A Systems Approach to Freshwater Management: Waterbody Treatments

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- US Environmental Protection Agency, Neurotoxicologist, 1984-2007

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US Environmental Protection Agency Webinar

May 14, 2014

Overview

- The Clean Water Act
  - Calls for Watershed and Waterbody Management

- A Systems Approach to Freshwater Management
  - Uses Most Cost-Effective Watershed & Waterbody Tools
    - Quicker, Less Expensive Water Quality Improvement

- Waterbody Management Technologies
  - Suppress Cyanobacteria
  - Remove or Inactivate Nutrients

- Will Jordan Lake, NC, become the 1st Large, Eutrophic Waterbody to attain Water Quality Standards?

The Clean Water Act

- Watershed Management Program - reduce nutrient input

  * Point sources, Implemented NPDES - now 5-10% nutrient input
    - 1972-1986: $49B Title II grants
    - 1987: Replaced Title II with Title VI CW State Revolving Fund
      - 1987-2012: $36B to capitalize CWSRF loan program
    - Jurisdiction & locality spending is approximately $63B annually

  * Non-point sources, Implemented BMPs - now 90-95% input
    - 1987-2012: $3.2B Section 319 grants, $200M/yr since 1999
      - Almost all spent on BMP implementation
    - 1989-2012: $650M CWSRF used for BMP implementation
    - Jurisdiction & locality spending is $??B annually

The Clean Water Act

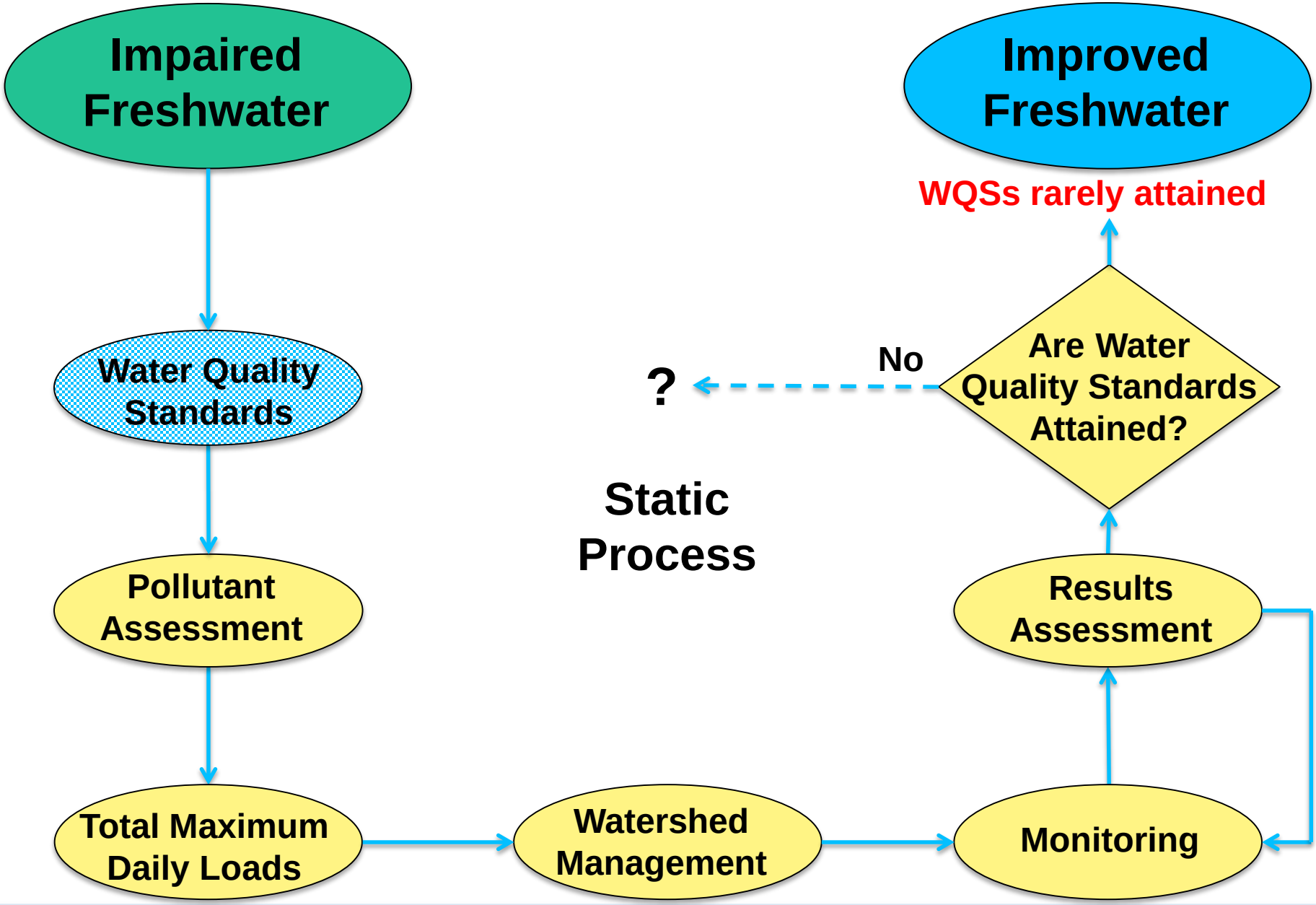
- Clean Lakes Program- treat impaired waterbodies

  * Waterbody mangement - Not Currently implemented
    - 1972-1995: $145M Section 314 grants, none since
    - Reauthorized in 2000, but no appropriation requests
    - 2000: Encourage use of 5% Section 319 grant funds for Waterbody Management
    - 2002: Focused Section 319 funding on Nonpoint source BMP implementation

- Safe Drinking Water Act, some source water protection funding

- HABHRCA - The Harmful Algal Bloom and Hypoxia Research and Control Act
  - Research grant funds for NOAA and coastal HABs, but not for EPA and all freshwater

Watershed Management Process



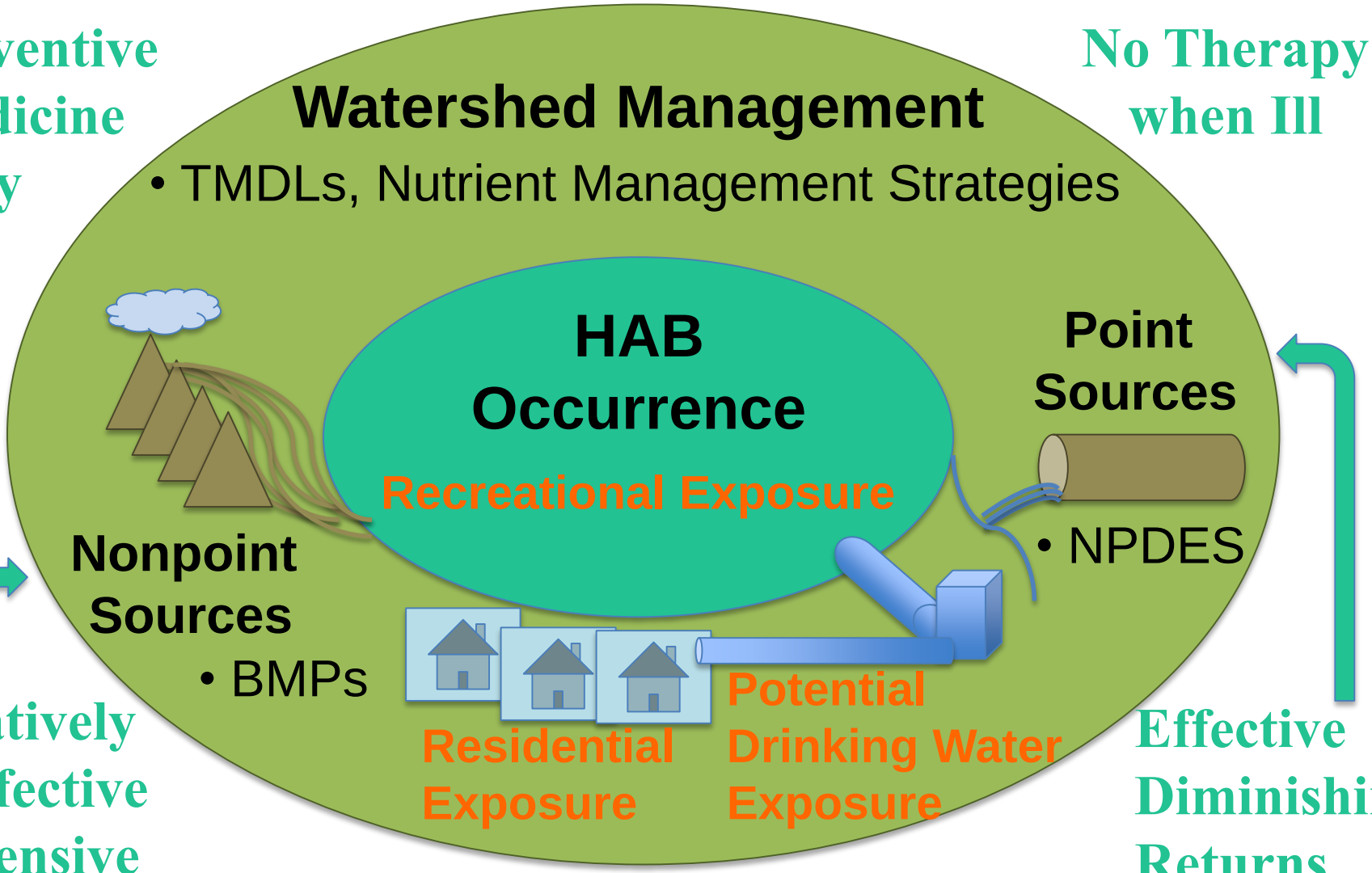
Watershed Management Results

- 44% of river & stream miles, & 64% of lake & reservoir acres are Impaired (CWA Section 303(d))
  - EPA estimate - 7.9% pre-2003 impaired now attain WQSs
    - Most small & point source dominated
- Eutrophication - 1972: 10-20% US lakes & reservoirs
  - 2007: approximately 50%
- Cyanotoxin health risks - 2007: 27-41% moderate to high
- Rivers & streams with excessive phosphorus - 2004 = 47%, 2008-2009 = 66%, primarily agricultural sources
- EPA data, OW, 10 regions - No impaired reservoir $\geq$ 1,000 ac & $\geq$ 90% input from nonpoint sources ever attained WQSs

