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Lake Mattamuskeet Watershed Restoration Plan

December 3, 2018 Public Symposium

Agenda Overview

10:00 a.m. Welcome

10:05 a.m. Update on Plan Development: Erin Fleckenstein

10:15 a.m. Priority Actions as agreed upon by CST: Michael Flynn

10:30 a.m. Water Quality Concerns and Solutions – Panel Discussion

11:15 a.m. Coffee Break

11:30 a.m. Active Water Management – Panel Discussion

12:30 p.m. Lunch

1:30 p.m. Plan Implementation – Panel Discussion

2:00 p.m. Adjourn

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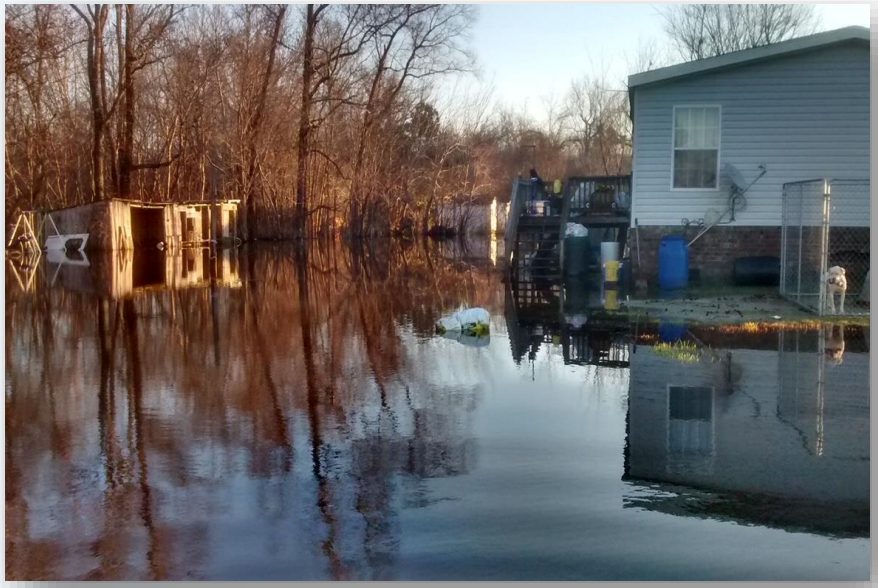
Developing a Watershed Restoration Plan

Concerns about Lake Mattamuskeet



Flooding of Residential and Agricultural Lands

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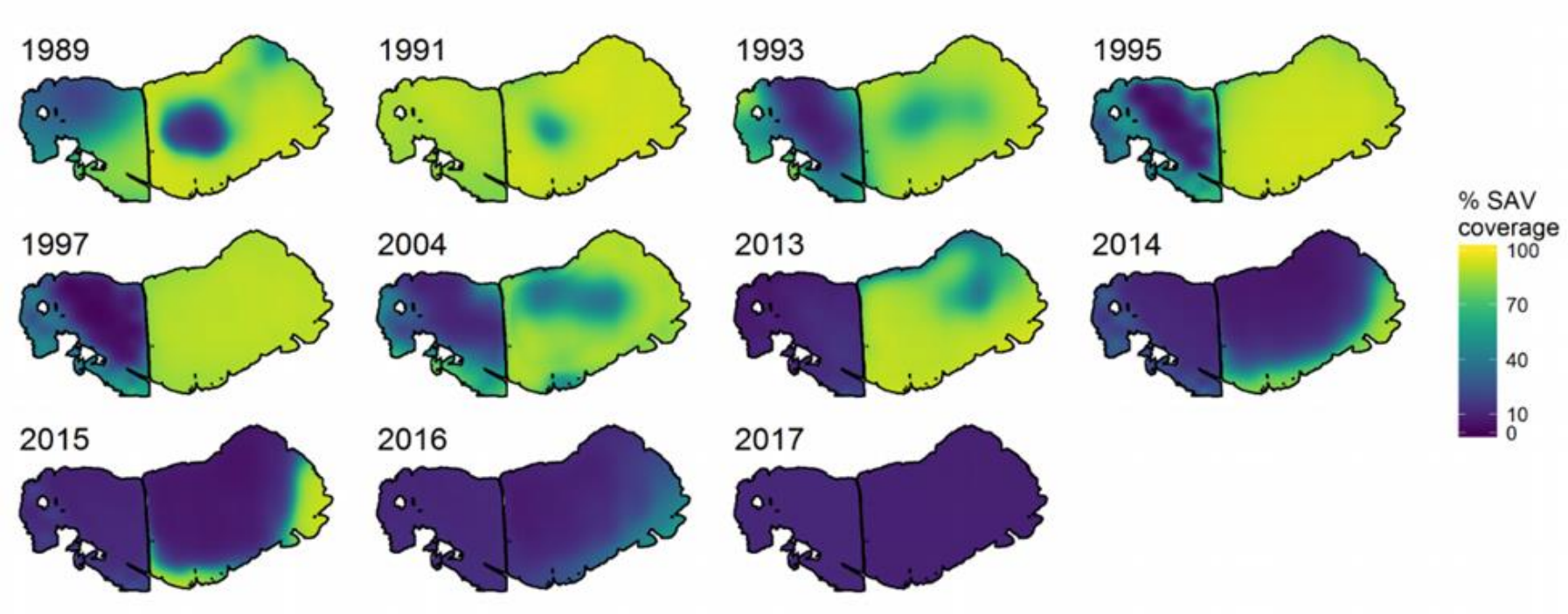
Concerns about Lake Mattamuskeet



Loss of SAV from the Lake by 2017

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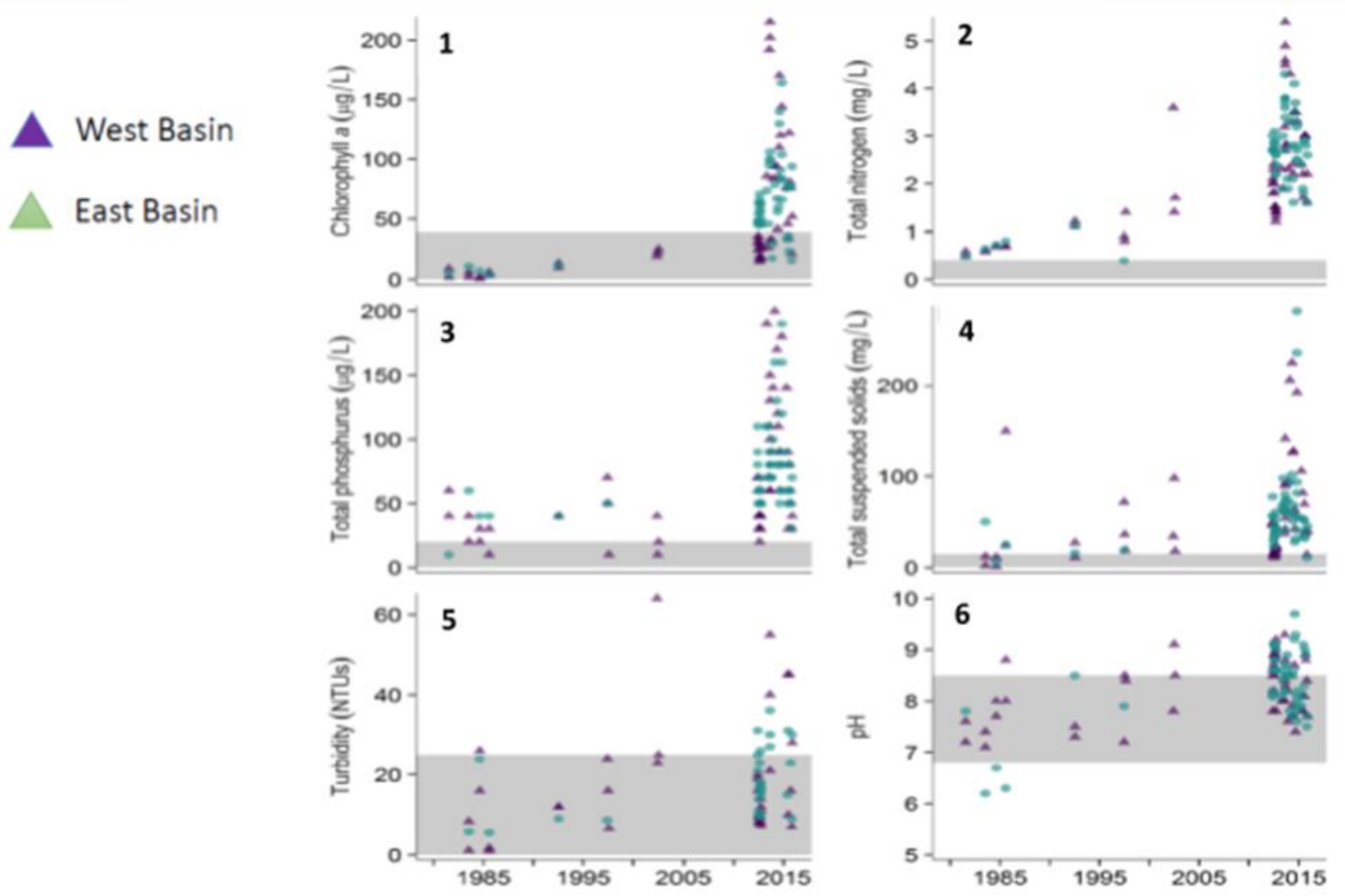
Concerns about Lake Mattamuskeet



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Lake was listed on NC303(d) list of impaired waters in 2016 for elevated levels of pH and chlorophyll-*a*

What is a watershed restoration plan?

- A voluntary plan for a specific waterbody
- Identifies pollutants and causes of impairment
- Provides the framework and guidance to restore an impaired waterbody and outlines future action
- Recommends management strategies devised by all stakeholders
- Adaptive plan that can be updated over time
- Once approved, it can be used to secure grant funds for implementation

Key Steps in Developing a Watershed Restoration Plan

Assemble Planning Team

Engage stakeholders and the public in the plan development

Determine Water Quality and Quantity Conditions and Impairments

- Summarize research on the current status and trends of the lake water quality
- Capture oral and written history of changes to or improvements in hydrology around the lake

Complete Watershed Characterization

Establish Plan Goals, Objectives and Action Items

Identify Stormwater Reduction or Water Management Techniques

Analyze impact of solutions

Develop Management Plan including priorities and next steps

Major Progress to Date

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Analyze impact of solutions

Develop Management Plan including priorities and next steps

Stakeholder Team

Daniel Brinn- Hyde County Water and Flood Control

Pete Campbell- U.S. Fish and Wildlife Service

Michael “Slim” Cahoon- Farming Community

Doug Howell- N.C. Wildlife Resources Commission

Art Keeney- Residential Community

Bill Rich- Hyde County Manager

Ben Simmons- Farming Community/Fairfield Drainage

Pat Simmons- Hospitality Industry

J.W. Spencer- Hyde County Soil and Water Board

James “Booboo” Topping- Residential Community

Joey Ben Williams- Impoundments

Working with Stakeholders and the Public

5 Public Meetings

14 Stakeholder Meetings

Webpage for updates and comments:

nccoast.org/lakemattamuskeet

Press Releases

E-mail update after Public Meetings

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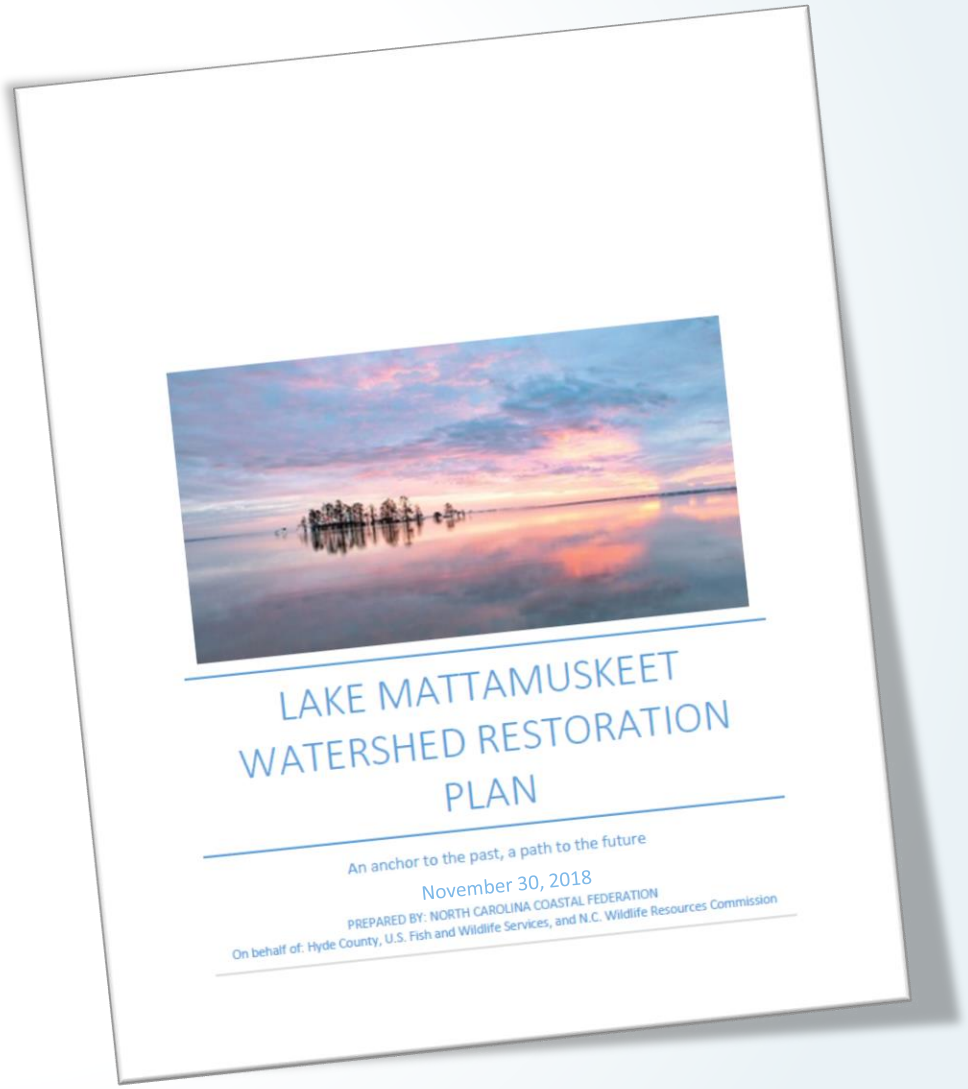
Watershed Restoration Plan

Draft was made available for public review on October 16th

Final draft presented at the public symposium on December 3rd



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Plan Goals

Protect the way of life in Hyde County:

Maintain existing land uses and industries in the watershed (residential, farming, fishing and tourism) and enhance and maintain the health of the lake's natural resources (waterfowl and wildlife).

Plan Goals

Actively manage the lake water level:

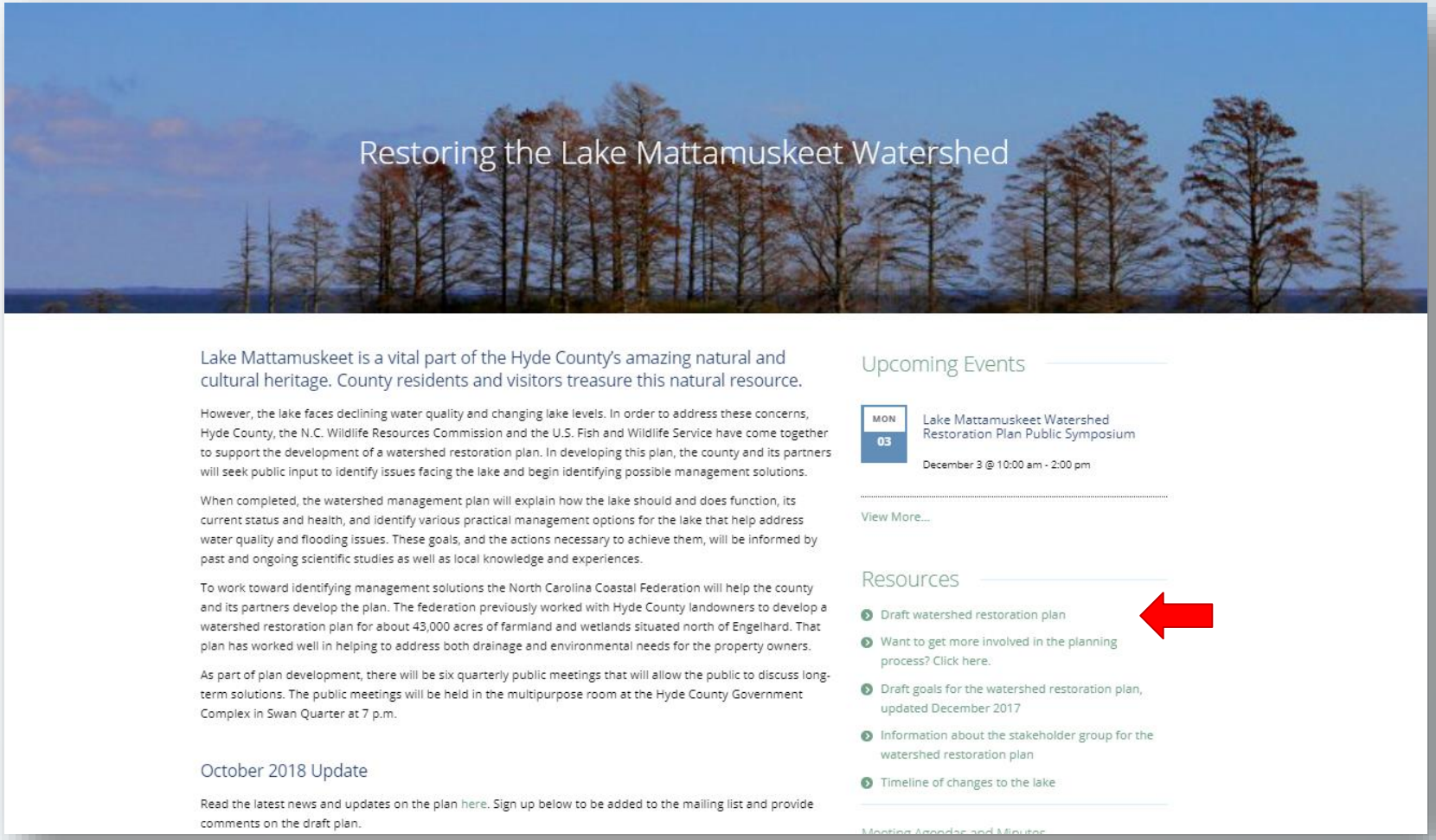
Minimize flooding of residential, business, and farm properties. Allow for annual drawdowns as appropriate and in compliance with the Refuge's management objectives defined in its Comprehensive Conservation Plan to establish and maintain submerged aquatic vegetation within the lake, and to establish and maintain a zone of emergent vegetation around the lake periphery.

Plan Goals

Restore water quality and clarity:

Reduce nutrients, sediments, and phytoplankton blooms, promote the growth of submerged aquatic vegetation and remove the lake from the NC 303(d) list of impaired waters.

Review the Final Draft



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nccoast.org/lakemattamuskeet

Submit Comments Online

Submit Comments and Subscribe to Lake Mattamuskeet updates

Email *

First Name

Last Name

County

Please leave a comment for the watershed restoration planning team here. Please understand that the comments will be provided to the stakeholder team for their consideration. Comments received will not necessarily receive a personal response, but all will be taken into consideration in the development of watershed management strategies for the Lake watershed.

Notes

Submit

In The News

- "Restoring Lake Mattamuskeet In North Carolina" — June 29, 2017. U.S. Fish and Wildlife Service.
- "Secrets of Lake Mattamuskeet" — NC Science Now | UNC-TV
- "Where Has the Grass Gone?" — Wildlife in North Carolina, November/December 2016. Printed by N.C. Wildlife Resources Commission.

