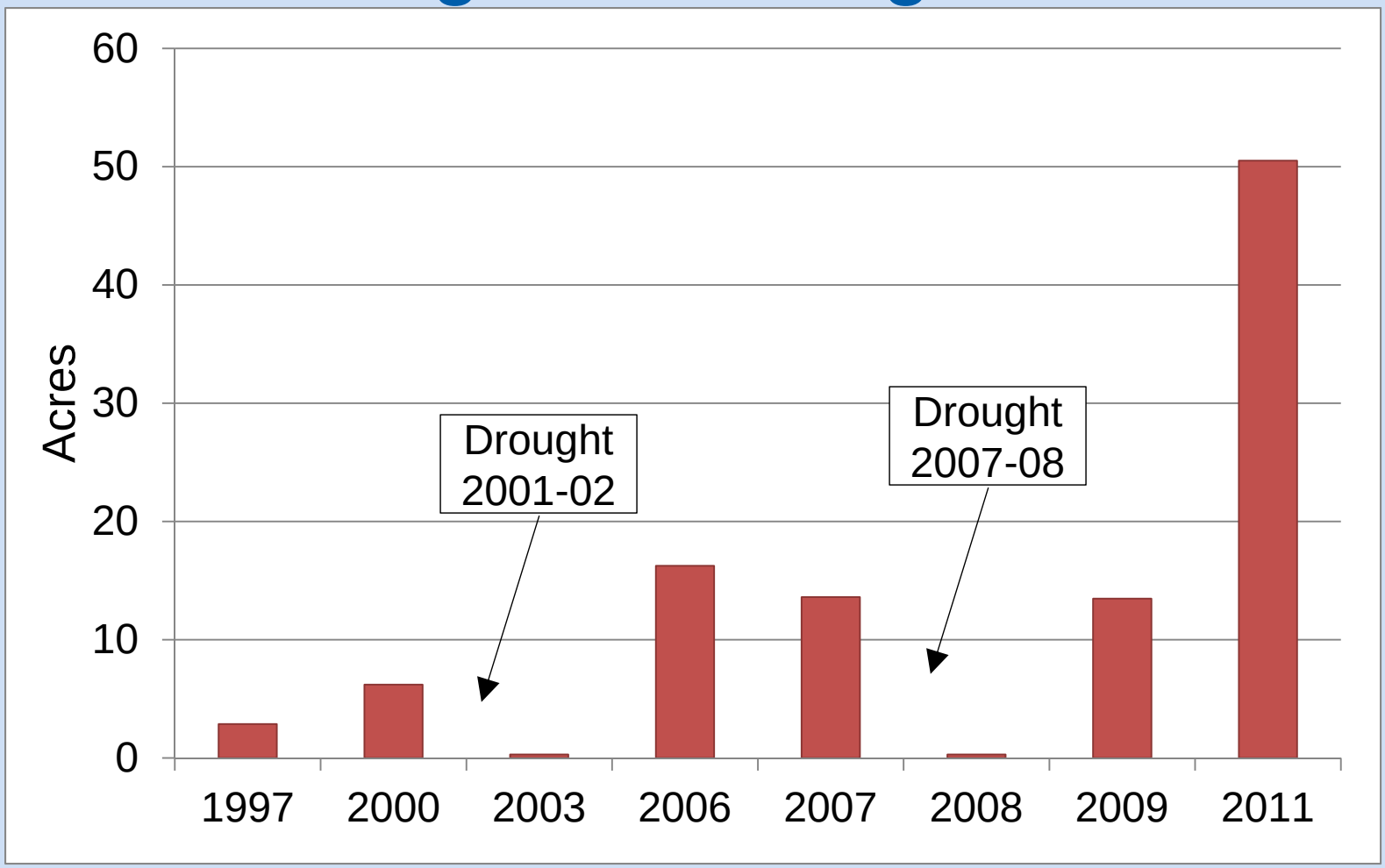
3. Lower Levels of Algae – Chlorophyll concentrations, a measure of algal density, also have decreased