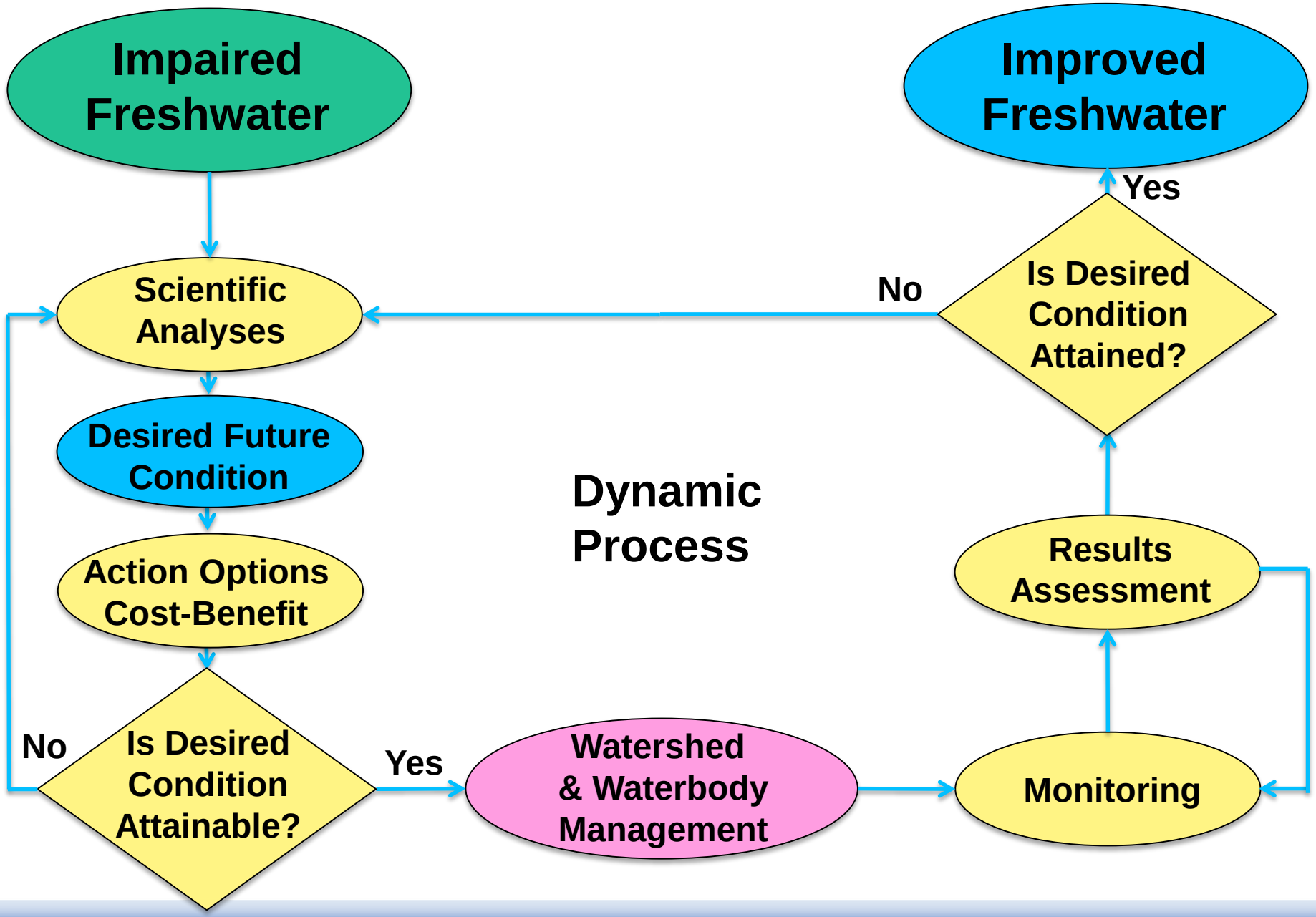
Watershed Management Drawbacks

- Addresses only some new pollutant (HABs nutrients) inputs
  - Misses groundwater and atmospheric inputs
- Misses internal legacy loads that cycle from sediment to water column, stimulating HABs
- Agriculture is exempt from the CWA
- Nonpoint source BMPs difficult to implement over large areas, many are expensive, only marginally effective & lack cost-benefit analyses
- Does not address cyanobacteria's need for quiescent, stagnant water to predominate
- Gives the "sick patient" "preventive medicine" by not "therapy"

Watershed Management Alone is Not Preventing HABs



Systems Approach Process



A Systems Approach

Uses cost effective WSM & WBM approached to restore designated uses in the near term at reduced costs

- **Watershed Management - Preventive medicine**
- **Waterbody Management - Supportive therapy**
  - Circulation
  - Aeration
  - Side-stream flow-ways
  - Flocculants & oxidizers
  - Floating artificial wetlands
  - N & de-N bacteria
  - Biological manipulations
  - Hydrologic manipulations
  - Suppress HABs
  - Channel nutrients up trophic levels
  - Remove or deactivate nutrients
  - Degrade toxic substances
  - Deactivate pathogens

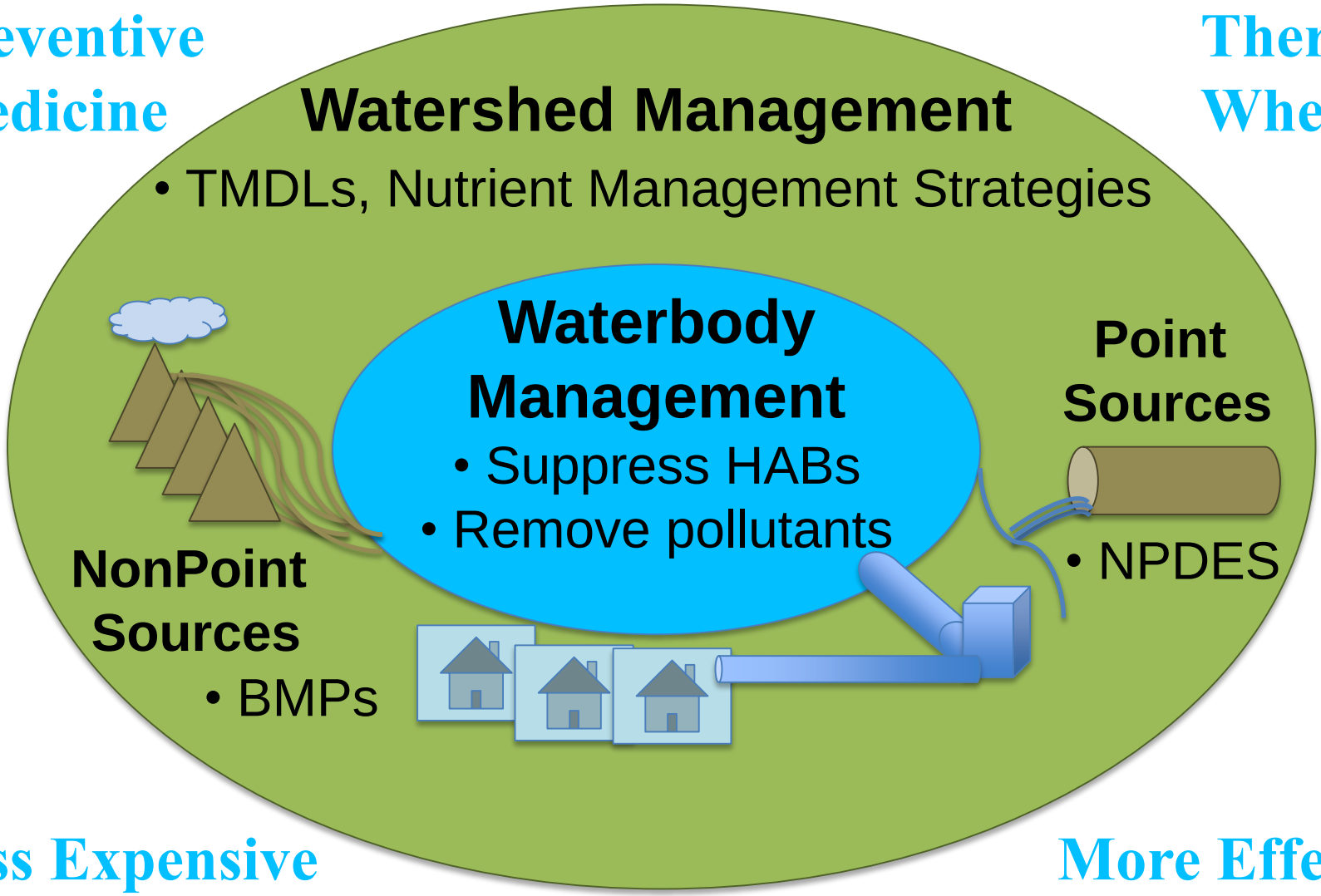
Hudnell (2013) An Alternative Approach to Regaining Designated Uses of Clean Water Act Section 303(d) Impaired Waters. Florida Water Resources Journal, 65/2:20-26.

Systems Approach

Systems Approach = Waterbody + Watershed management

Preventive Medicine

Therapy When Ill



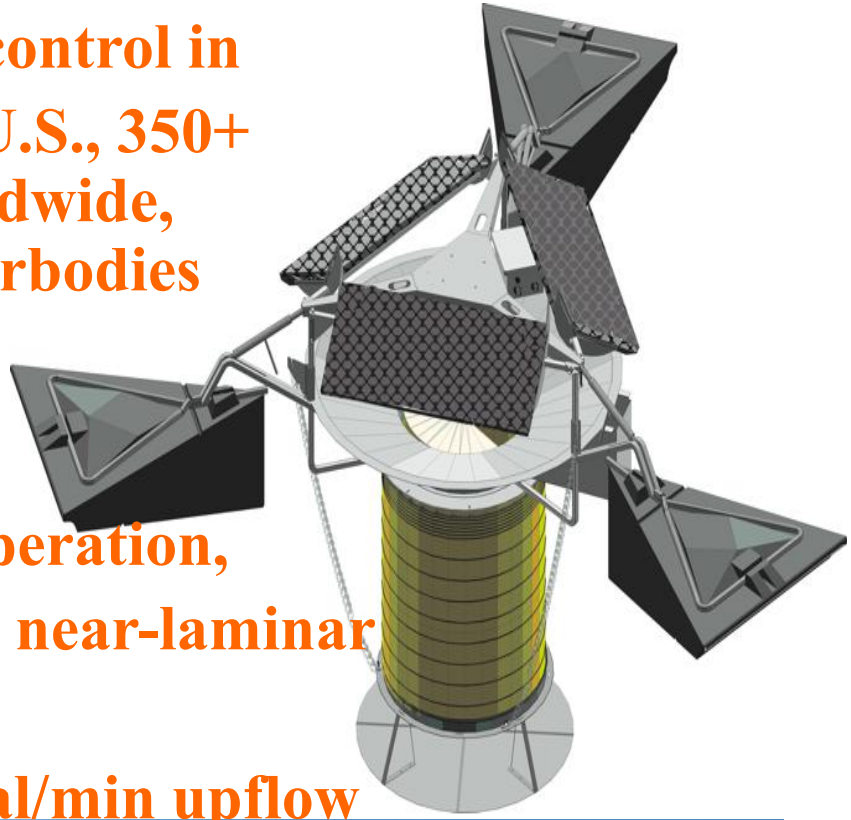
Less Expensive

More Effective

Waterbody Management Technologies

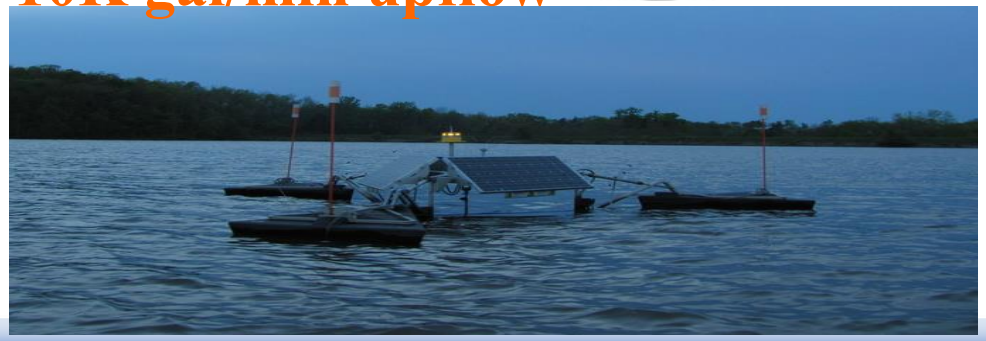
Solar-powered, long-distance circulation