Additional Resources

- Study Shows New Flap Gates at Lake Mattamuskeet Bring Minimal Water Flow Change — N.C. Wildlife Resources Commission
- Mattamuskeet National Wildlife Refuge Website — U.S. Fish and Wildlife Service
- Updates on current and historic status of the lake's ecosystem and wildlife — U.S. Fish and Wildlife Service
- Continuous Water-Quality Monitoring at Lake Mattamuskeet, North Carolina — U.S. Geological Survey
- Mattamuskeet Foundation

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Lake Mattamuskeet Watershed Restoration Plan

Priority Actions

Current State of the Lake and Watershed

1. No active management of lake level other than tide gates
    - Flooding of residential property, septic system failures, & inadequate drainage of croplands
2. Turbid and hypereutrophic water (excessive nutrient levels)
    - Frequent phytoplankton & cyanobacteria blooms
3. SAV coverage is absent along lakebed
4. Minimal emergent vegetation
5. Abundance of common carp
6. Listed on NC 303(d) list of impaired waters
    - Chl-*a* (40 µg/l, AL, NC)
    - pH (8.5, AL, SW)

Desired State of the Lake and Watershed

1. Active management of lake level in addition to tide gates
    - Less frequent flooding of residential property
    - Fewer septic system failures & adequate drainage of croplands
2. Clear and mesotrophic water (moderate nutrient levels)
    - Fewer phytoplankton & cyanobacteria blooms
3. Increased SAV abundance along lakebed
4. Increased emergent vegetation
5. Reduced common carp populations
6. Increased game fish and blue crab populations
7. Removal from the NC 303(d) list of impaired waters
    - Chl-*a* and pH within federal and state guidelines

Priority Actions

- Create a formal body that provides managing authority for active water management within the watershed in close coordination with the Refuge, which would be excluded as party to the formal body since USFWS cannot cede management authority.
- Perform hydrologic study of the watershed.
- Design engineered plans for active water management within the lake watershed
    - Infrastructure Improvements
    - Additional Outlet Evaluation
    - Potential Sheet Flow Sites

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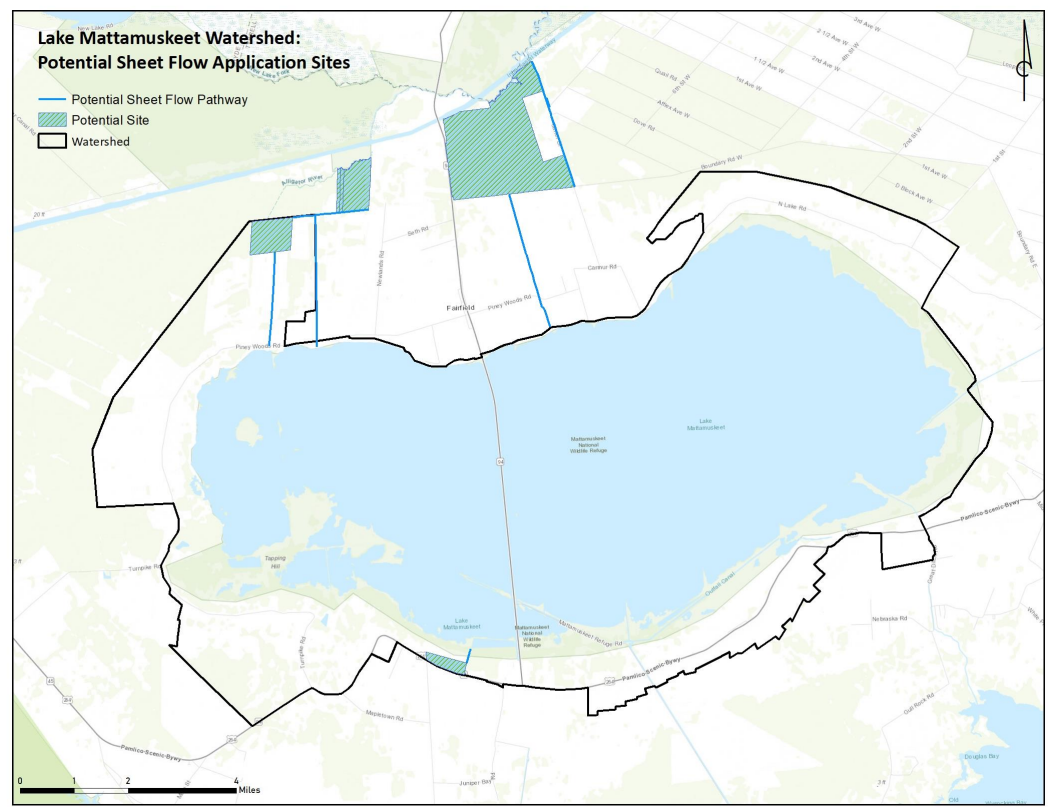
Potential Sheet Flow Sites

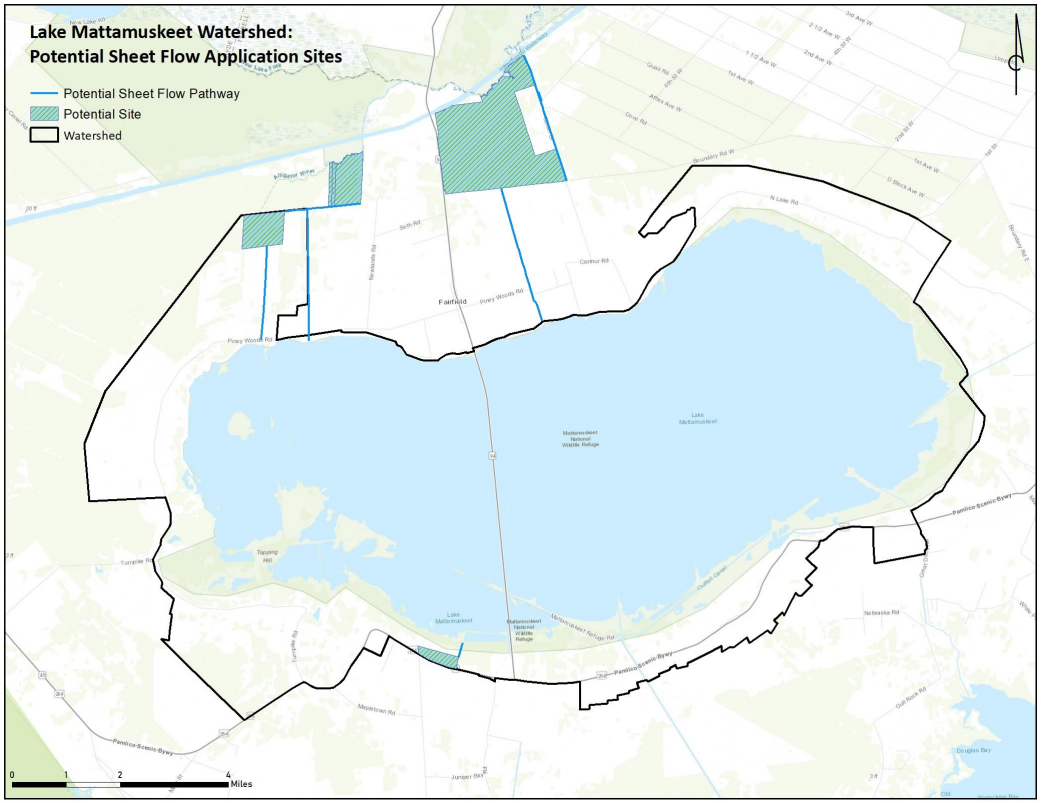


378 acres within watershed

2,477 acres outside watershed

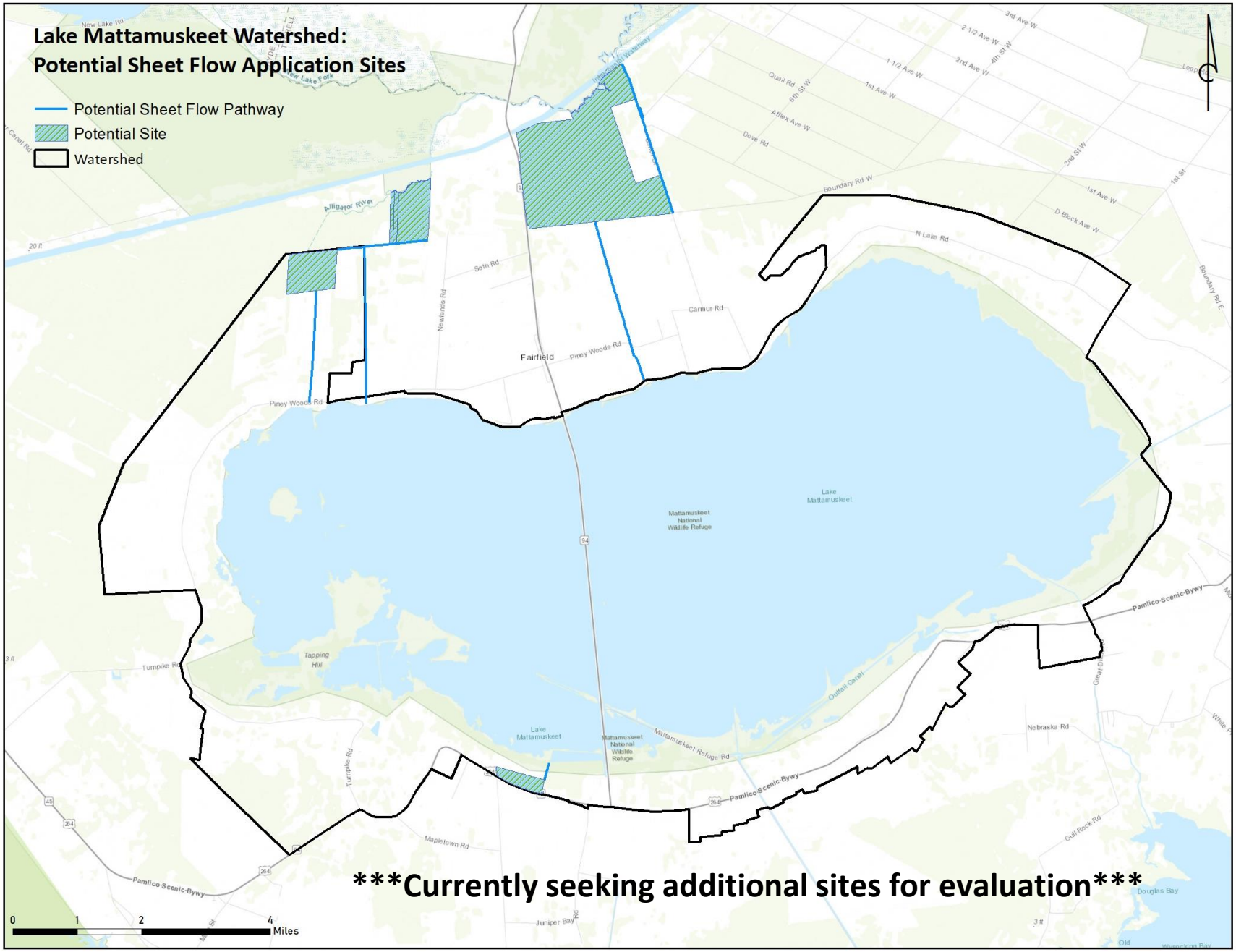
Currently seeking additional sites for evaluation.

Potential Sheet Flow Sites

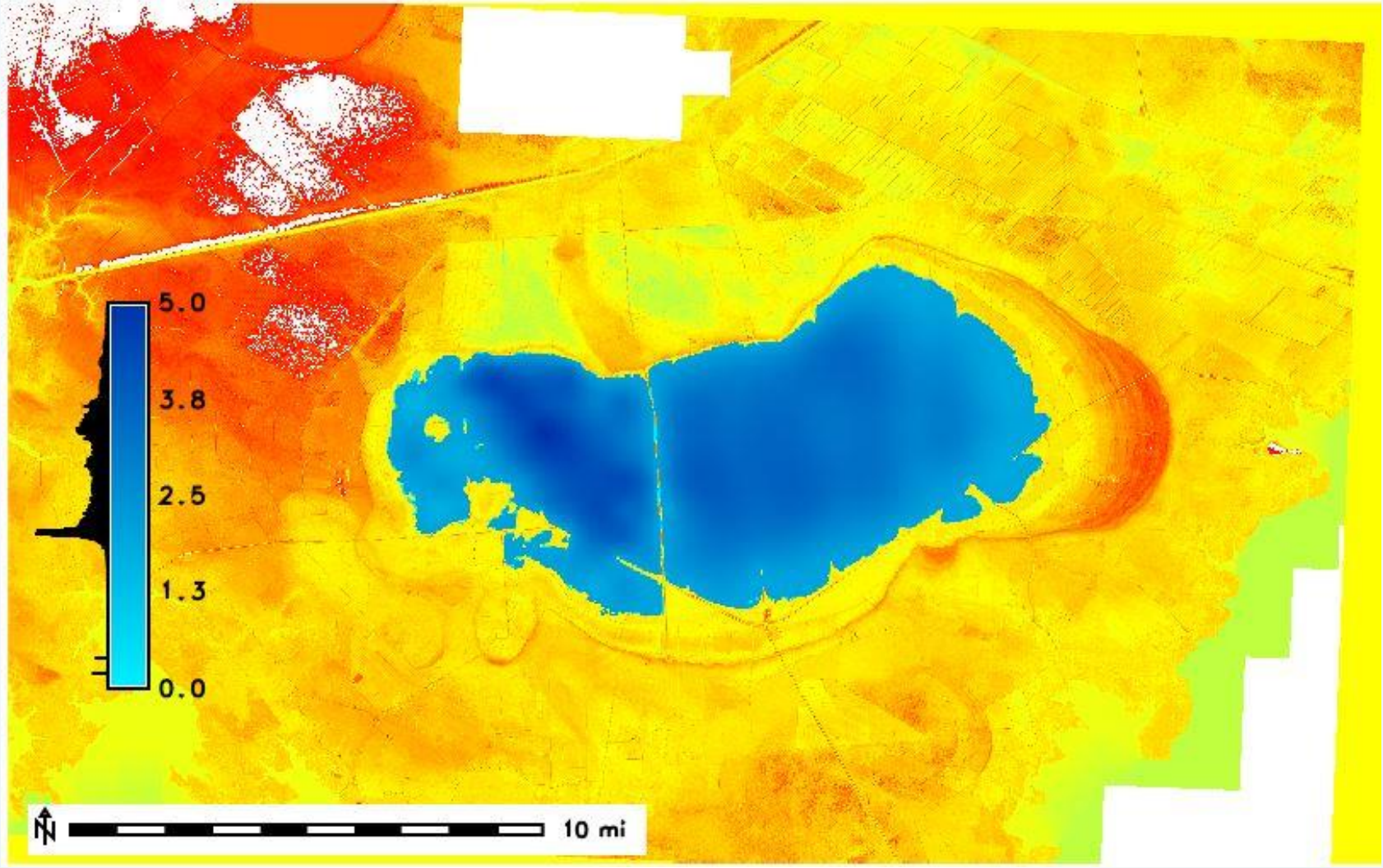


Benefits include:

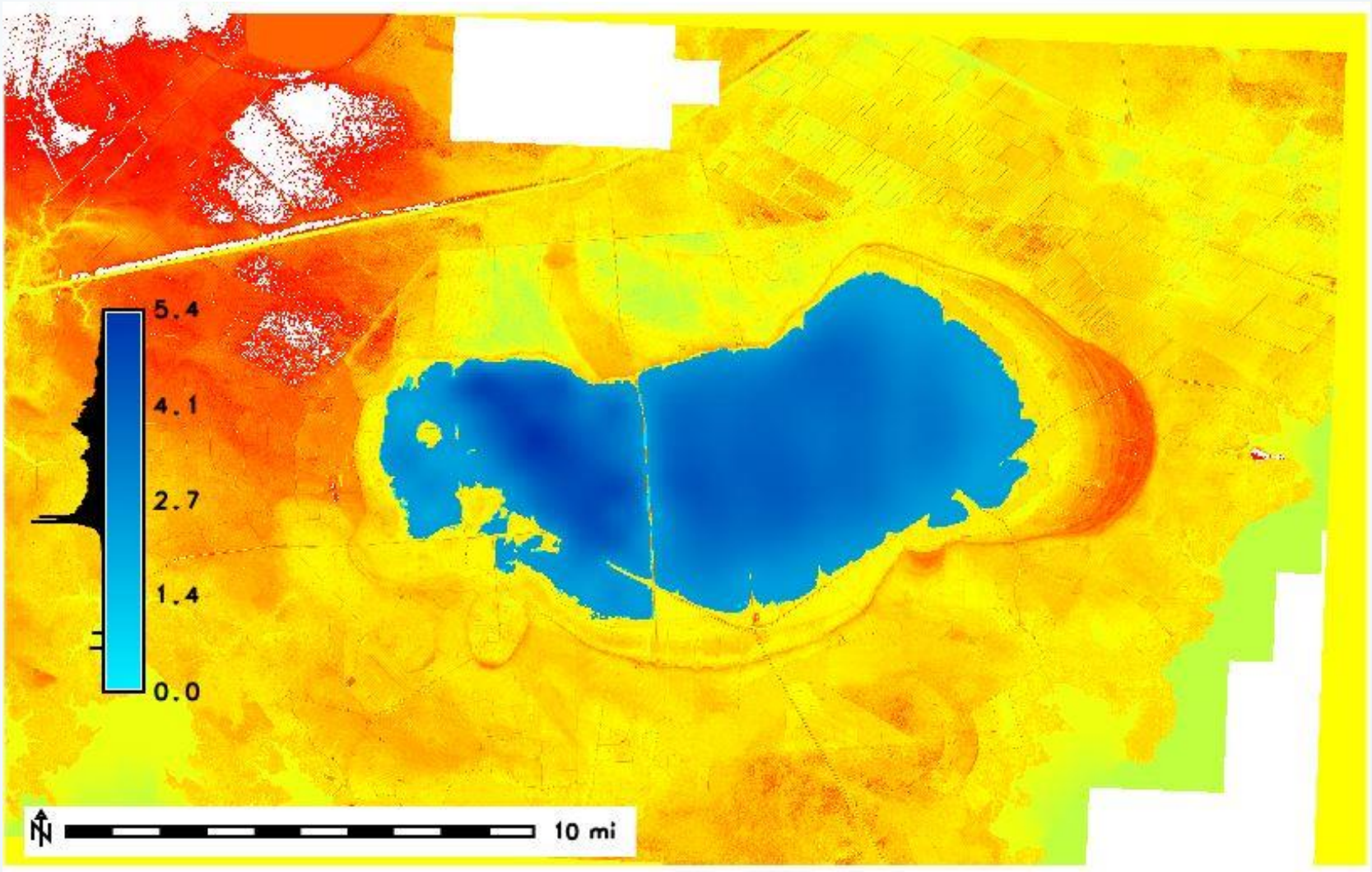
- Water quality treatment
- Restoring the natural hydrology
- Reduction of water volume draining to the lake


Lake Mattamuskeet Watershed:
Potential Sheet Flow Application Sites
Potential Sheet Flow Pathway
Potential Site
Watershed
Currently seeking additional sites for evaluation
0
1
2
4
Miles

