UNIVERSITY OF MINNESOTA EXTENSION

MAKING A DIFFERENCE IN MINNESOTA: ENVIRONMENT + FOOD & AGRICULTURE + COMMUNITIES + FAMILIES + YOUTH

HARMFUL ALGAL BLOOMS

Potential Water Quality Challenges

Harmful Algal Bloom Research

Shahram Missaghi
Water Resources Team
University of Minnesota Extension
Extension; 4100 220th Street W.
Farmington, MN 55024-

Ramsey County
Monday, March 18, 2019 | 4:00 p.m. - 6:00 p.m.

Acknowledgements:

http://HAB.umn.edu

State Agencies: MPCA, MDH

Local Government, Counties, Cities,

Researchers, colleges, universities

.....

YOU!

Educators

Home owners

Photo: Prairie Lake algae3 -

TOPIC: HARMFUL ALGAL BLOOM RESEARCH

1. **Algae– a quick look**
2. **Why do we care? Urgency, problem**
3. **Research:**
4. **Next**

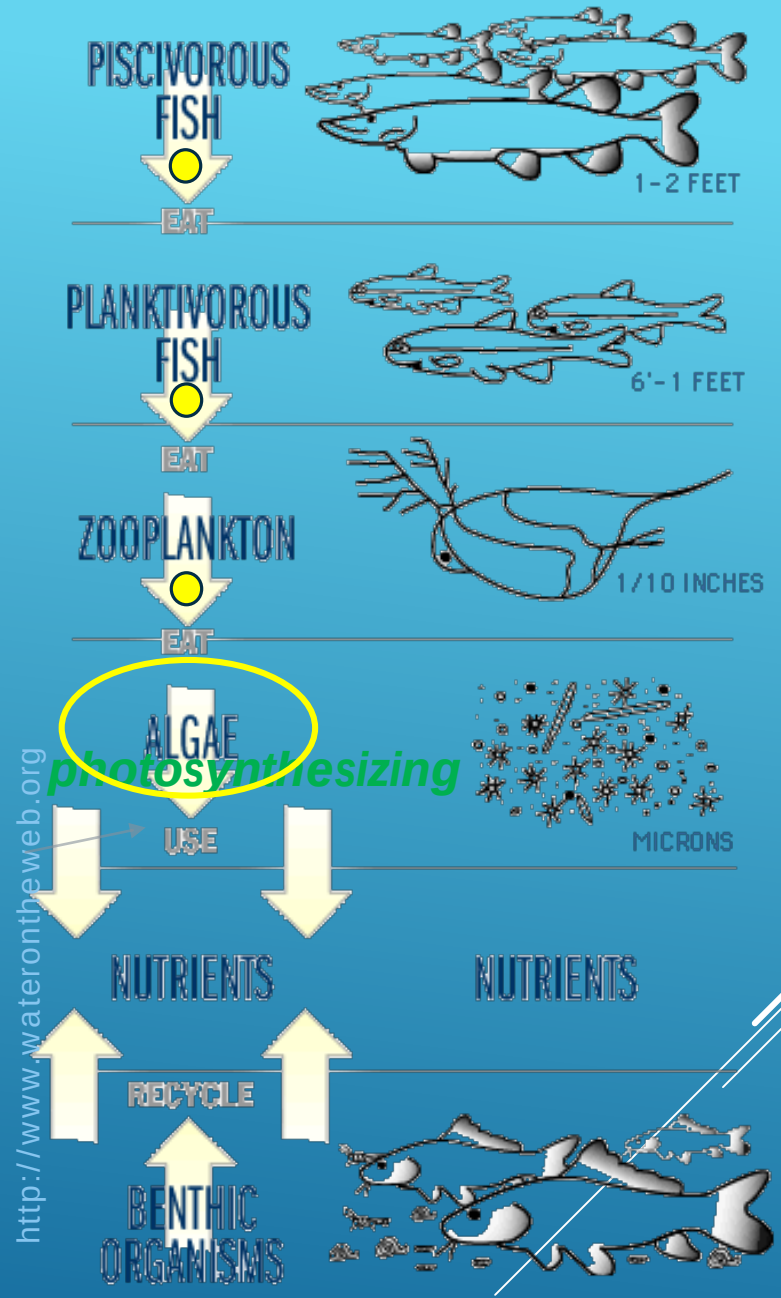
TOPIC:

ALGAE– A QUICK LOOK

Lake system: Who eats who?

Algae **is not** a type, group, domain, or kingdom of living things, but rather **a collection of various organisms** represented from different aquatic groups **that can make their own food and are autotrophs.**

➔ **Any shape or form in almost anywhere in the world**



http://www.waterontheweb.org

Algae

many shapes, forms, and places

?

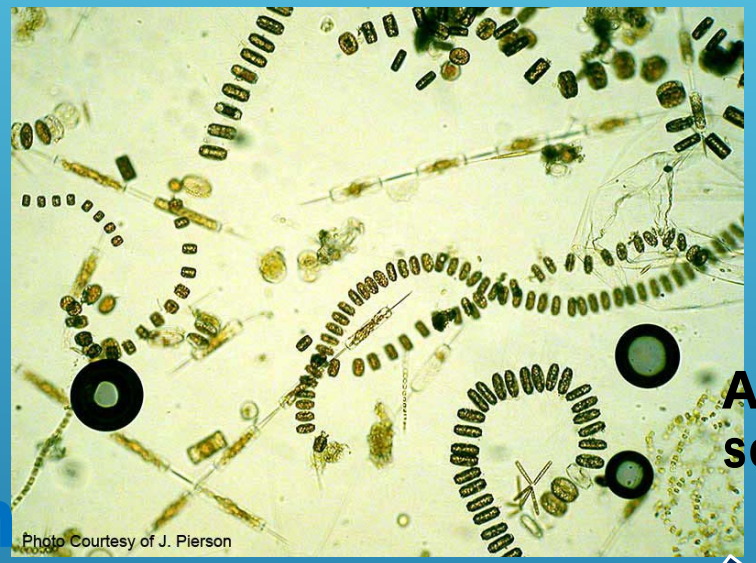
Bottom sediment

Attached sediment

Attached to other things

Suspended in water

phytoplankton



periphyton

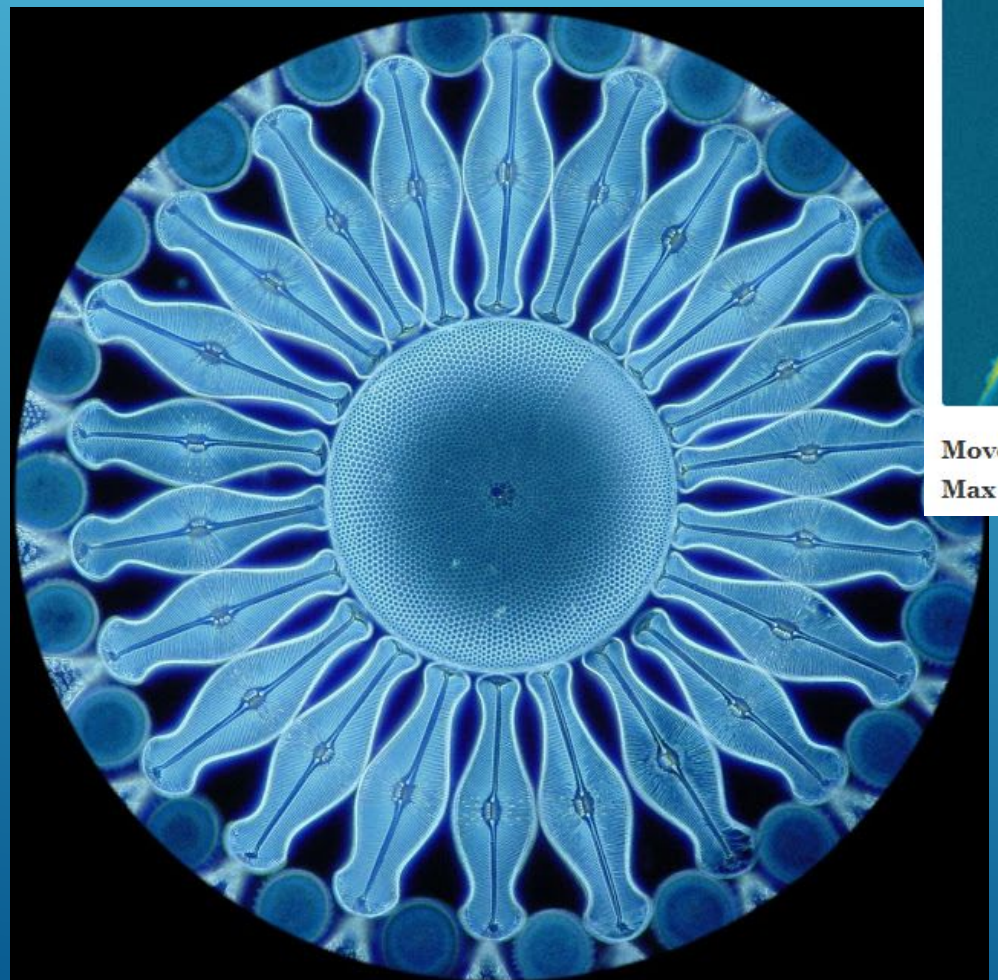
Algae

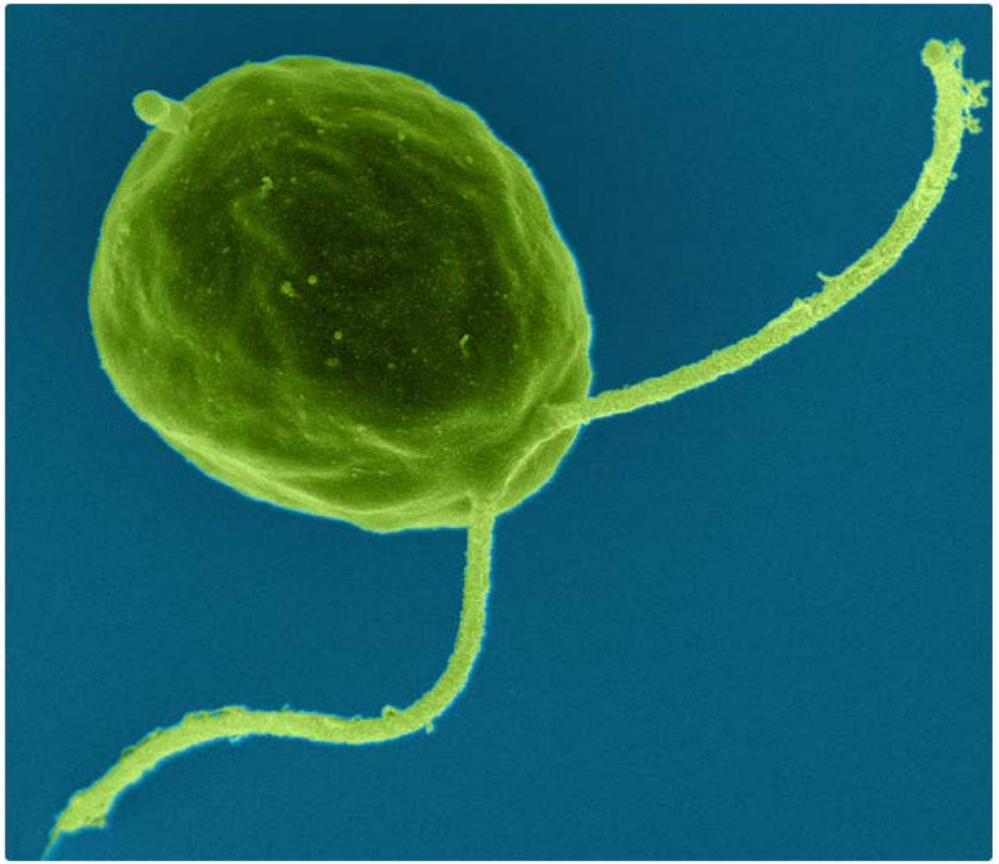
many shapes, forms, and places

Algae are good!

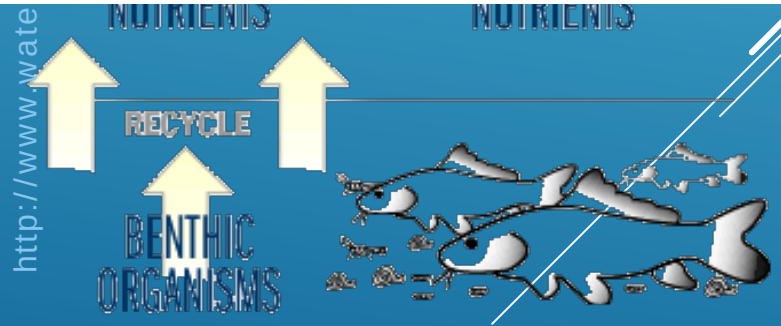
Architects of earth's atmosphere

3.5 billion years old





Movement of *Chlamydomonas reinhardtii* studied by Dr. Veikko Geyer at Max Planck researchers in Dresden, Germany.

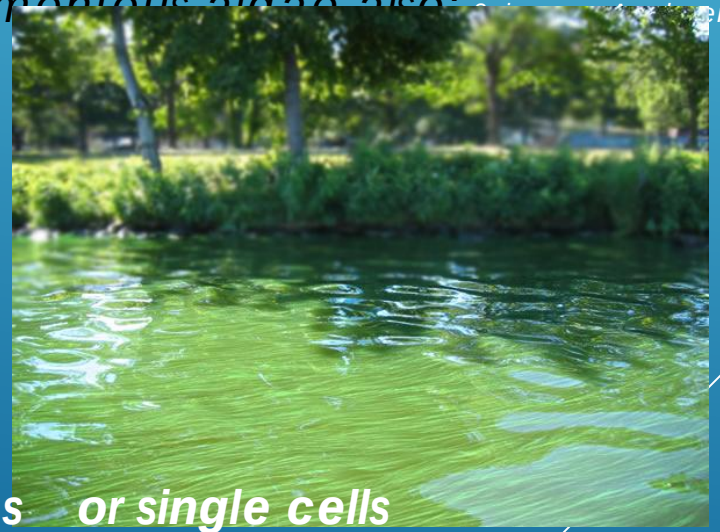


Algae

many shapes, forms, and places

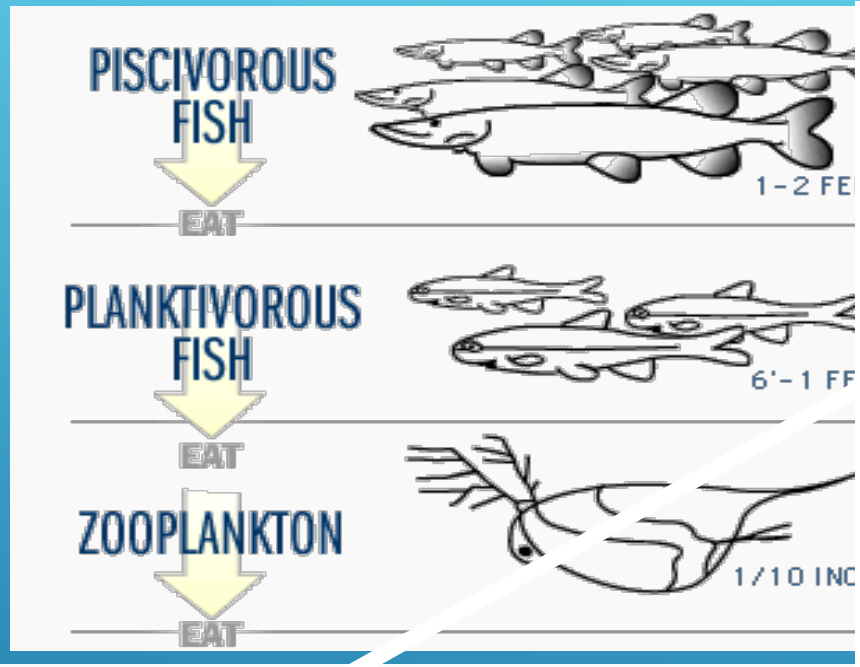
Muskgrass (Chara) –

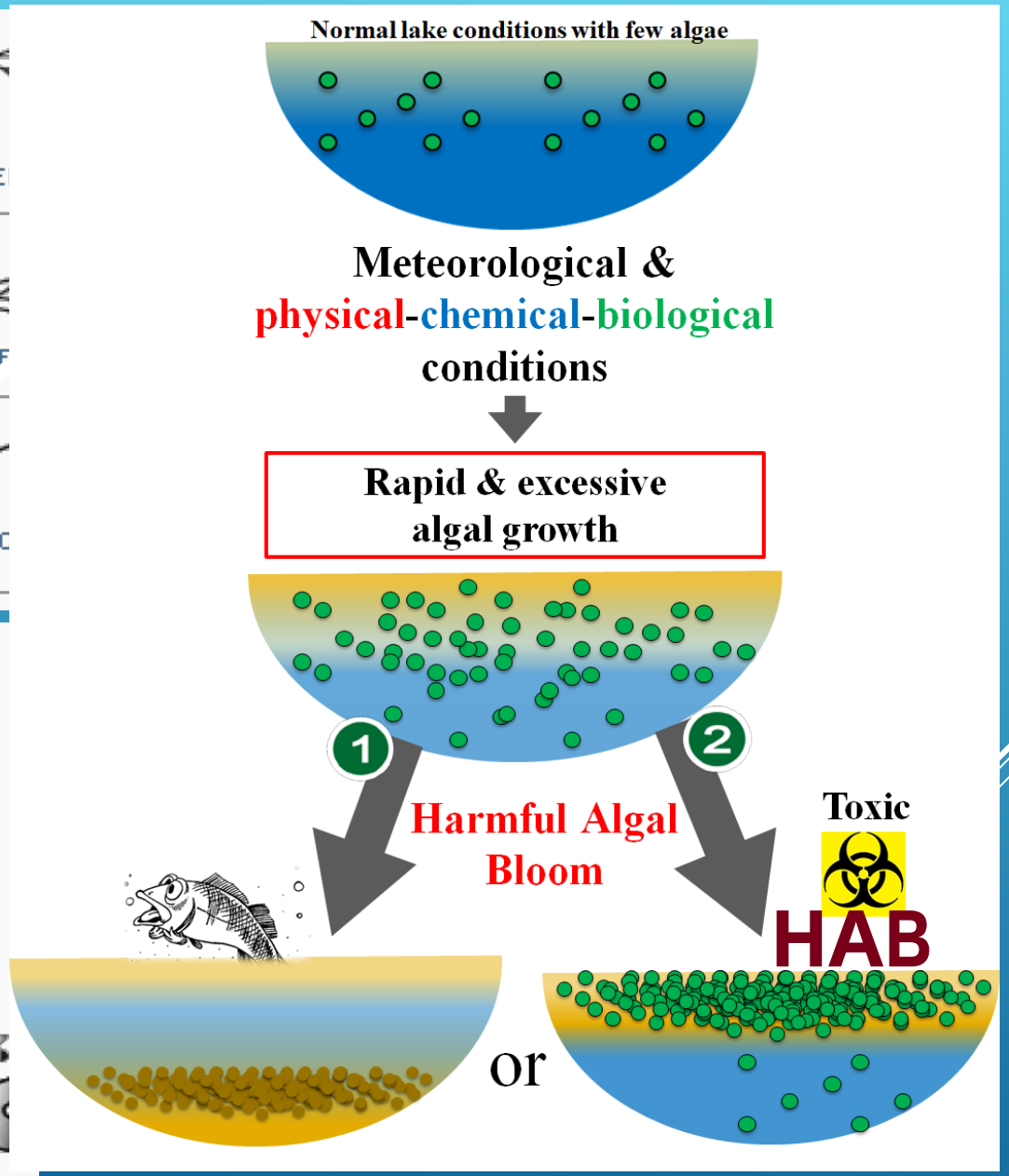
Filamentous algae also: ena, Oscillatoria, Lyngbya



THE **PROBLEM**: THEY CAN GROW!