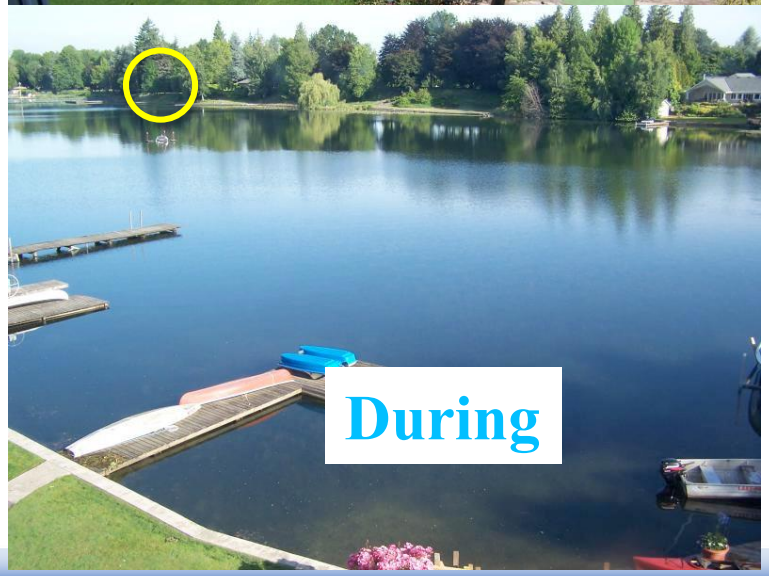
HAB control in 300+ U.S., 350+ worldwide, waterbodies



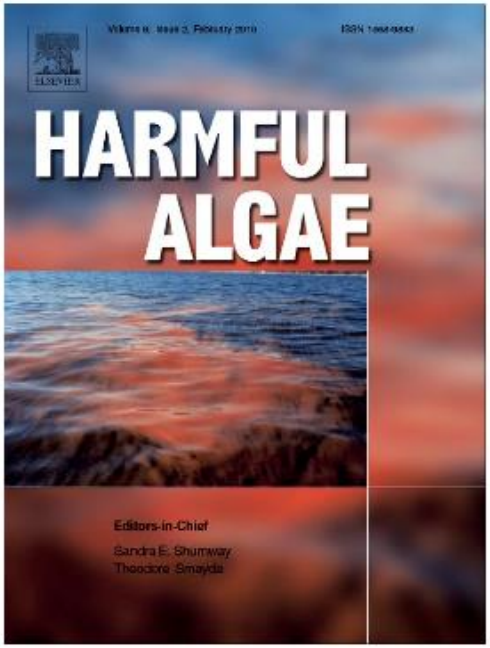
24/7 operation, radial, near-laminar inflow

10K gal/min upflow

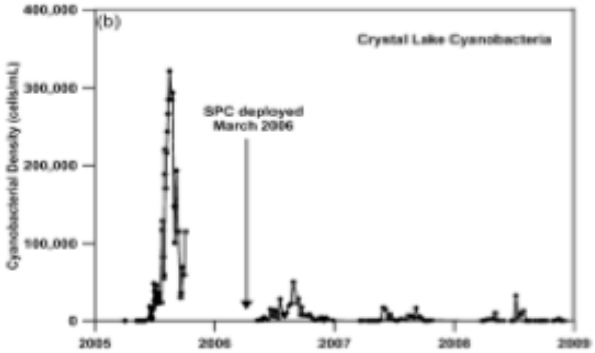




Solar-Powered Long-Distance Circulation



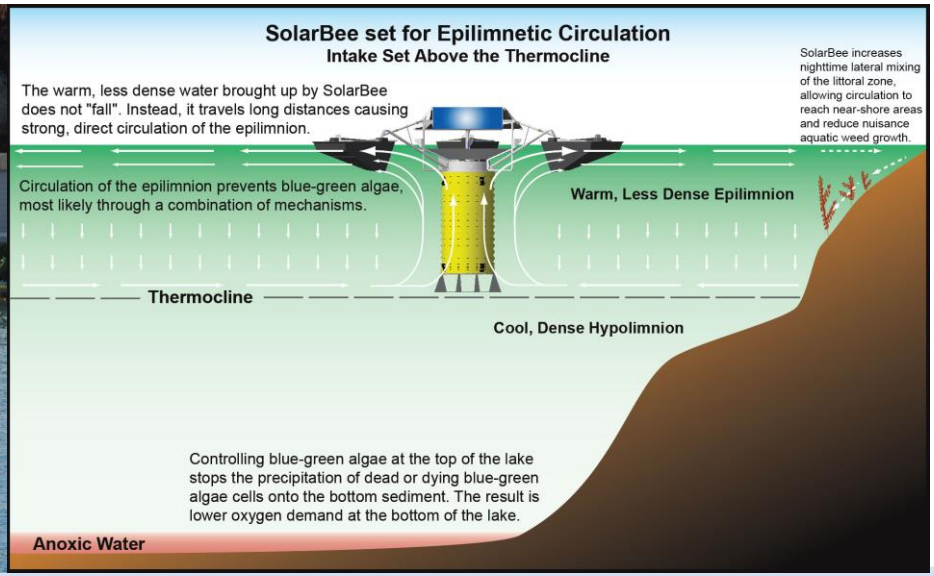
Hudnell *et al.* (2010) Freshwater harmful algal bloom (HAB) suppression with solar-powered circulation (SPC). Harmful Algae, 9, 208-217



HAB suppression in 3 source water reservoirs

Increased densities of: Green algae Diatoms Zooplankton

35 acres/unit treatment area



Waterbody Management Technologies

HAB Suppression: Oxidizers, Peroxygen

peroxygen solutions

PAK®27 Algaecide

An Environmentally Safe Algaecide

Jeff Morgan

www.peroxygensolutions.com

336-272-0127

EPA registered

- White, granular, free flowing, non-dusting
- Active ingredient: hydrogen peroxide (H_2O_2)
- Inert Ingredient: Soda ash
- Effective dosing rate dependent on:

•Species
•Stage of Algae Growth
•Density of Algae
•Light Intensity
•Water Temperature
•Water Quality
•Metals Concentration
•Turbidity
•Organic Content

$$2\ Na_2CO_3 \cdot 3\ H_2O_2 \rightarrow 2\ Na_2CO_3 + 3\ H_2O_2$$

Penetrates cyanobacteria membrane and kills cell

Degrades

$$2\ H_2O_2 \rightarrow 2\ H_2O + O_2$$

HAB Suppression: Oxidizers, Peroxygen

California Department of Water Resources - Dyer Reservoir Study

During the spring of 2012, Dyer Reservoir developed a cyanobacterial bloom of Aphanizomenon flos-aquae and Anabaena flos-aquae. This bloom adversely affected the water utility by clogging the intake filters of the pumping station.

Cyanobacteria cells/mL		
04/04/2012	0	
04/17/2012	42	
04/23/2012	156	
04/30/2012	370	
05/07/2012	4,166	
05/14/2012	2,953	
05/21/2012	11,400	
05/25/2012	28,975	PAK®27 Treatment @ 21 pounds / acre foot
05/25/2012	2,342	7 hours Post-Treatment
05/26/2012	2,298	
05/29/2012	10	
06/05/2012	0	
06/11/2012	0	
06/18/2012	31	

Waterbody Management Technologies

HAB Suppression: Ultrasound

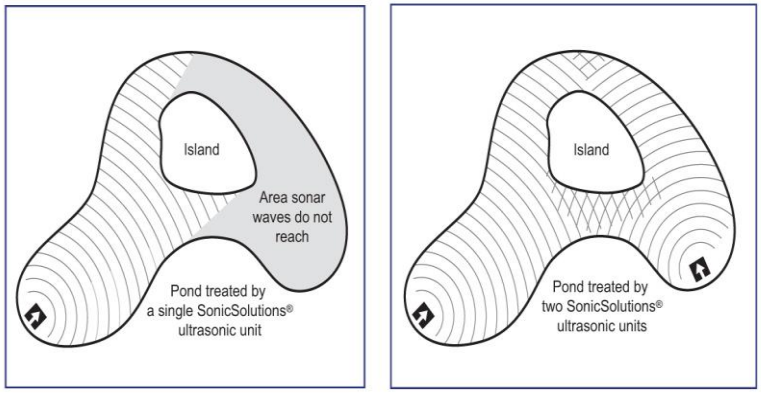
Kirk Whatley

www.sonicsolutionsllc.com

866-562-5423

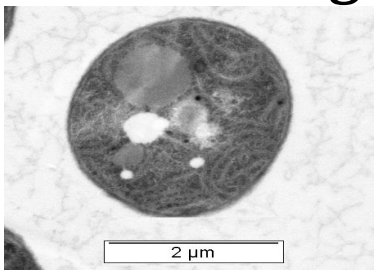
24volts DC
Grid or Solar
0.2 to 0.7 amps

- Submerge transducer
  - 2 feet minimum depth
  - Above first thermocline
  - "Line of Sight" device



Blue-Green Algae - Ruptures Gas vesicles

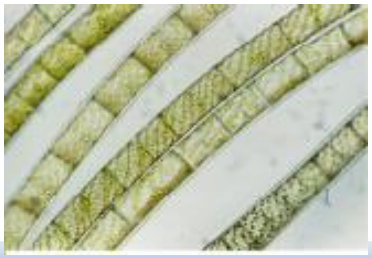
Before



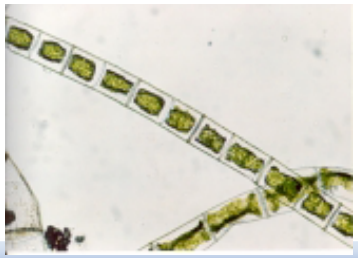
After

Green Algae - Vibration breaks bond between cell wall and inside of cell

Before



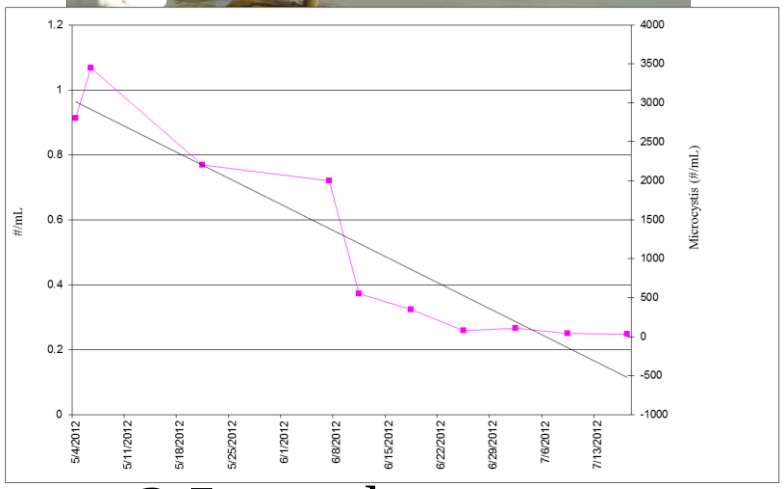
After



HAB Suppression: Ultrasound

- Evaluation of Sonic Solutions Ultrasound for Control of HABs

Paul V. Zimba,
Center for Coastal Studies,
Texas A&M University, Corpus Christi, TX