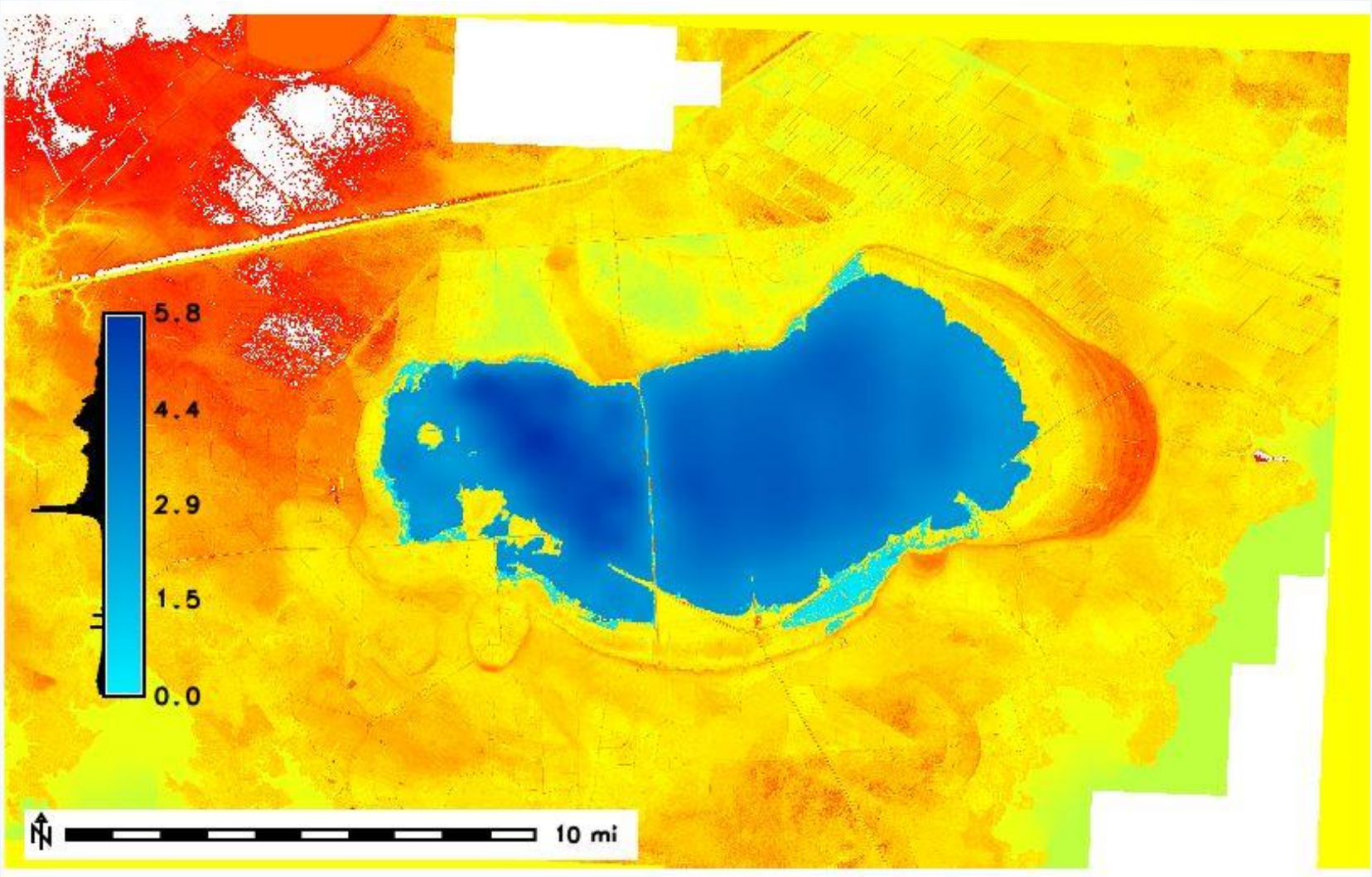
Water Level = -0.3 ft (MSL)



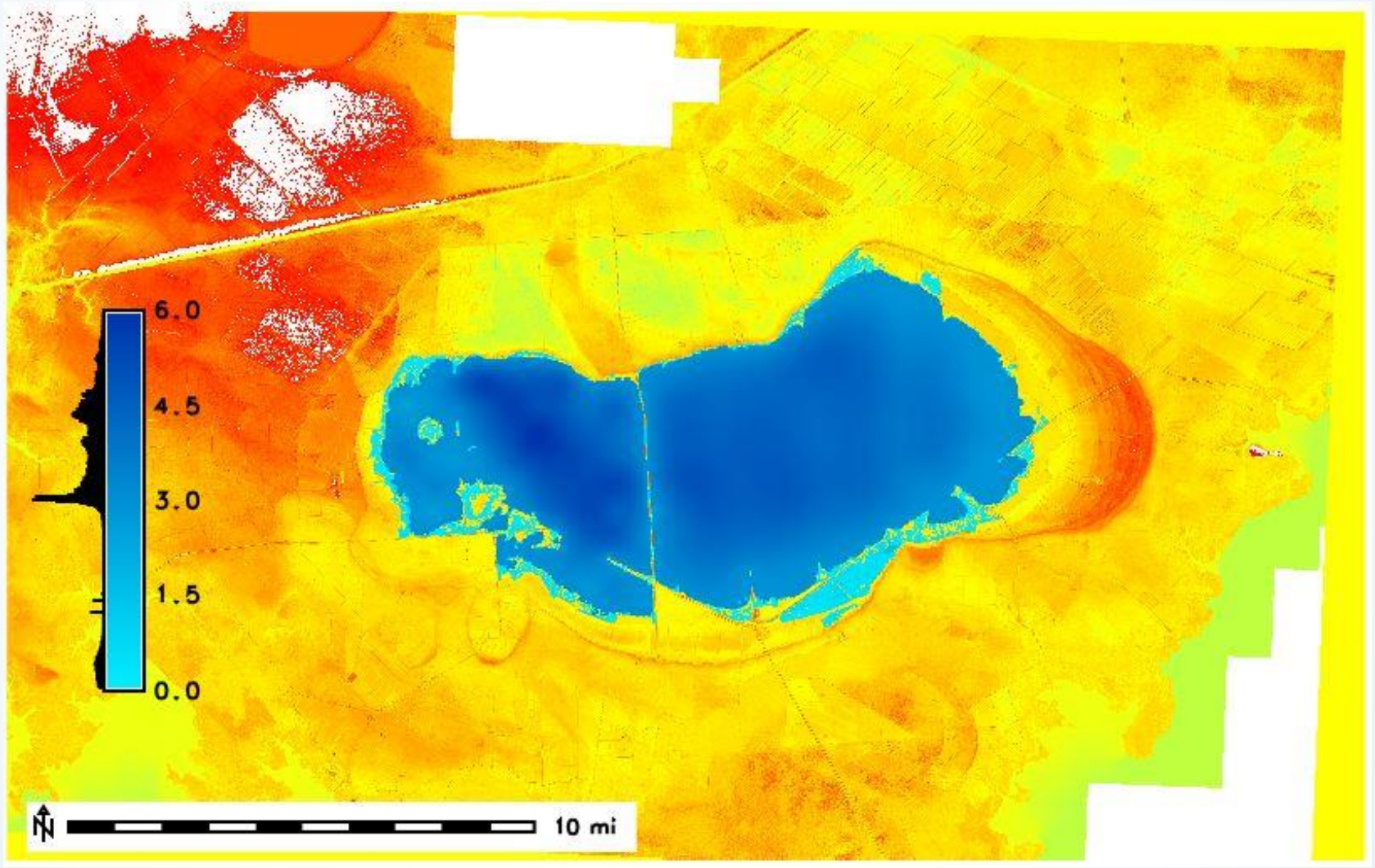
Water Level = 0.1 ft (MSL)



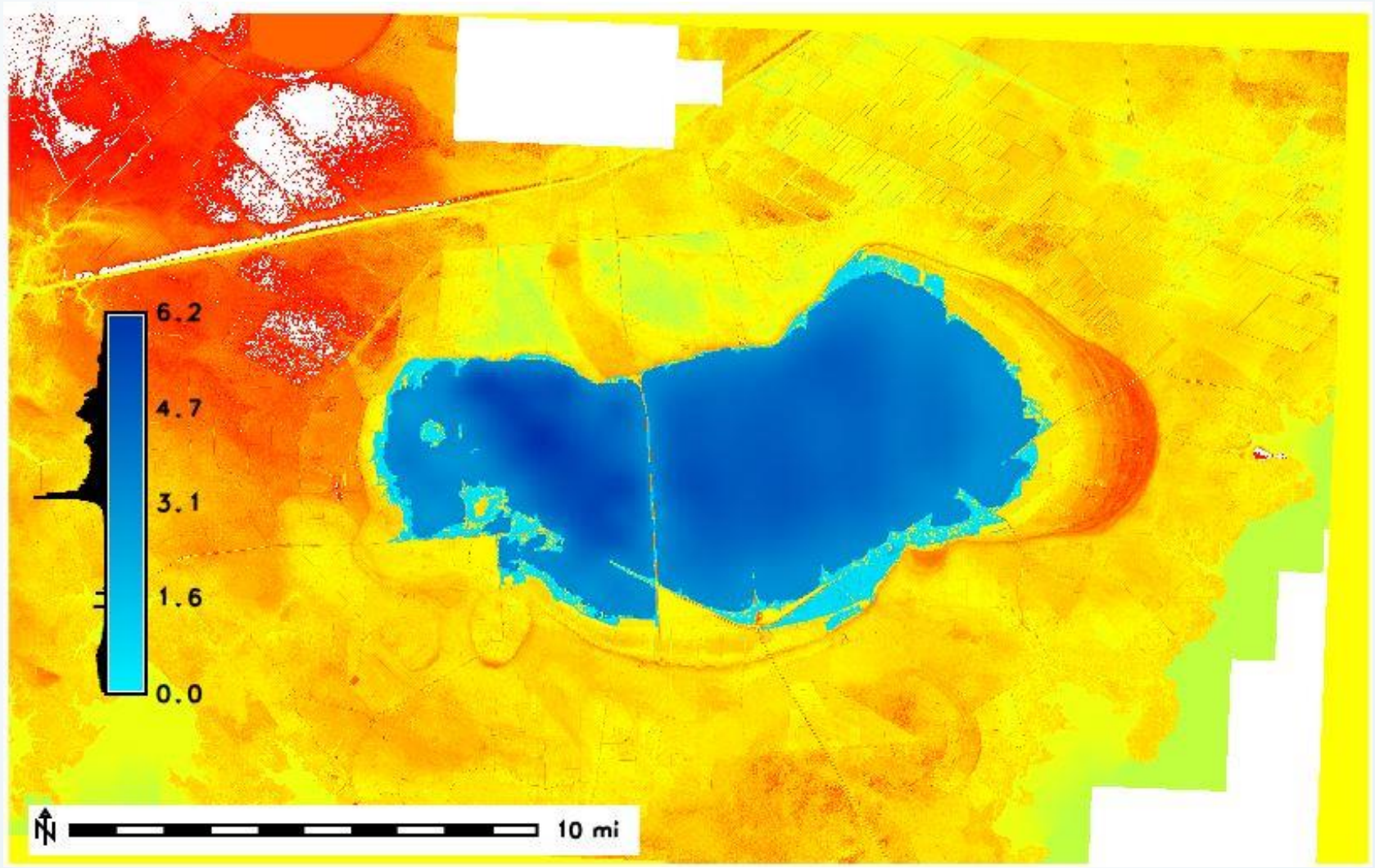
Water Level = 0.5 ft (MSL)



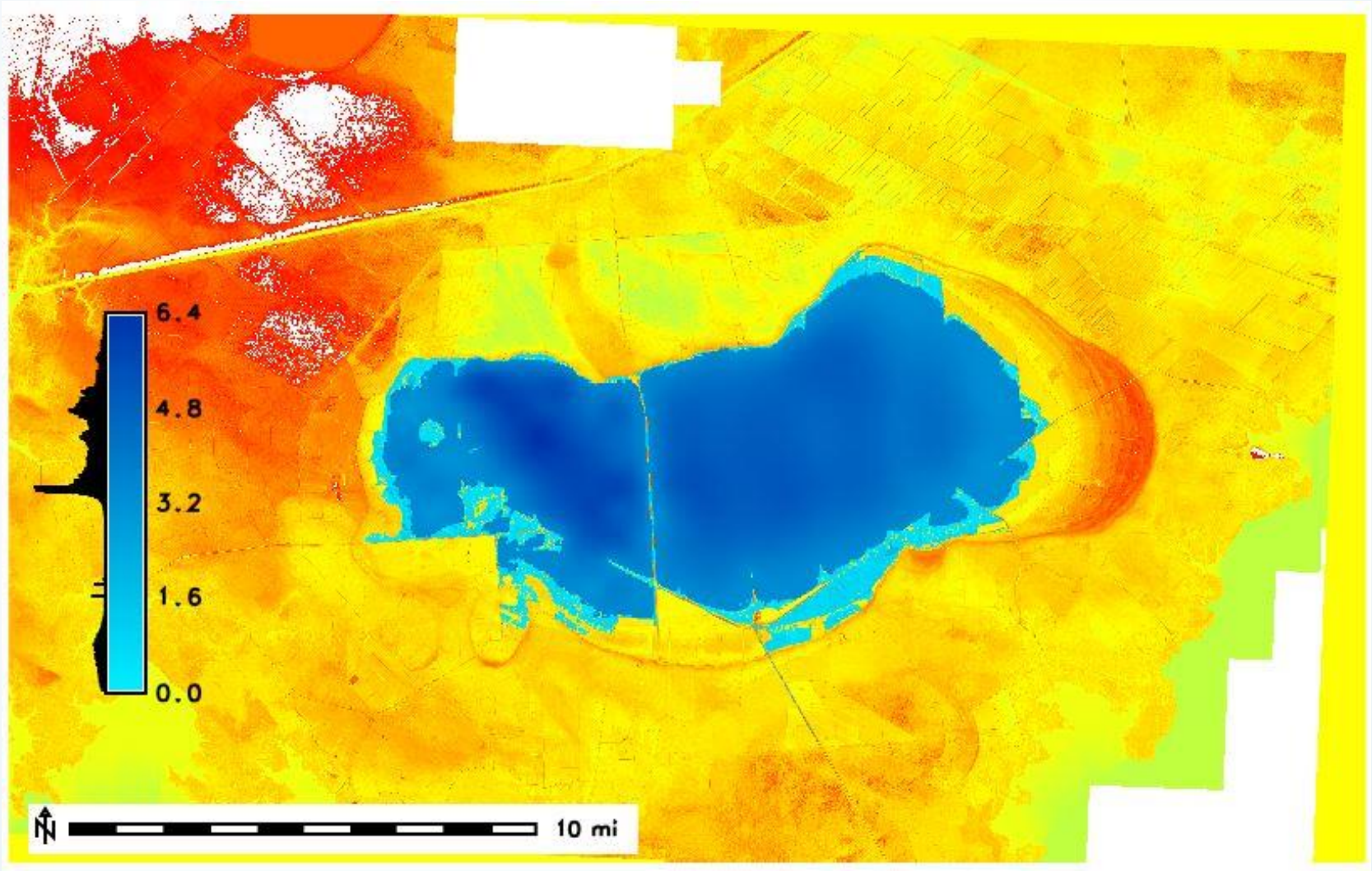
Water Level = 0.7 ft (MSL)



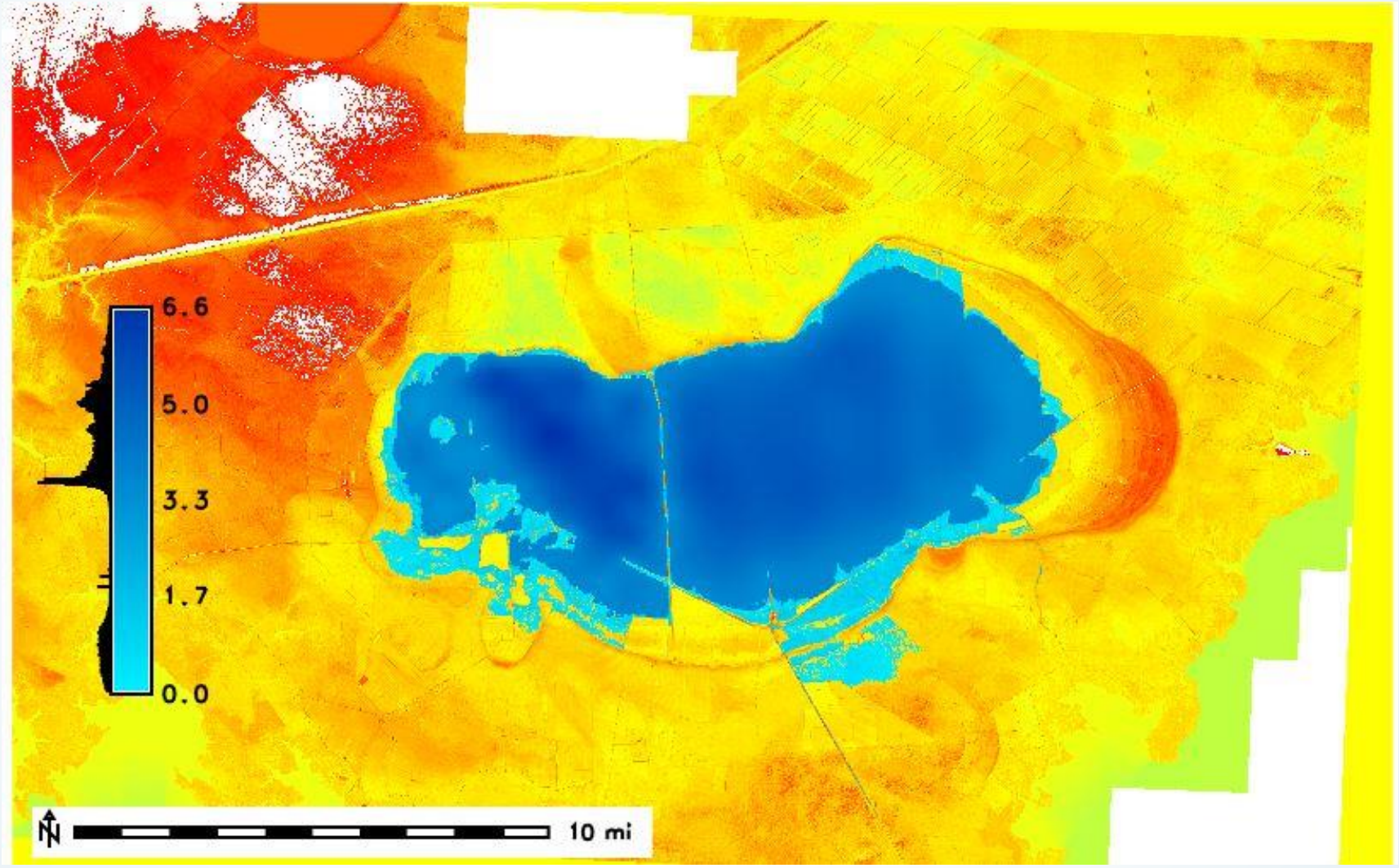
Water Level = 0.9 ft (MSL)