4. Higher Water Transparency– As measured by Secchi disc, water transparency has increased

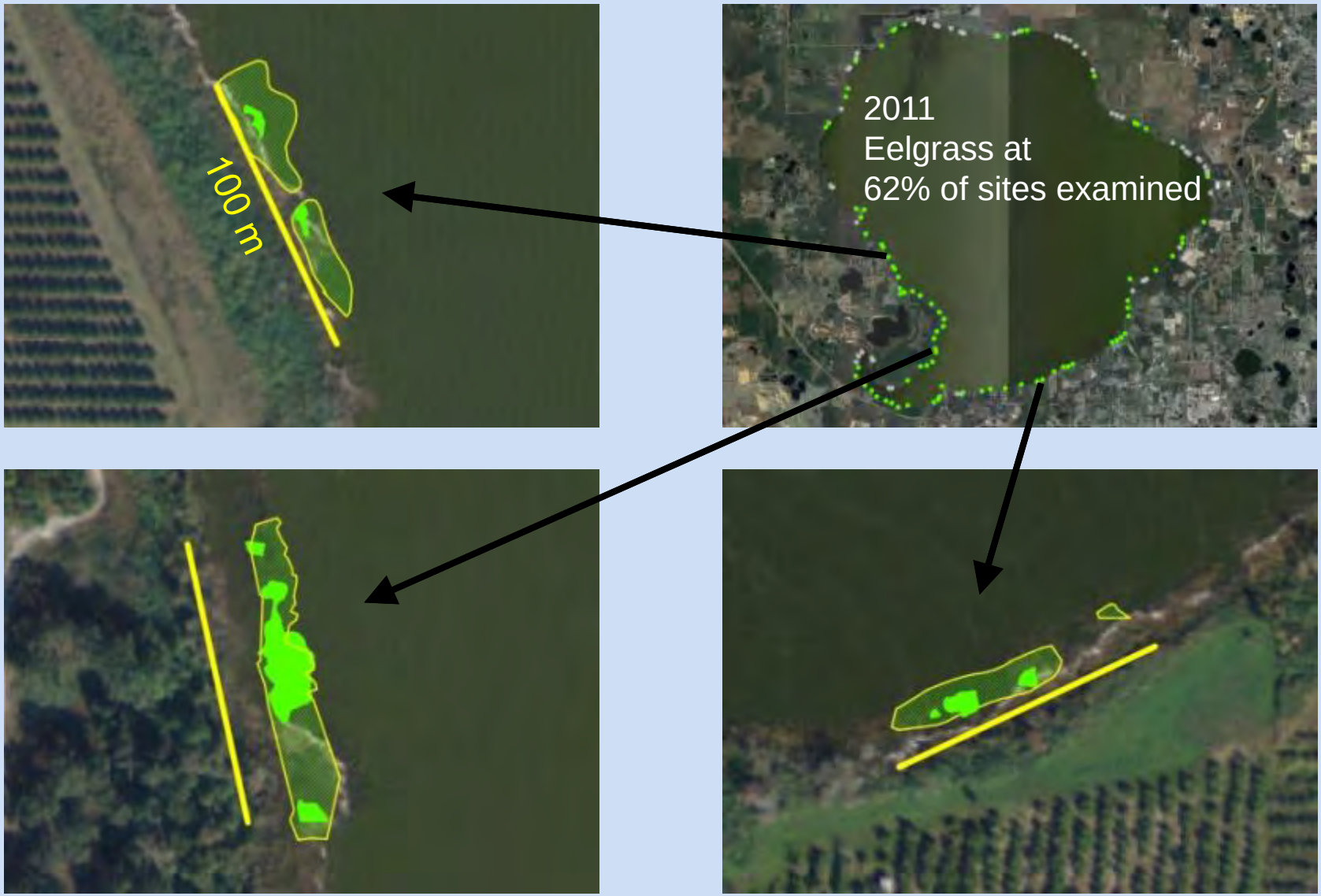


5. Expansion of Aquatic Vegetation – Significant Progress



5. Expansion of Aquatic Vegetation – Eelgrass now present over much of the lake's shore

Expansion of Eelgrass 2009–2011



5. Expansion of Aquatic Vegetation – Eelgrass has colonized areas with deep muck

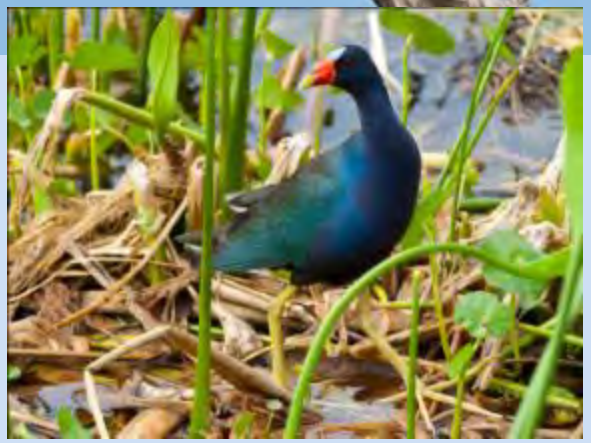
6. Increased Game Fish Populations

- Some indications of progress
- No monitoring data for fish populations
- In Lake Griffin, where a similar program is further along, game fish populations have improved substantially in recent years

Important Ancillary Benefits

- Improved flood control
- Alternative water source
- Potential for better management of lake levels and improved low flow discharges
- Wetland re-creation
- Benefits for populations of fish and wildlife
- Potential for ecotourism