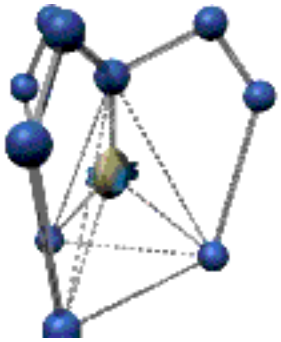


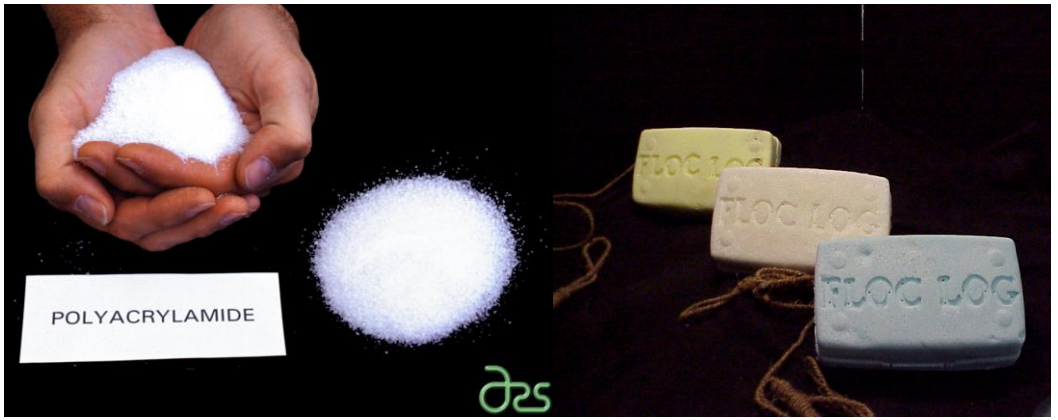
3.5 months

- Rockland County Club, Sparkill NY
  - Chronic algae problems
  - Helped to achieve Audubon Certification

Waterbody Management Technologies

Nutrient Reduction: Flocculants, Anionic Polyacrylamide

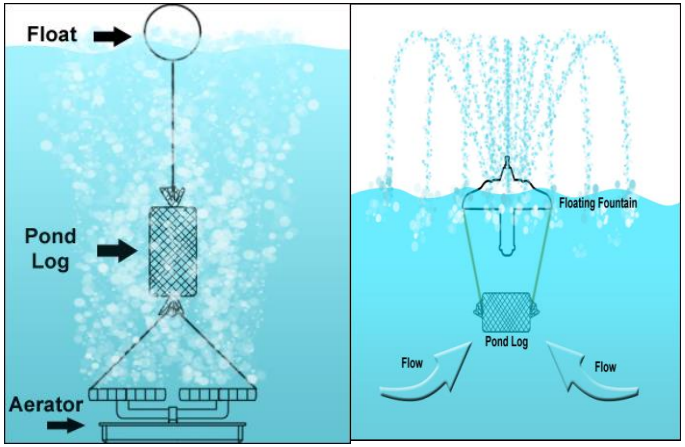


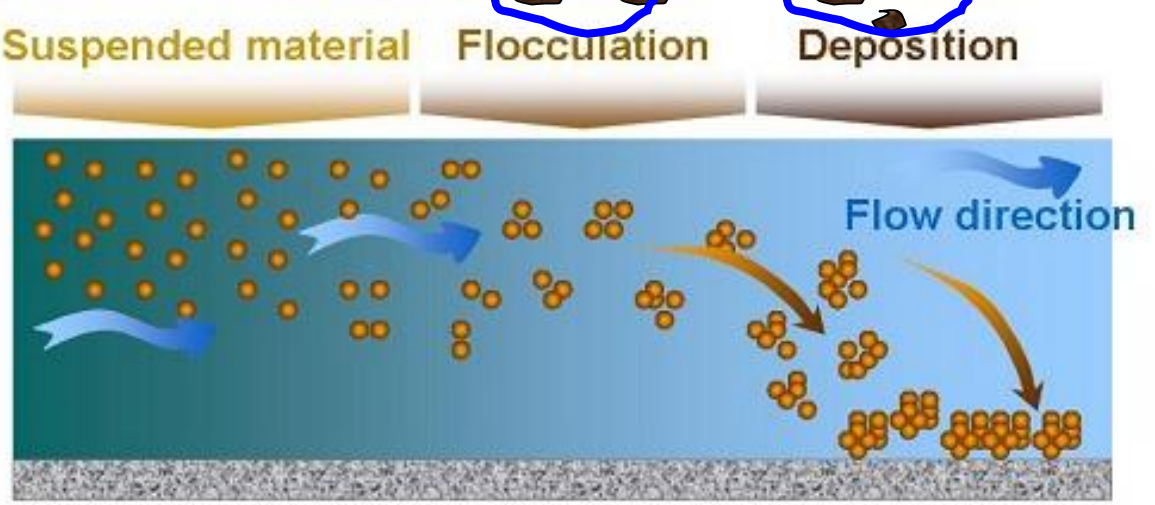


>150,000 chained monomers/molecule

Applied Polymer Systems, Inc
Seva Iwinski
info@siltstop.com
386-428-8578

EPA registered





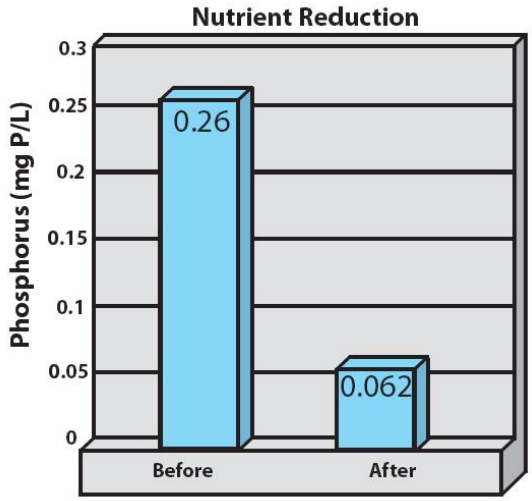
Nutrient Reduction: Flocculants, Anionic Polyacrylamide

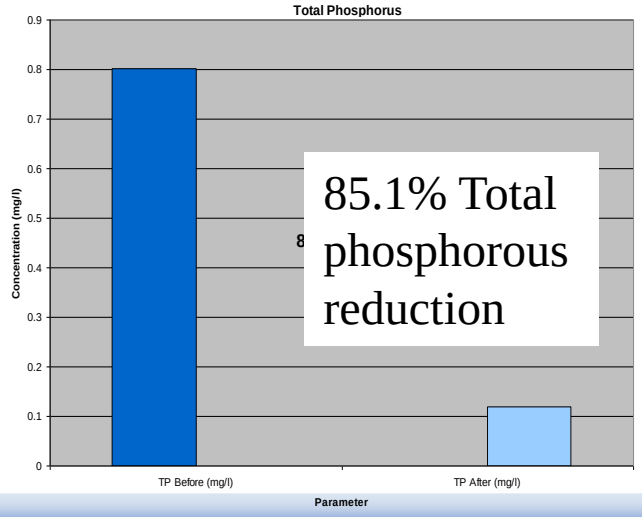
Florida DEP phosphorus sequestration with circulation & floc logs in Lake Hilaman

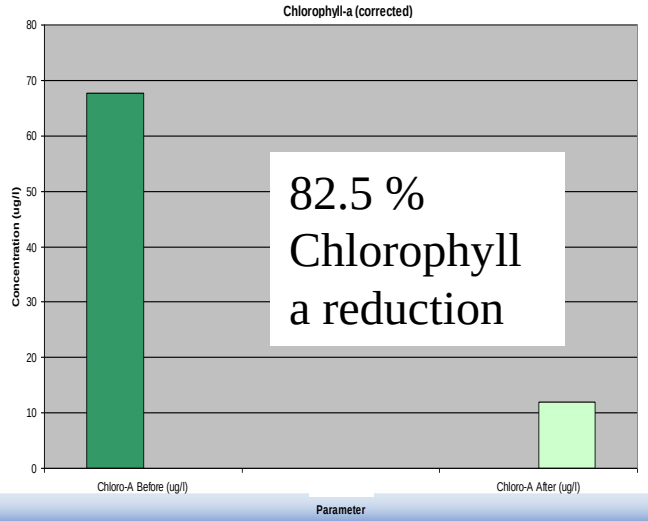
Reedy Creek Water District stormwater pond study.

Stormwater Pond With SolarBee & Floc Logs

Stormwater Pond With SolarBee & Floc Logs







Waterbody Management Technologies

Nutrient Reduction: Floating Artificial Wetlands: Beemats

Steve Beeman

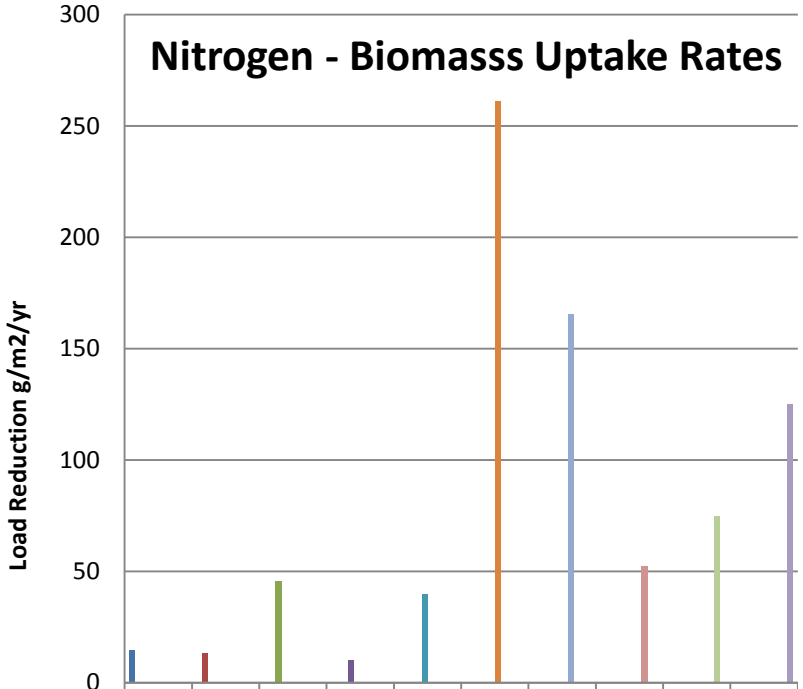
www.beemats.com

386-428-8578

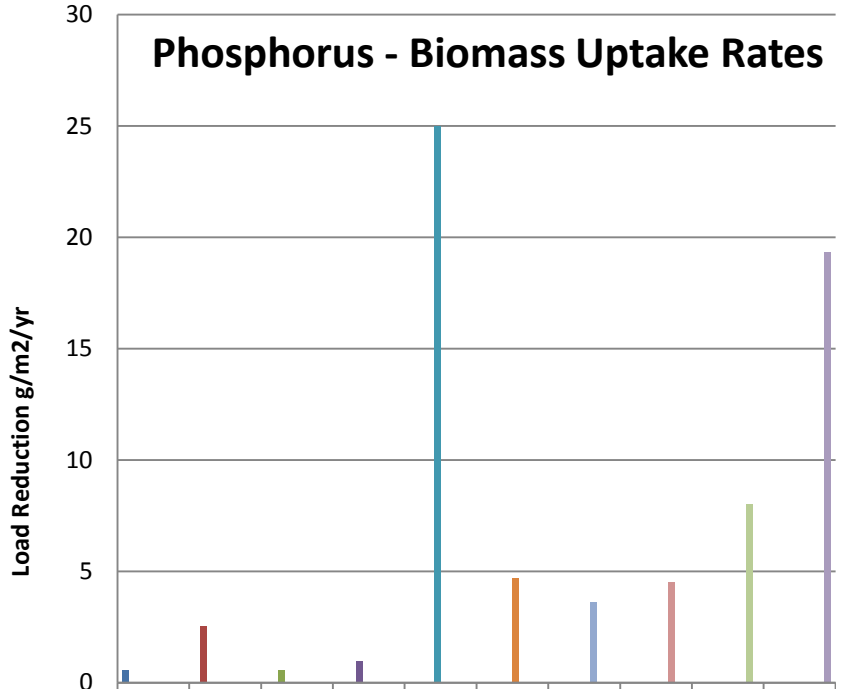
Floating Lettuce Garden

- Mats ½” pva foam
- 2.5 plant holes/ft^2

Nutrient Reduction: Floating Artificial Wetlands: Beemats



	Input 0.07 mg/L	Input 0.49 mg/L	Input 0.70 mg/L	Input 0.76 mg/L	Input 1.02 mg/L	Input 1.31 mg/L	Input 1.34 mg/L	Input 3.00 mg/L	Input 4.86 mg/L	Input 6.77 mg/L
Clemson 08	14.67									
UCF		13.28								
Patrick			45.4							
Lake Leon				9.9						
Mulloch Creek					39.91					
Deep Creek						261				
Deer Creek							165.55			
Clemson 10								52.2		
D.O.T.									74.78	
Beeman's										125