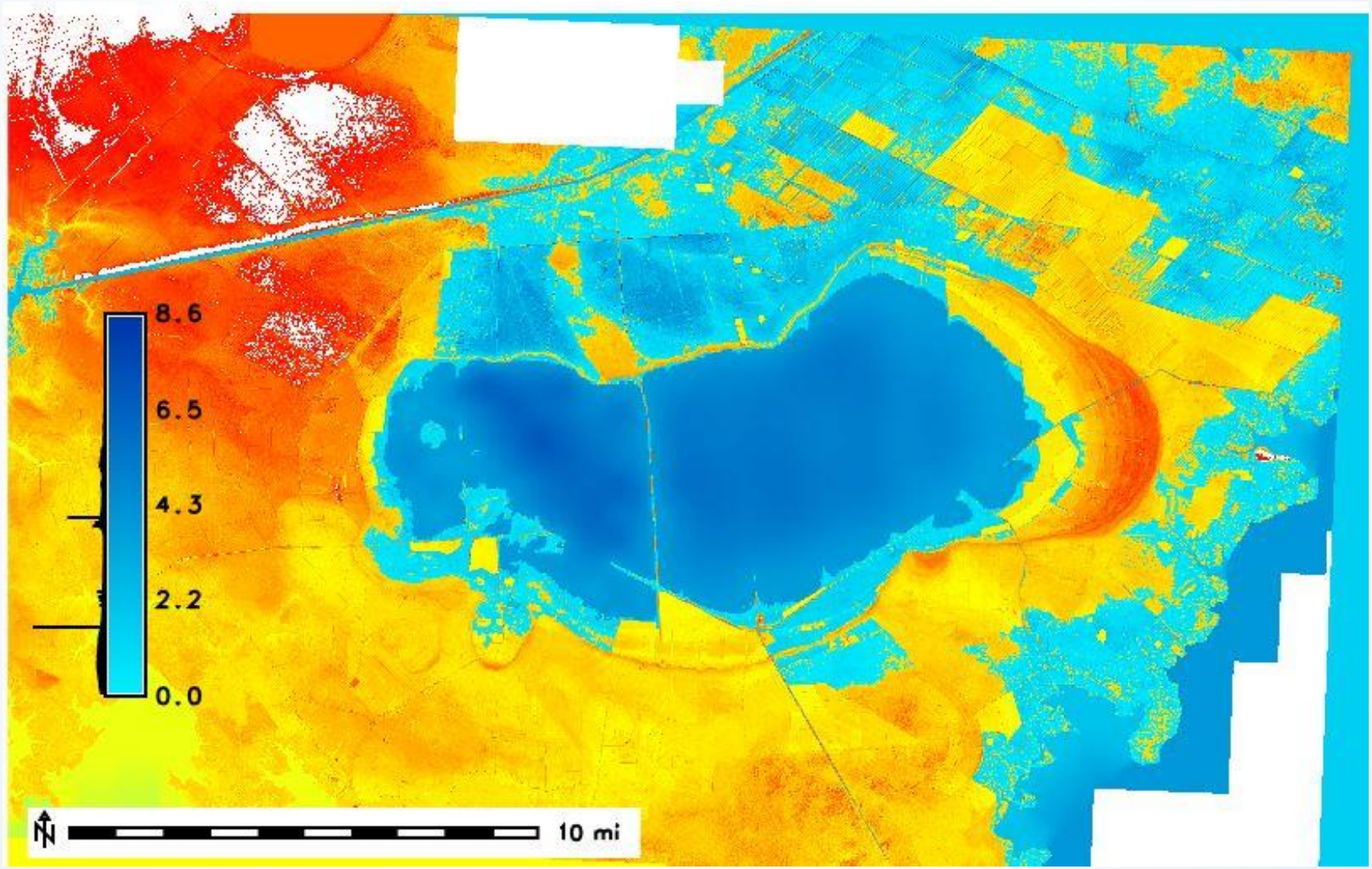
Water Level = 1.1 ft (MSL)



Water Level = 1.3 ft (MSL)



Water Level = 1.5 ft (MSL)



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Water Quality Concerns and Solutions

Panelist Introductions

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Wendy Stanton

U.S. Fish and Wildlife Service

Mattamuskeet National Wildlife Refuge

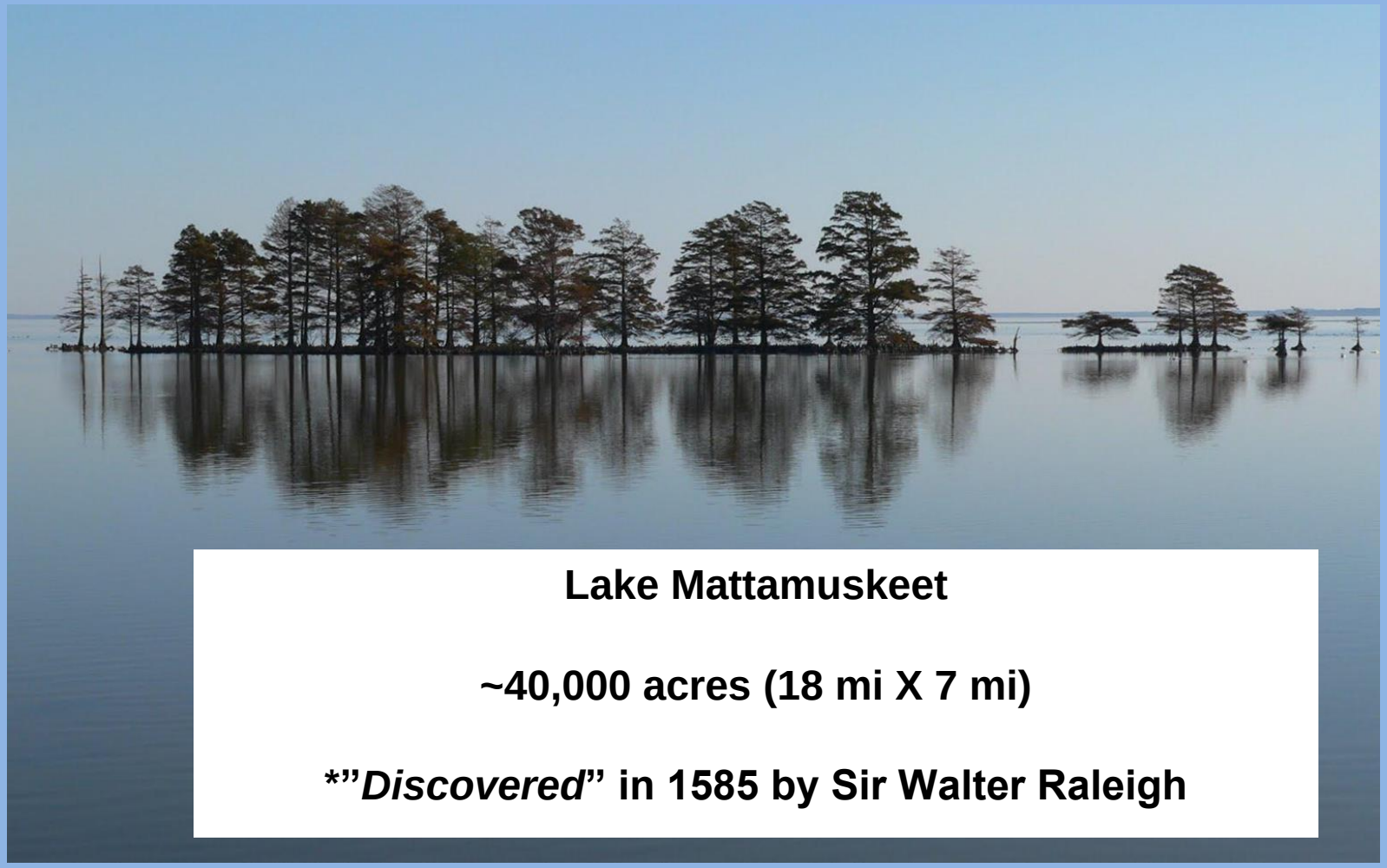
Lake Mattamukseet Watershed Restoration Plan Symposium
December 3, 2018
Wendy Stanton

Special thanks to Dr. Michelle Moorman!

Mattamuskeet Refuge Purpose

is to protect and conserve migratory birds and other wildlife resources through the protection of wetlands

“The Centerpiece”



Lake Mattamuskeet

~40,000 acres (18 mi X 7 mi)

***”*Discovered*” in 1585 by Sir Walter Raleigh**


Redhead grass
Wild Celery
Lake: Submerged Aquatic Vegetation
Muskgrass
Southern Naiad

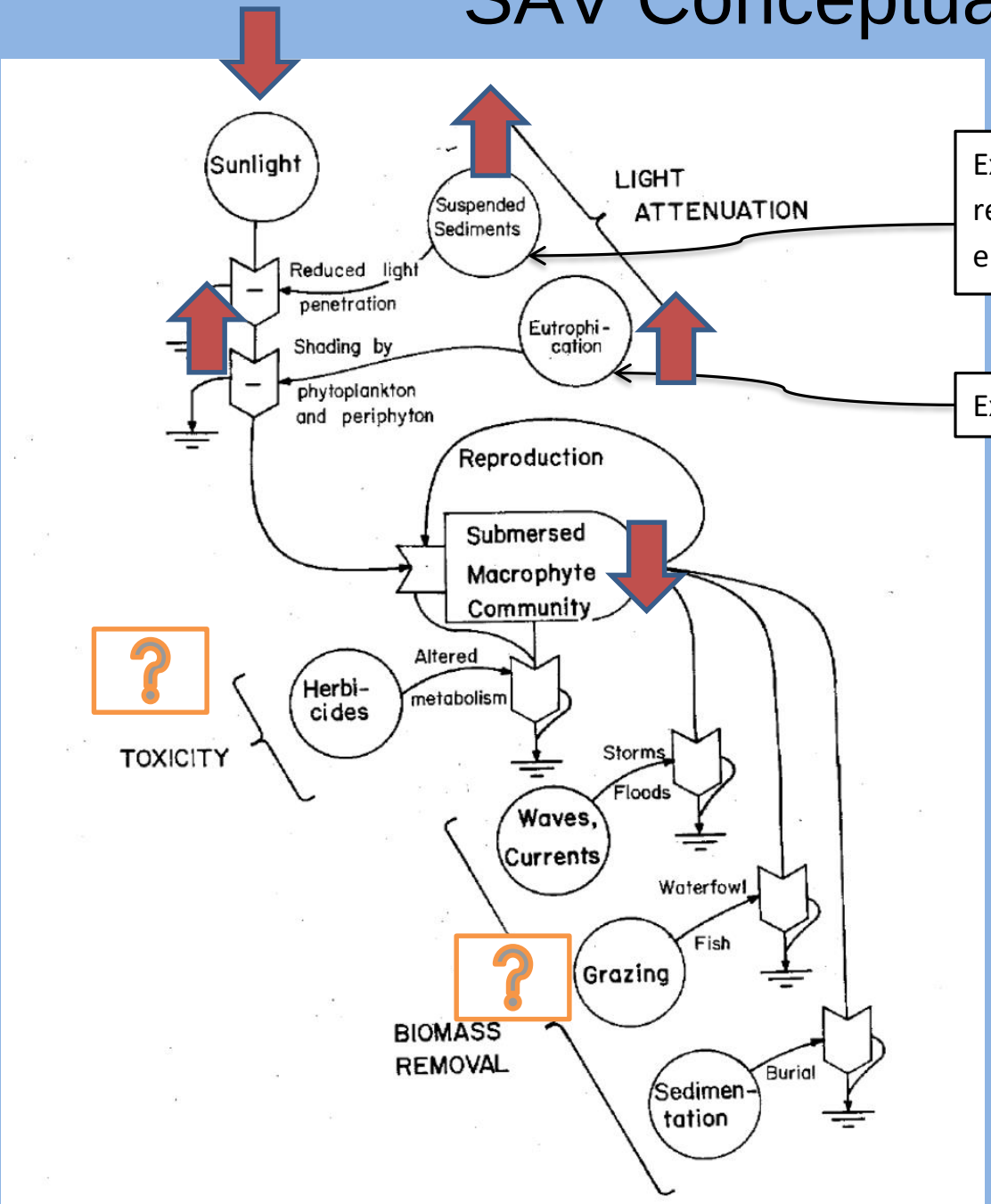
The state of Lake Mattamuskeet has shifted: Water quality and clarity has declined (eutrophic), SAV has disappeared, and cyanobacteria is abundant which is negatively affecting waterfowl habitat

Current state: Turbid waters dominated by cyanobacteria lacking SAV

Desired state: Heathy SAV community with clear water

***SAV is the indicator for water quality in Lake Mattamuskeet**

SAV Conceptual Model



Excess sediment input, or re-suspension from wind, erosion, benthic foraging

Excess N and P

Light attenuation, toxicity, and biomass removal are three general stressors which can be influenced by other specific factors (from Davis and Brinson 1980)

Monitoring parameters for water quality include:

USGS Continual Water Quality Stations (e & w sides of lake):

Water depth
pH,
Specific conductance
*USGS weather station on Hwy 94
Temperature (ºC)
DO
Turbidity

Water samples (taken at CWQS): Many thanks to NCDWR for conducting analysis!

Total nitrogen (mg/L)
Total phosphorous (mg/L)
Phytoplankton
Secchi dish (water clarity) (decimeters)
Total suspended solids (mg/L)
Chlorophyll a (*u*g/L)
Cyanotoxin samples
Light attenuation

Canal water quality parameters:

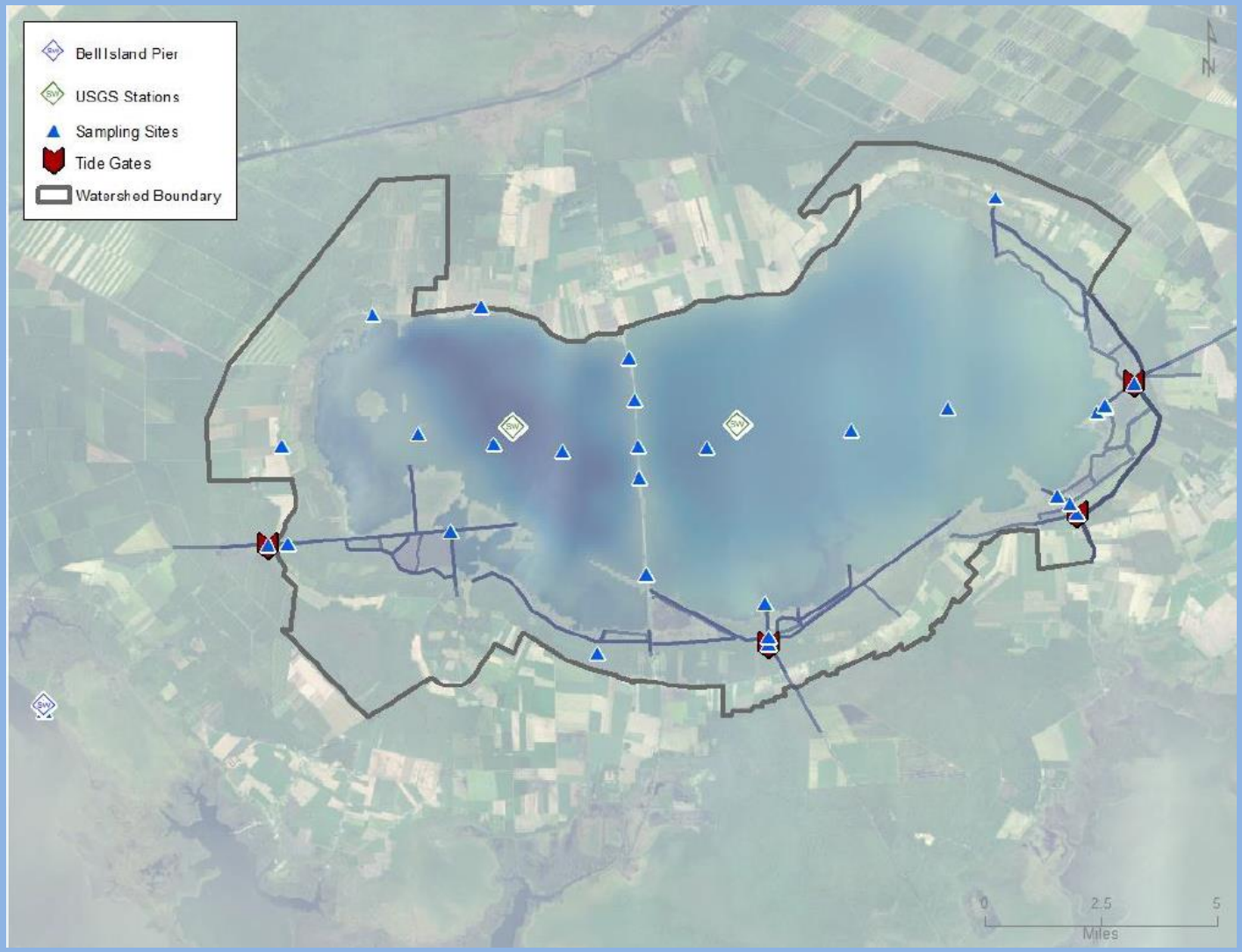
Water depth (ft)
Temperature (ºC)
Secchi dish (water clarity)
Specific conductance
Salinity (ppt)
pH, DO

Continuous Tide gauge at Bell Island Pier (Pamlico Sound)

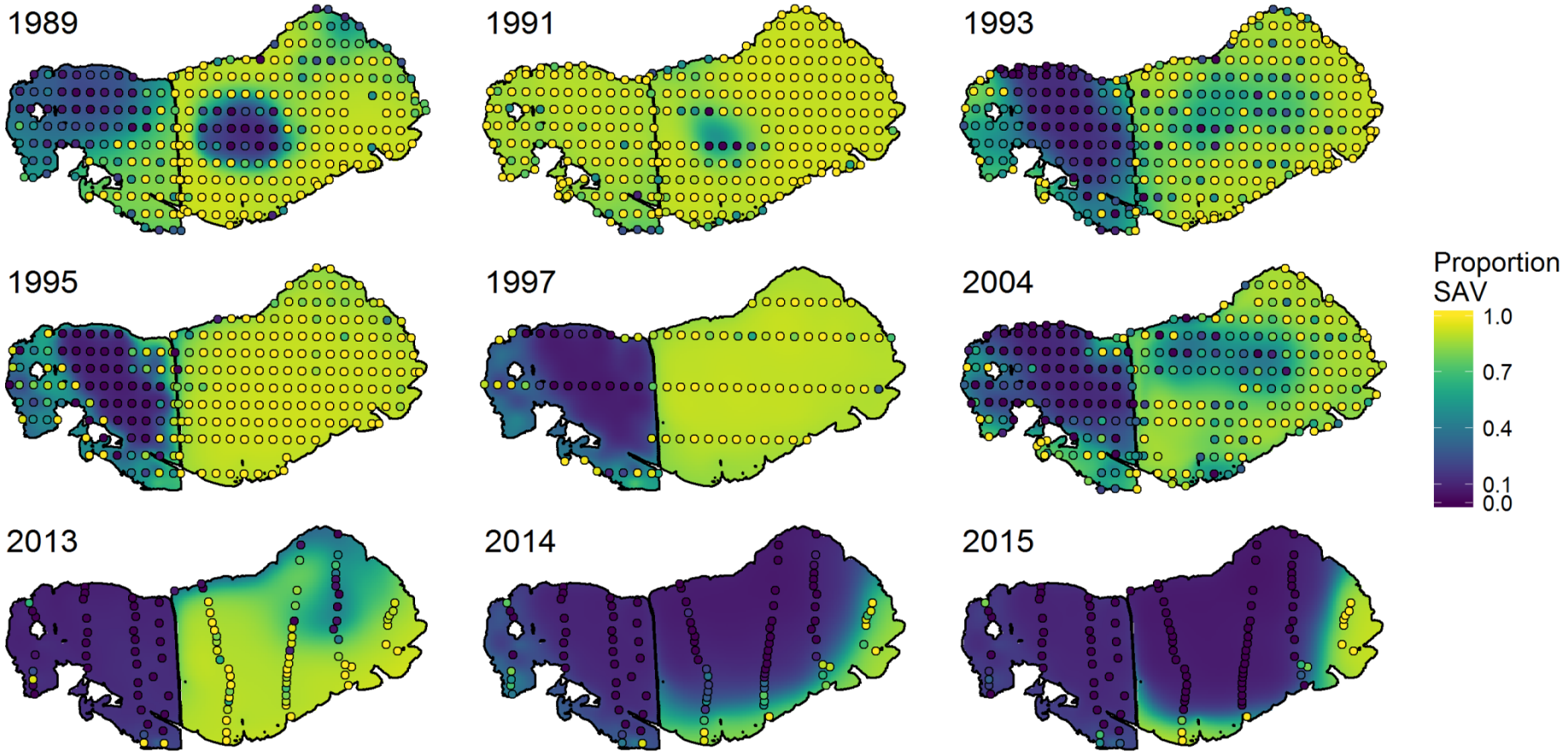
Water depth (ft)
Temperature (ºC)
Salinity (ppt)
Specific conductance (microsiemens)

*Annual SAV surveys in the lake
Ground and aerial waterfowl surveys from November – March
Annual fish monitoring by NCWRC