The **problem**: they can grow!





The problem: they can grow!

Clear water → **Visible algae** → **Nuisance** → **Harmful**

Number of *Microcystis* cells per milliliter of water

0 | 10,000 | 100,000 | > 1,000,000

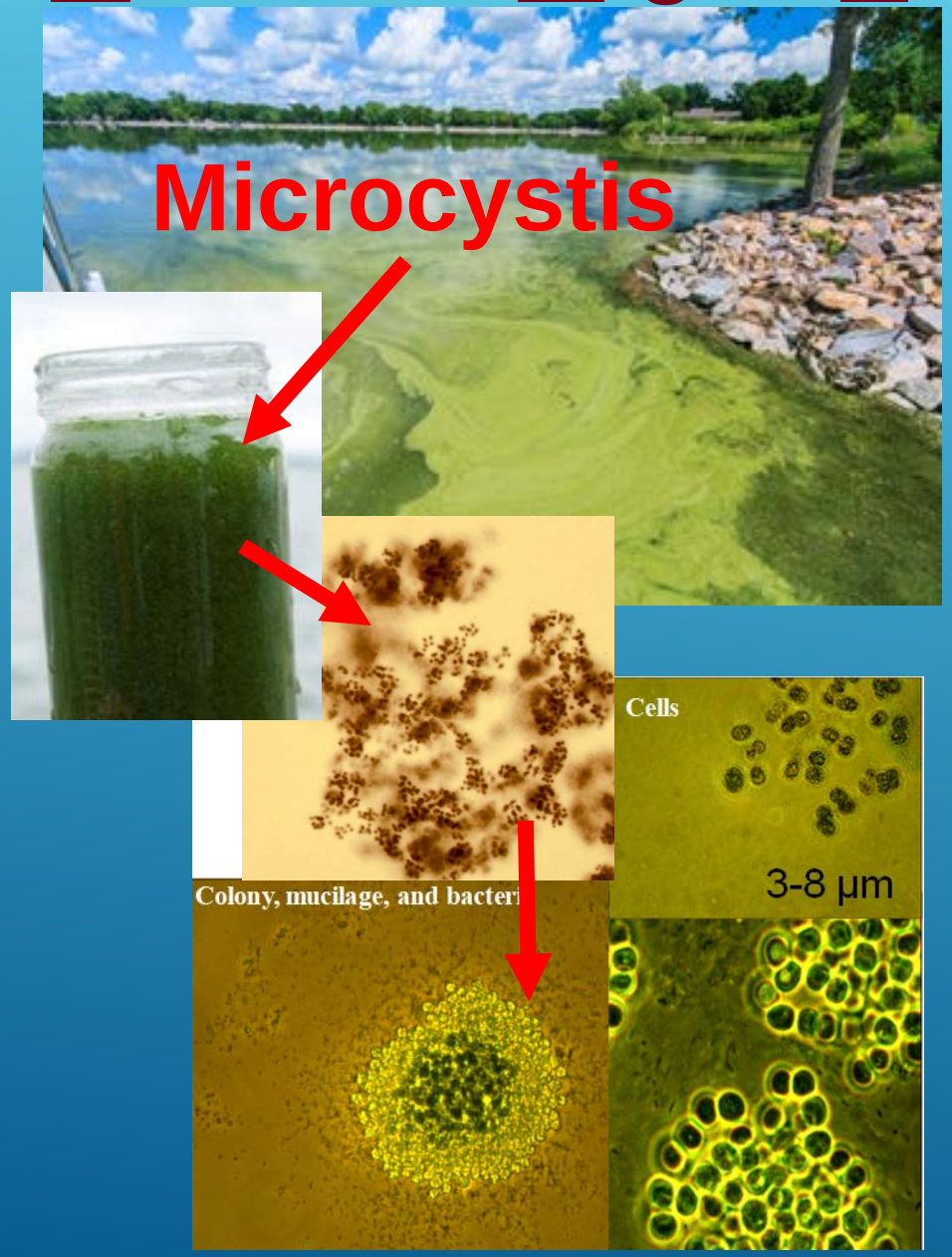
Are all algae HABs?

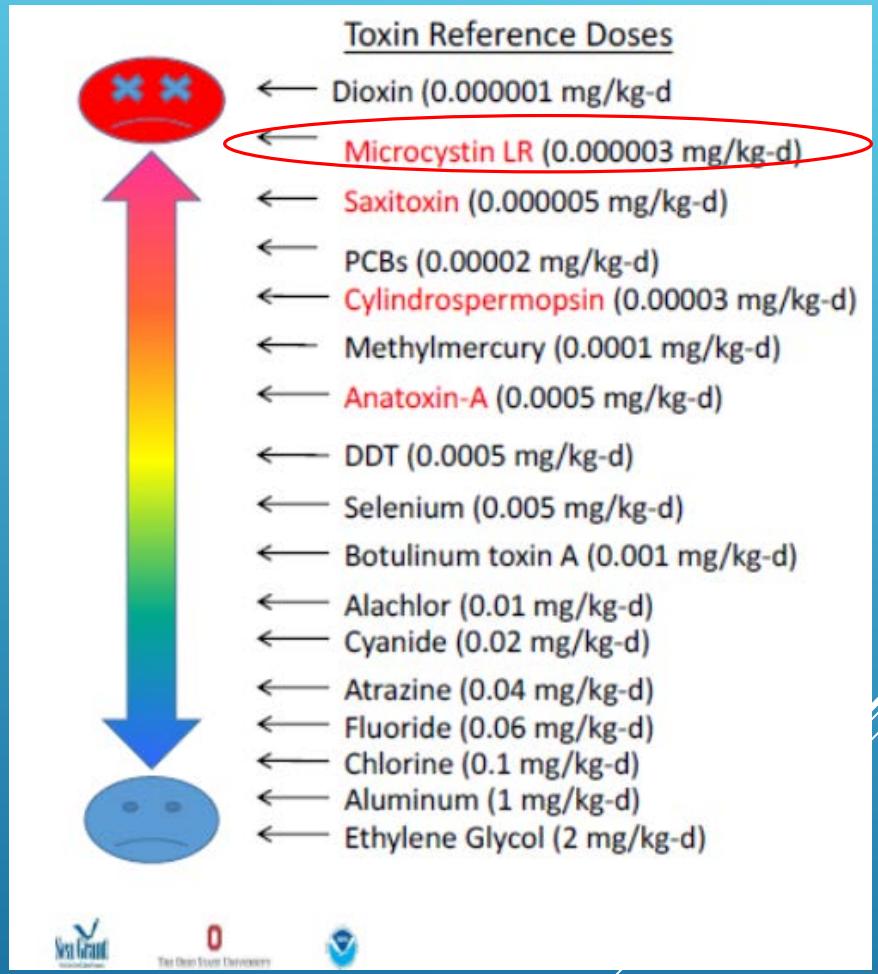
Put the jar in the refrigerator and leave it undisturbed overnight (MPCA-wq-swm1-04)

\-

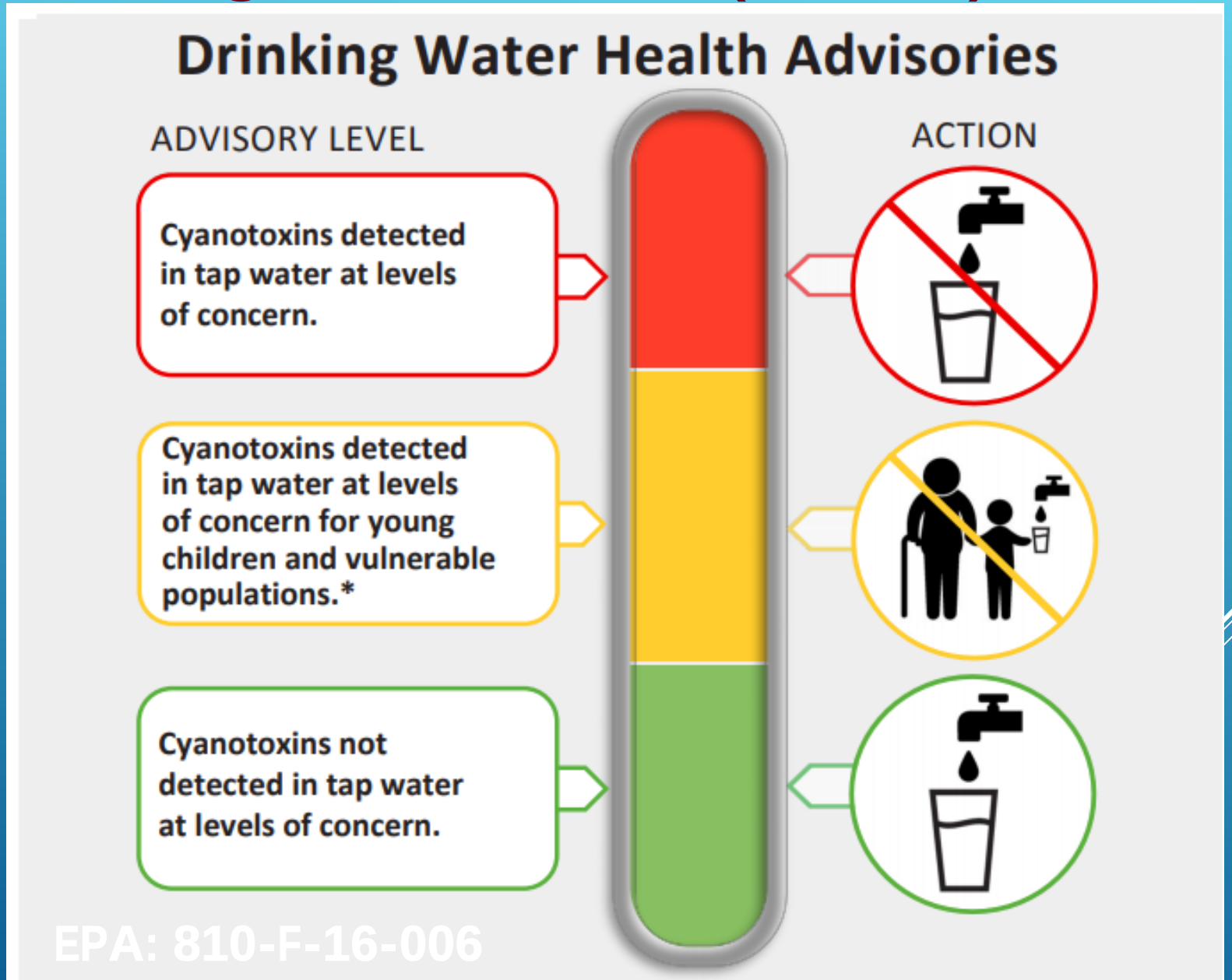
\+

Harmful Algal Blooms (HABs)

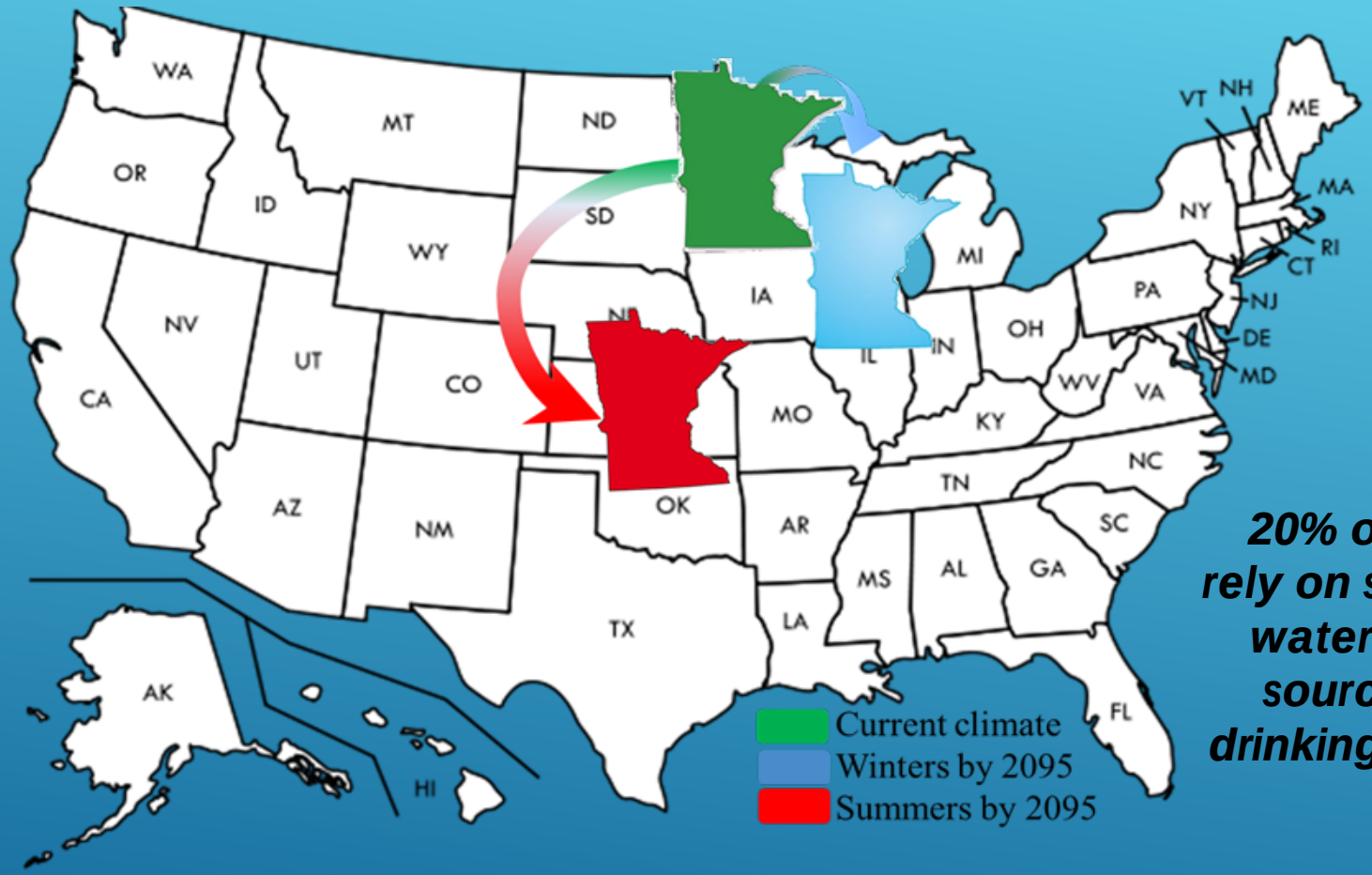




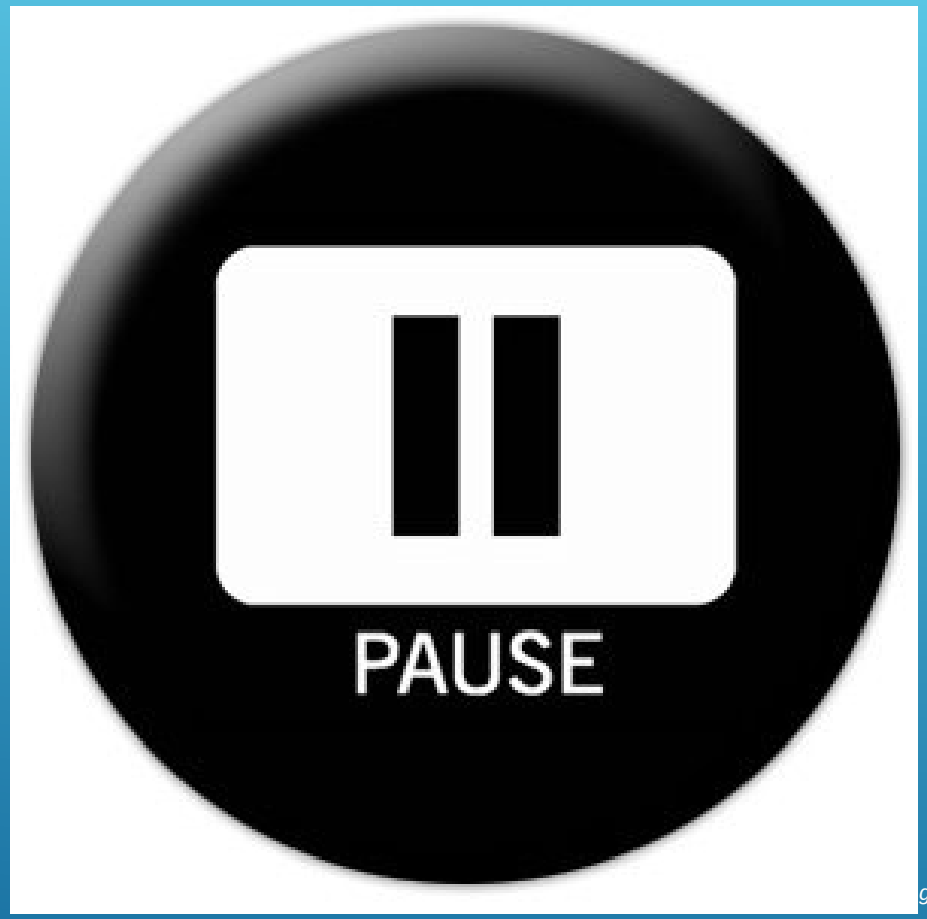
Harmful Algal Blooms (HABs)



Why does it matter?