Important Ancillary Benefits – Birds

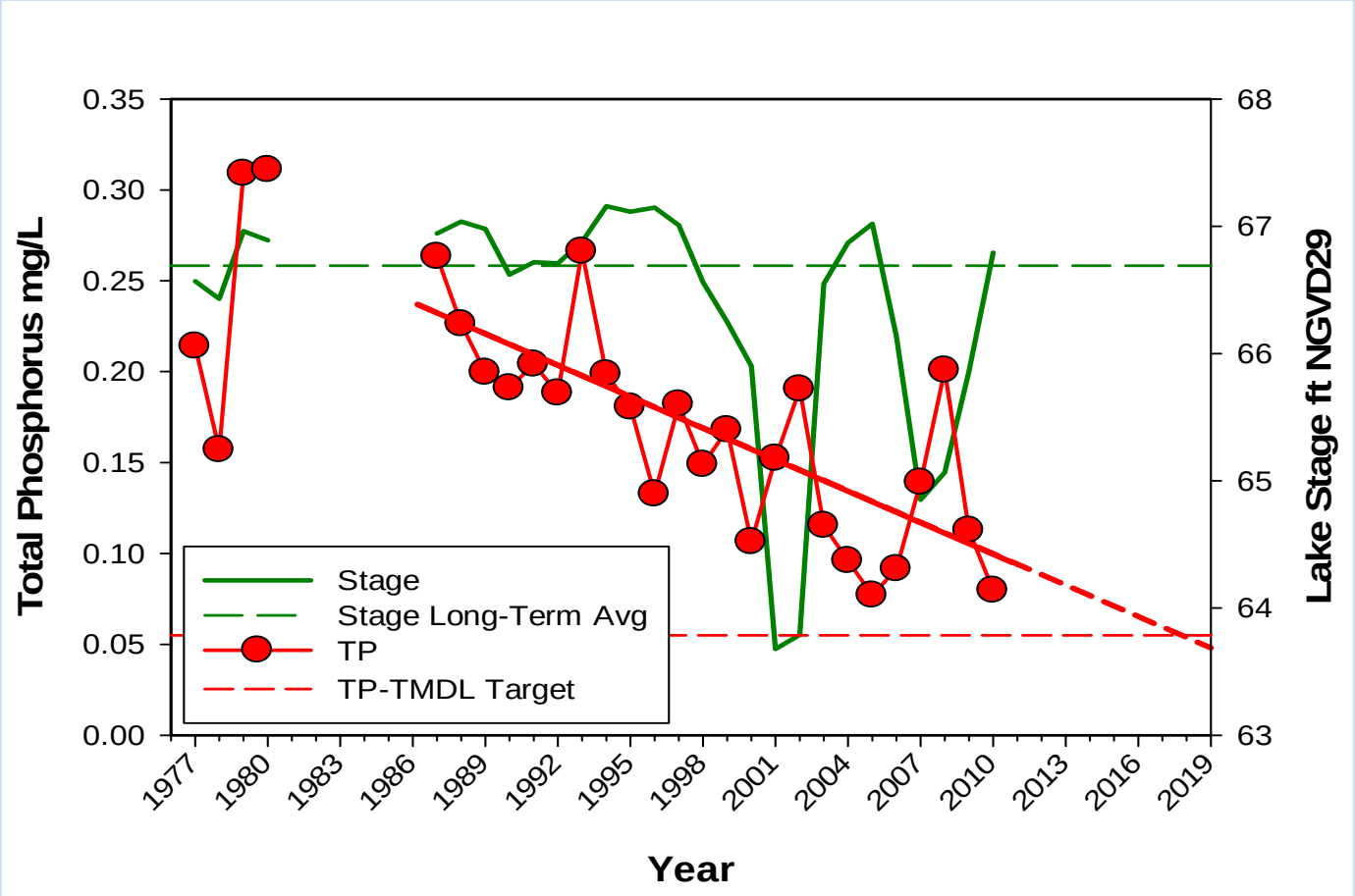


Important Ancillary Benefits – Ecotourism potential similar to Merritt Island, St. Marks, and Ding Darling national wildlife refuges