Monitoring Locations on Lake Mattamuskeet



The decline of SAV at Lake Mattamuskeet is concerning



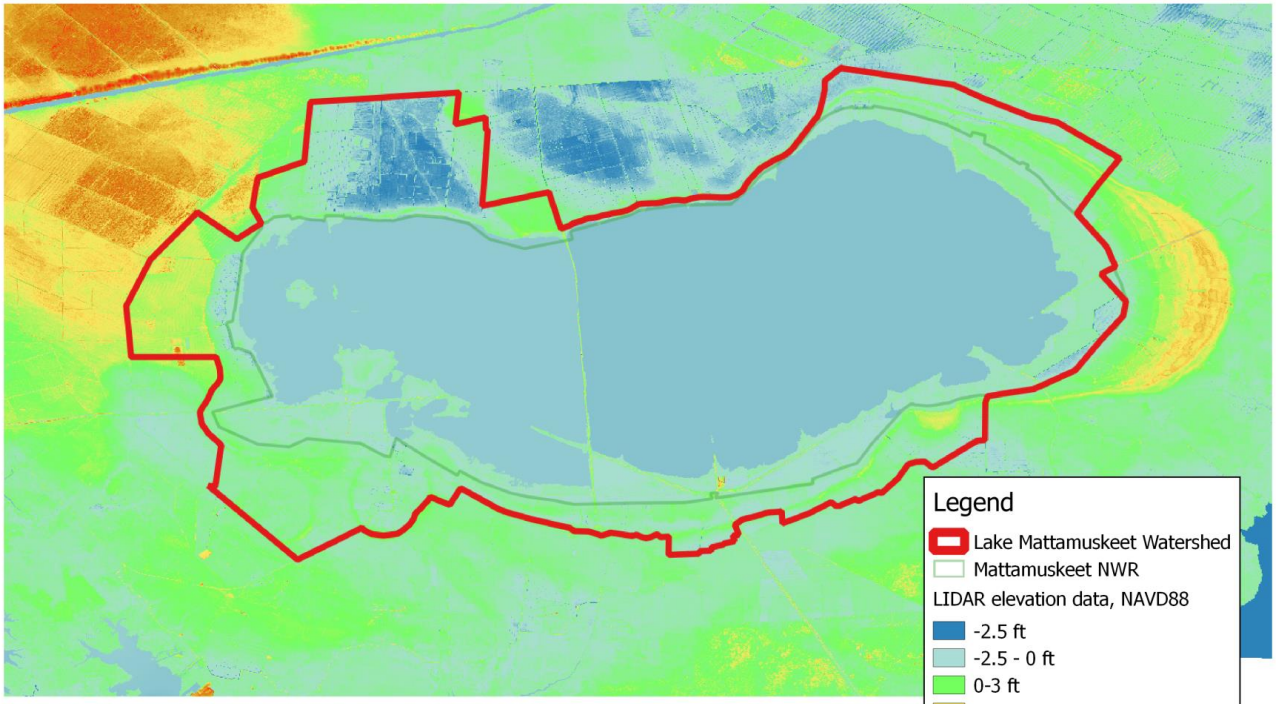
Survey results from 2017 and 2018:

NO SAV

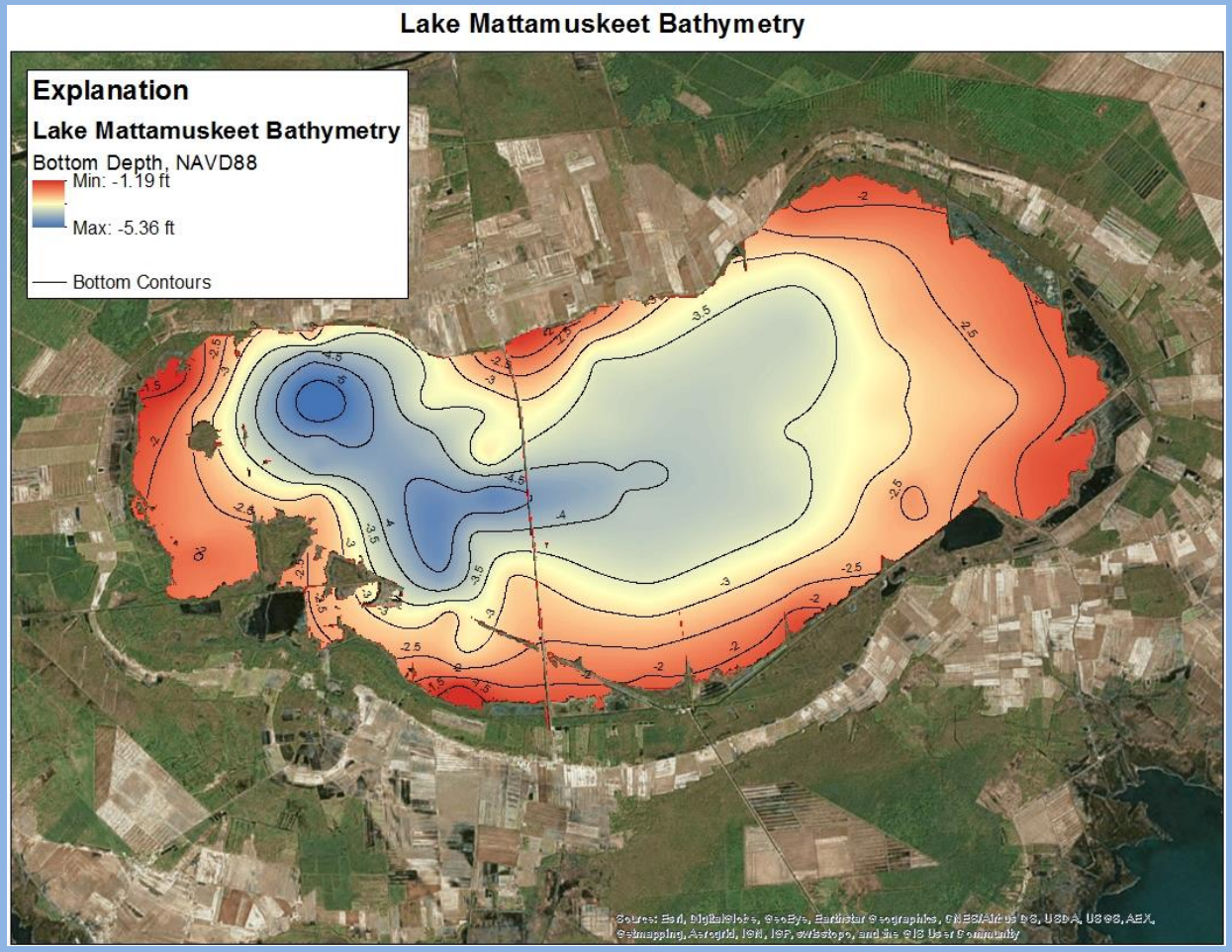
in Lake Mattamuskeet

*2016 the lake was designated as 303d for impaired waters based on elevated levels chlorophyll a and high pH.

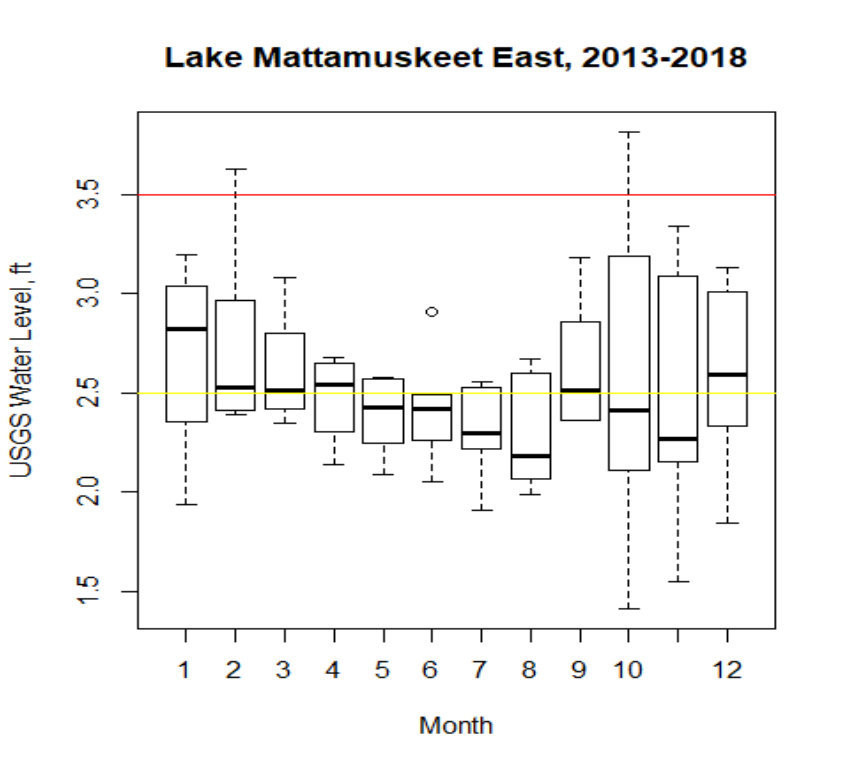
Water Management:
Land is low and drainage system is complex suggests most land is 3 ft below MSL

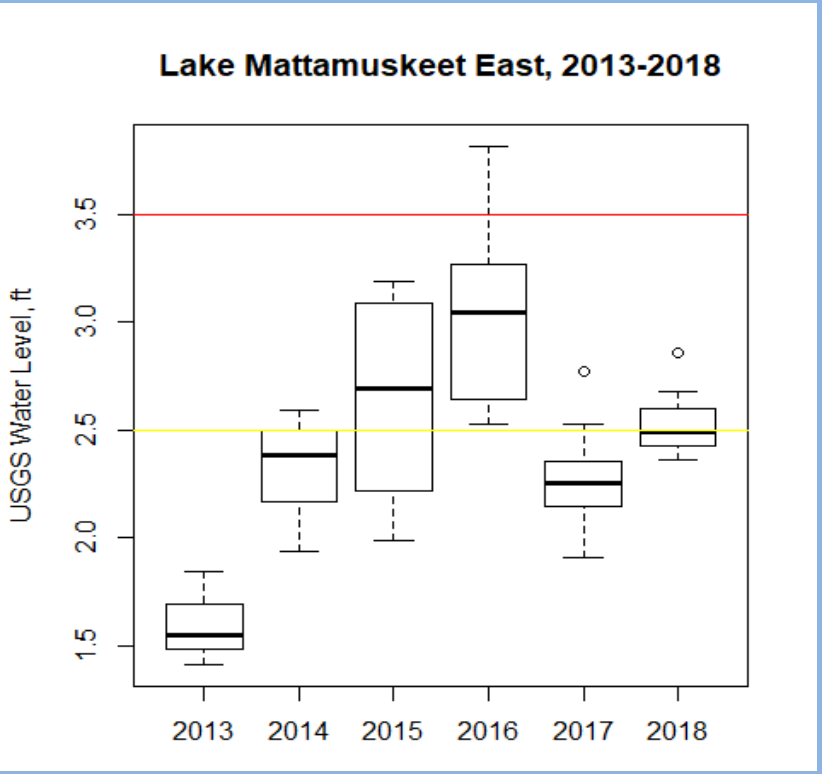


Lake Mattamuskeet bottom depths are lower than the Pamlico Sound



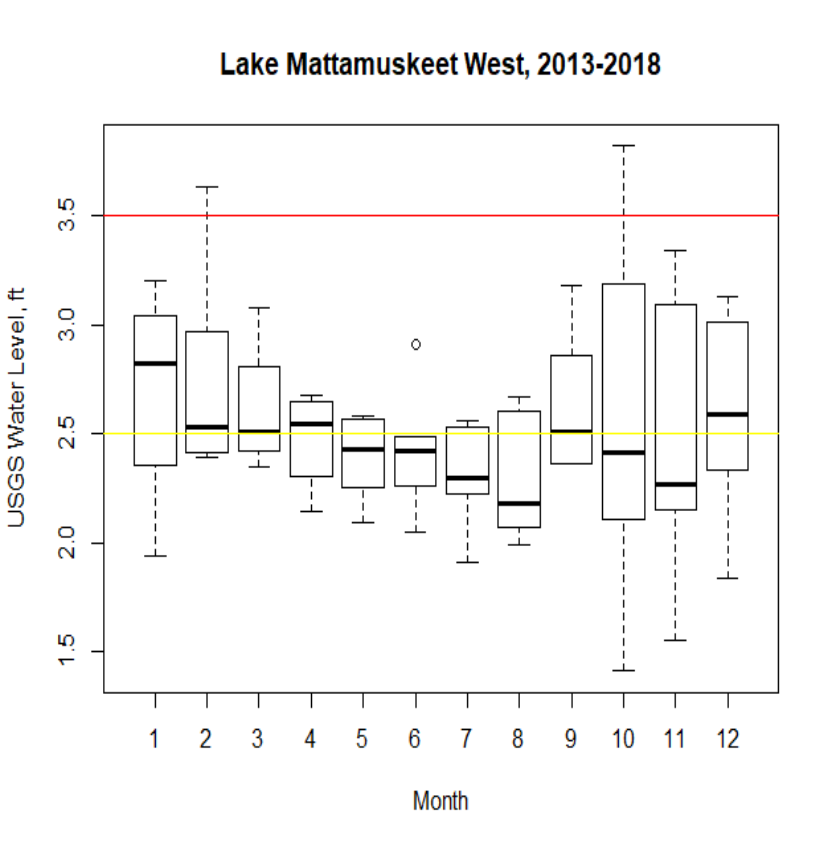
USFWS has been monitoring lake levels since 2012

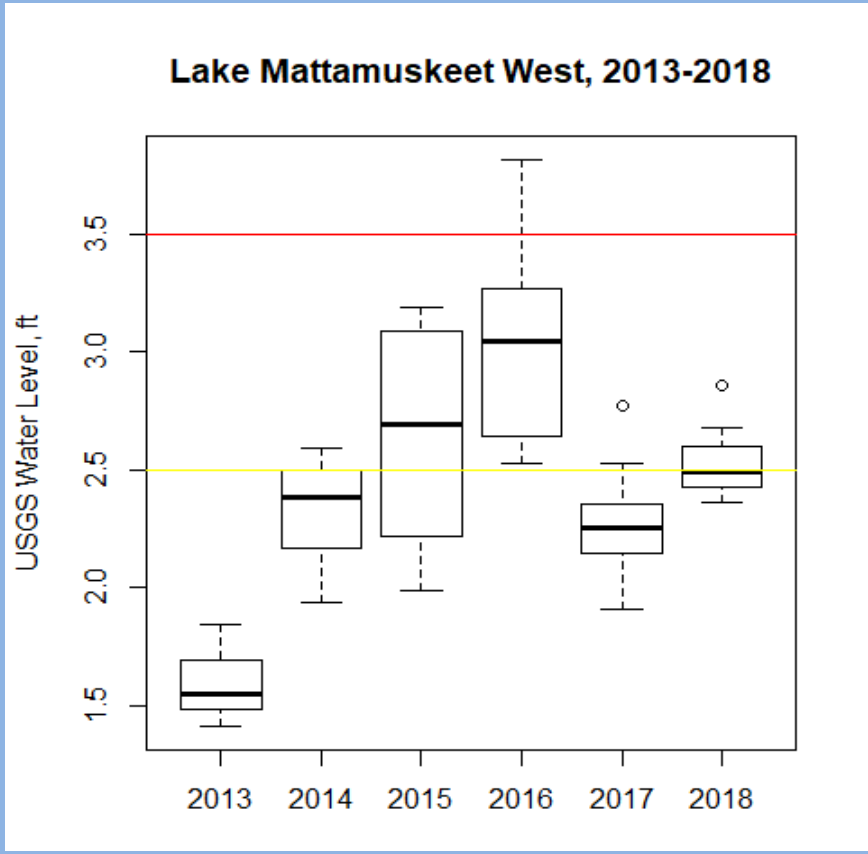




Maximum monthly water level measured each month. Yellow lines= gage heights for hot spot flooding, red lines = chronic flooding (as identified by local stakeholders)

USFWS has been monitoring lake levels since 2012: USGS Continuous WQ Stations.





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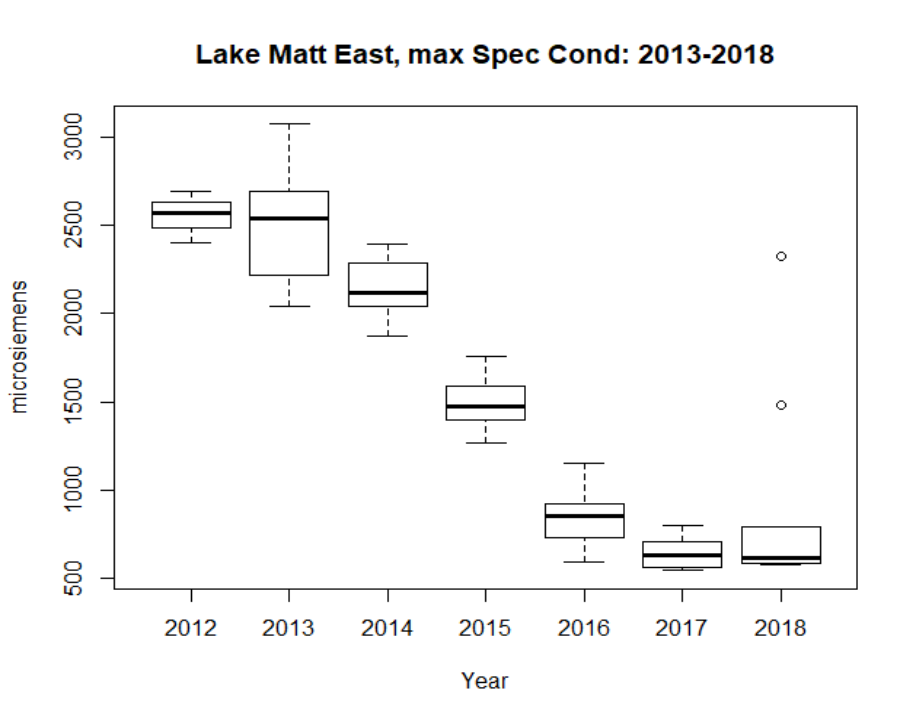
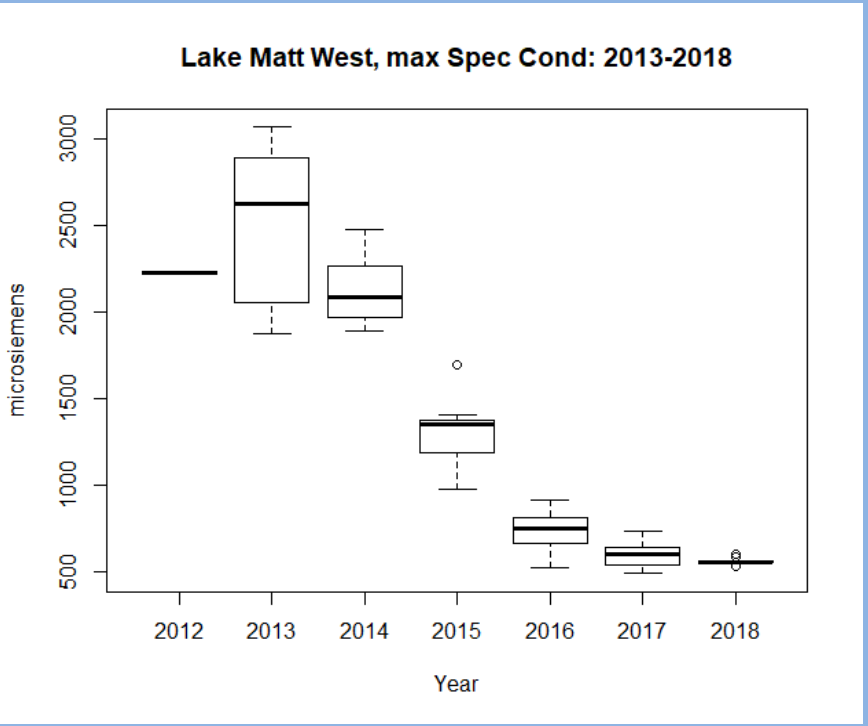
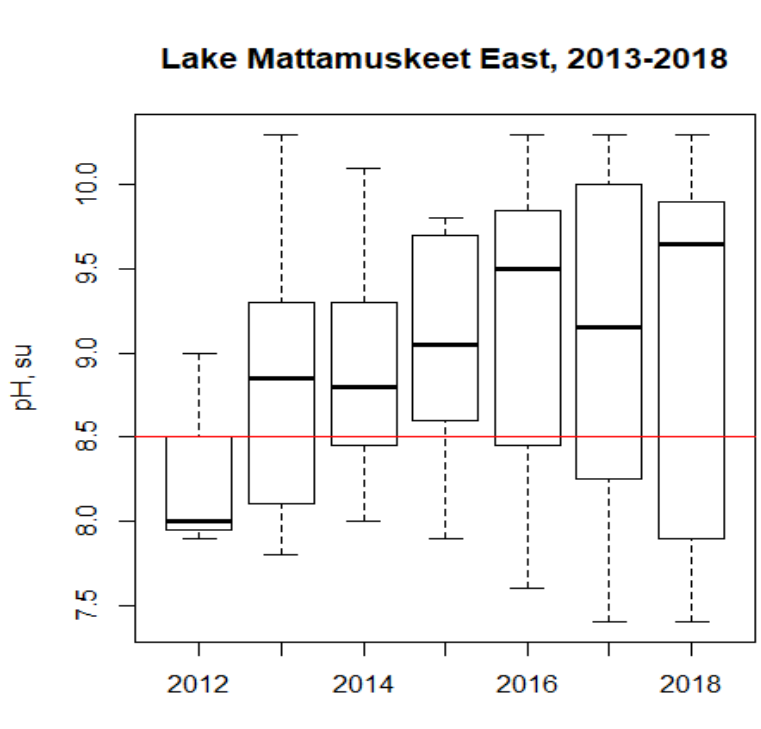
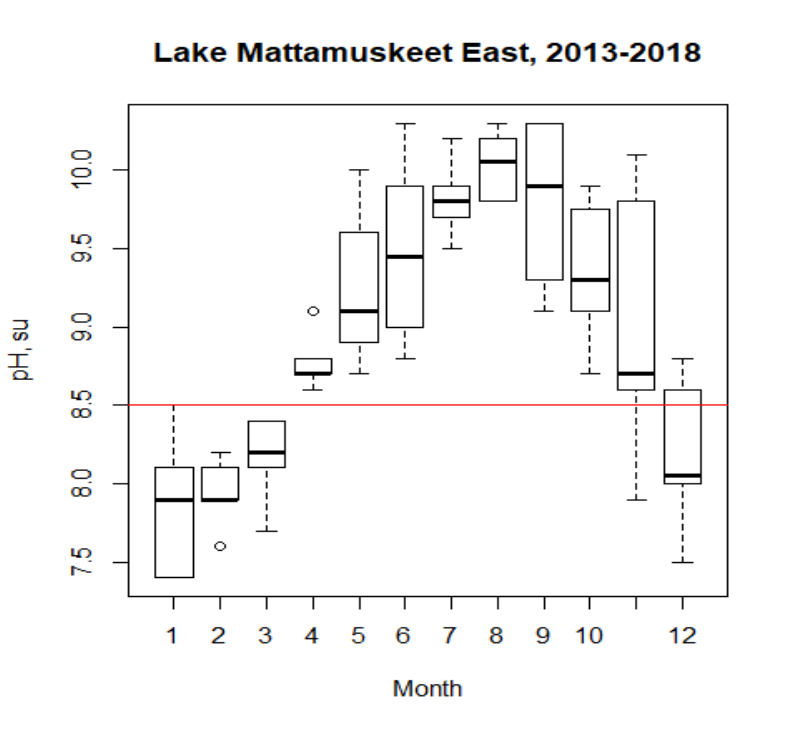