20% of MN rely on surface water as a source of drinking water


PAUSE

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HAB
Harmful blue-green algae in Minnesota lakes

Home | HAB FAQs | HAB News | People | Workshops

Blue-green algae in Minnesota lakes

Understanding and predicting harmful algal blooms

Algae blooms can turn water green and smelly, contribute to fish kills, and at times produce toxins that pose a health risk to people and animals. These types of algae blooms are referred to as Harmful Algal Blooms, or HABs, and their occurrence is on the rise in Minnesota lakes, streams and wetlands.

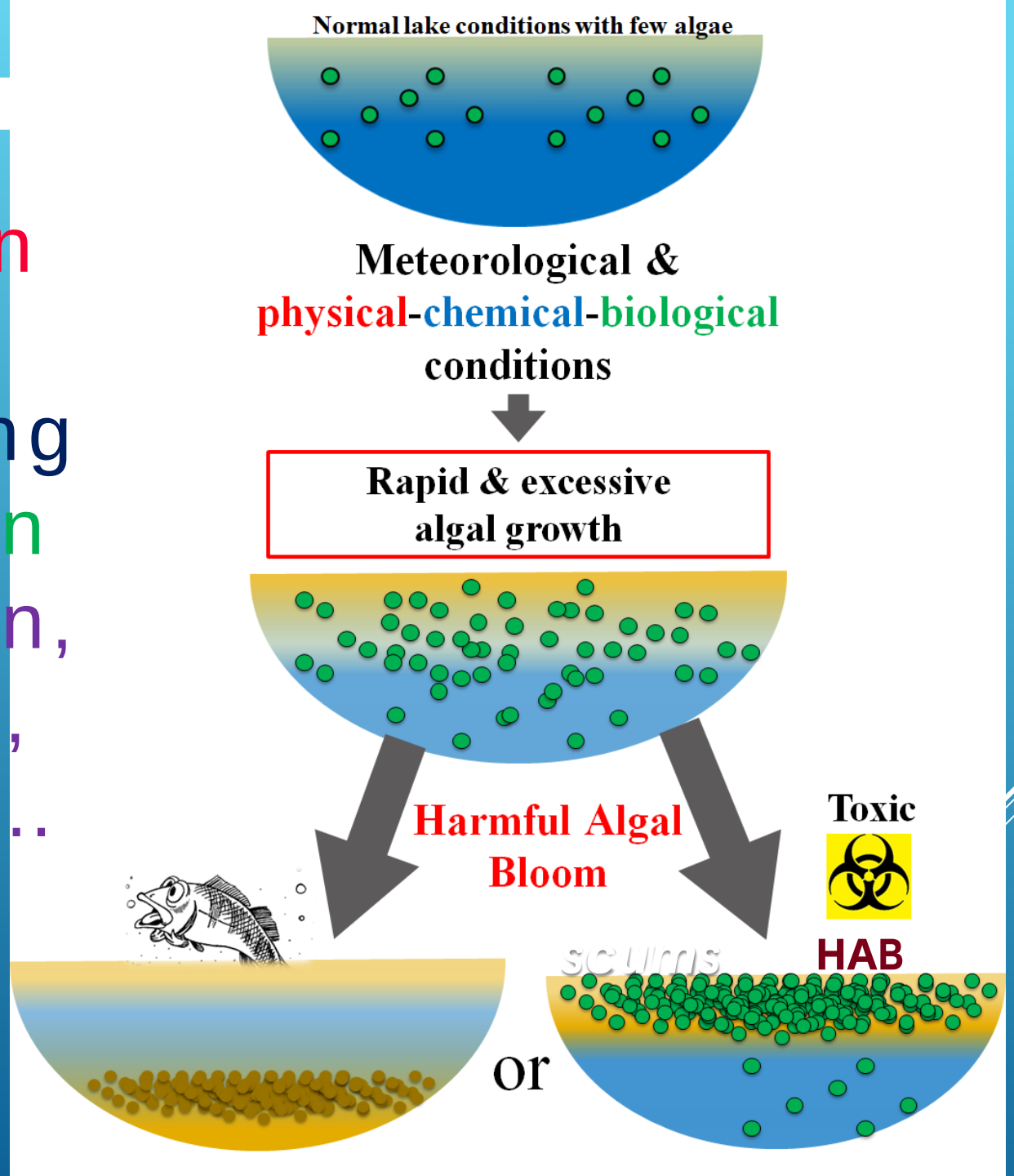
Algae occur naturally in almost all surface waters. They are an essential source of food for many aquatic organisms and come in many shapes and forms.

Under the right temperature and water conditions, blue-green algae (cyanobacteria) can grow very rapidly and form extremely high-density populations or "blooms." These colonies can then float to the water surface and form a dense layer of scum.

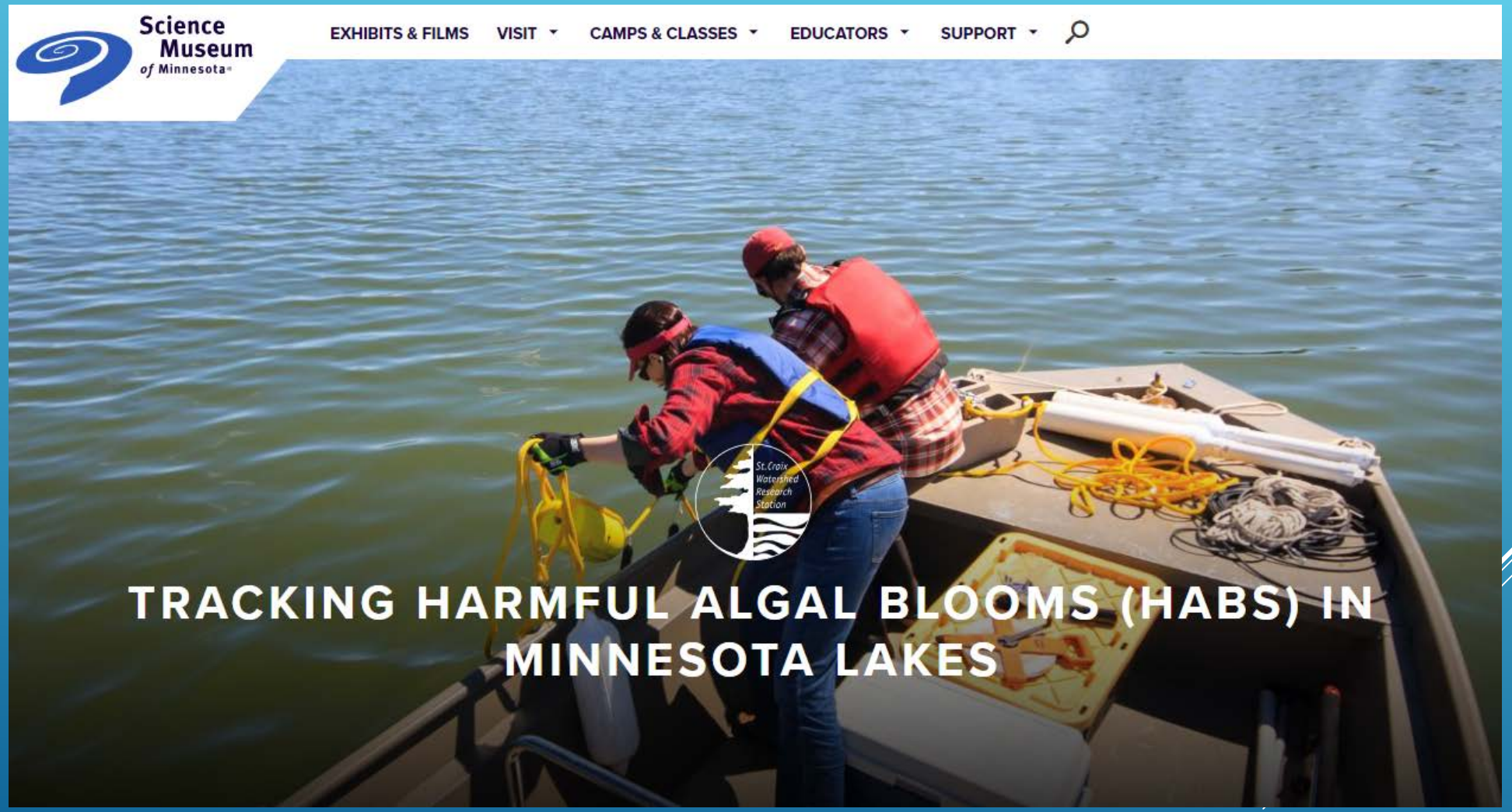
More frequent HABs may be triggered by a number of factors, including urban and agricultural runoff and climate change.

Research ar

- Detection
- Tracking
- Monitoring
- Mitigation
- Education, outreach, training,...



Research areas
Detection & Tracking



Science Museum of Minnesota

Plankton tow sample, Madison Lake (July 2016)

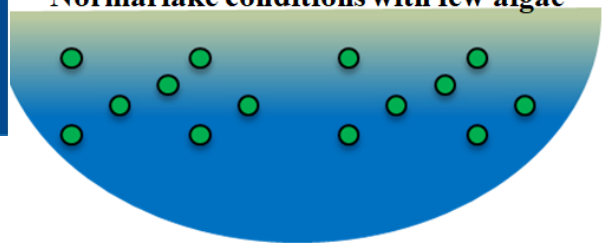
Filtered Chlorophyll a sample from St. James Lake (June 2016)

***Sediment* cores**
To see changes through time!

Research areas
Detection & Monitoring

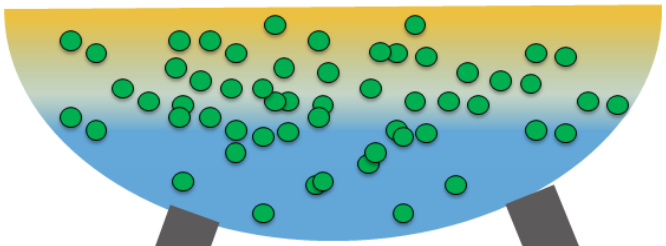
ST. ANTHONY FALLS LABORATORY

Normal lake conditions with few algae



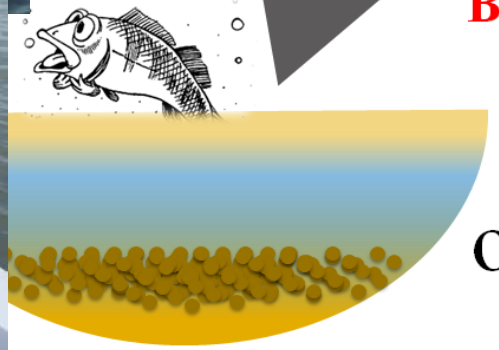
Meteorological & physical-chemical-biological conditions

Rapid & excessive algal growth

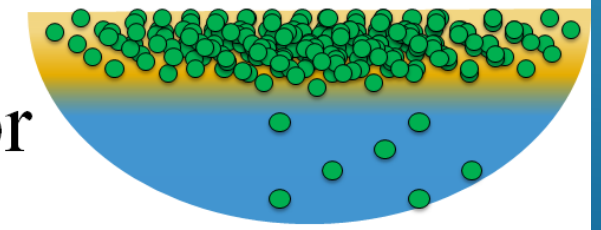


Harmful Algal Bloom

Toxic



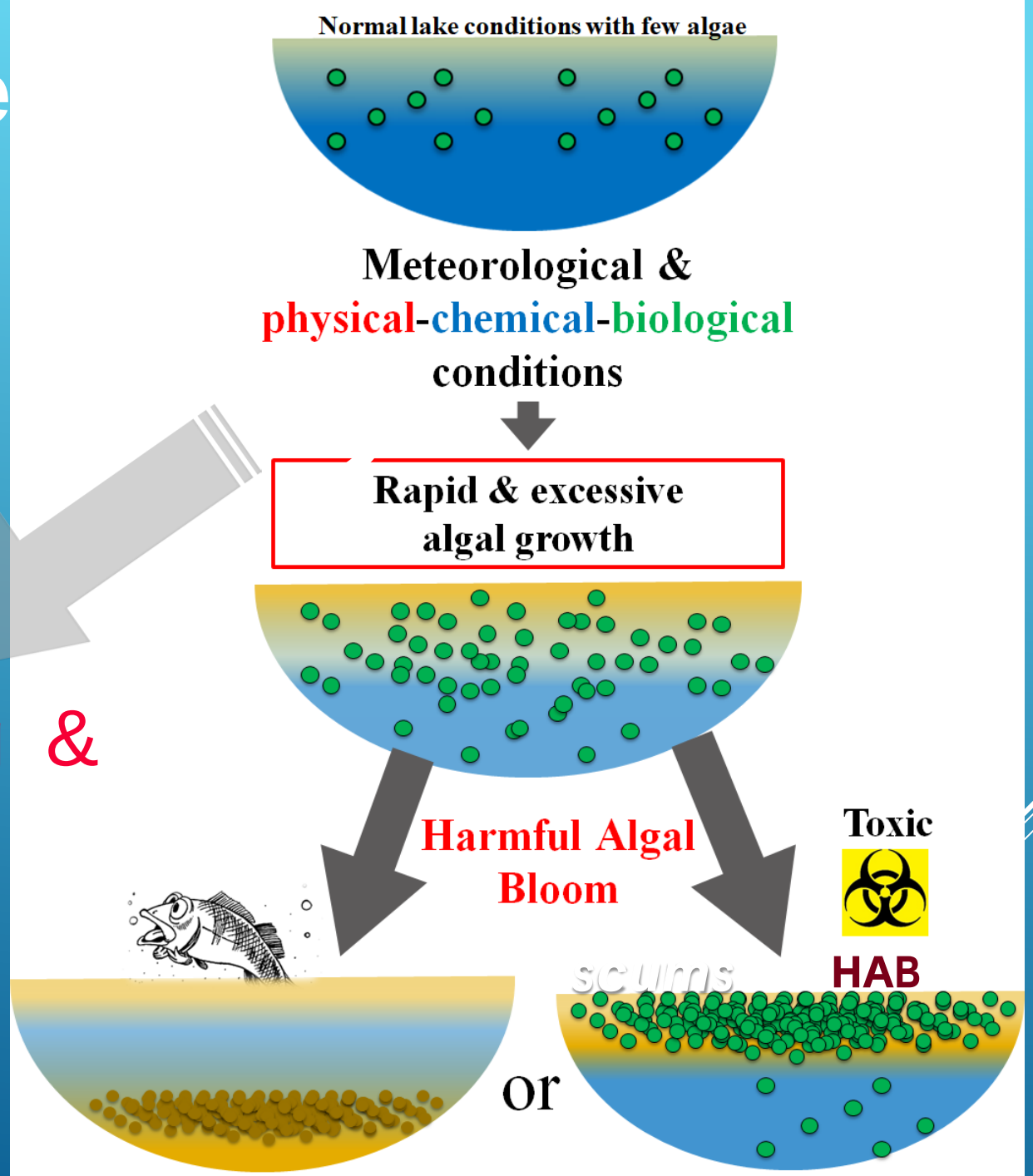
or



Why the rese

- Detection
- Tracking
- Monitoring
- Mitigation
- Education, outreach, training,...