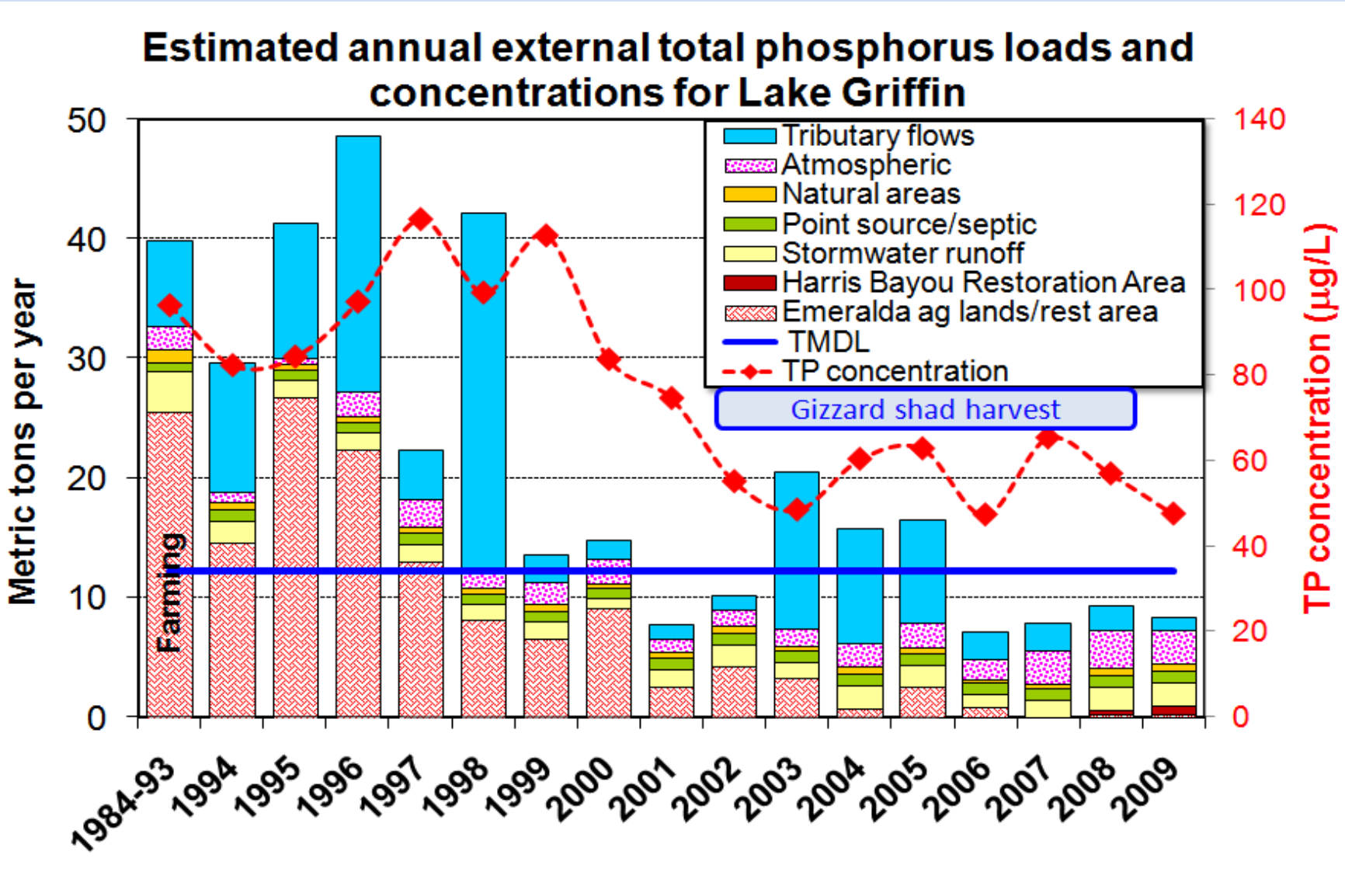
Summary of Progress

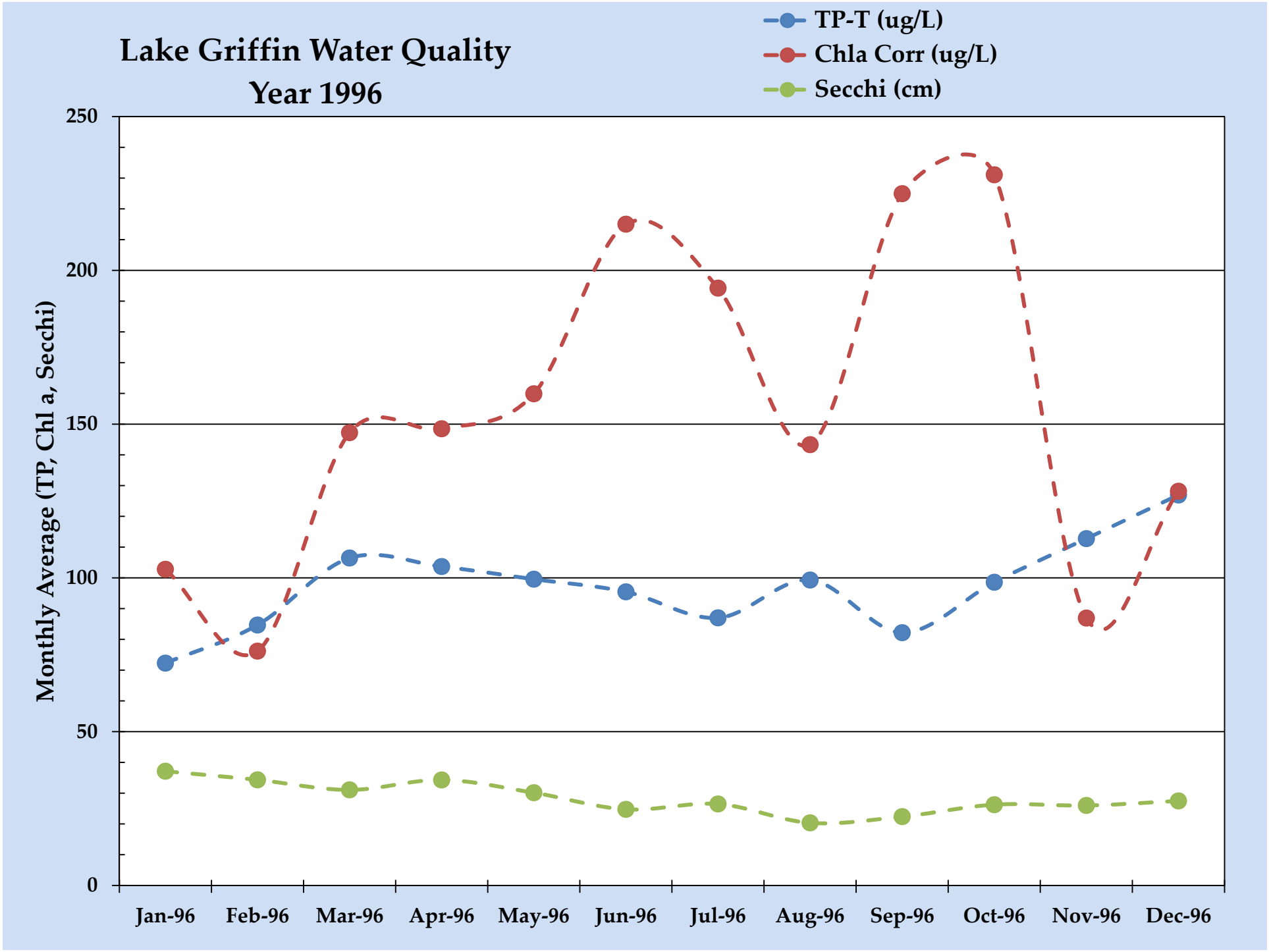
- Reduced phosphorus loading
- Lower phosphorus concentrations
- Lower levels of algae
- Higher water transparency
- Expansion of aquatic vegetation
- Substantial ancillary benefits
  - Wetland habitat
  - Water supply
  - Flood control
  - Fish and wildlife benefits