Specific Conductance summarized by max monthly levels measured each month.

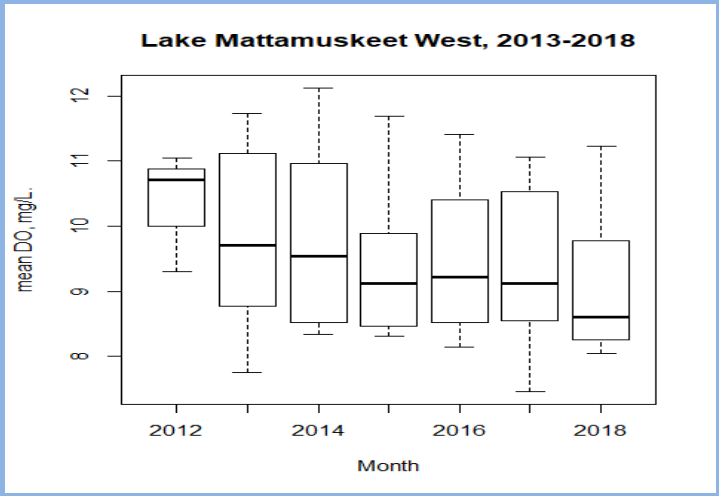
USGS Continuous WQ Stations:

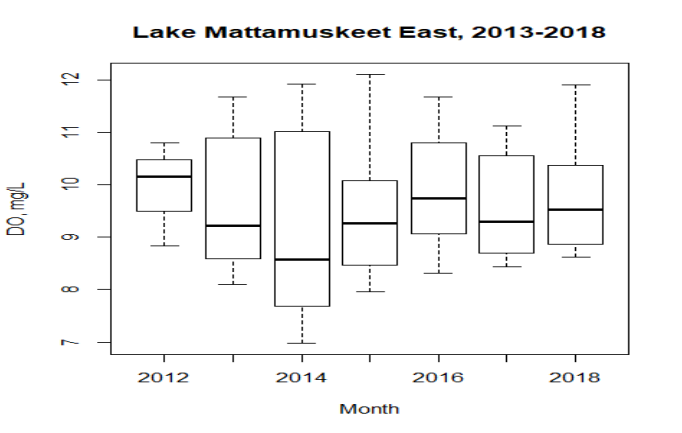


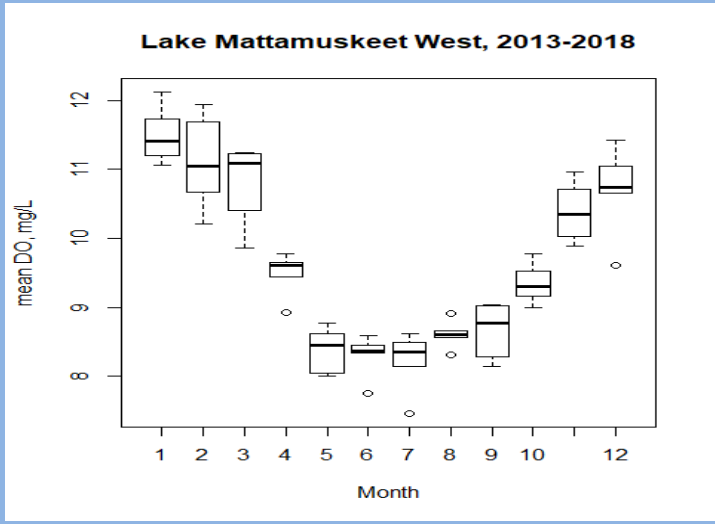


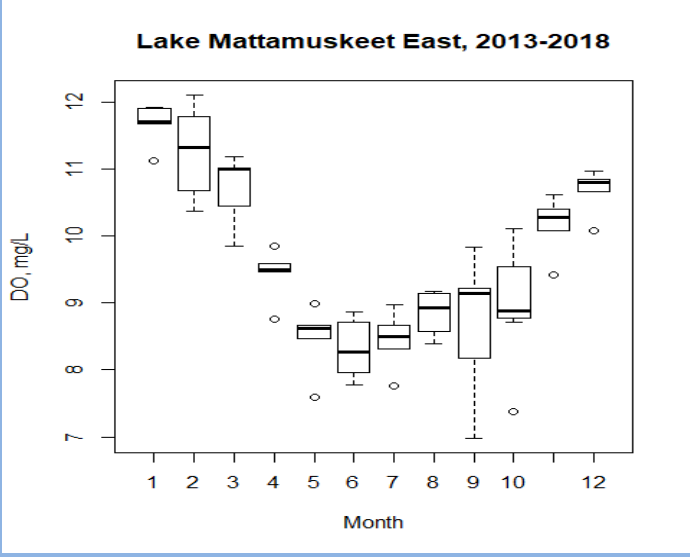
pH summarized by max monthly pH values measured each month. Red line = waters NOT meeting state water quality standard of 8.5 and indicative of an algae bloom..

USGS Continuous WQ Stations:



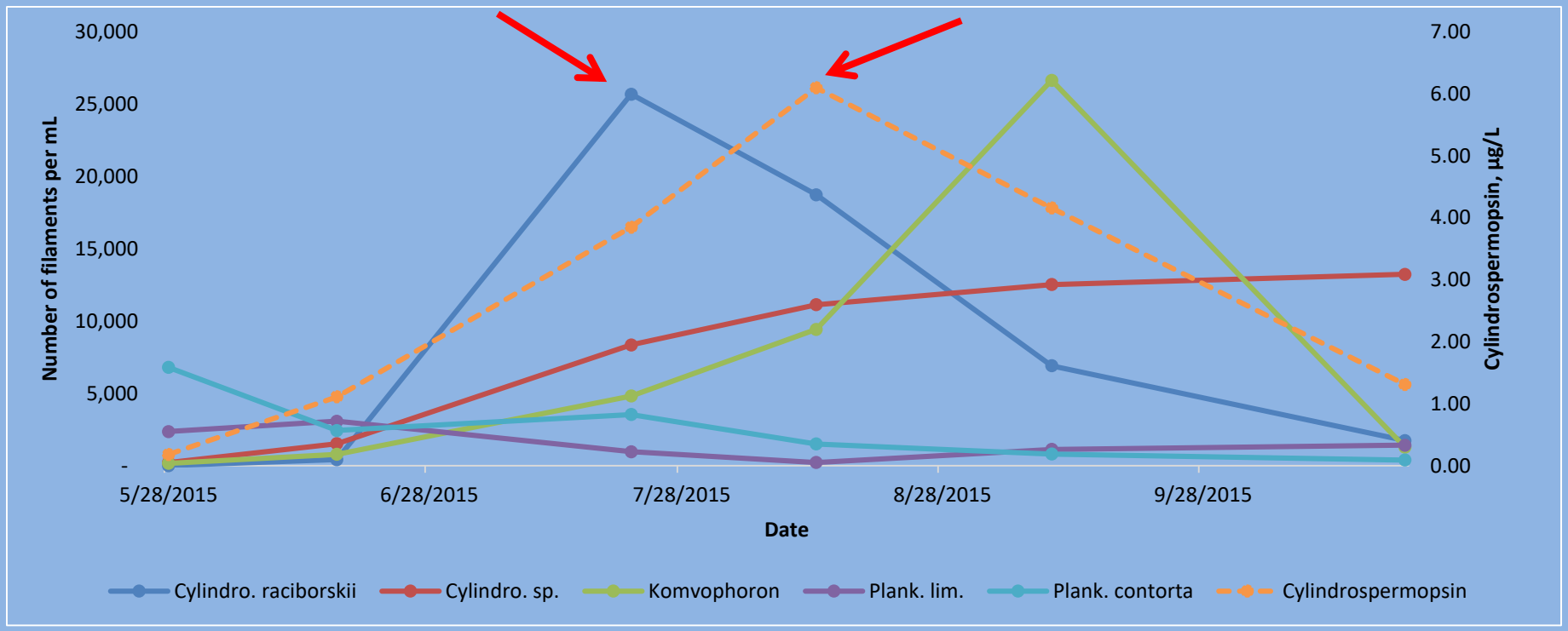






DO: Mean monthly DO reported for east and west annually and monthly..

High counts of *Cylindrospermopsis raciborskii* correlated with production of cyanotoxin, Cylindrospermopsin, in summer



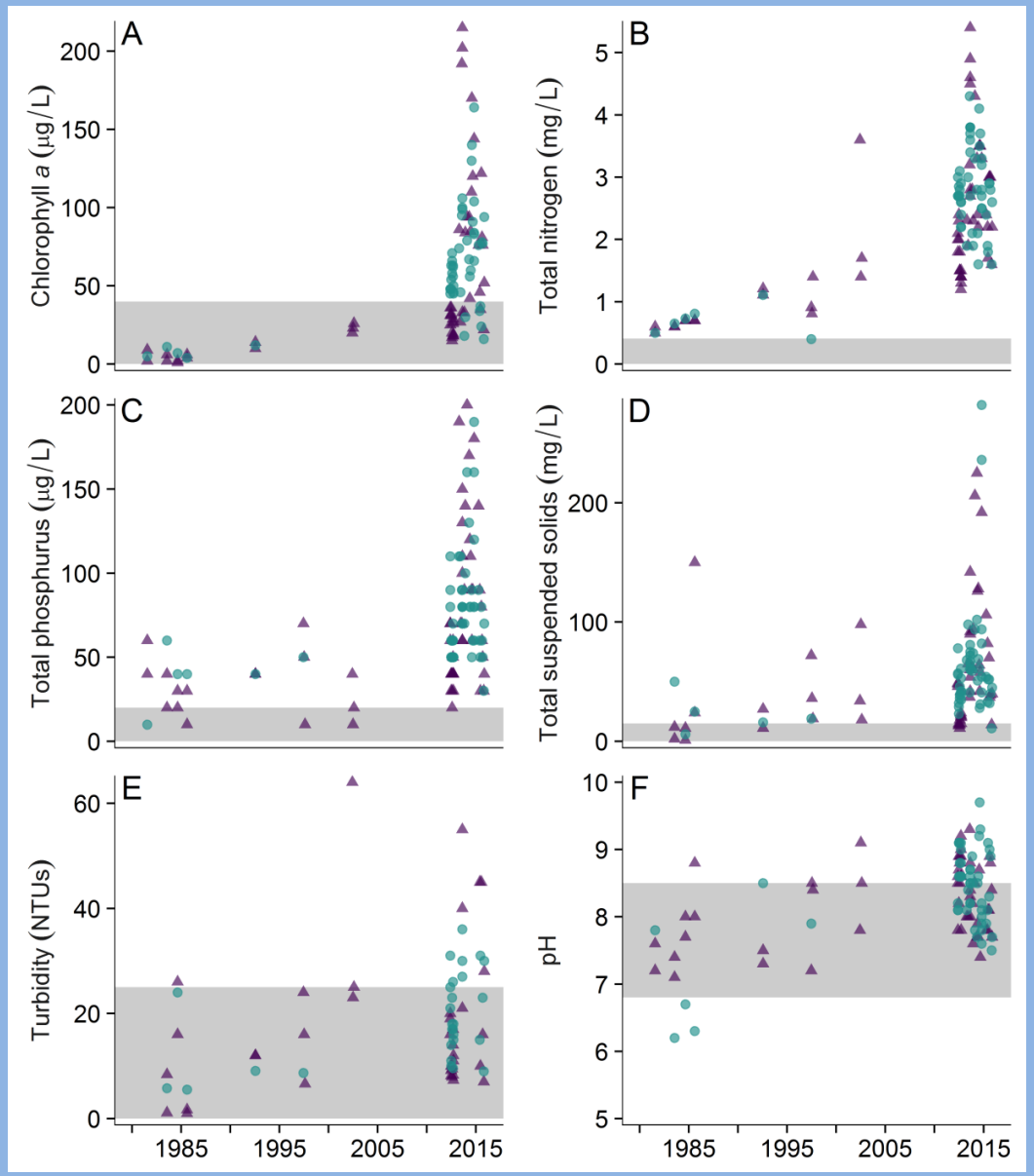
Cylindrospermopsin

- Can impact a wide variety of species
- Bioaccumulation and trophic transfer through the food web is possible
- Can inhibit growth of other phytoplankton and zooplankton grazing
- Human-health effects include flu like symptoms and respiratory problems and adverse impacts on the liver and kidneys
- EPA proposed guideline for recreational waters = 8.0 µg/L

Water quality data suggests lake has become more eutrophic since the 1980s and puts lake on 303d list for chl *a* and high pH

West Basin

East Basin



Special thanks to Michelle Moorman for summarizing the WQ data!

The End

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April Lamb

North Carolina State University

Evaluating the Feasibility of Common Carp Exclusion and Targeted Vegetation Restoration in Lake Mattamuskeet

April D. Lamb and Jesse R. Fischer
North Carolina State University, Department of Applied Ecology

What is a Common Carp and why are they disruptive?

- Non-native, but naturalized
- Bottom feeders
- Uproot vegetation
- Increase turbidity
- Re-suspend sediment into the water column
- Impact both “top-down” (e.g. predator abundance) and “bottom-up” (e.g. phytoplankton abundance) biological processes

Is removal an option?

- Common Carp removal has been shown to increase water clarity and facilitate the re-emergence of aquatic vegetation

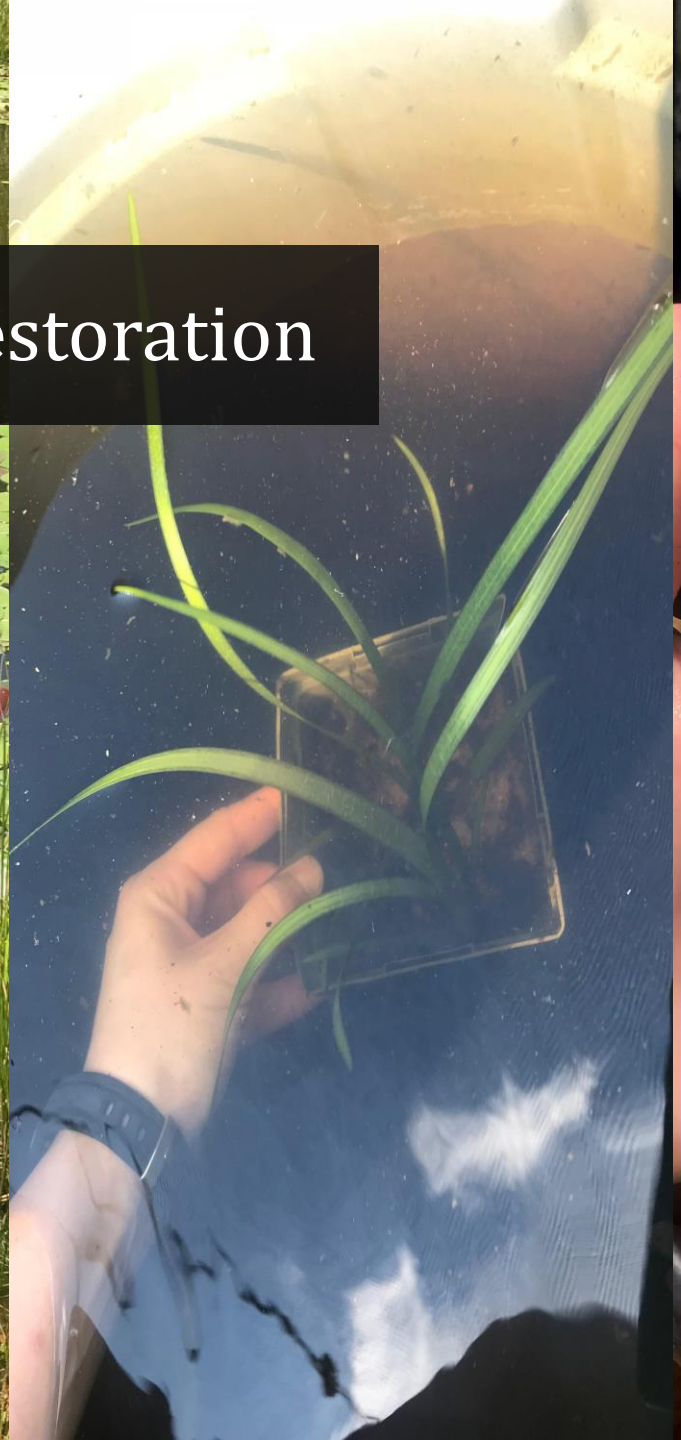
- But is this a "one and done" fix?
  - If not enough carp are removed, they may bounce back even stronger, because Common Carp are excellent at surviving and producing offspring

- A carp management plan is critical to ensuring that population numbers remain at a manageable level