Forecasting &
Predication



Prediction of Algal Blooms

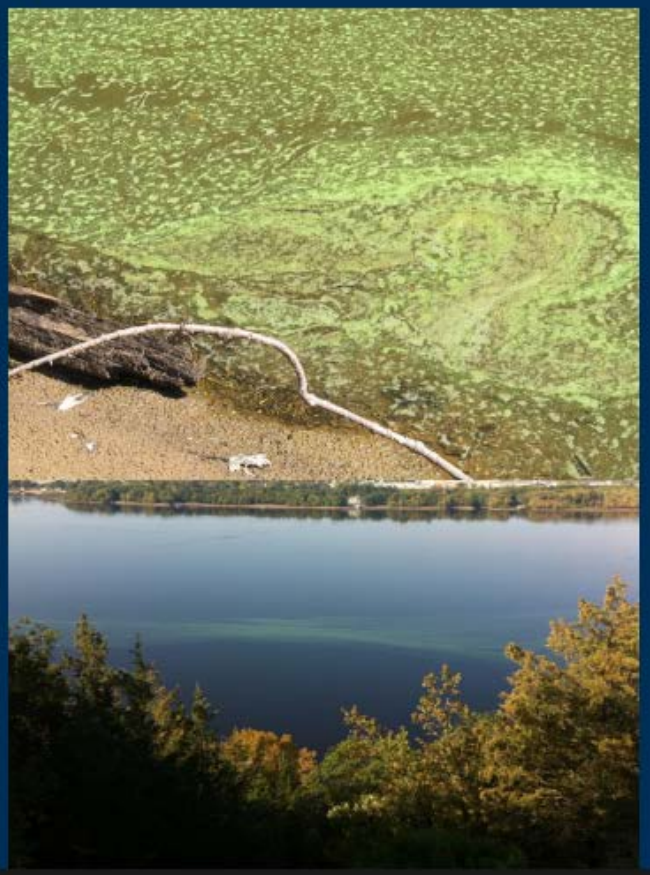
Erik Smith
Richard Kiesling

Upper Midwest Water Science Center (USGS) - Minnesota

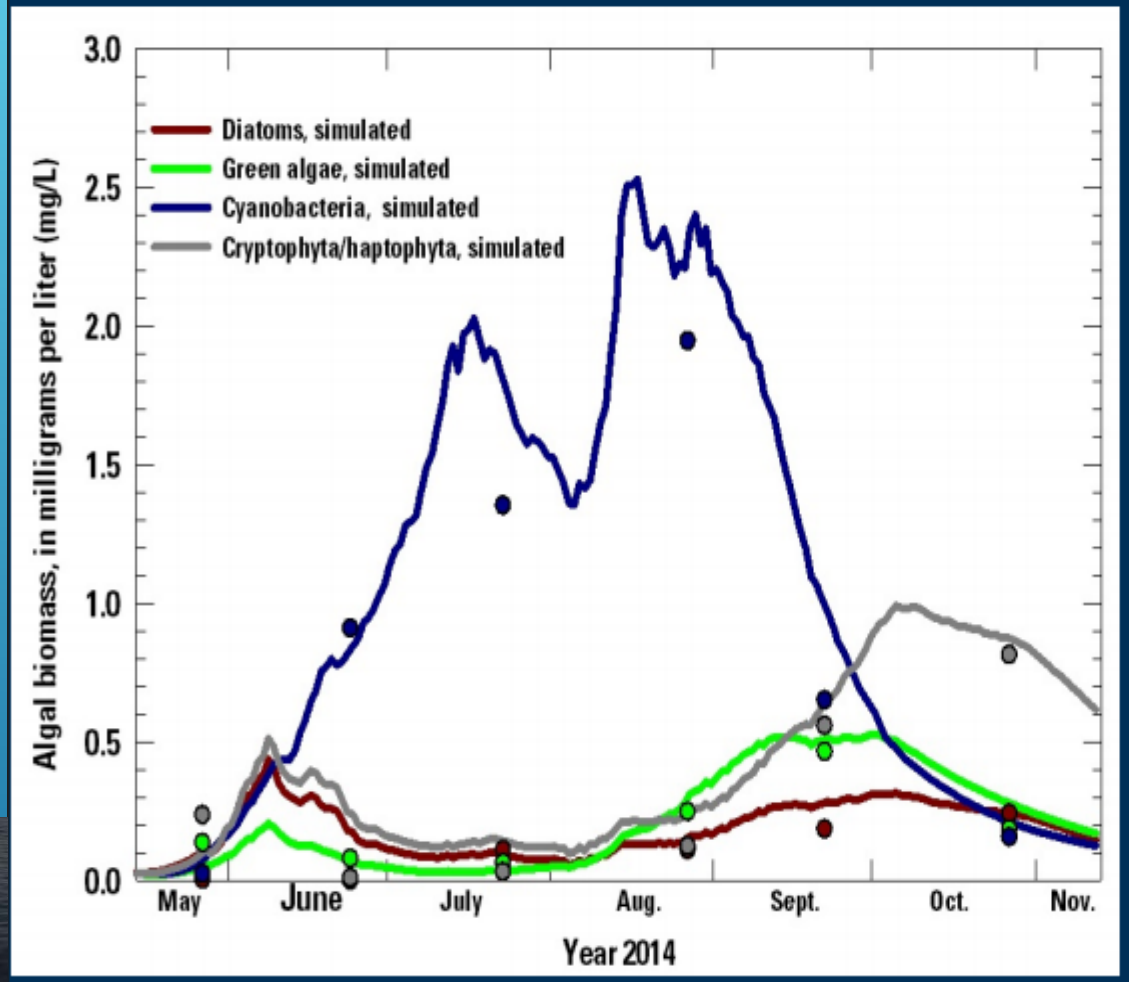
USGS
science for a changing world

Lake St. Croix and Madison Lake: Two Different Scales, Same Problem

Cyanobacteria



Pearl Lake Algal Biomass



- Very good correlation to different classifications
- Dominant classification: cyanobacteria
- (measured data: mostly *Microcystis aeroginosa*)
- Cryptophyta / haptophyta late in year

Erik Smith
Richard Kiesling

Upper Midwest Water Science Center (USGS) - Minnesota

USGS
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USGS

Why the rese

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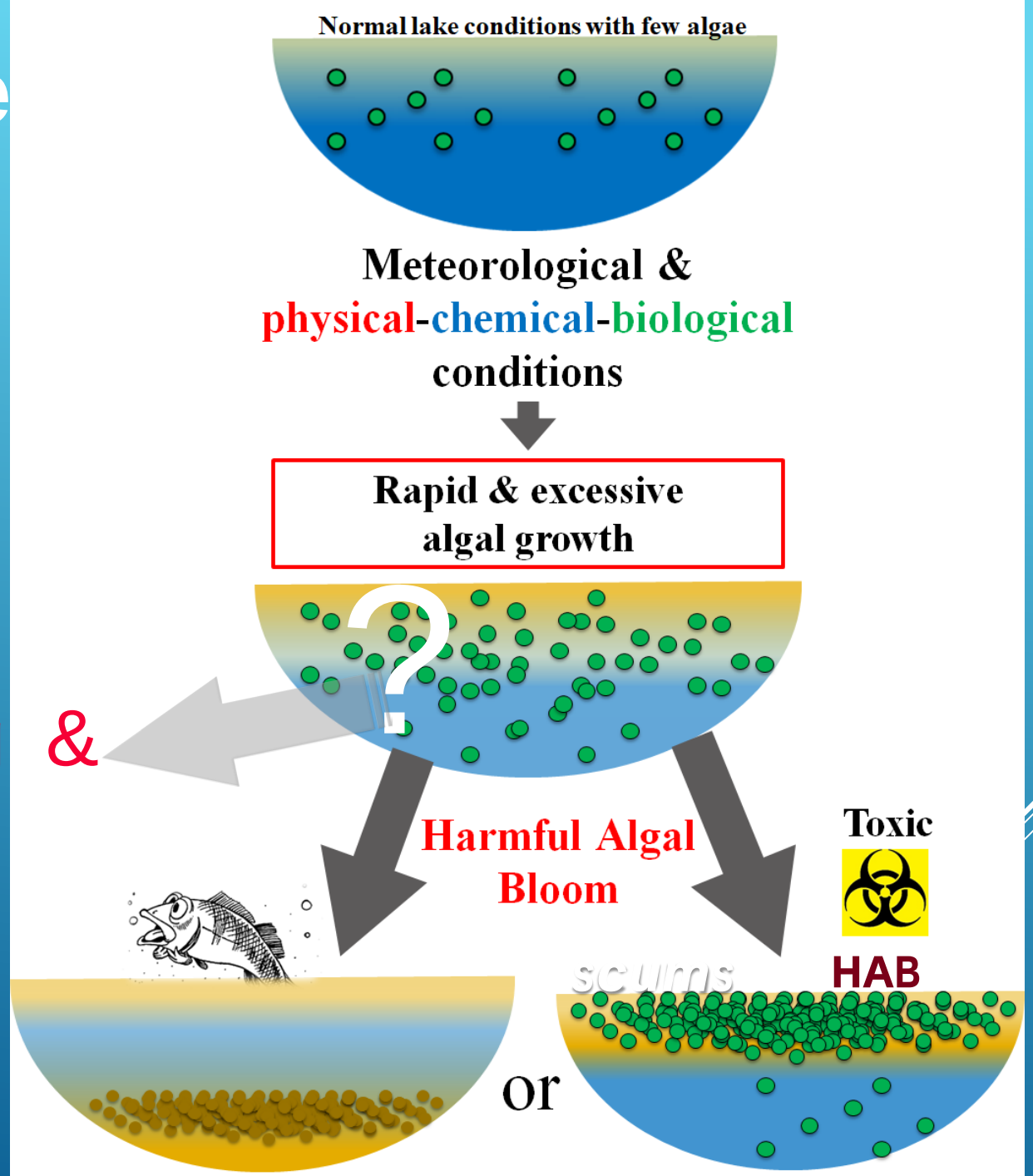
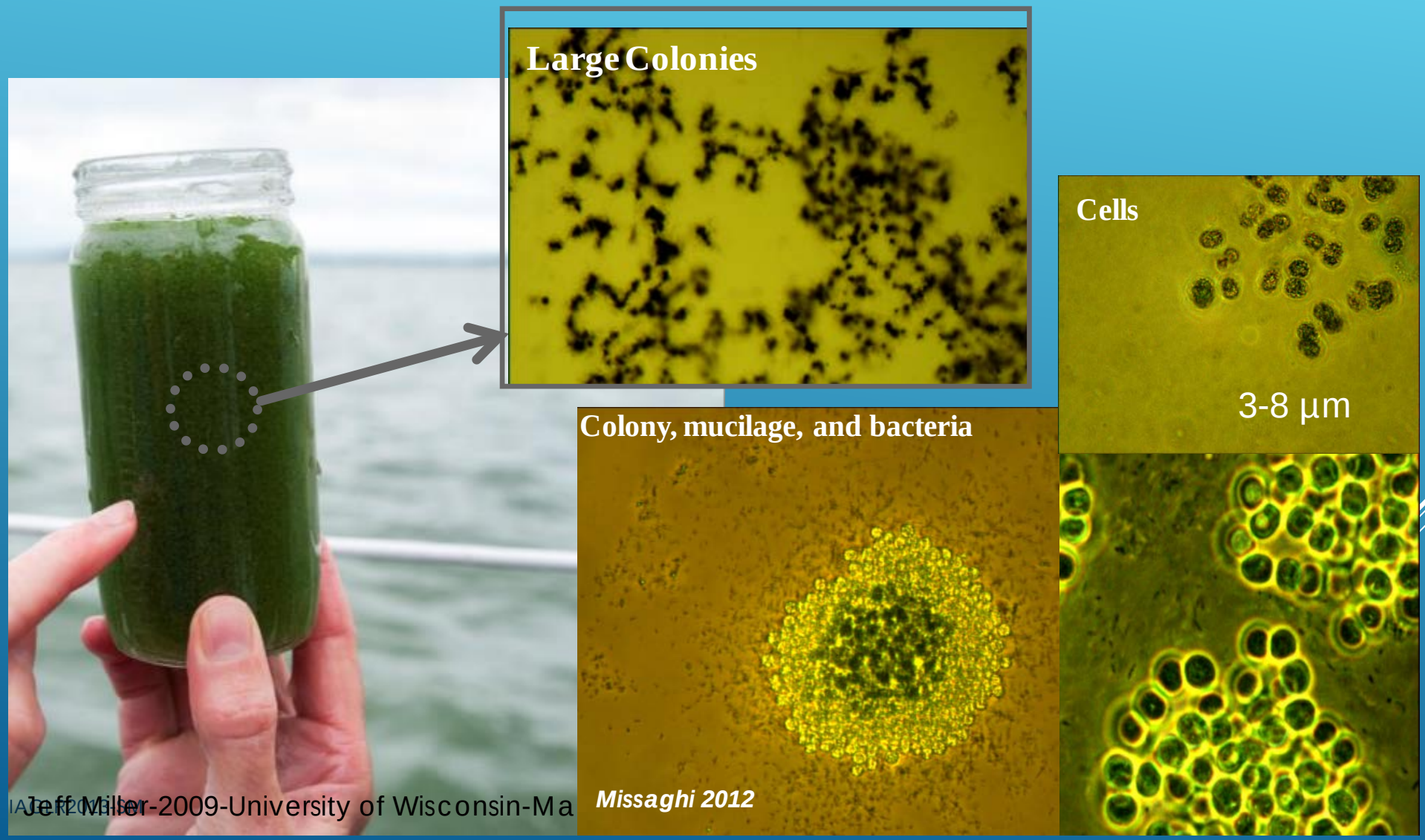


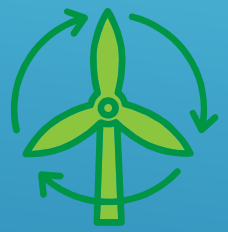
PHYLUM GENUS *SPECIES*

CYANOBACTERIA ***MICROCYSTIS*** *AERUGINOSA*

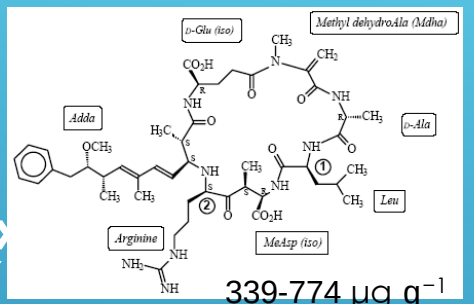


MICROCYSTIS - HARMFUL ALGAL BLOOM

Rapid growth ➔ blooms ➔ scums ➔ issues



~ > 3 ms^{-1} ~ < 2-3 ms^{-1} Tox



339-774 μg g^{-1}

Surface water

blooms

?