	Input 0.02 mg/L	Input 0.03 mg/L	Input 0.06 mg/L	Input 0.07 mg/L	Input 0.15 mg/L	Input 0.21 mg/L	Input 0.22 mg/L	Input 0.22 mg/L	Input 0.42 mg/L	Input 0.53 mg/L
UCF	0.54									
Mulloch		2.54								
Lake Leon			0.54							
Clemson 08				0.94						
Patrick					25					
Deer Creek						4.7				
D.O.T.							3.62			
Clemson 10								4.5		
Beeman's									8	
Deep Creek										19.31

Waterbody Management Technologies

Nutrient Reduction: Bacteria, MicrobeLift

Bioaugmentation

Ecological Laboratories, Inc.
Doug Dent
www.microbelift.com
215-208-0815

➢ Multistage fermentation process: Aerobic, facultative, anaerobic, photosynthetic bacteria

- Enhance organic matter, sludge digestion
- Enhance ammonia conversion to nitrate
- Enhance nitrate conversion to nitrogen gas
- Enhance H_2S conversion to sulfate
- Compete with algae for nutrients

Clean Room Pressurized Fermentation area

Photosynthesis growth process

- 29 Species
  12 Genius
  (including purple sulfur eating bacteria)
- Vegetative cultures
  adapt to variety of environments

Nutrient Reduction: Bacteria, MicrobeLift

Xiba River, China, Study

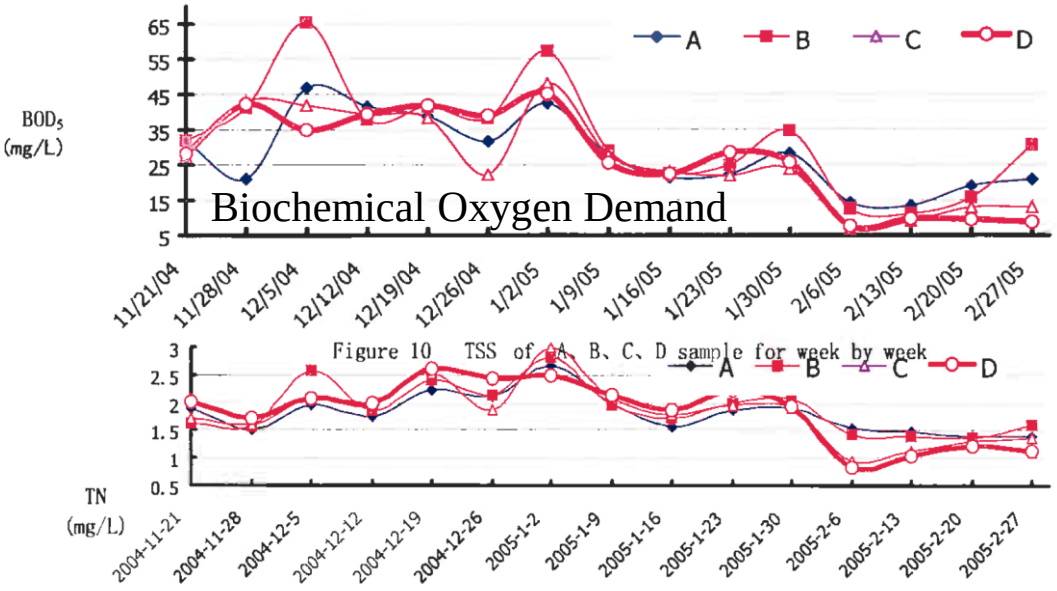
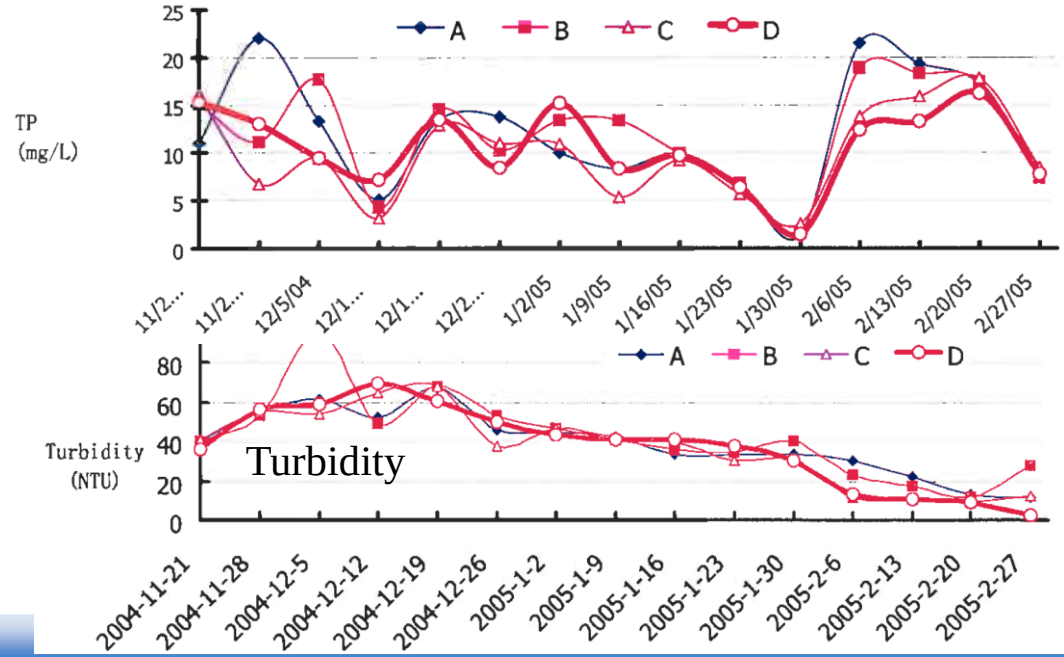


Figure 10 TSS of A、B、C、D sample for week by week

Figure 11 TN of A、B、C、D sample for week by week

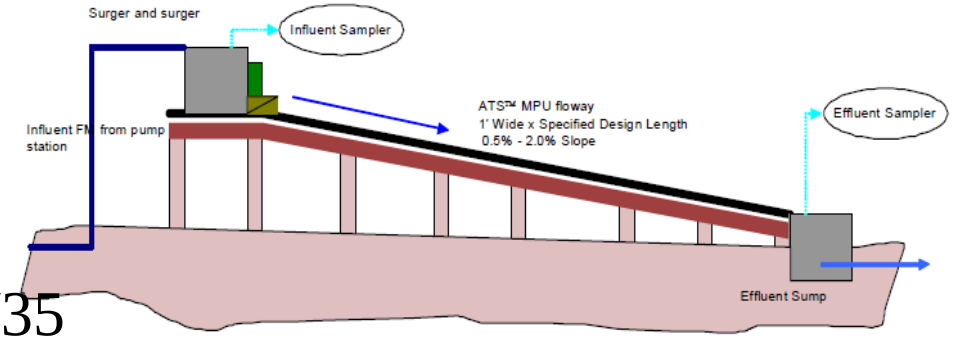


Waterbody Management Technologies

Nutrient Reduction: Flow-way, Algal Turf Scrubber

Mark Zivojnovich

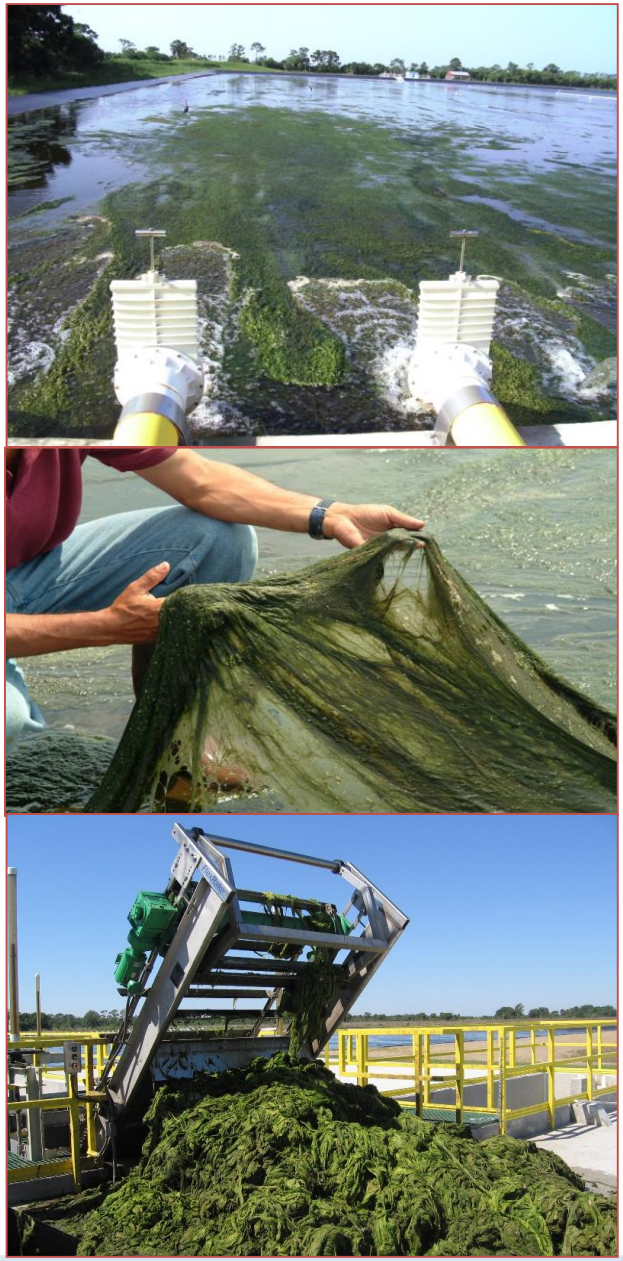
http://www.hydromentia.com/352-804-5126



What is an Algal Turf Scrubber®?