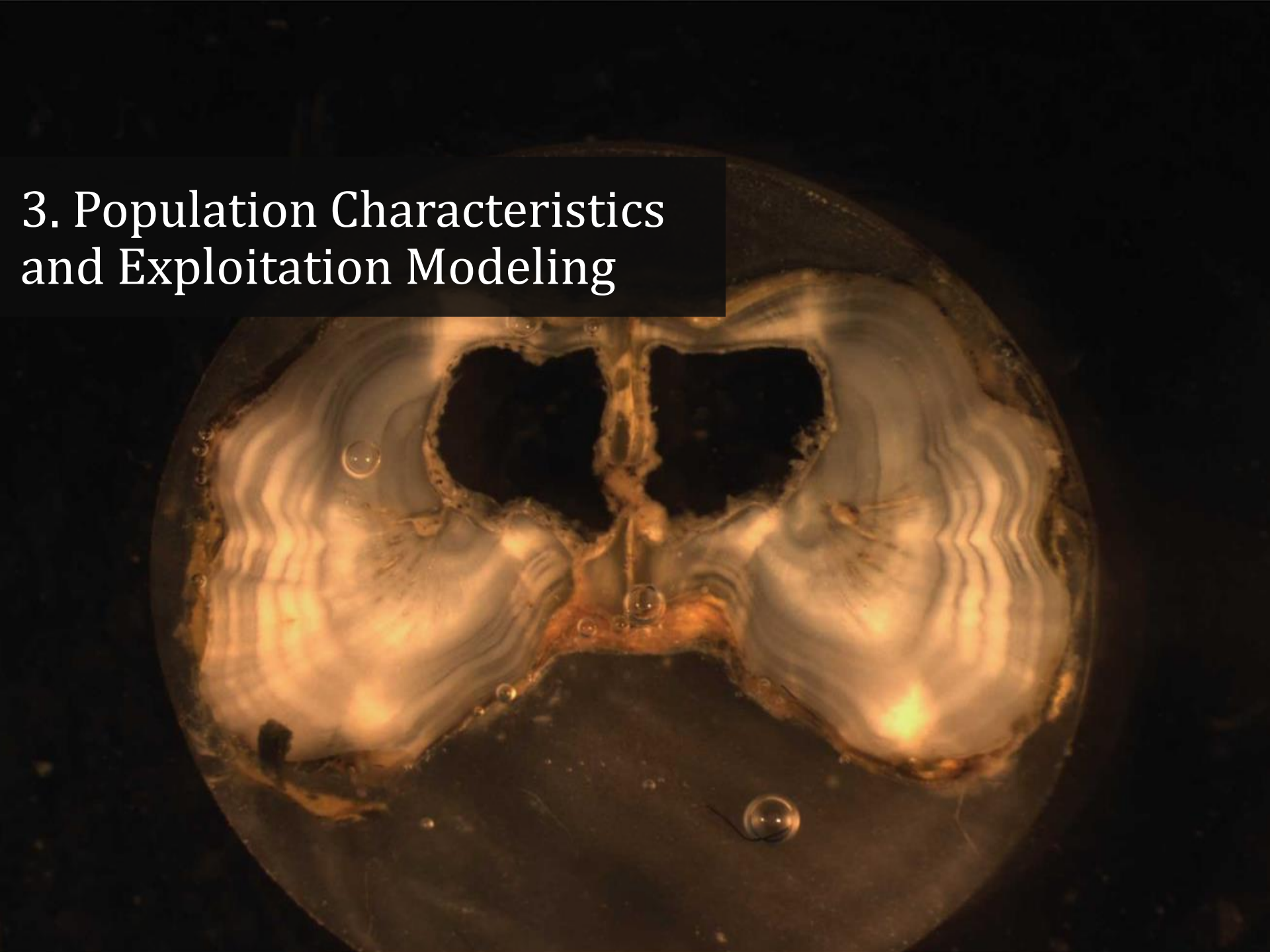
This project aims to investigate the role of Common Carp in the regime shift observed at Lake Mattamuskeet and assess the feasibility of Common Carp removal as a restoration strategy for submerged aquatic vegetation.

1. Common Carp Biomanipulation

2. Vegetation Restoration



3. Population Characteristics and Exploitation Modeling



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Dr. Randall Etheridge

East Carolina University

Waterfowl Impoundments in the Lake Mattamuskeet Watershed

December 3, 2018

Randall Etheridge
East Carolina University
Department of Engineering, Center for Sustainable Energy and Environmental Engineering

ECU ENGINEERING

Management Strategies

- Outflow control
  - Pump
  - Water control structure
- Drawdown
  - As fast as possible
  - Gradual
- Vegetation
  - Corn
  - Millet
  - Soybeans
  - Milo
  - Native vegetation

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Water Quality Data Collected

- Monitored water quality from August 2016 through May 2018
- Moist soil management unit – managed by the Refuge
- Impoundment planted with corn – managed by a local farmer

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Impoundment Management

- Smart pump controls
- Drawdown timing and rate
- Other agricultural best management practices

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Allie Mulligan

Hyde County Soil and Water Conservation District

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Bill Edwards

Natural Resources Conservation Service

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Water Quality Concerns and Solutions

Panel Discussion

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Coffee Break

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Active Water Management

Panelist Introductions

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Dr. Randall Etheridge

East Carolina University

Flow Reduction of Lake Mattamuskeet Outlet Canals

December 3, 2018

Randall Etheridge
East Carolina University
Department of Engineering, Center for Sustainable Energy and Environmental Engineering

In partnership with:
Hyde County Soil & Water Conservation District

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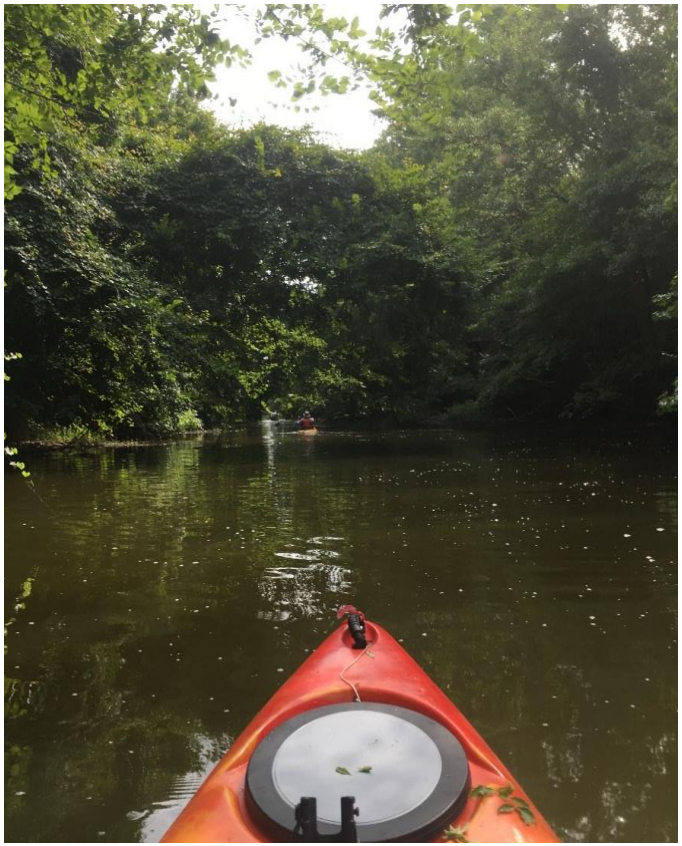
Methods



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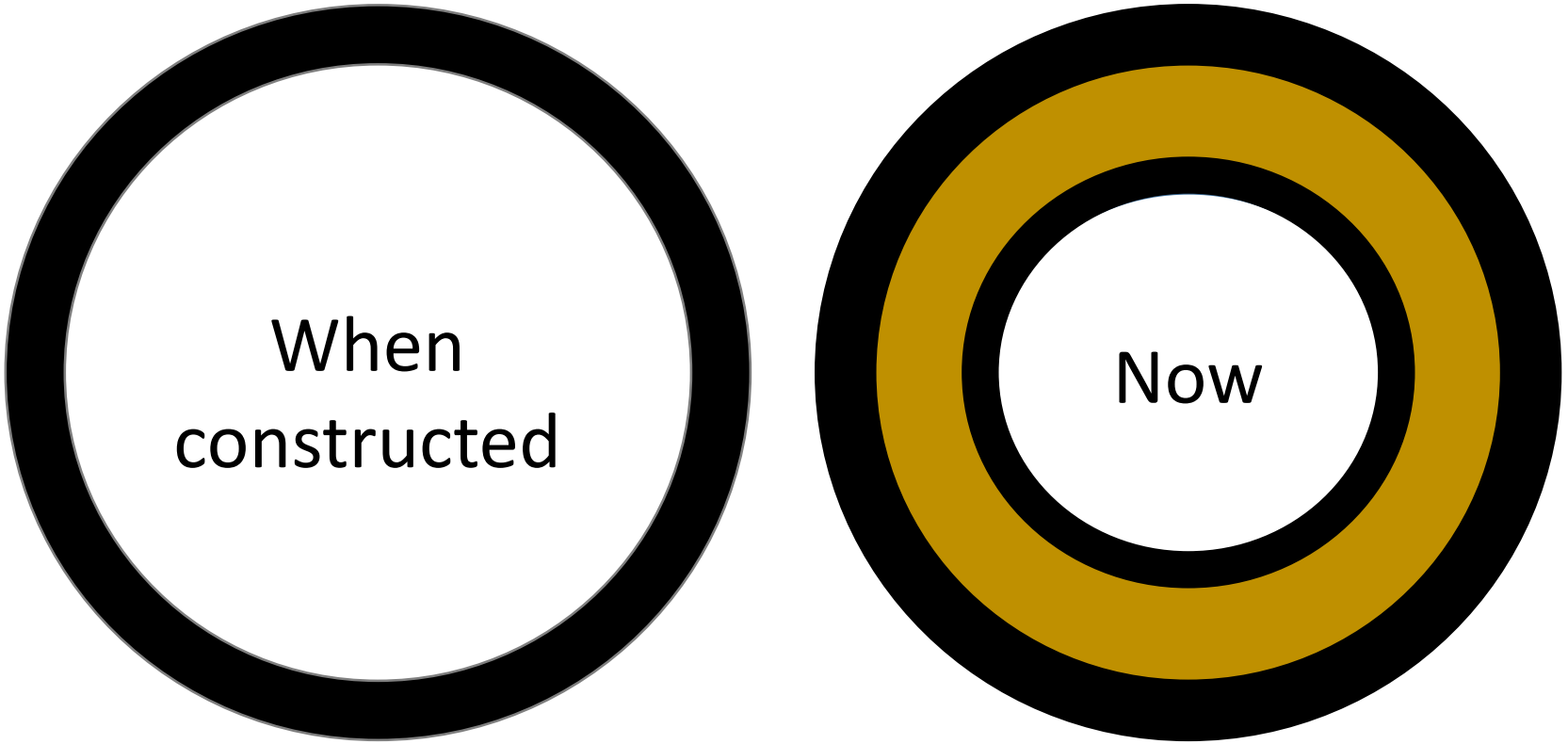
Sedimentation



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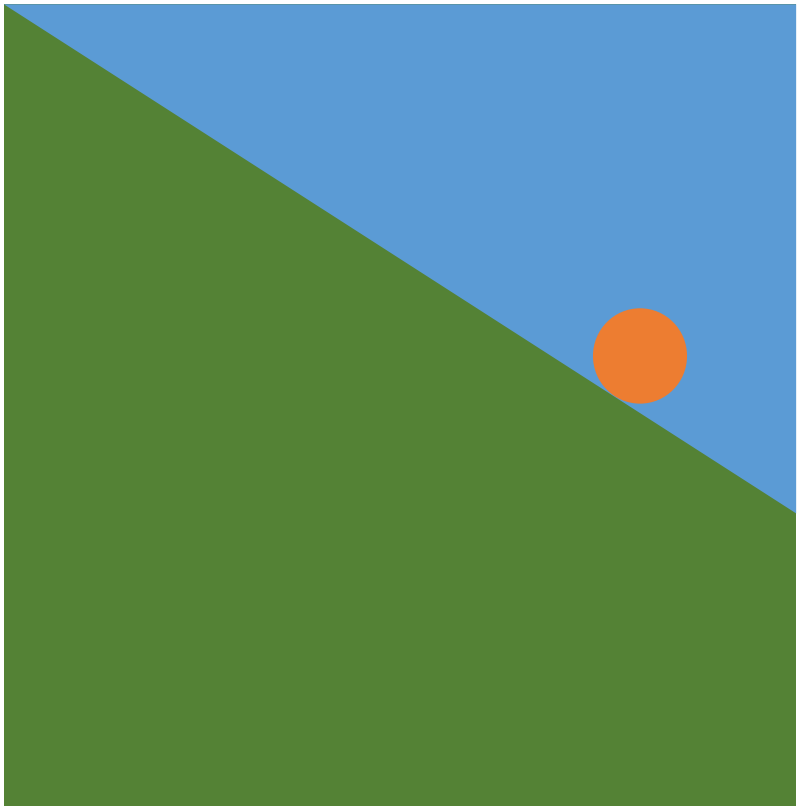
Sea Level Rise



When constructed

Now

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Tide Gates

- Flow occurs only when water level in the lake is above water level in the sound
- Dredging will have minimal impact on when tide gates are open

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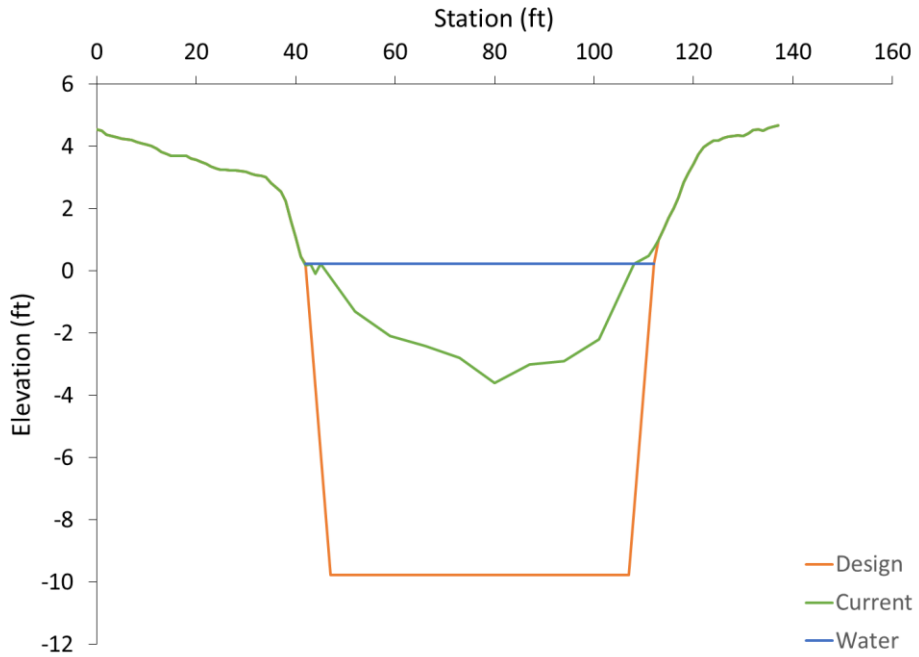
Cross Section Area

- Outfall Canal
- Minimum reduction in area is 43%
- Maximum reduction in area is 81%



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Results

- Percent reduction in flow for sedimentation and sea level rise are independent of each other and not additive
- Dredging the canals will not result in full restoration of flow due to sea level rise

Canal	Original Canal Flow (cfs)	Sedimentation Reduction	2 ft Sea Level Rise Reduction
Outfall	2230	85%	49%
Lake Landing	1260	80%	45%
Rose Bay	860	66%	48%
Waupoppin	630	76%	44%

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Dr. Raymond Smith

East Carolina University

The Hydrological Modeling of Lake Mattamuskeet

Raymond Smith[1]
Randall Etheridge[1,2]
East Carolina University
[1]Department of Engineering
[2]Center for Sustainable Energy and Environmental Engineering

Why Model Lake Mattamuskeet?

- Develop an understanding of lake stage level in response to variations in input.
- Provide a resource to support decision-makers and stakeholders in pursuit of watershed restoration goals.
- Provide a resource to explore identified scenarios, management policies, and *what-if's* leading to improved water management.

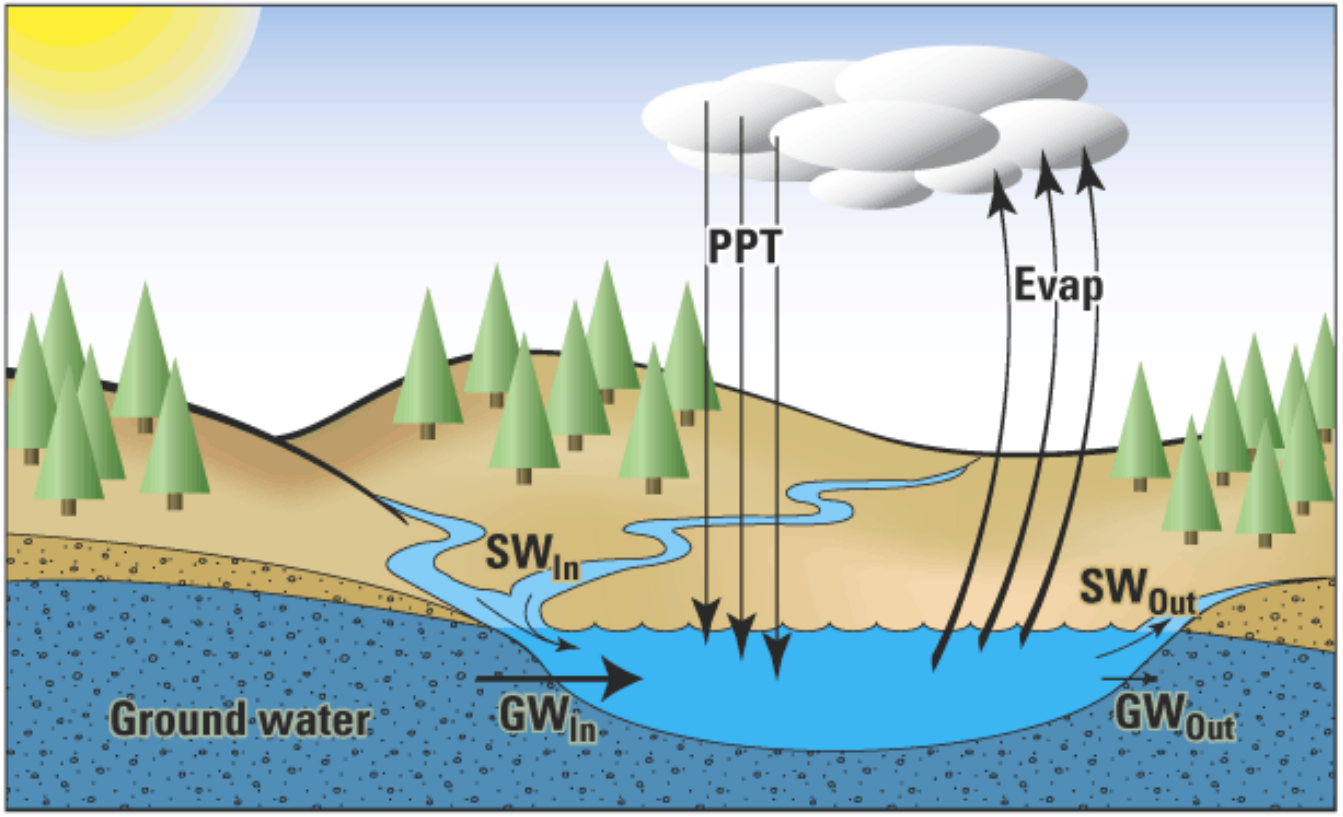
What is a Hydrologic Model?

- A simplification of a real-world system that aids in the understanding, predicting, and managing water resources.

- Hydrologic analyses are performed to quantify the flow rate of water draining from the watershed over time.