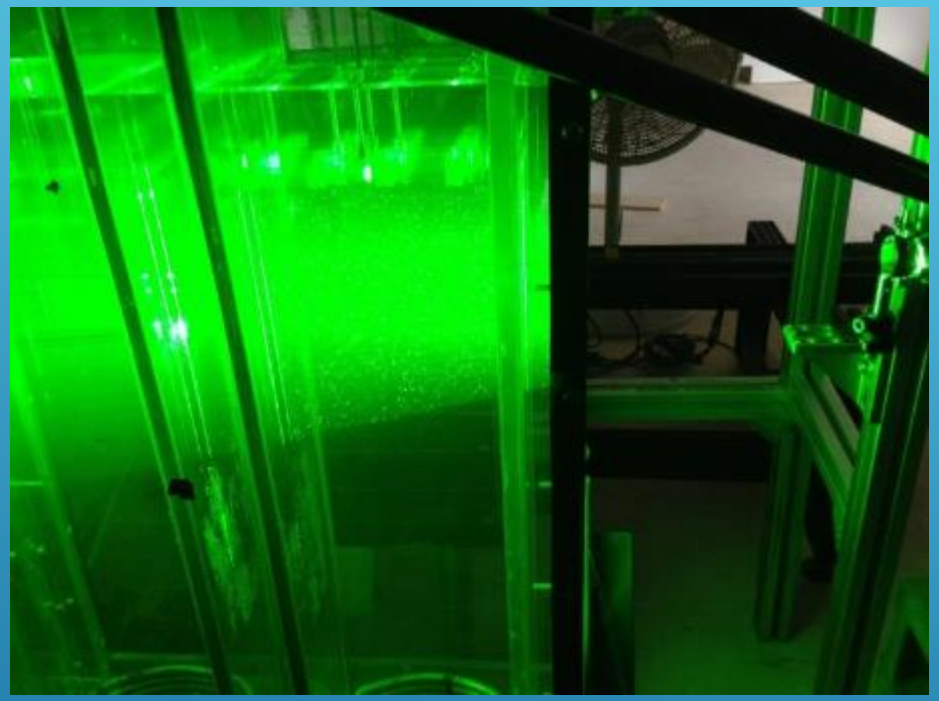
scums

Die-off

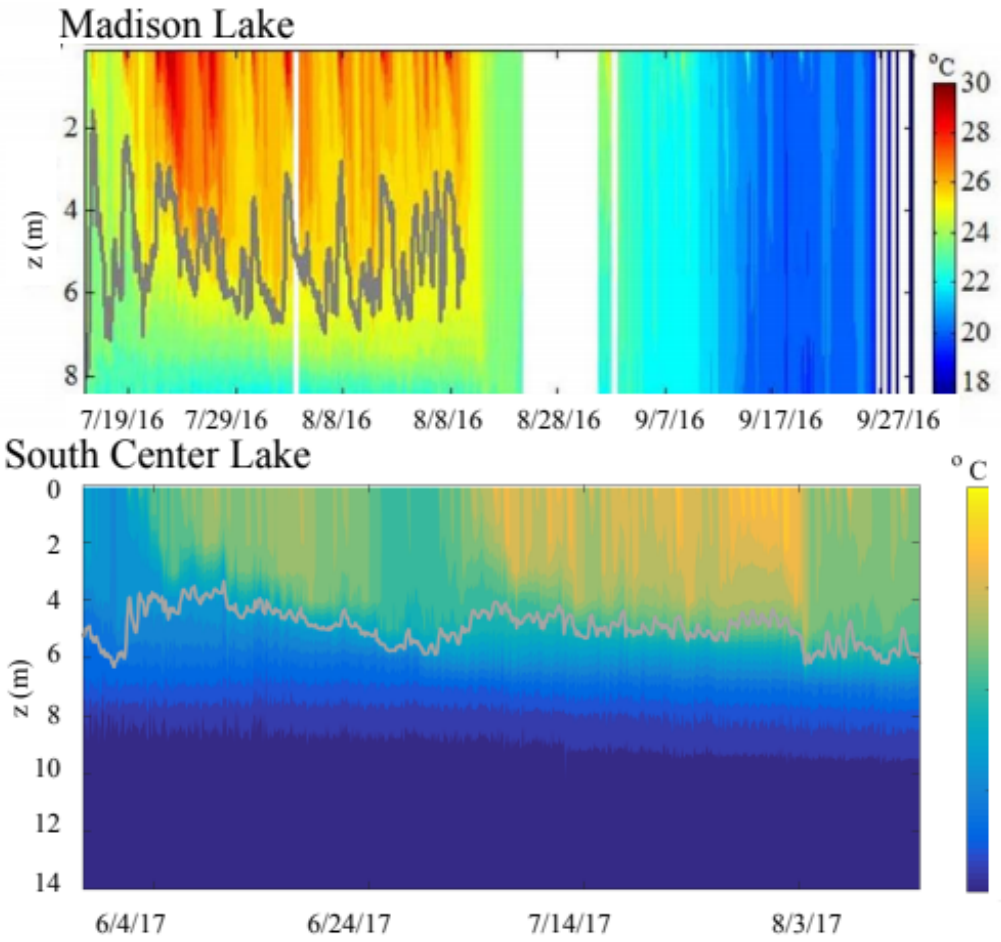
Decomposition depleting DO

sediment


Oscillating
Grid
x
z
Depth
a) Control
Column
b) Turbulent
Column
Plankton Tower



Lake Physical Lake Conditions



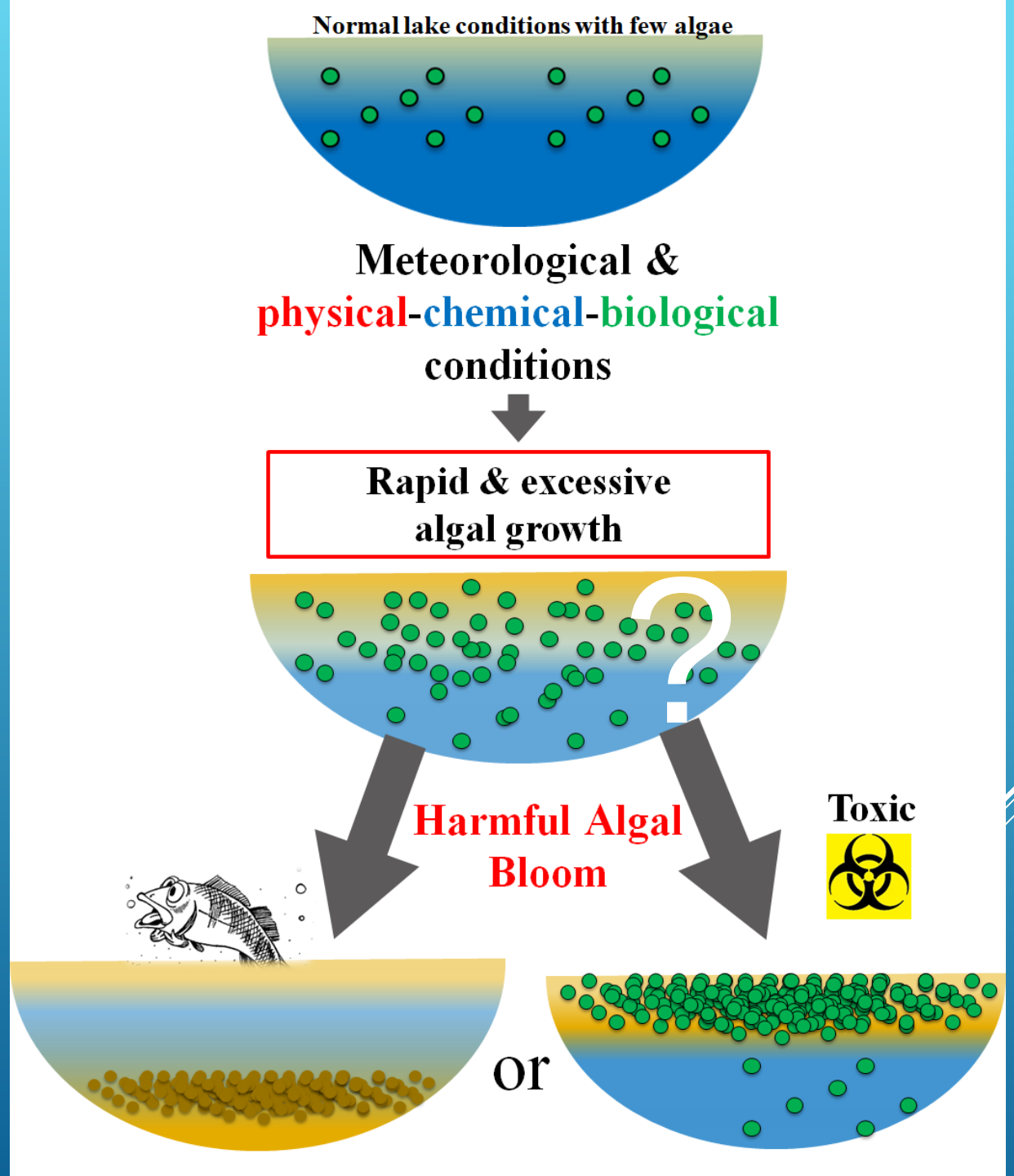
- The temperature is maximum in the surface layer during mid July and into August
- Madison Lake is warmer and the thermocline is less stable

We observe lake turnover in Madison Lake in mid August

Researchers: Anne Wilkinson & Jackie Taylor at SAFL

Solutions

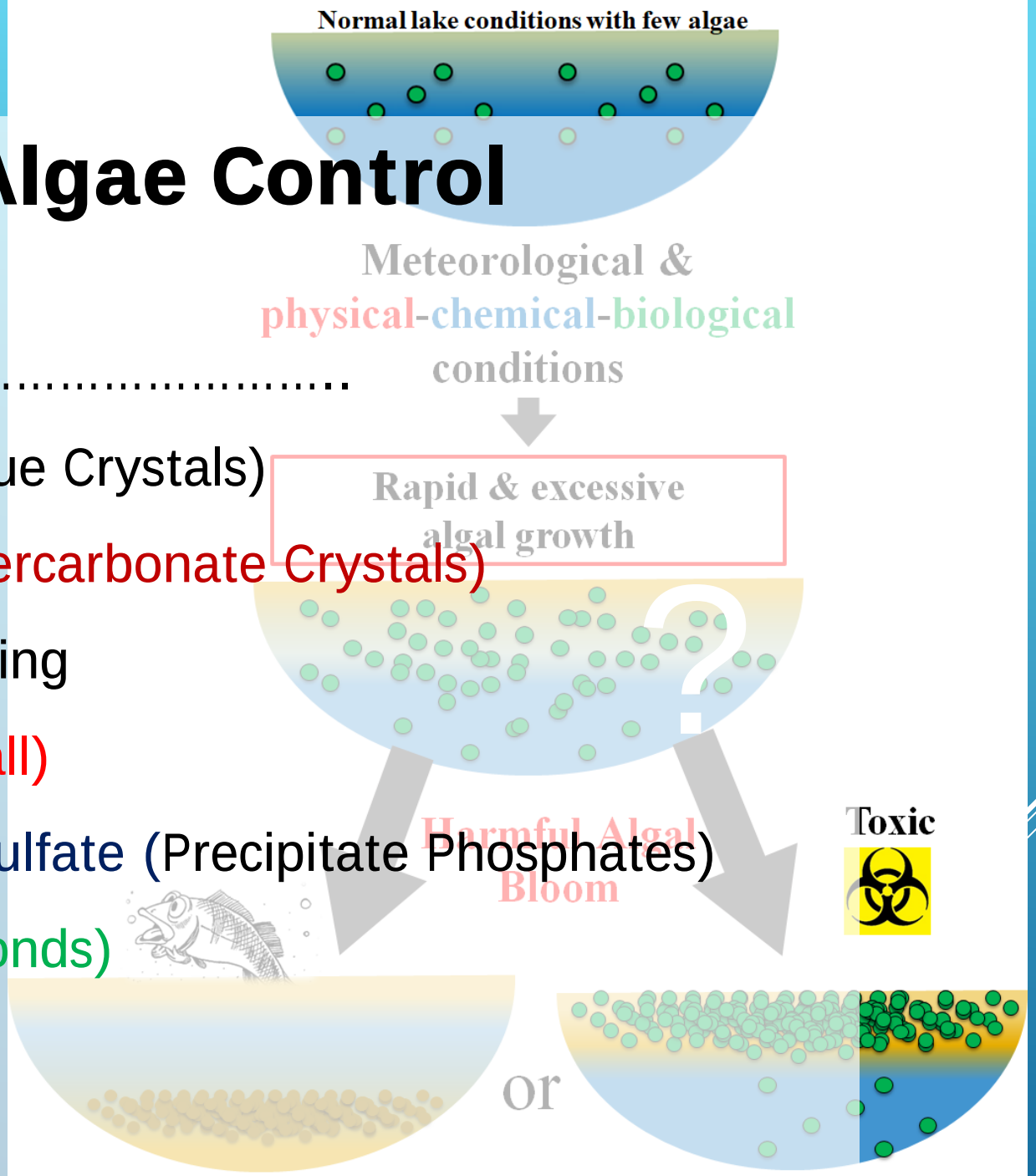
Solutions



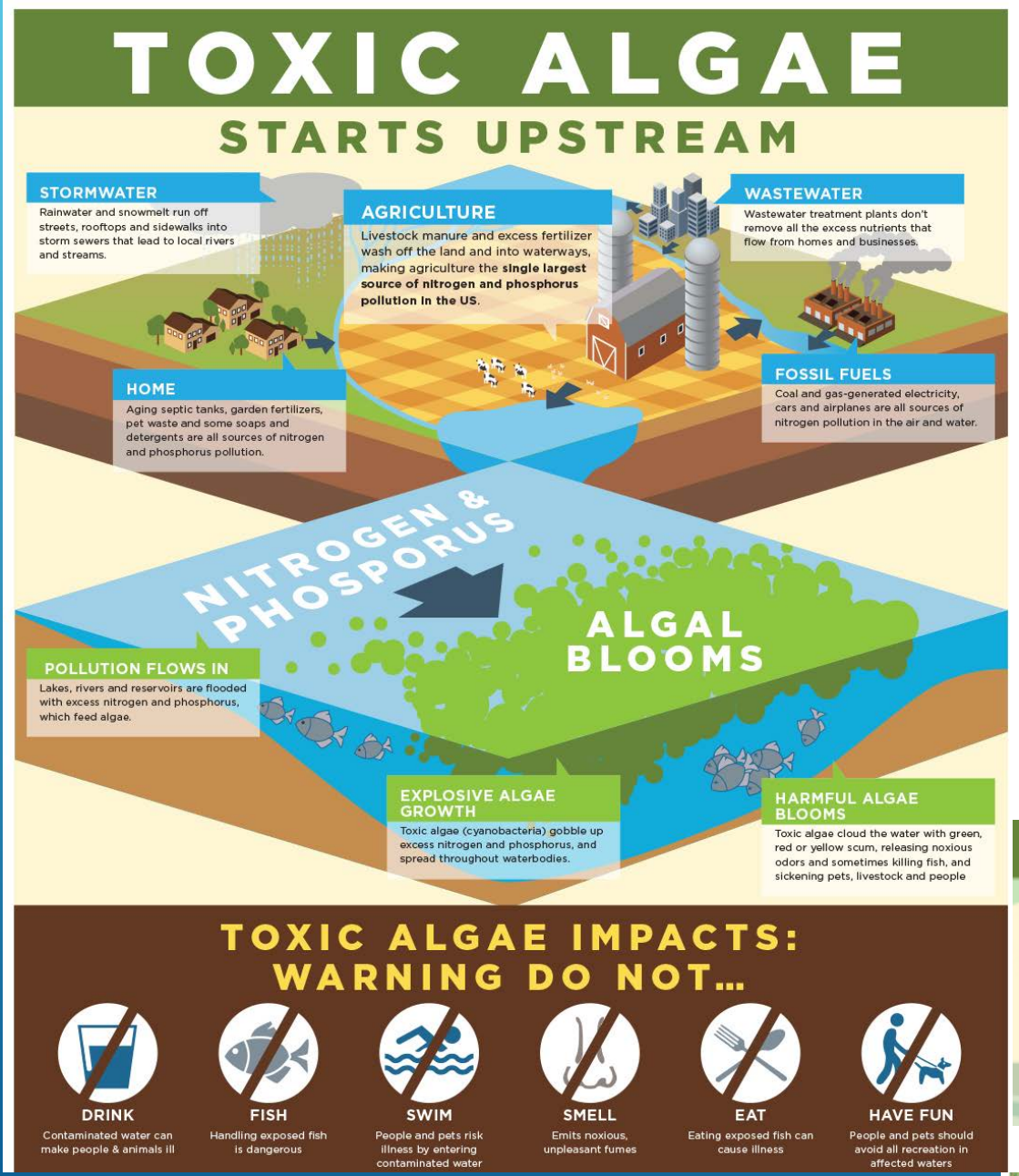
Solutions

Examples of Algae Control Methods

- ……
- **Copper Sulfate** (Blue Crystals)
- **Peroxide** (Sodium Percarbonate Crystals)
- **Pond Dyes** For Shading
- **Herbicides** (Endothall)
- **Alum** or Aluminum Sulfate (Precipitate Phosphates)
- Ultraviolet (smaller ponds)
- **barley straw**,
- …….



Solutions



WETLAND CONSERVATION

Solutions

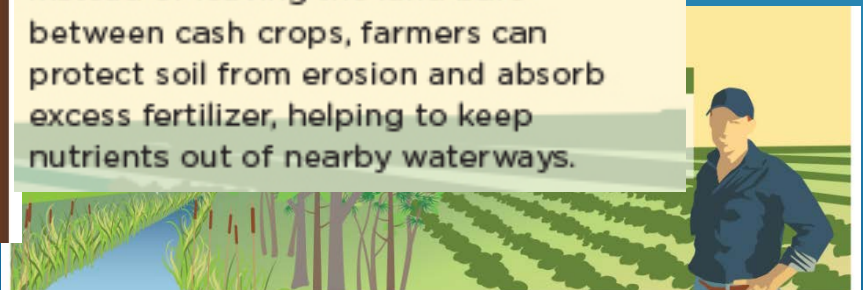
Protecting wetlands from development and agriculture can maintain a healthy environment for fish, wildlife & plants, and make it harder for toxic algae to take hold.

AQUATIC BUFFERS

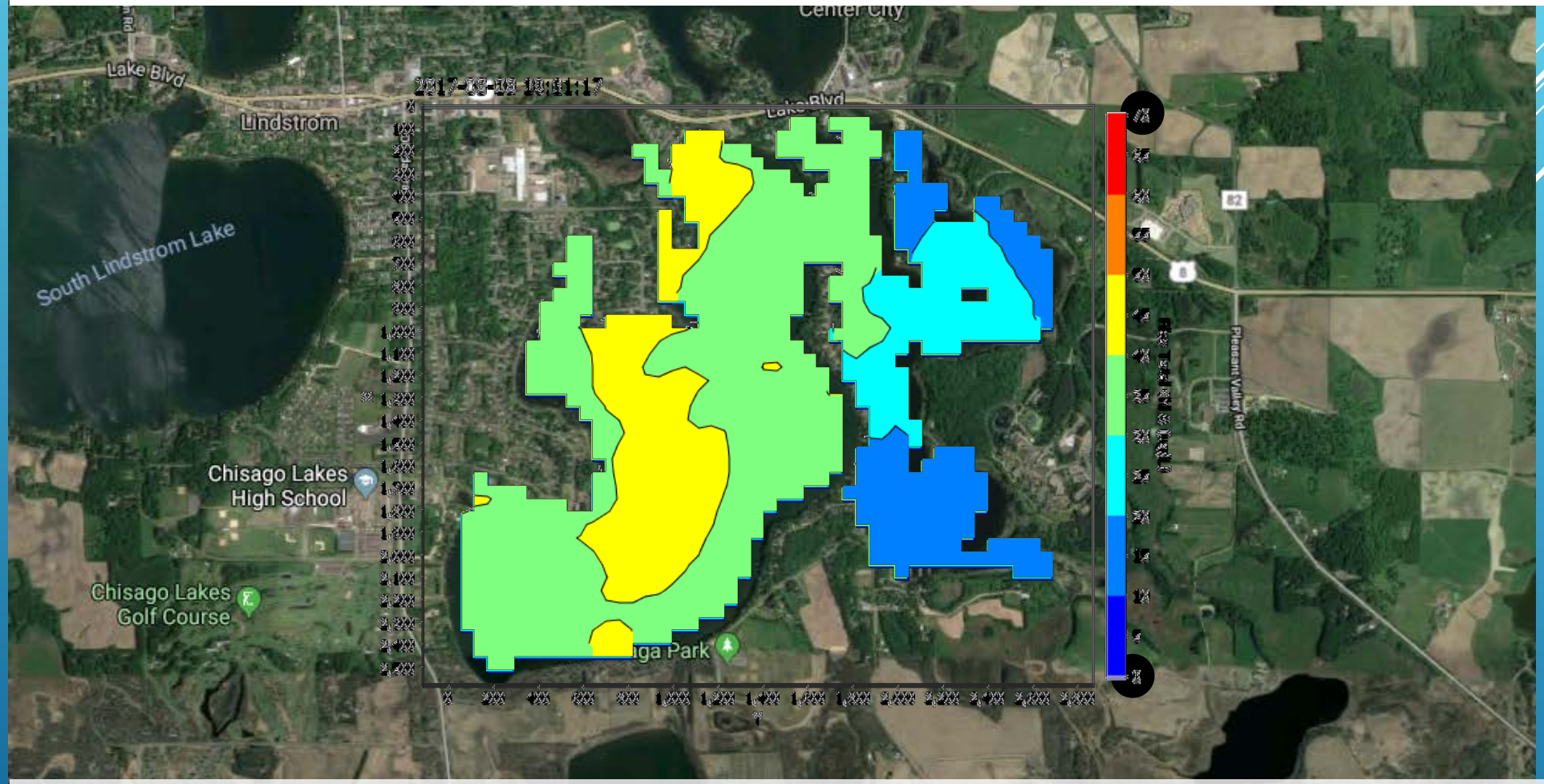
Creating and maintaining natural buffers – using trees, shrubs and other plants - between farmland, development and waterways can help filter out excess nitrogen and phosphorus before they reach the water.

COVER CROPS

By planting farmland with cover crops instead of leaving the land bare between cash crops, farmers can protect soil from erosion and absorb excess fertilizer, helping to keep nutrients out of nearby waterways.