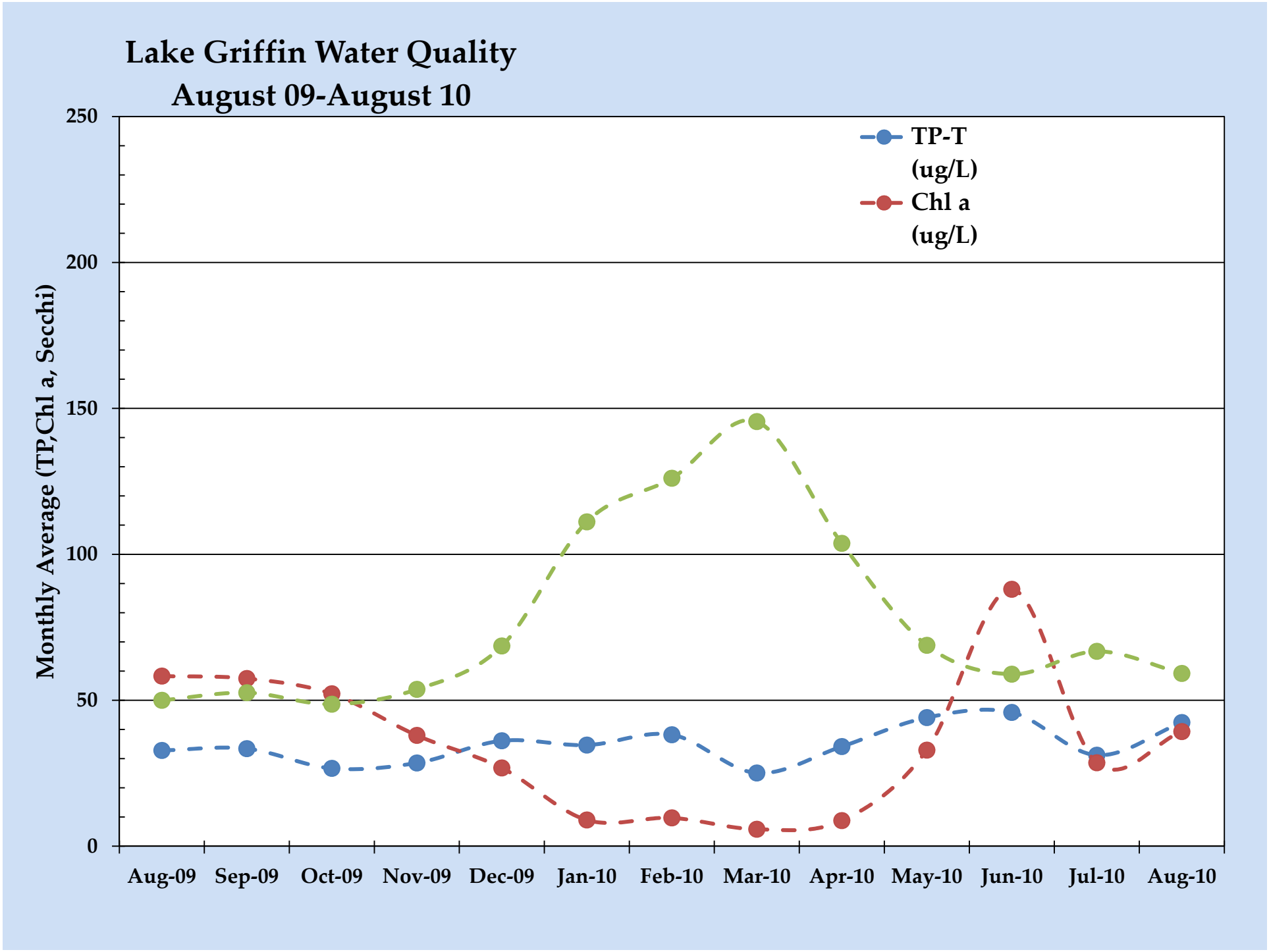
TMDL Target Concentration: Projected for 2017-2019



IV. Harris Chain Case Study: Lake Griffin


Estimated annual external total phosphorus loads and concentrations for Lake Griffin
Metric tons per year
TP concentration (µg/L)
0
10
20
30
40
50
0
20
40
60
80
100
120
140
Tributary flows
Atmospheric
Natural areas
Point source/septic
Stormwater runoff
Harris Bayou Restoration Area
Emeralda ag lands/rest area
TMDL
TP concentration
Gizzard shad harvest
Farming
1984-93
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009


Lake Griffin Water Quality
Year 1996
TP-T (ug/L)
Chla Corr (ug/L)
Secchi (cm)
Monthly Average (TP, Chl a, Secchi)
250
200
150
100
50
0
Jan-96
Feb-96
Mar-96
Apr-96
May-96
Jun-96
Jul-96
Aug-96
Sep-96
Oct-96
Nov-96
Dec-96


Lake Griffin Water Quality
August 09-August 10
Monthly Average (TP,Chl a, Secchi)
250
200
150
100
50
0
TP-T (ug/L)
Chl a (ug/L)
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10


Success!


More
Success!

Reaping the Rewards!

Lake Apopka Restoration FSA 2012


Questions?
Lake Apopka Restoration FSA 2012