Reference: https://www.scribd.com/document/248148732/What-is-the-Difference-Between-Hydrology-and-Hydraulics

Hydrologic Balance of a Lake



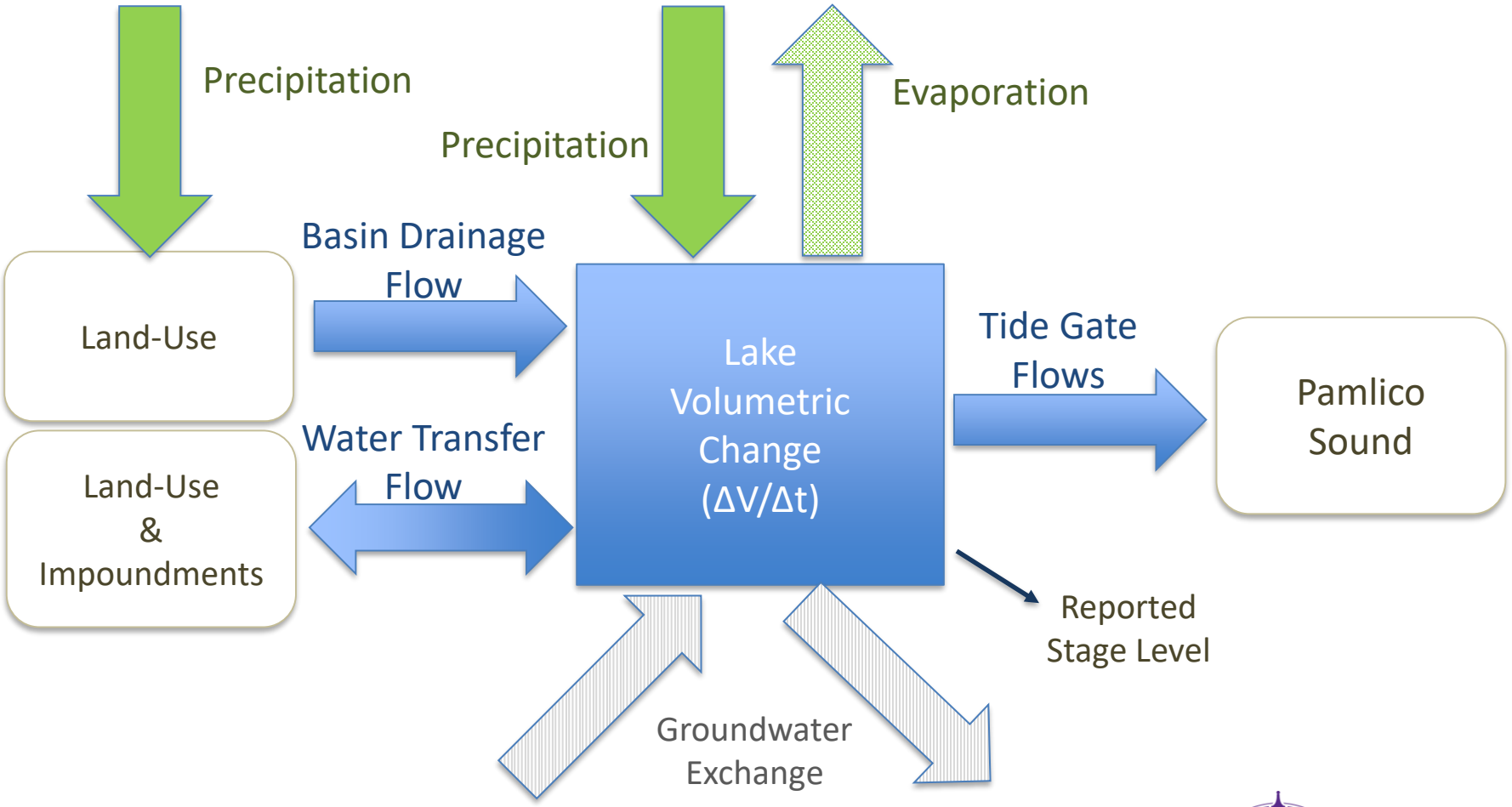
NOT TO SCALE

EXPLANATION

Evap	Evaporation
GW_{In}	Ground-water inflow
GW_{Out}	Ground-water outflow
PPT	Precipitation
SW_{In}	Surface-water inflow
SW_{Out}	Surface-water outflow

Reference: https://serc.carleton.edu/integrate/teaching_materials/earth_modeling/student_materials/index.html

Hydrologic Balance of Lake Mattamuskeet
"A Water Budget"



Steps of the Modeling Process

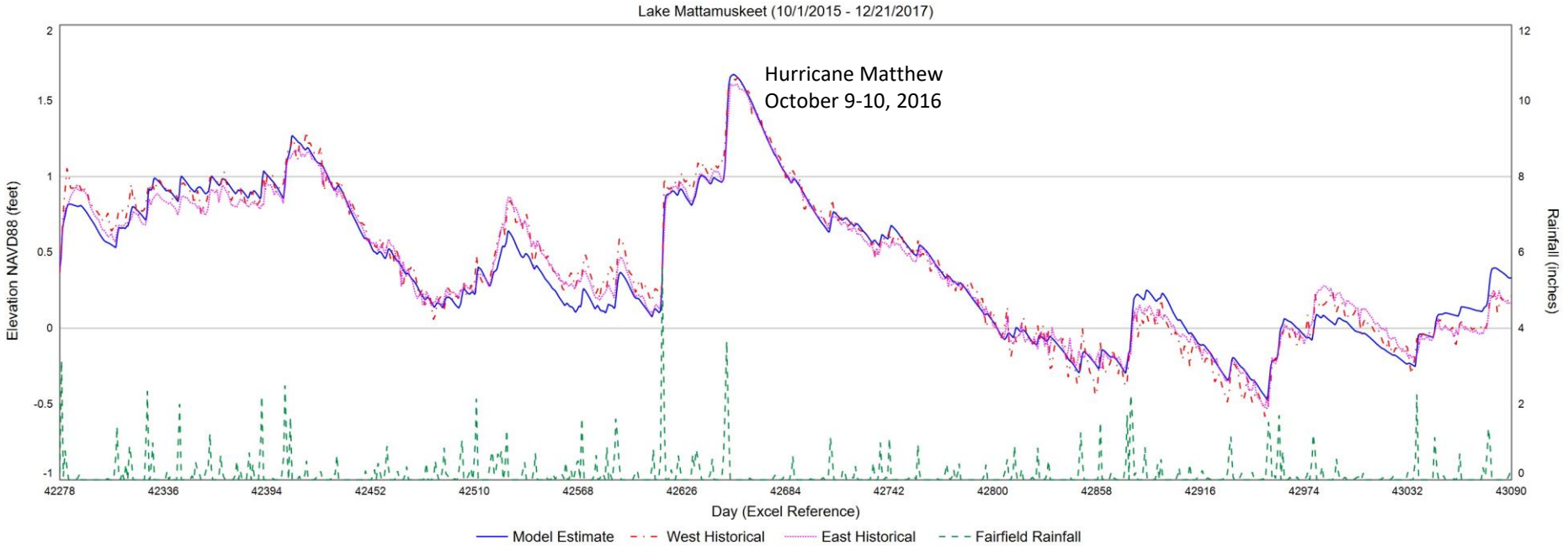
1. Articulate the goals
2. Perform appropriate data collection
3. Build and calibrate the model
4. Validate the built model
5. Policy design and evaluation
6. Conduct simulation experiments
7. Analyze results and report findings

Iterative

Preliminary Model Dynamics

(unvalidated model 8/1/2018)

Lake Mattamuskeet - Stage Level (feet)



Next Steps

1. Secure research funding resources
2. Enhancement of the model:
   a) Incorporate surrounding land-use types and interactions
   b) Incorporate water transfers *into* and *out of* impoundments
   c) Evaluate impact of wind
   d) Obtain additional observational data
3. Perform model calibration
4. Conduct a rigorous model validation

Then …

5. Study identified scenarios, management policies, and *what-if* questions through experimentation and report findings.

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Daniel Brinn

Hyde County Water and Flood Control

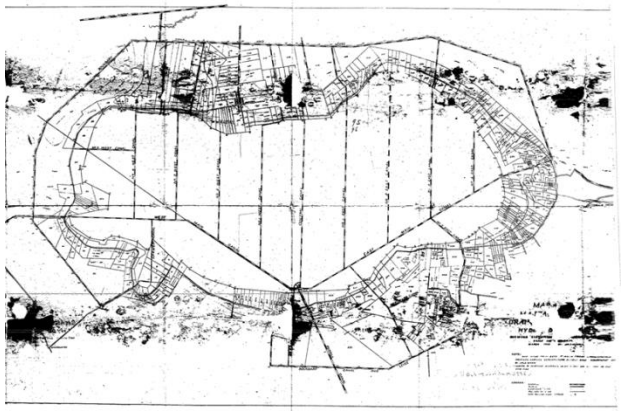
Facilitating Active Water Management

Lake Mattamuskeet Watershed

Daniel Brinn

Historic Water Management Activities

- Lake Landing Canal
  - Earliest efforts in 1773, Constructed in 1837
- Hyde County Drainage District #1
  - Public Law 509
  - The creation of the Mattamuskeet Drainage District set in motion a plan that eventually drained Lake Mattamuskeet three times—in 1916, 1920 and in 1926.
- Rose Bay Canal

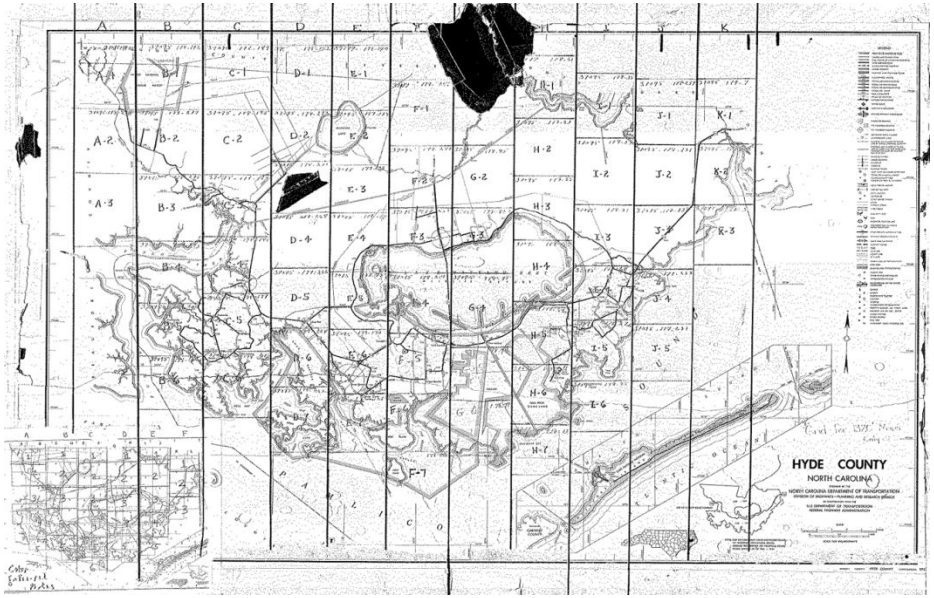


The Need for Active Management

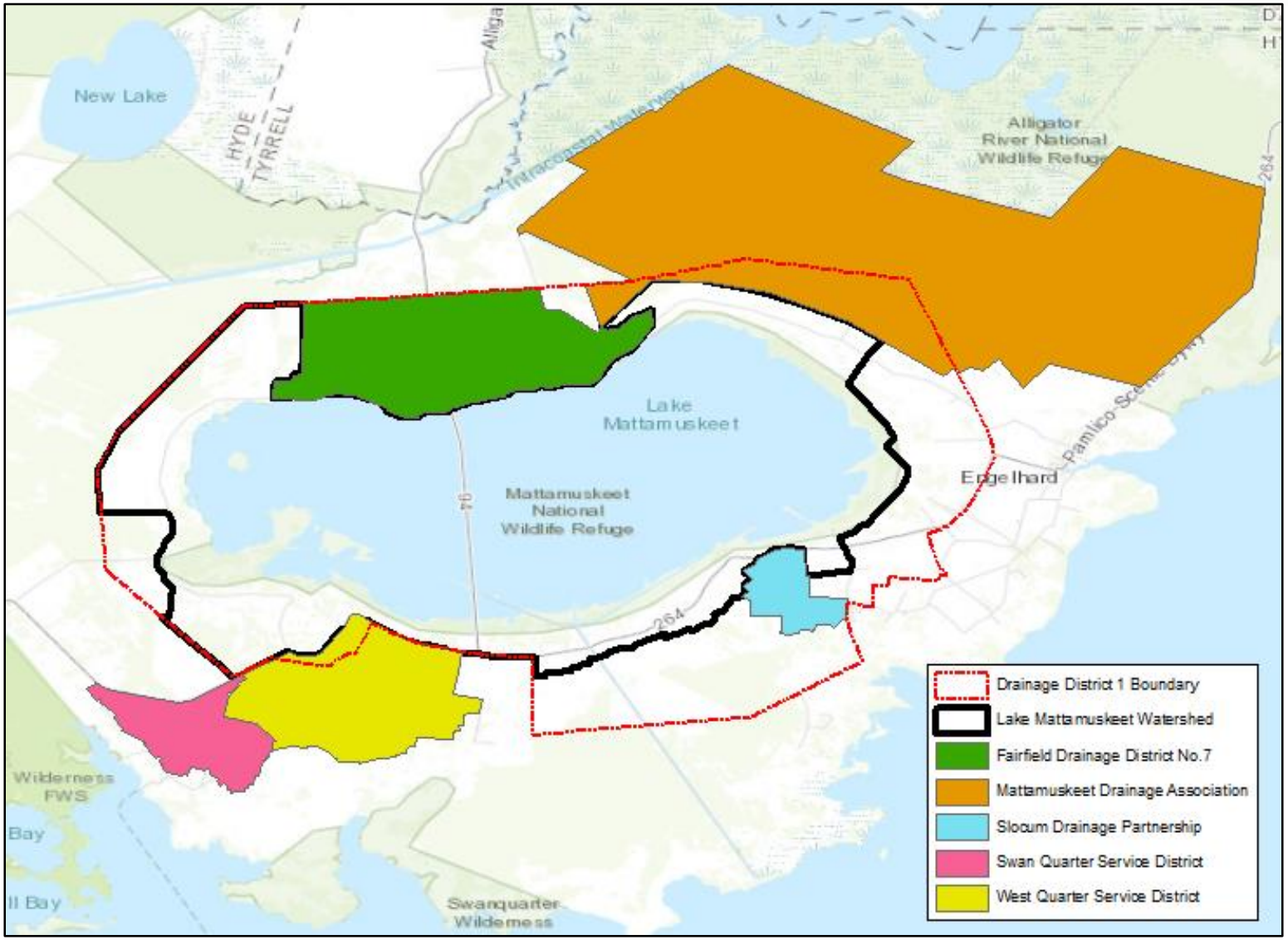
- Preserving the way of life within the watershed
- Water Quantity issues
- Water Quality concerns

Making it Happen

- Plan
- Engineering
- Infrastructure
- Funding
- Continued Operation



Water Management Boundaries



Establishing a Service District for the Lake Mattamuskeet Watershed

- NCGS 153
- Process
- Boundaries
- Responsibilities
- Governance
- Funding

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Wilson Daughtry

Mattamuskeet Drainage Association


Hyde County Drainage Districts
Hyde County, North Carolina
Cartography by: Justin L. Gibbs, HCESD
Date Prepared: March 3, 2017
Exhibit B
Alligator River
Pungo River Drainage District
& Hyde County Drainage District #8
Mattamuskeet Association
Hyde County Drainage
District #7 (Fairfield)
Lake Mattamuskeet
Slocum Drainage
District
Pamlico Sound
Pungo River
Swan Quarter
Drainage District
West Quarter
Drainage District
Pamlico River
Google Earth
Image Landsat
Image © 2016 DigitalGlobe
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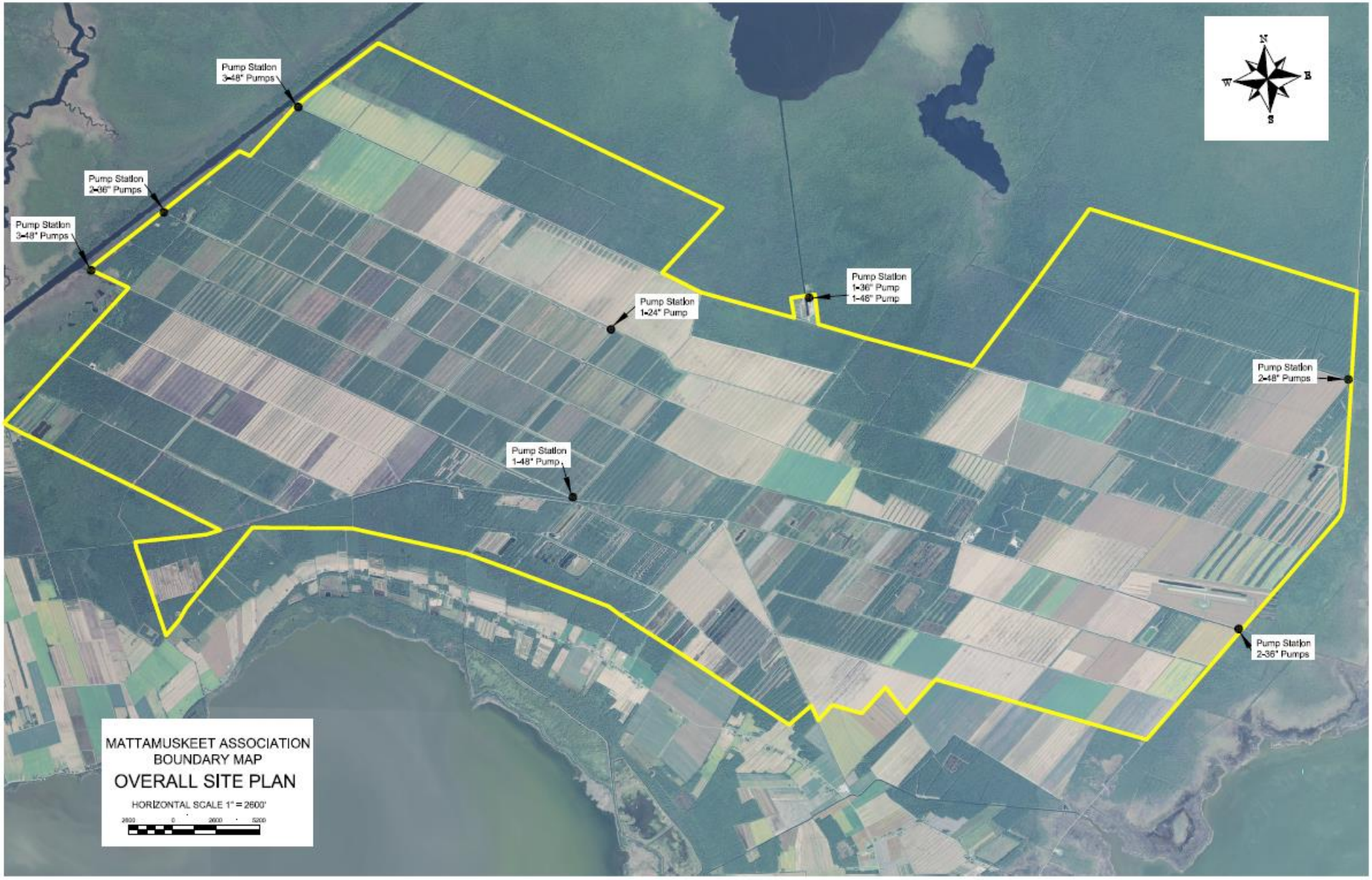
Pump Station
3-48" Pumps
Pump Station
2-36" Pumps
Pump Station
3-48" Pumps
Pump Station
1-24" Pump
Pump Station
1-36" Pump
1-48" Pump
Pump Station
1-48" Pump
Pump Station
2-48" Pumps
Pump Station
2-36" Pumps
N
W
E
S
MATTAMUSKEET ASSOCIATION
BOUNDARY MAP
OVERALL SITE PLAN
HORIZONTAL SCALE 1" = 2600'
2600
0
2600
5200

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Joey Ben Williams

Fairfield Drainage District

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Active Water Management

Panel Discussion

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Lunch

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Plan Implementation

Panel Discussion

Questions and Comments