Ultimately: to be ready for (prediction) HABs



Then we can measure associated health & economical costs


WATER WARNING
AVOID CONTACT WITH THE WATER
This water contains a blue-green algal bloom that can be harmful to humans and pets.
For your safety:
• Do not swim, waterski, or tube in the water
• Avoid swallowing water
• Stay away from areas of scum when boating

HARMFUL ALGAL BLOOMS

Potential Water Quality Challenges

Harmful Algal Bloom Research

THANK YOU

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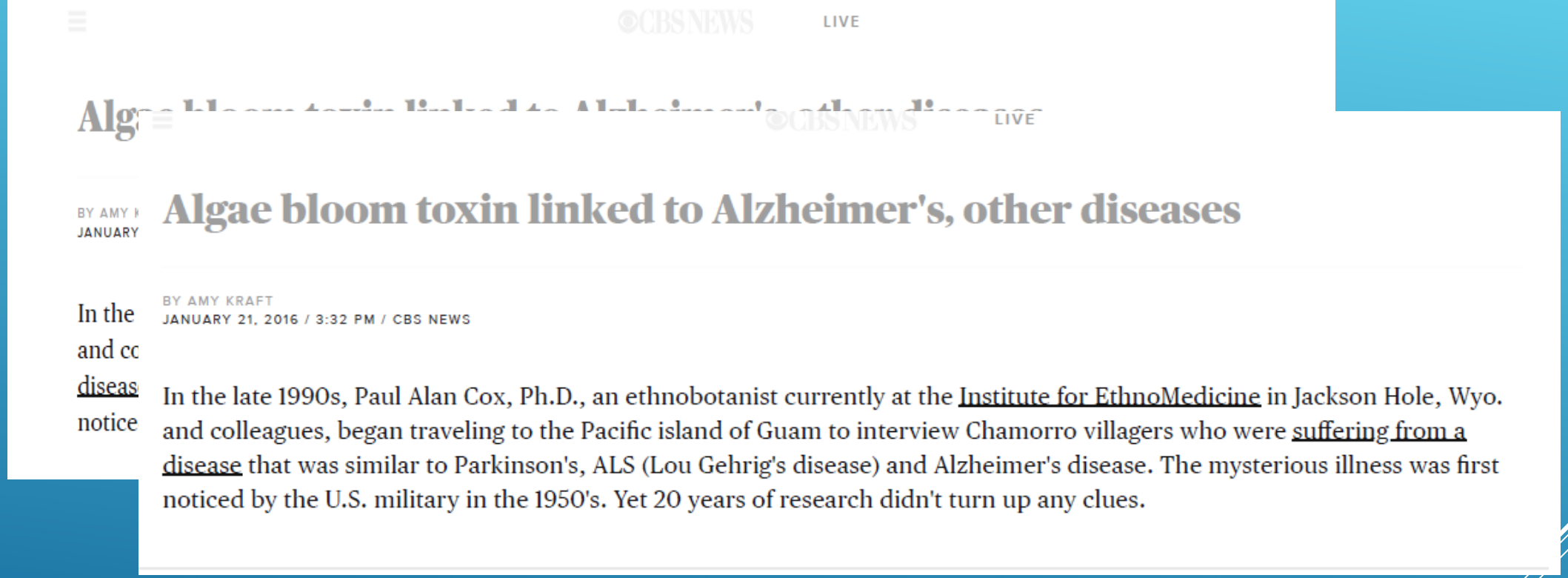
Water Resources Team
University of Minnesota Extension
Extension; 4100 220th Street W.
Farmington, MN 55024-

Ramsey County
Monday, March 18, 2019 | 4:00 p.m. - 6:00 p.m.


LIVE
LIVE
Algae bloom toxin linked to Alzheimer's, other diseases
BY AMY KRAFT
JANUARY 21, 2016 / 3:32 PM / CBS NEWS
In the late 1990s, Paul Alan Cox, Ph.D., an ethnobotanist currently at the Institute for EthnoMedicine in Jackson Hole, Wyo. and colleagues, began traveling to the Pacific island of Guam to interview Chamorro villagers who were suffering from a disease that was similar to Parkinson's, ALS (Lou Gehrig's disease) and Alzheimer's disease. The mysterious illness was first noticed by the U.S. military in the 1950's. Yet 20 years of research didn't turn up any clues.

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CBS NEWS LIVE

Algae bloom toxin linked to Alzheimer's, other diseases

BY AMY KRAFT
JANUARY 21, 2016 / 3:32 PM / CBS NEWS

In the late 199
and colleague
disease that w
noticed by the

Harmful Algae 54 (2016) 194–212

Contents lists available at ScienceDirect

Harmful Algae

journal homepage: www.elsevier.com/locate/hal

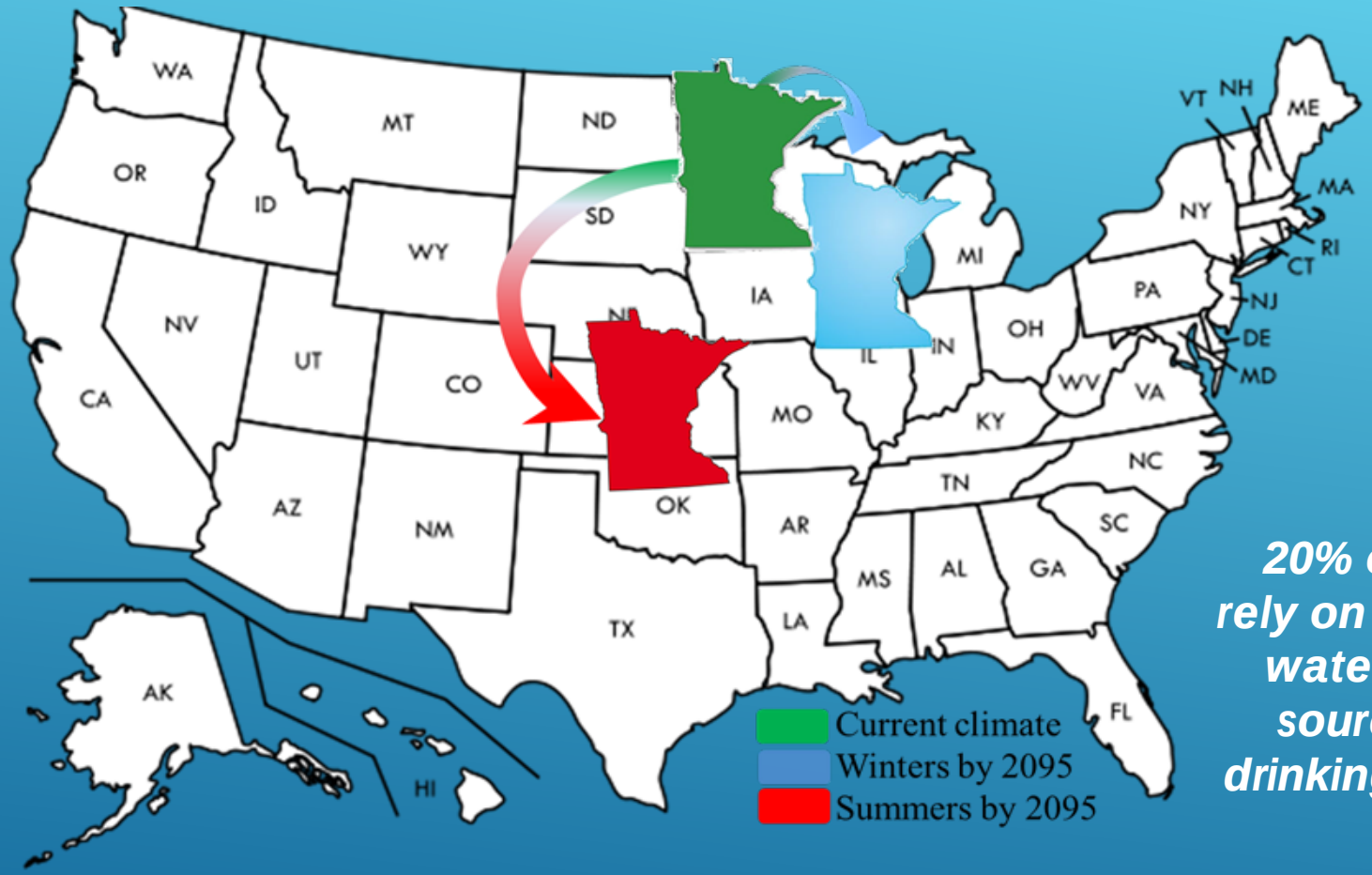
Review

Health impacts from cyanobacteria harmful algae blooms: Implications for the North American Great Lakes

Wayne W. Carmichael [a,*], Gregory L. Boyer [b]

[a] Department of Biological Sciences, Wright State University, Dayton, OH 45435, USA
[b] Department of Chemistry, State University of New York—College of Environmental Science and Forestry, Syracuse, NY 13210, USA

Why does it matter?



20% of MN rely on surface water as a source of drinking water

Motivation: **Mobilizing MN communities to fight HABs & become resilient**

“Annie, Fannie, and Mike”

Blue Greens

- Unicellular, (non-N_2 fixing) *Microcystis**, *Gomphosphaeria*

Mike

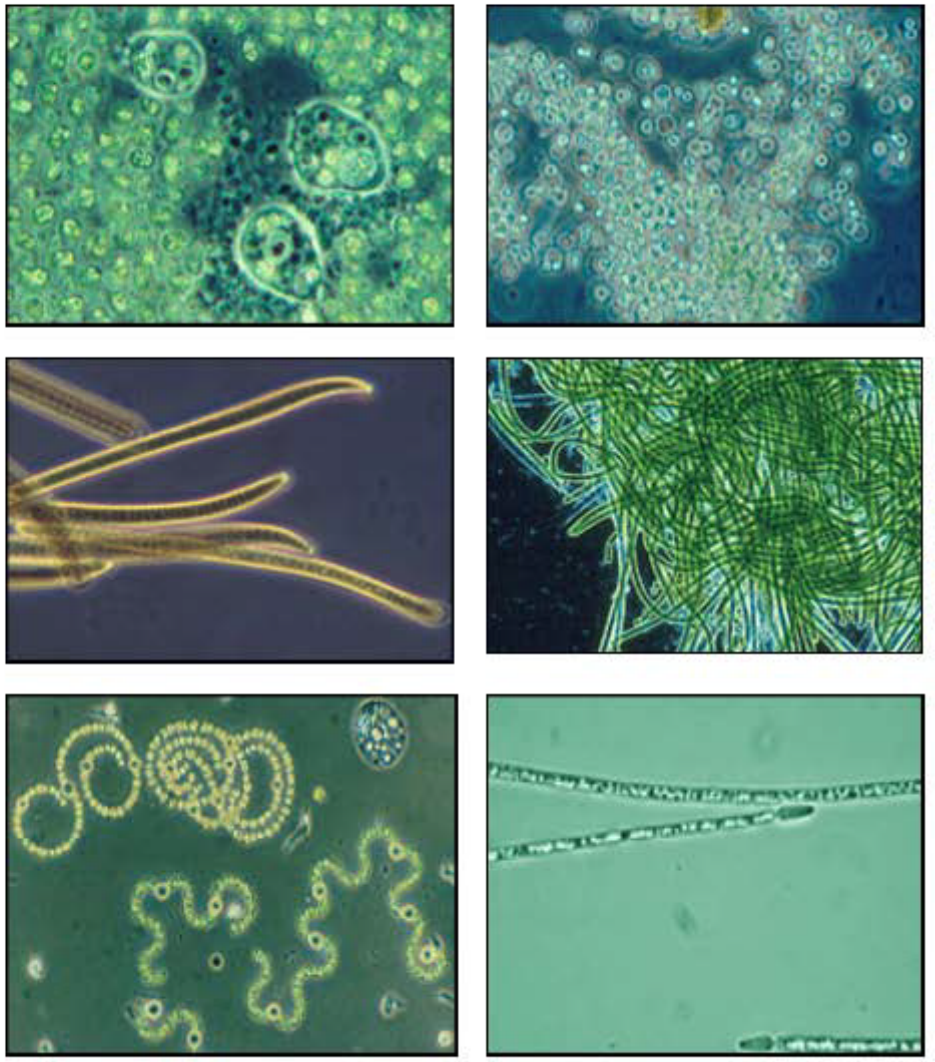
- Filamentous, non-heterocystous (mostly non-N_2 fixing) *Lyngbya**, *Oscillatoria**

Annie

- Filamentous, heterocystous (N_2 fixing) *Anabaena**, *Aphanizomenon**, *Cylindrospermopsis**, *Nodularia**

Fannie

* Contains Toxic strains



Hans Paerl, UNC

Solutions

Examples of Algae Control Methods

- .....
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- Ultraviolet (smaller ponds)
- **barley straw**,
- .....

What we know:
The problem

Toxins produced by freshwater planktonic cyanobacteria

Toxin type	Primary organ affected	Produced
microcystins	liver	*Microcystis* *Anabaena* *Oscillatoria*
anatoxins	nervous	*Anabaena* *Aphanizomenon* *Oscillatoria*
saxitoxins	nervous system	*Anabaena* *Aphanizomenon* *Cylindrospermopsis*
cylindrospermopsins	liver	*Cylindrospermopsis* *Aphanizomenon*
LPS	skin irritant	

Plankton
(floating)

ZooPlankton
(heterotroph)

PhytoPlankton
Planktonic algae
(autotroph; primary producers)

(bacteria) Blue-green algae
(not very tasty to Zoos - HAB)

other algae .....

What we know:
The problem

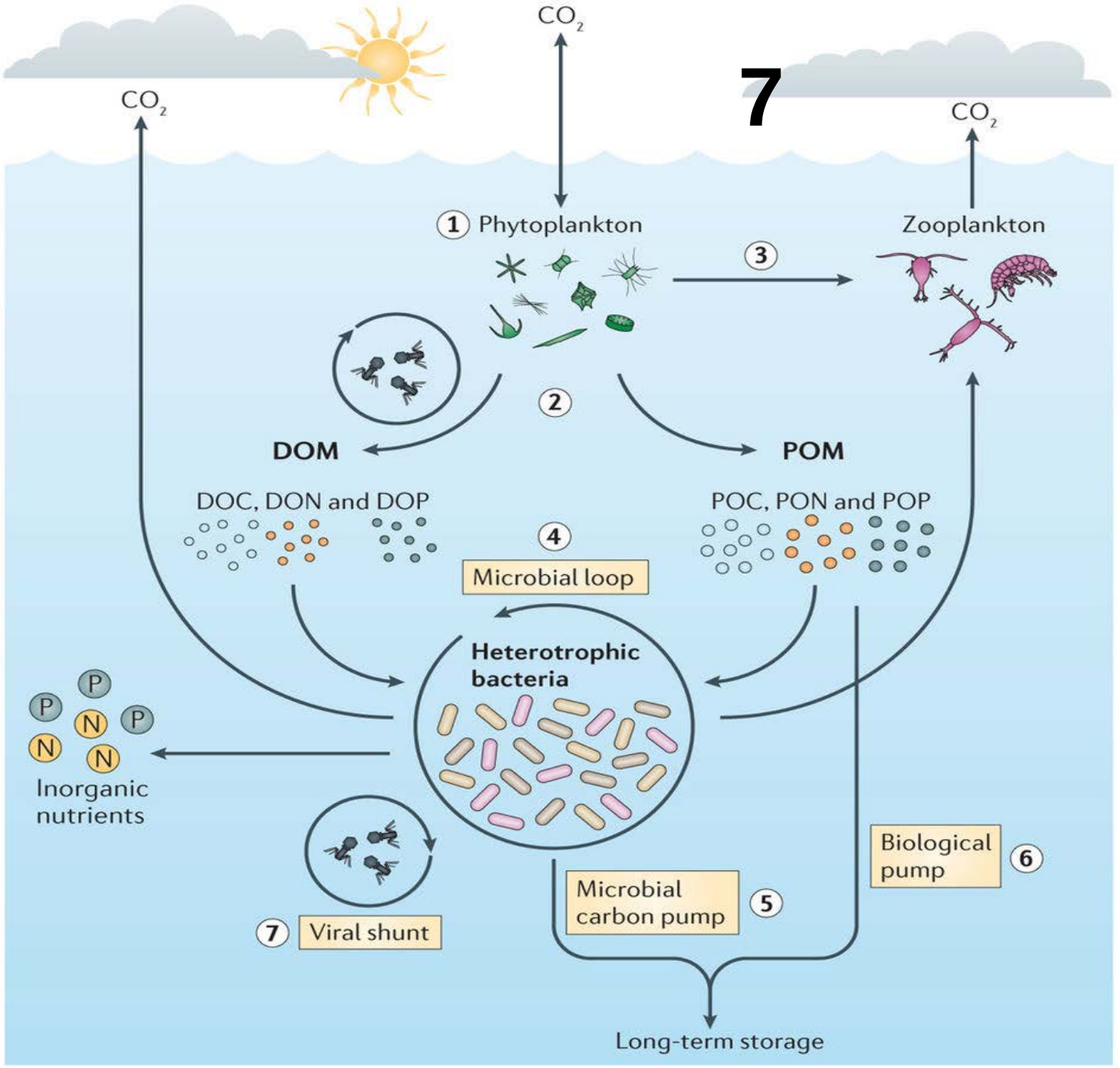
Relative Probability of Acute Health Effects	Cyanobacteria (cells/mL)	Microcystin-LR (µg/L)	Chlorophyll-a (µg/L)
Low	< 20,000	<10	<10
Moderate	20,000-100,000	10-20	10-50
High	100,000-10,000,000	20-2,000	50-5,000
Very High	> 10,000,000	>2,000	>5,000

https://www.epa.gov/nutrient-policy-data/guidelines-and-recommendations#what3

Microcystis - Harmful Algae Bloom

TOXIN	ACUTE EFFECT	SYMPTOMS
Anatoxin-a	Neurotoxicity	Not documented
Anatoxin-a (s)	Neurotoxicity	Not documented
Cylindrospermopsin	Hepatotoxicity, renal toxicity, chromosome breakage, aneuploidy	Enlarged liver, malaise, anorexia, vomiting, headache.
Microcystin	Hepatotoxicity	Paresthesia and numbness of lips and mouth within ½ to 3 hours after exposure, extending to face, neck, extremities; motor weakness; incoordination; respiratory and muscular paralysis.