- A culture unit for native attached algae
- The algae remove nitrogen and phosphorus and add dissolved oxygen to source water
- The algae is regularly recovered and processed
- Recovery of algal biomass maintains the culture units in an accelerated growth phase
- Optimally, nutrients are continuously recovered and removed from the treatment unit

Nutrient Reduction: Flow-way, Algal Turf Scrubber



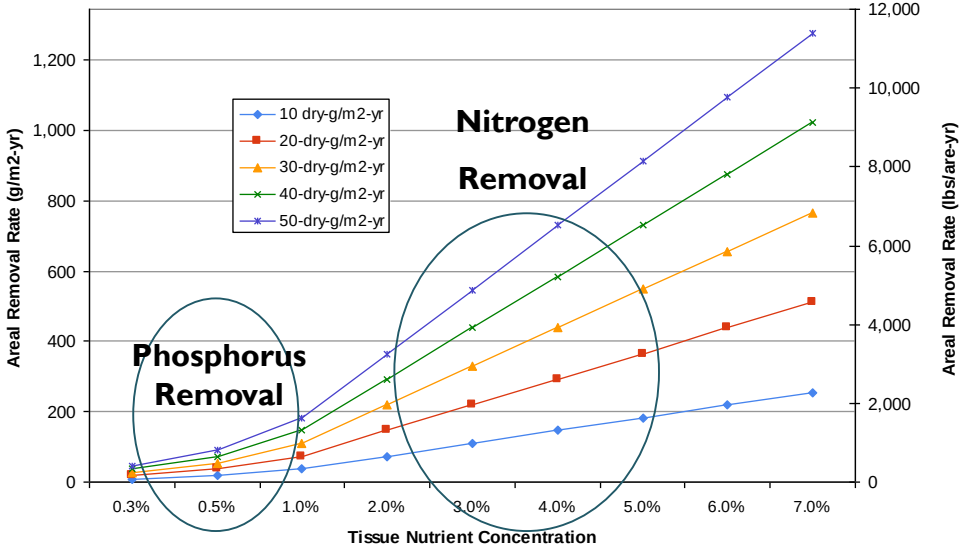
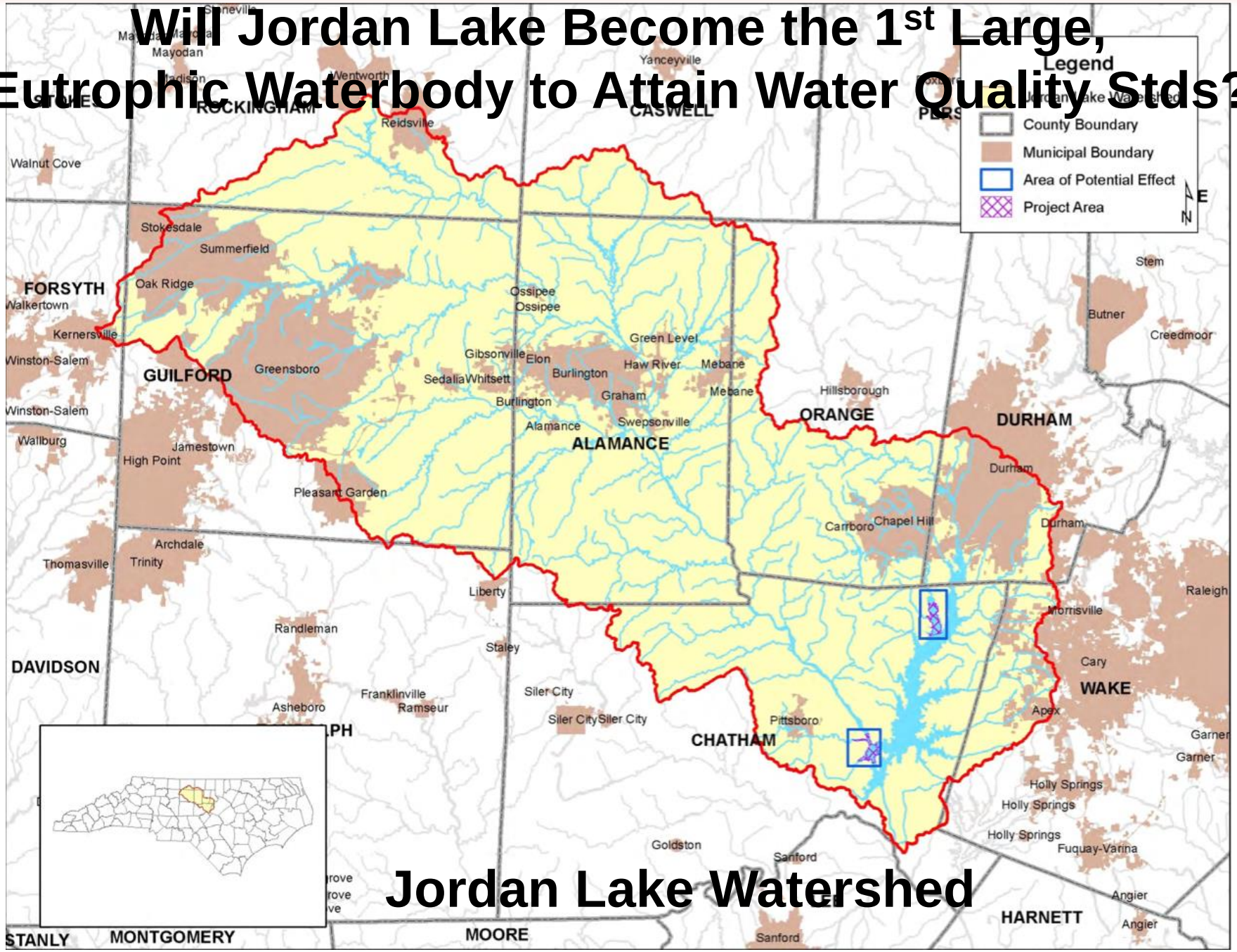


Figure 1. Nutrient Areal Removal Rates Based on Algal Productivity (dry-g/m2-yr) and Tissue Nutrient Concentrations.

Removal Rates Affected by:

- Nutrient concentrations in water
- Temperature
- Sunlight
- Available carbon (alkalinity)

Will Jordan Lake Become the 1st Large, Eutrophic Waterbody to Attain Water Quality Stds?



Jordan Lake Watershed

Jordan Lake

➢ History

- 13,940 ac reservoir completed in 1982 to provide flood control and designated uses – drinking source water, wildlife habitat, recreation
- Algal impairment predicted due to high nutrients & low flow rate

➢ Water Quality

- Harmful algal blooms (HABs) cause impairments: chlorophyll-a exceedances of state standard (40 μg/L), high pH, and turbidity

➢ NCDENR TMDL & Nutrient Strategy Rules

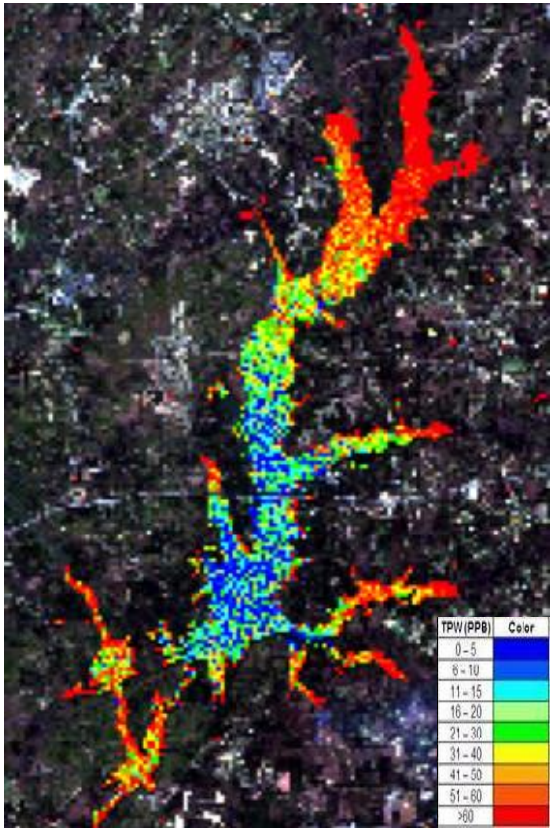
- 9 rules to reduce nutrient input (8 nonpoint-, 1 point-source)
  - Estimated cost of up to $2 billion

➢ 2013 NC Legislation

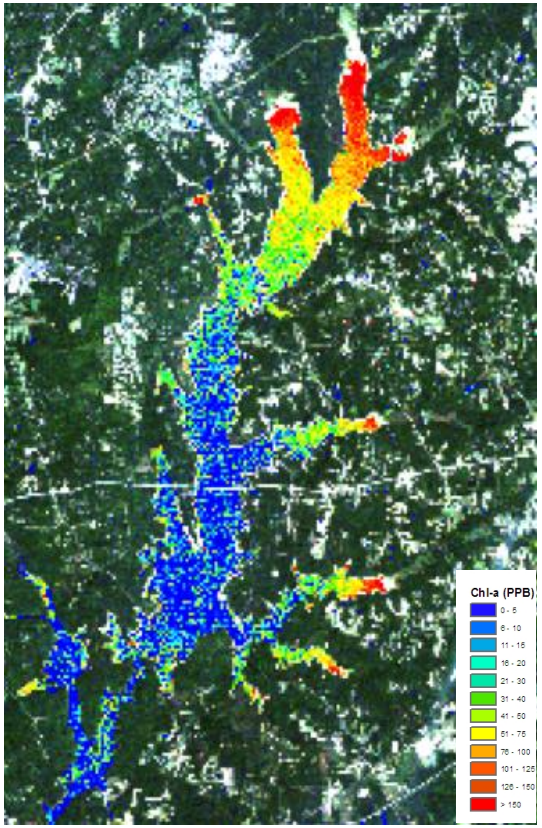
- Suspends 8 unimplemented rules for 3 years
- Budgets demonstration project in Jordan Lake to stop HABs
- Committee oversee systems approach plan development