Altering the Microbial loop



WATER QUALITY IN RAMSEY COUNTY

John Manske

Environmental Services, Lake Management

RAMSEY COUNTY

Working with you to enhance our quality of life

RAMSEY COUNTY LAKE MANAGEMENT SUMMER MONITORING PROGRAM

- 30 lakes sampled at deepest point
- Sampled 8 times between May 1st – September 30th
- Depth profile taken with sonde (DO, Temp, Cond, pH)
- Samples taken for in-house laboratory analysis
- 17 total parameters measured
- Aquatic vegetation monitoring
- AIS monitoring
- HAB risk assessment

HARMFUL ALGAL BLOOM RISK ASSESSMENT

- Based on the research of Steve Heiskary Et al. from the MPCA (5)
- pH > 9.0
- Secchi < 0.5 m
- Cyanobacteria Concentration > 100,000 cells/mL
- Chl A Concentration > 50mg/m^3

RAMSEY COUNTY LAKE MANAGEMENT LABORATORY

Phosphorus (All forms)

Nitrogen (All forms)

Chloride

Chlorophyll A

Turbidity

Phytoplankton

Zooplankton

Zebra Mussel Veliger

Total Hardness

Total Alkalinity

Total Nonfilterable Residue

Volatile Nonfilterable Residue

E. coli

eDNA

LAKE	2018	2017	2016	2015	2014	2013	2012
BALD EAGLE	B	A	A	B	C	C	C
BEAVER	C	B	B	B	B	B	B
BENNETT	C	C	C	C	C	D	D
COMO	D	D	D	D	D	D	D
CROSBY	C	C	C	C	D	C	C
GERVAIS	B	B	B	B	C	C	C
ISLAND NORTH	C	C	C	C	B	B	N/A
ISLAND SOUTH	C	B	B	B	B	B	B
JOHANNA	B	B	B	A	B	B	B
JOSEPHINE	C	B	B	B	B	B	B
KELLER	B	B	B	B	C	B	C
KOHLMAN	C	B	B	B	C	C	C
LITTLE CROSBY	C	B	B	C	D	B	B
LOEB	A	A	A	B	B	A	A
LONG NORTH	D	D	D	D	D	D	D
LONG SOUTH	C	B	B	C	C	C	C
MCCARRON	A	A	A	A	B	A	A
OTTER	A	A	A	A	A	A	A
OWASSO	B	B	B	B	B	C	C
PHALEN	A	A	A	A	B	B	B
ROUND(NR PHALEN)	B	A	A	B	C	B	B
SILVER E	C	C	C	C	C	D	D
SILVER W	C	C	C	B	C	C	C
SNAIL	A	A	A	A	A	A	A
TURTLE	A	A	A	A	A	A	A
TWIN	B	B	B	B	C	B	B
WABASSO	A	A	A	A	A	A	A
WAKEFIELD	D	C	C	D	C	C	C
WHITE BEAR	A	A	A	A	A	A	A

April 16, 2018

By the Numbers at MSP

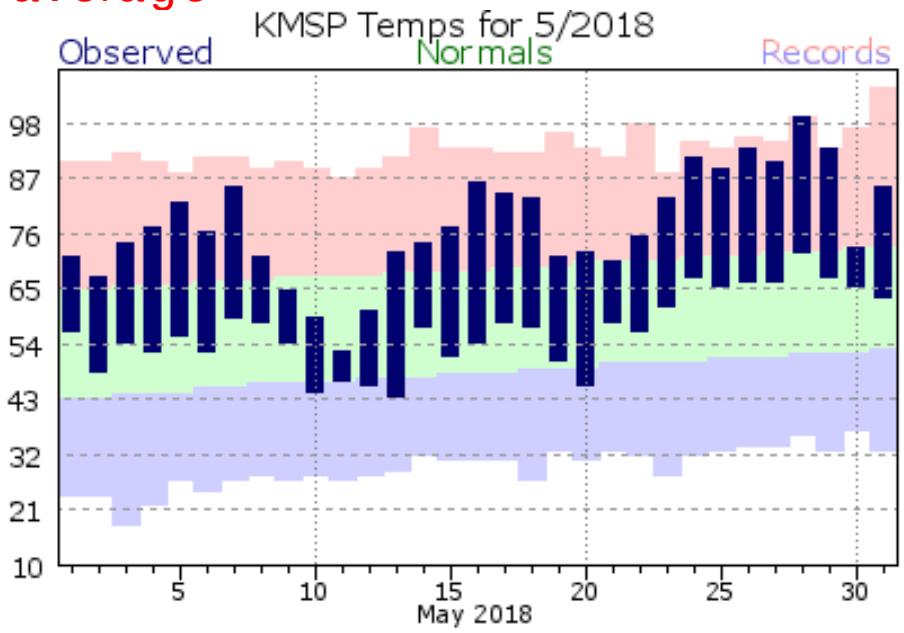
0	Number of days that have been above normal so far this April
15.8	Storm total snowfall at MSP
15.9	Monthly temperature departure below normal
26.1	April monthly snowfall at MSP, new record (21.8” 1983)
37.0	Today’s forecast high temperature
58.0	Today’s normal high temperature
78.3	Inches of snow so far this season

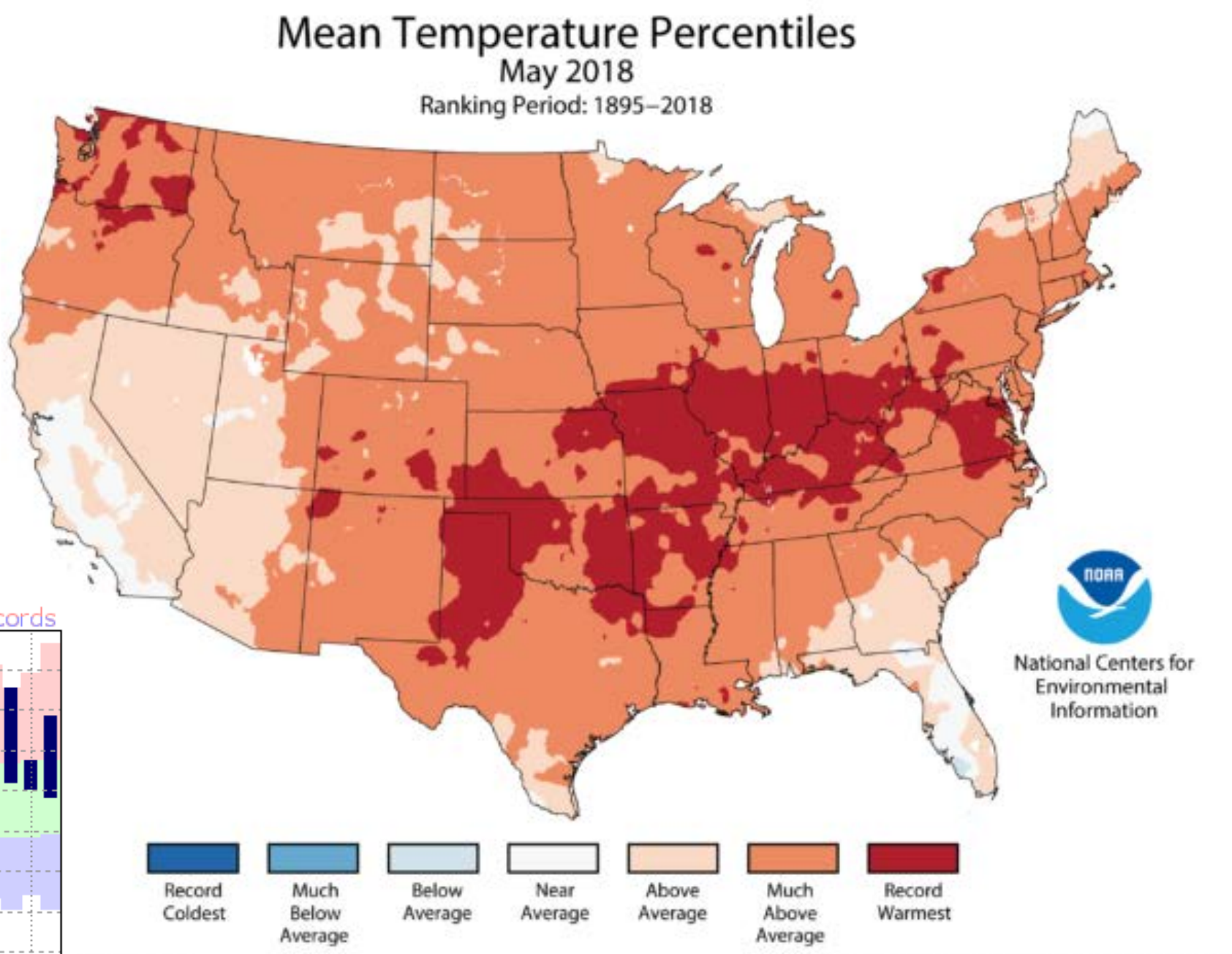
Created by NWS Twin Cities – April 16, 2018

Records set in May 2018

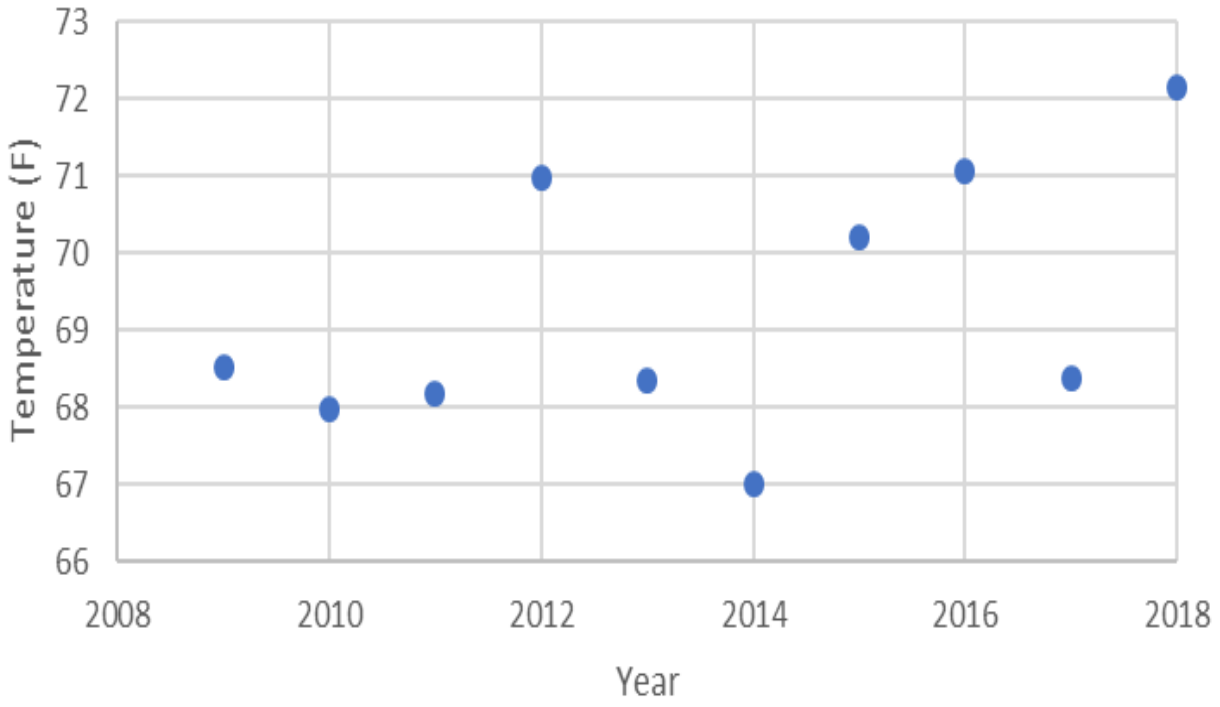
- Warmest Mean Temperature in USA
- 6 days above 90°F in the Twin Cities
- Earliest 100°F day in the Twin Cities (May 28th)

Twin Cities were 8.7°F above average

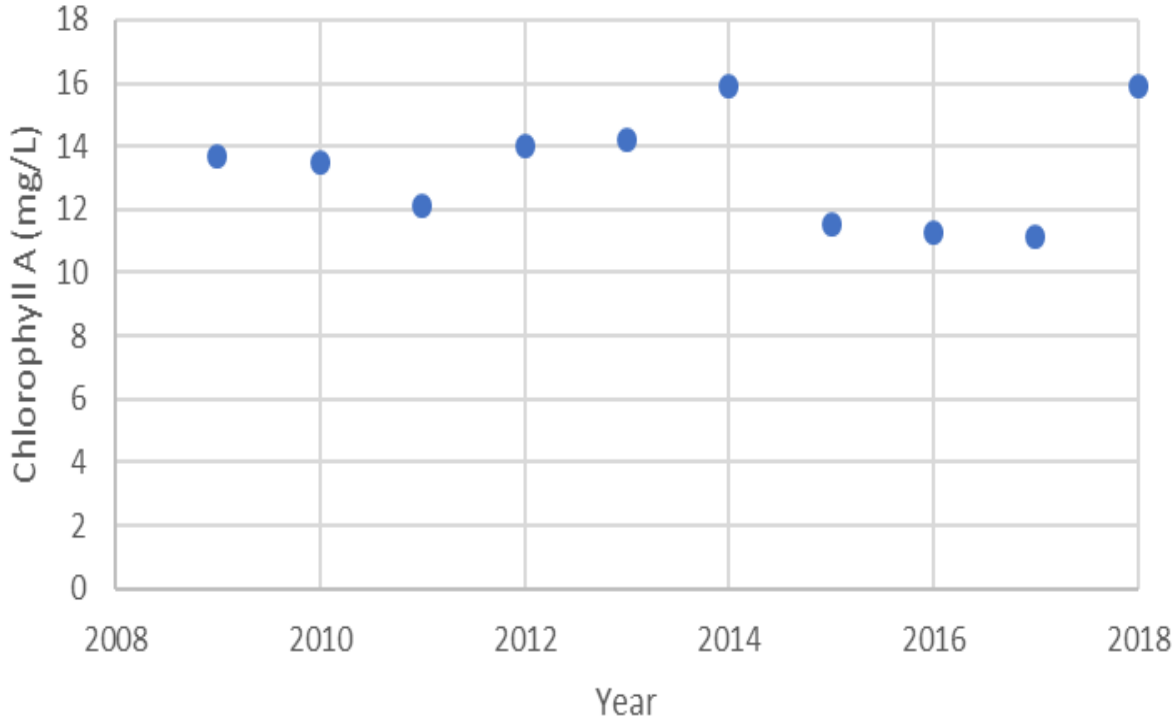


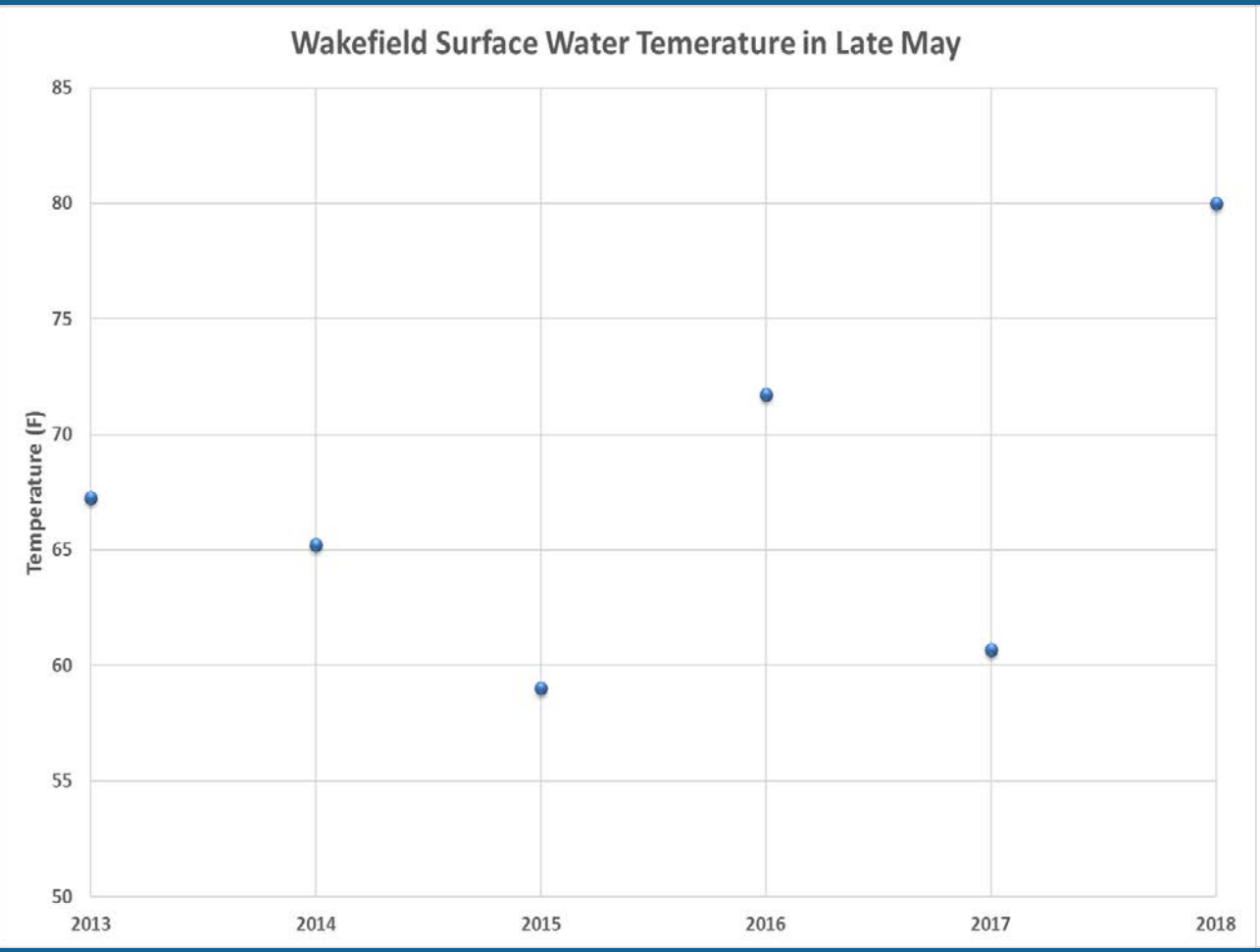


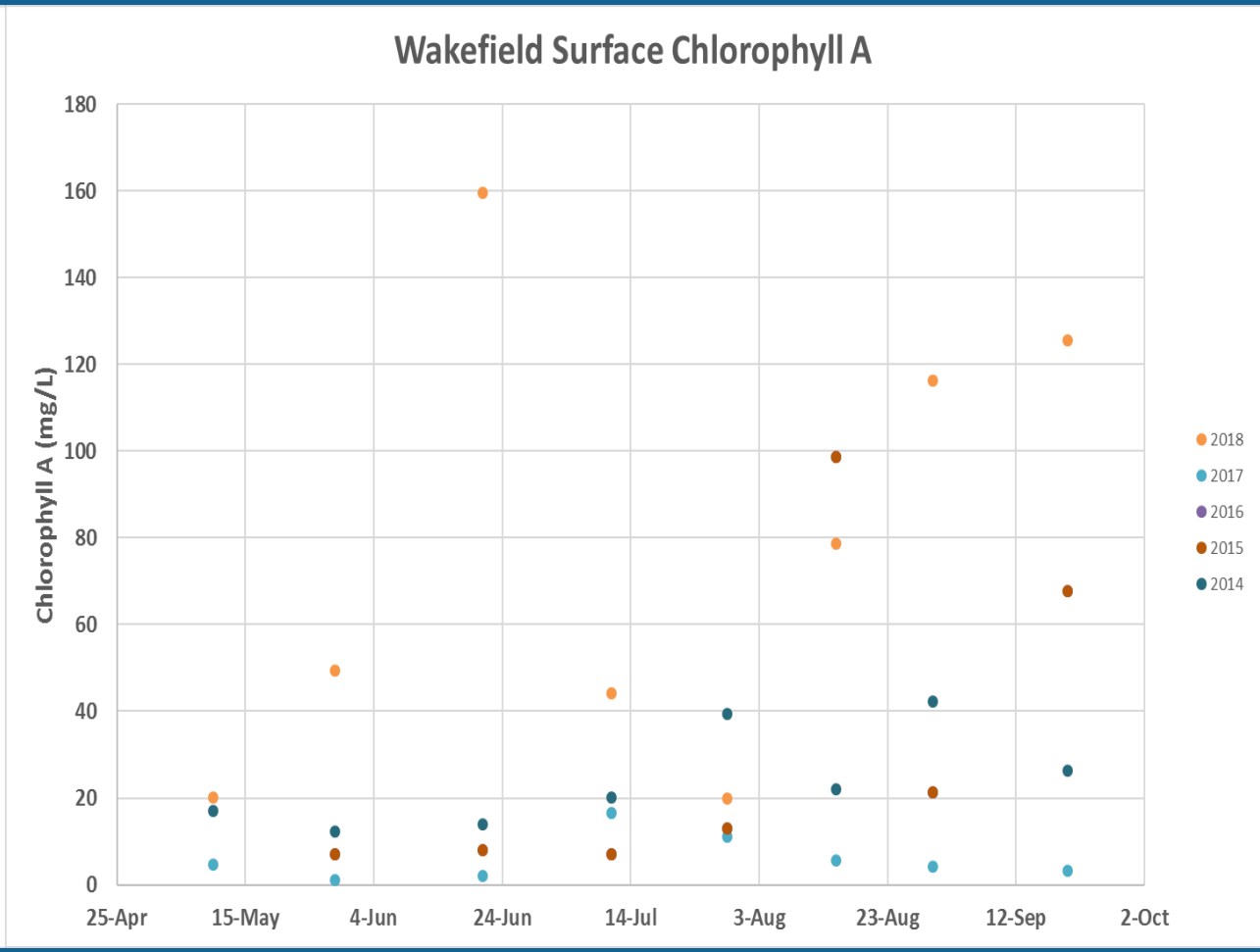
Average Temperature in the epilimnion of all Ramsey County lakes monitored May-Sept