Jordan Lake

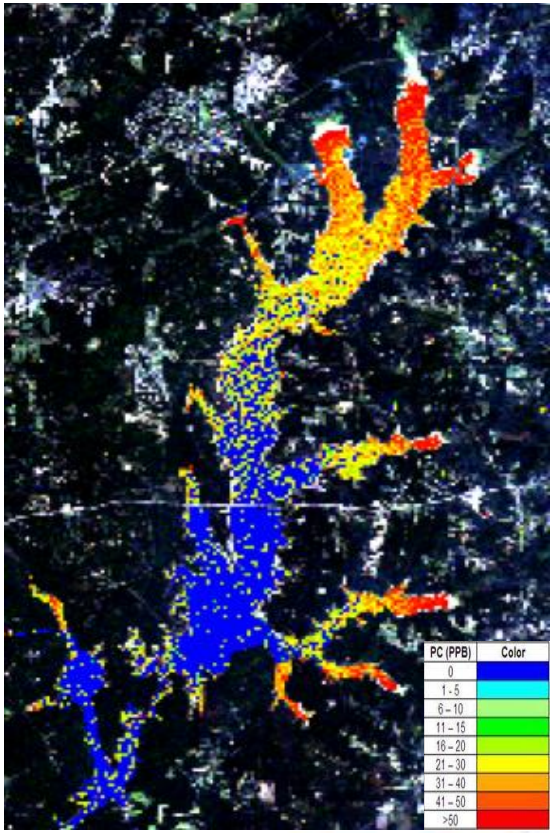
Phosphorus



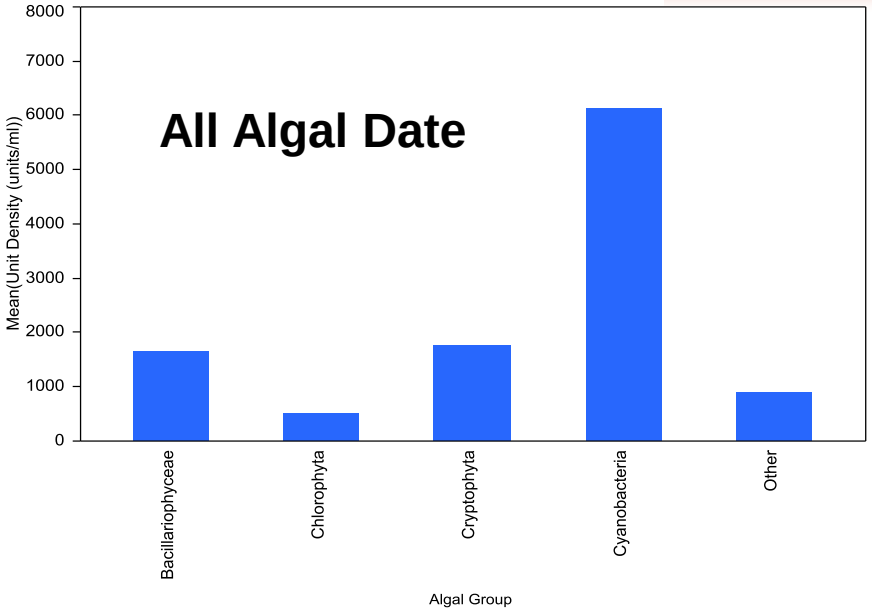
Chlorophyll-a

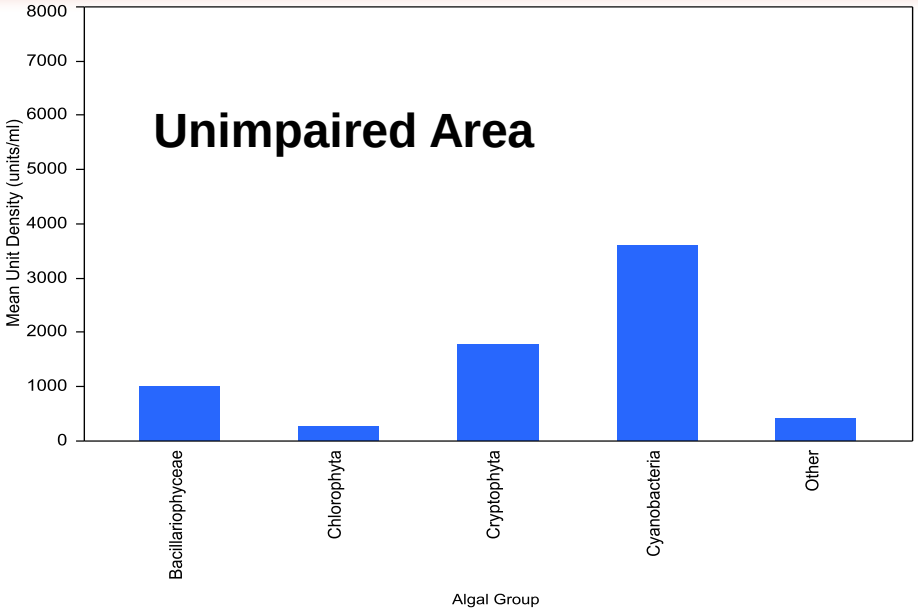


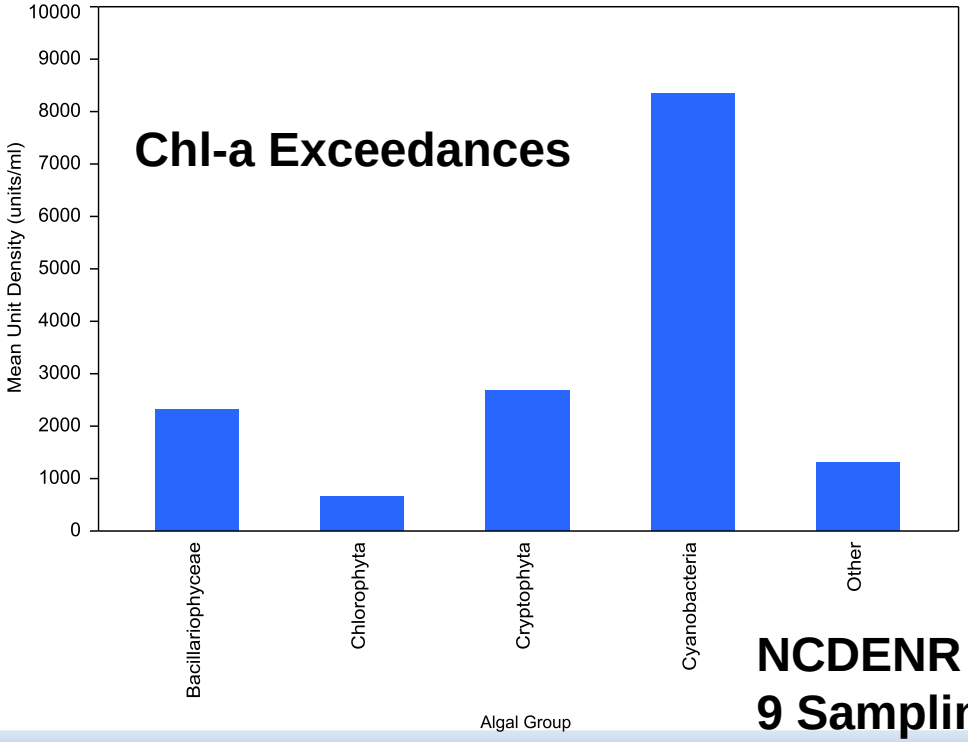
Phycocyanin



BLUE WATER
SATELLITE, INC





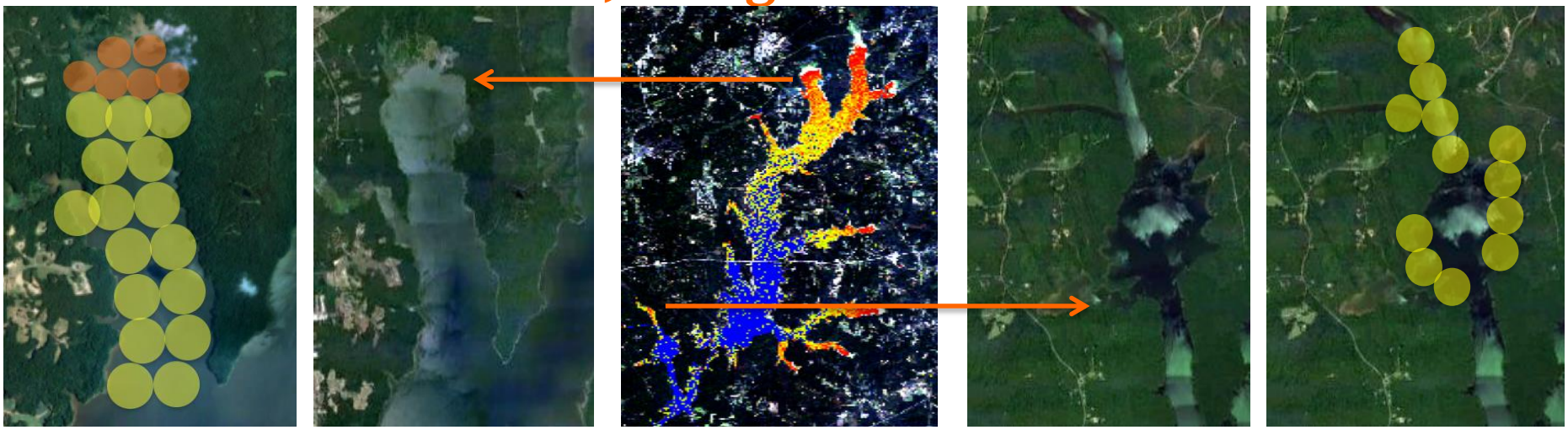


Cyanobacterial Predominance

NCDENR 2000-2013 Data, All 9 Sampling Stations

Jordan Lake Demonstration Project

Solar-Powered, Long-Distance Circulation

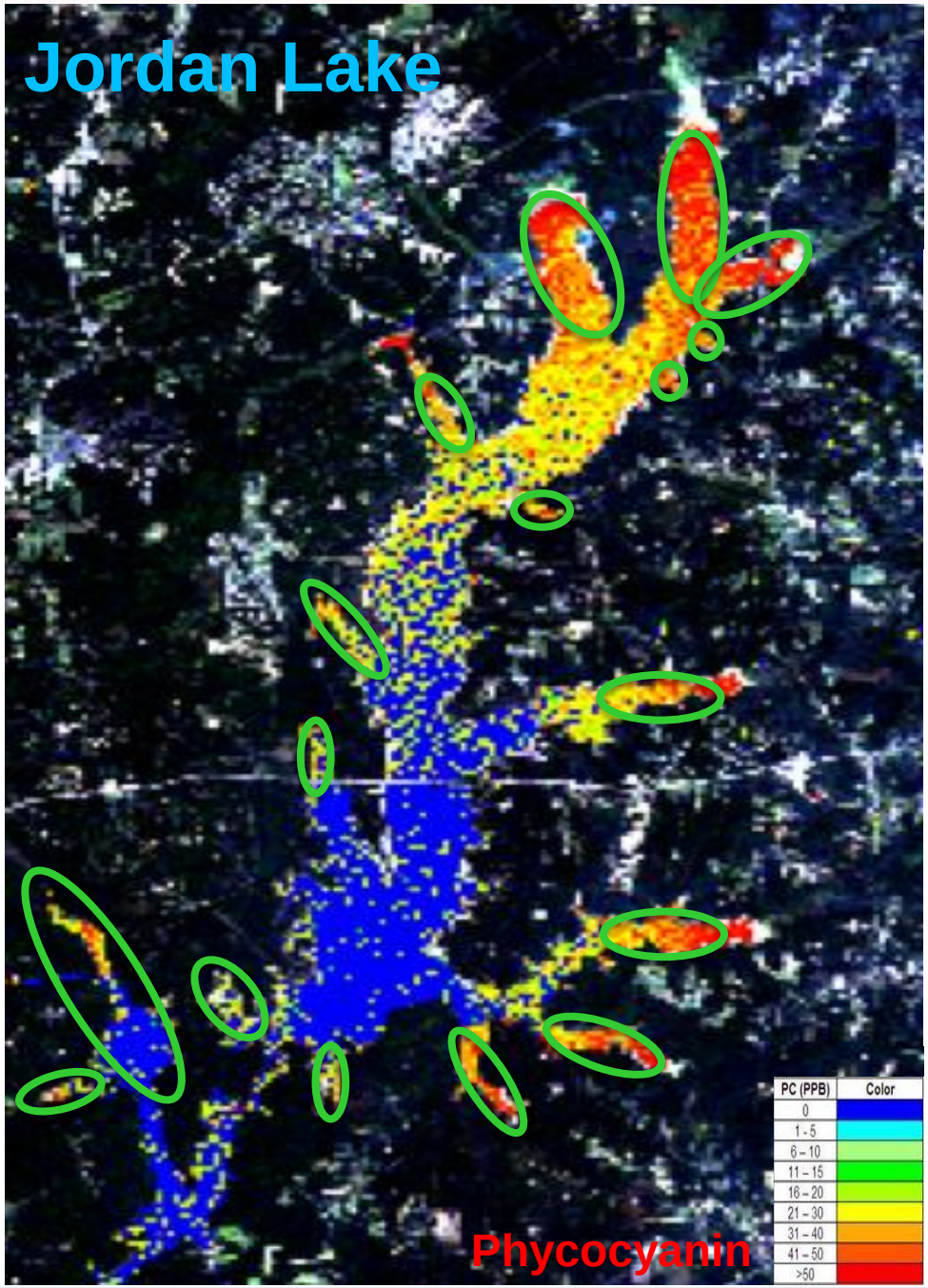


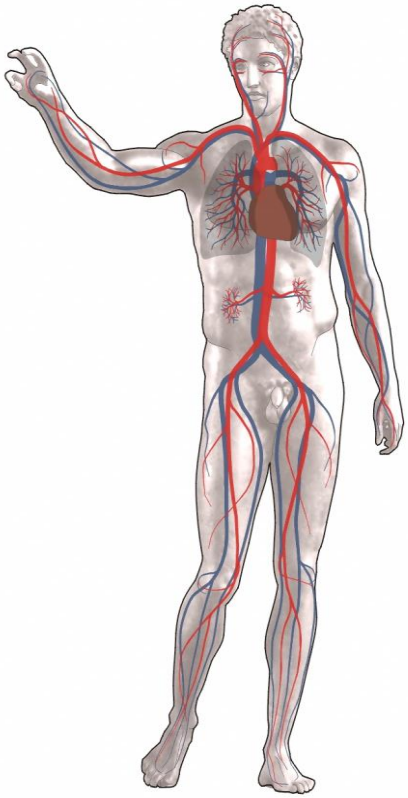
Morgan Creek Arm **Phycocyanin** **Haw River Arm**

- 2 year rental, study design, data collection & analysis by DENR,
  - Goal - suppress cyanobacteria
    - Chlorophyll-a exceedances ≤ 10% time May-September
- **Develop Comprehensive, Systems Approach Plan**
  - Watershed management upstream - Most cost-effective BMPs
  - Waterbody management in Jordan - Circulate & remove nutrients

Waterbody Treatments

- Whole Lake Protection with ~155 Circulation Units





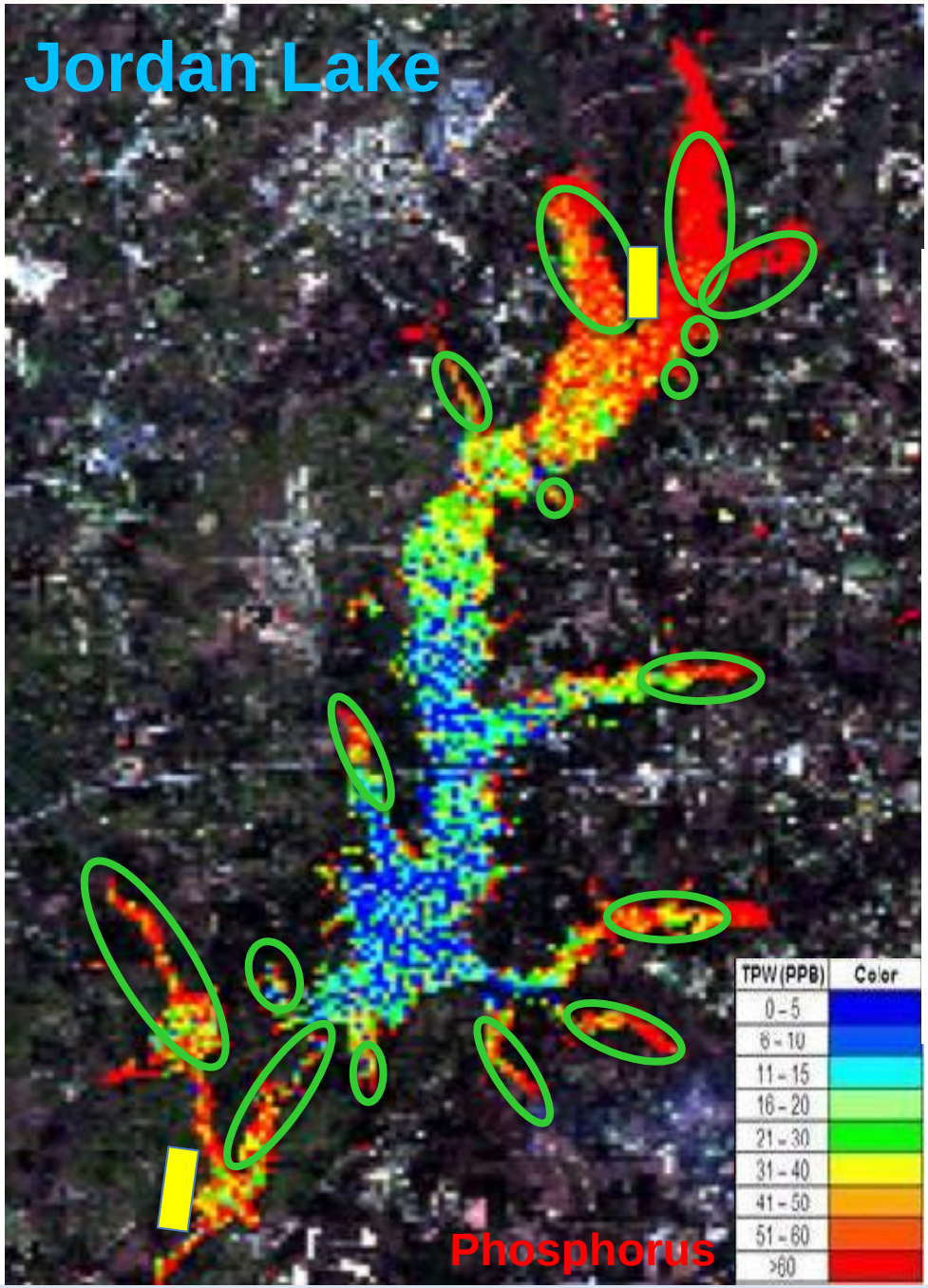
Suppress Cyanobacteria & Channel Nutrients Up Trophic Levels

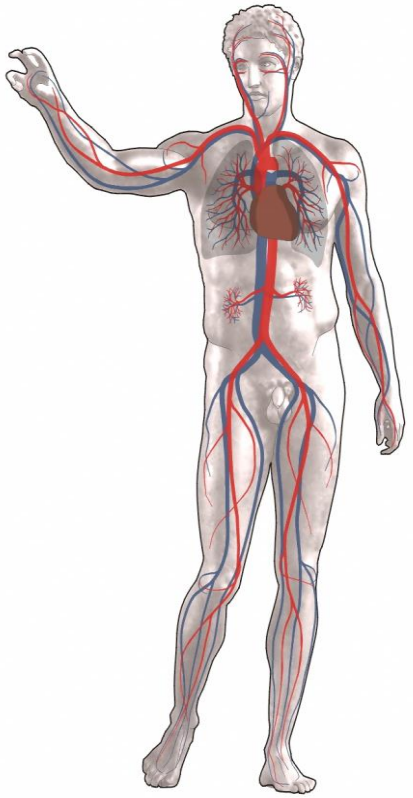
Waterbody Treatments

- Circulation
- Flocculants
- Bacteria
- Floating Artificial Wetlands

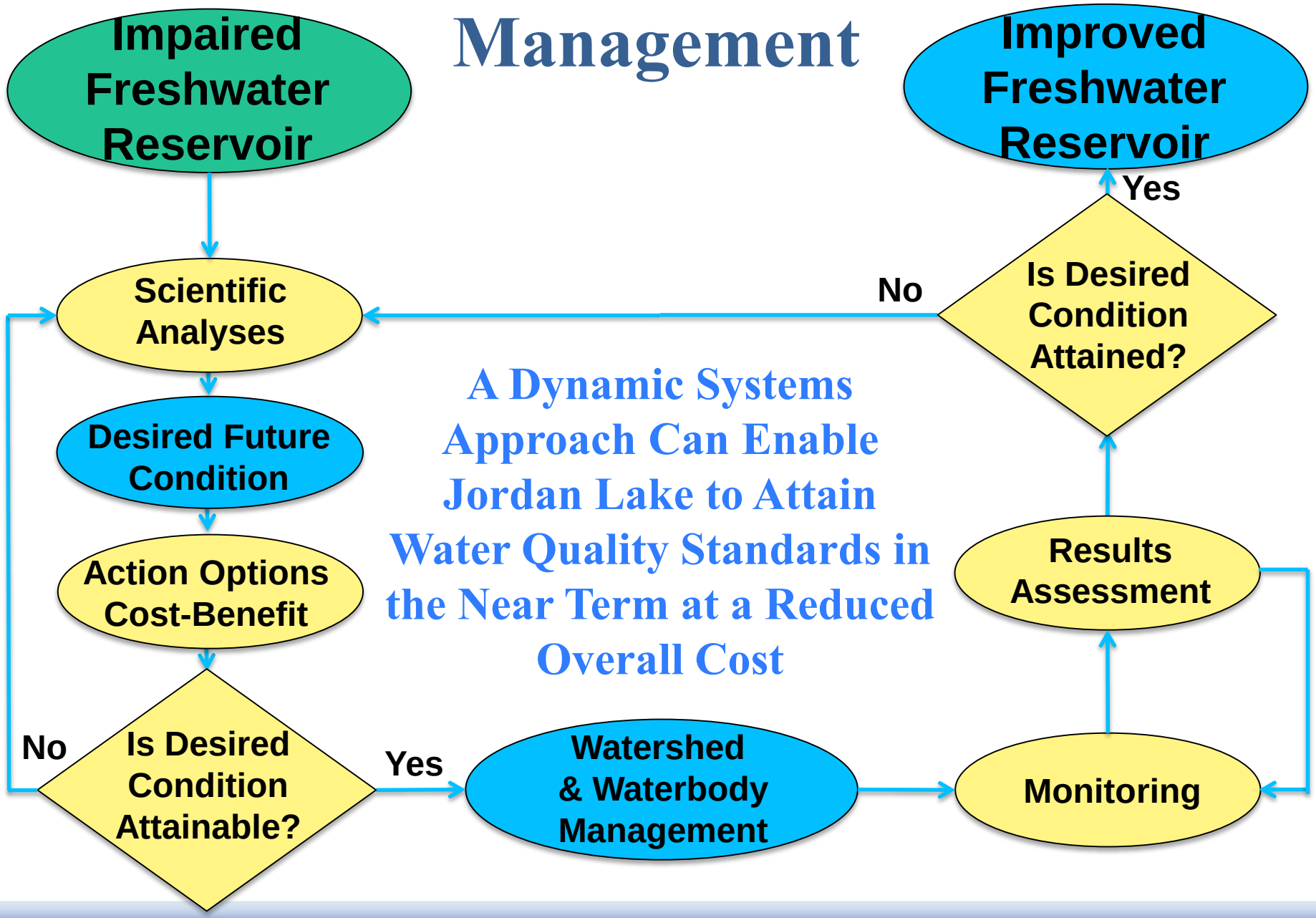
- Side-stream Flow Ways

Suppress Cyanobacteria & Remove Nutrients





Jordan Lake & Watershed Management



Before Heading Home, Thank You!