Average Chlorophyll A in the epilimnion of all RC lakes May-Sept




Wakefield Surface Water Temerature in Late May
Temperature (F)
85
80
75
70
65
60
55
50
2013
2014
2015
2016
2017
2018


Wakefield Surface Chlorophyll A
Chlorophyll A (mg/L)
180
160
140
120
100
80
60
40
20
0
25-Apr
15-May
4-Jun
24-Jun
14-Jul
3-Aug
23-Aug
12-Sep
2-Oct
2018
2017
2016
2015
2014

BALD EAGLE ALUMINUM SULFATE TREATMENT

Project Engineer: Wenck Engineers • Scientists Business Professionals

Contractor: HAB AquaticSolutions

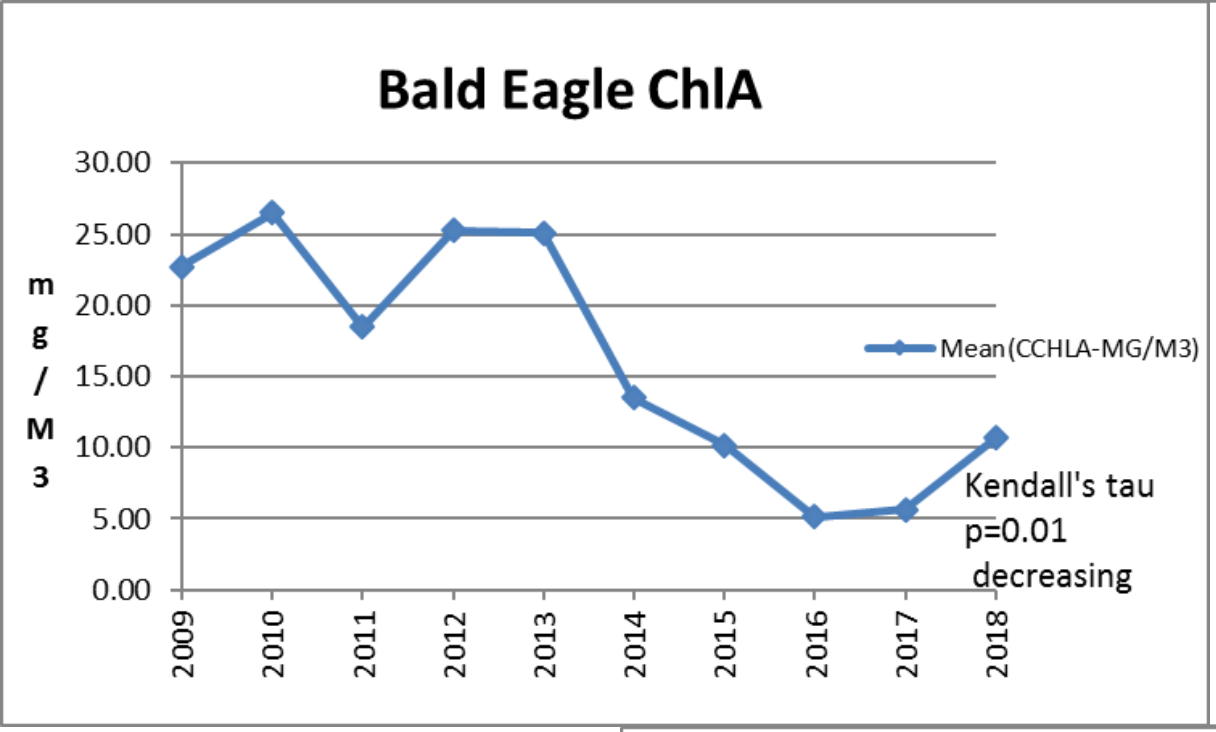
Treatment 1: 2014

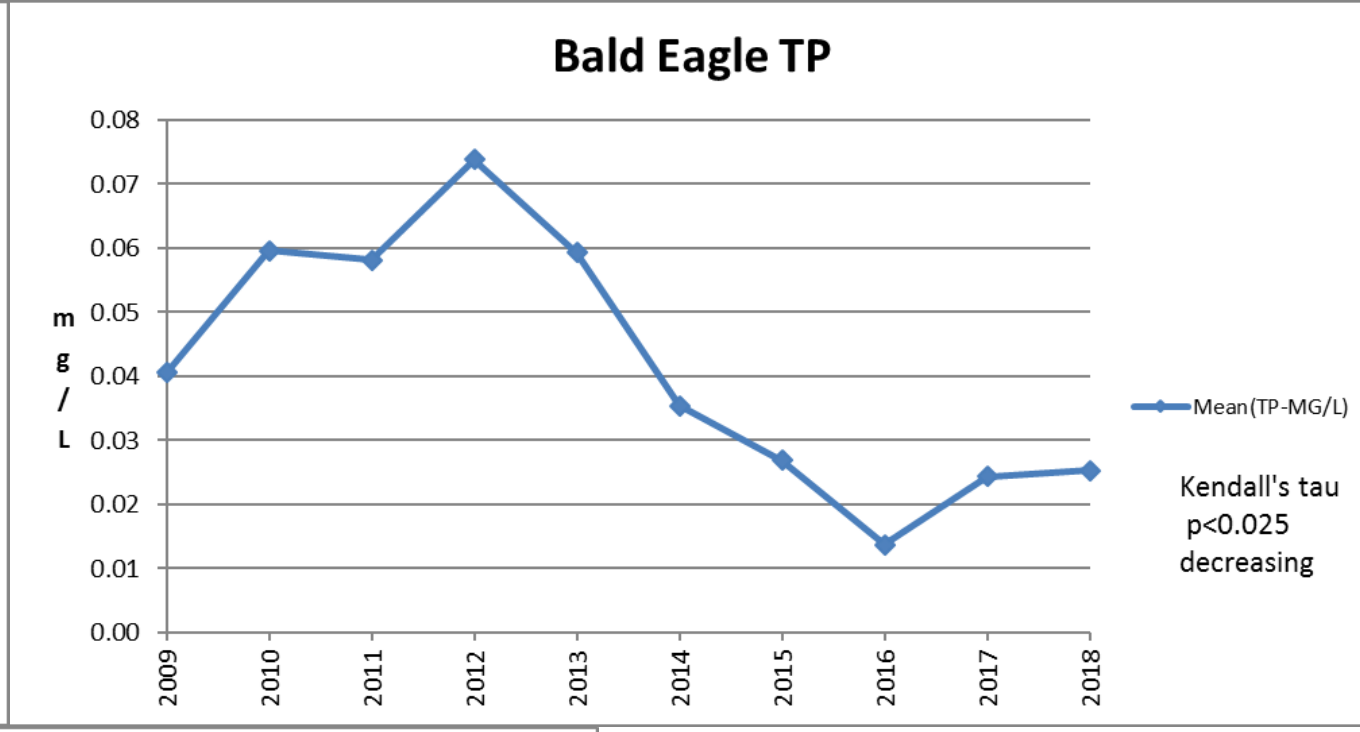
Treatment 2: 2016

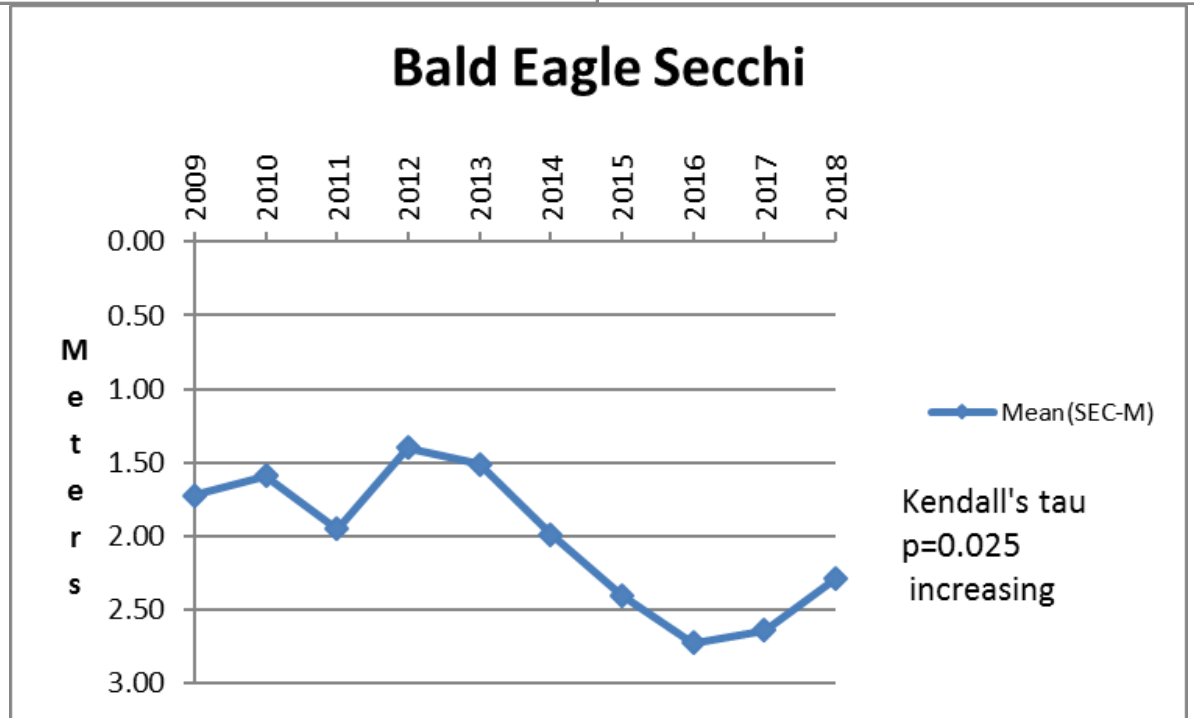
The largest alum treatment in MN

RCWD RICE CREEK WATERSHED DISTRICT

RCWD
RICE CREEK WATERSHED DISTRICT

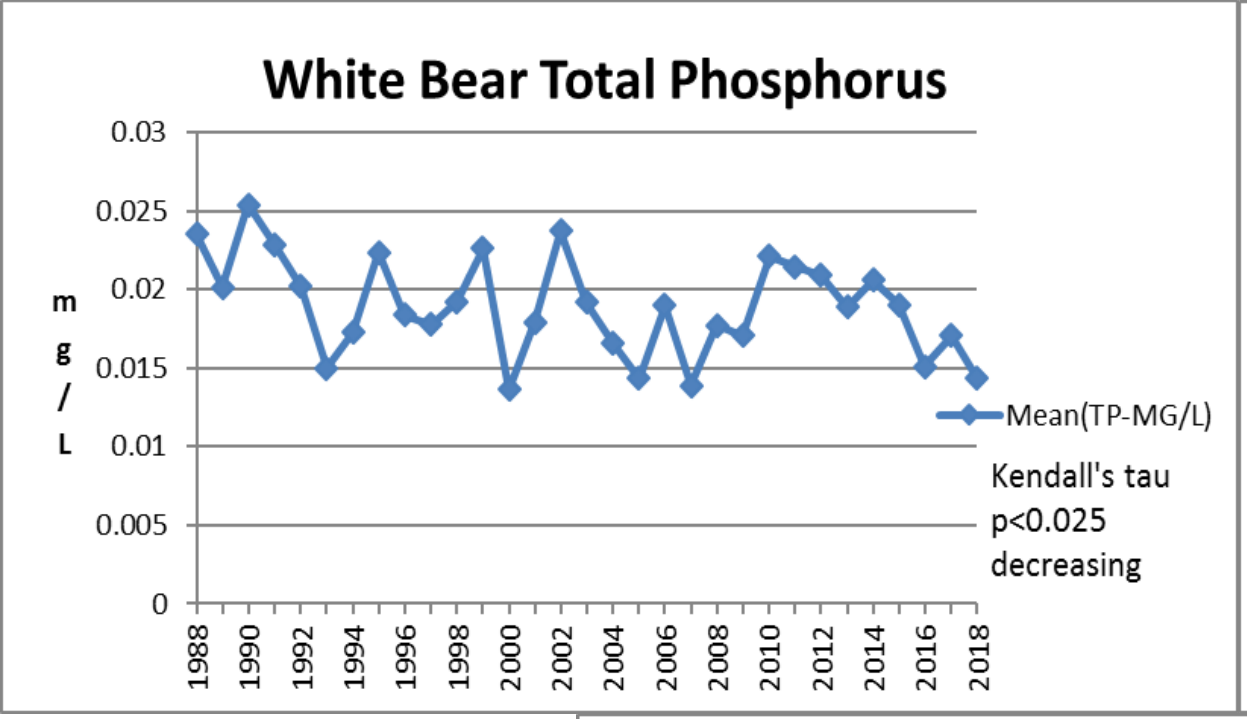


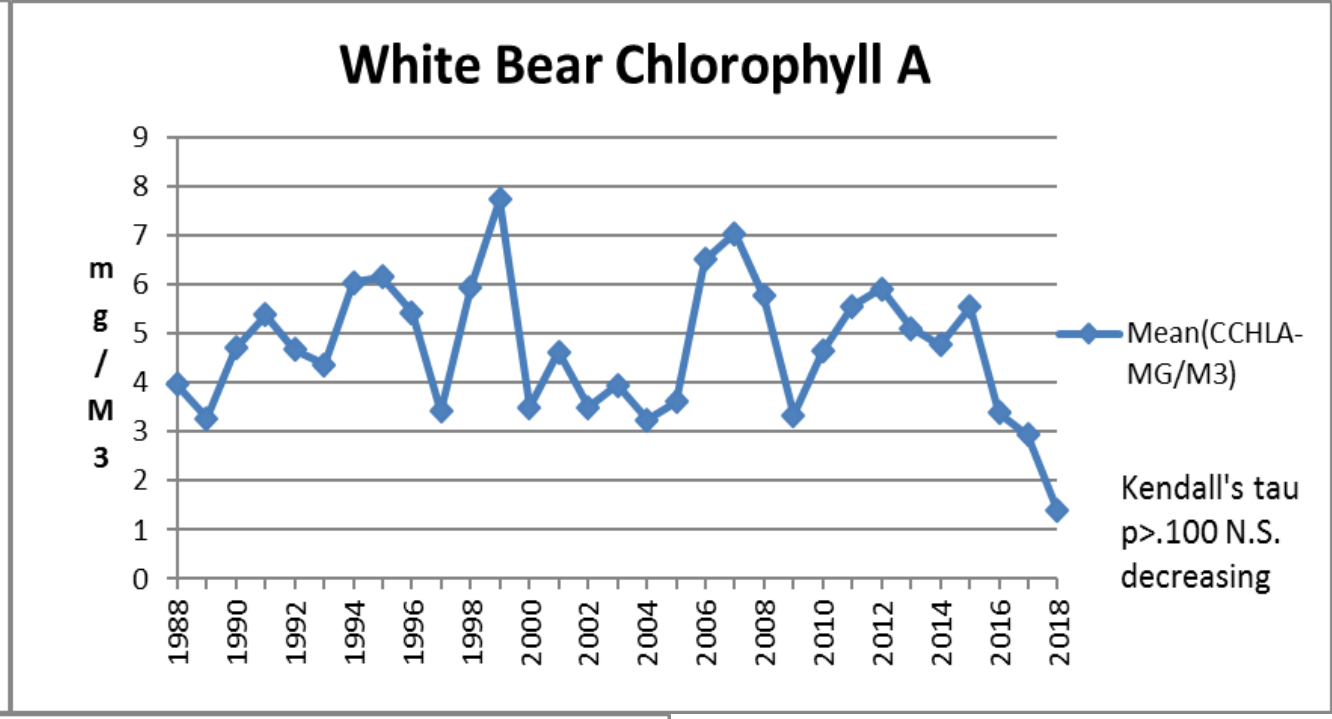


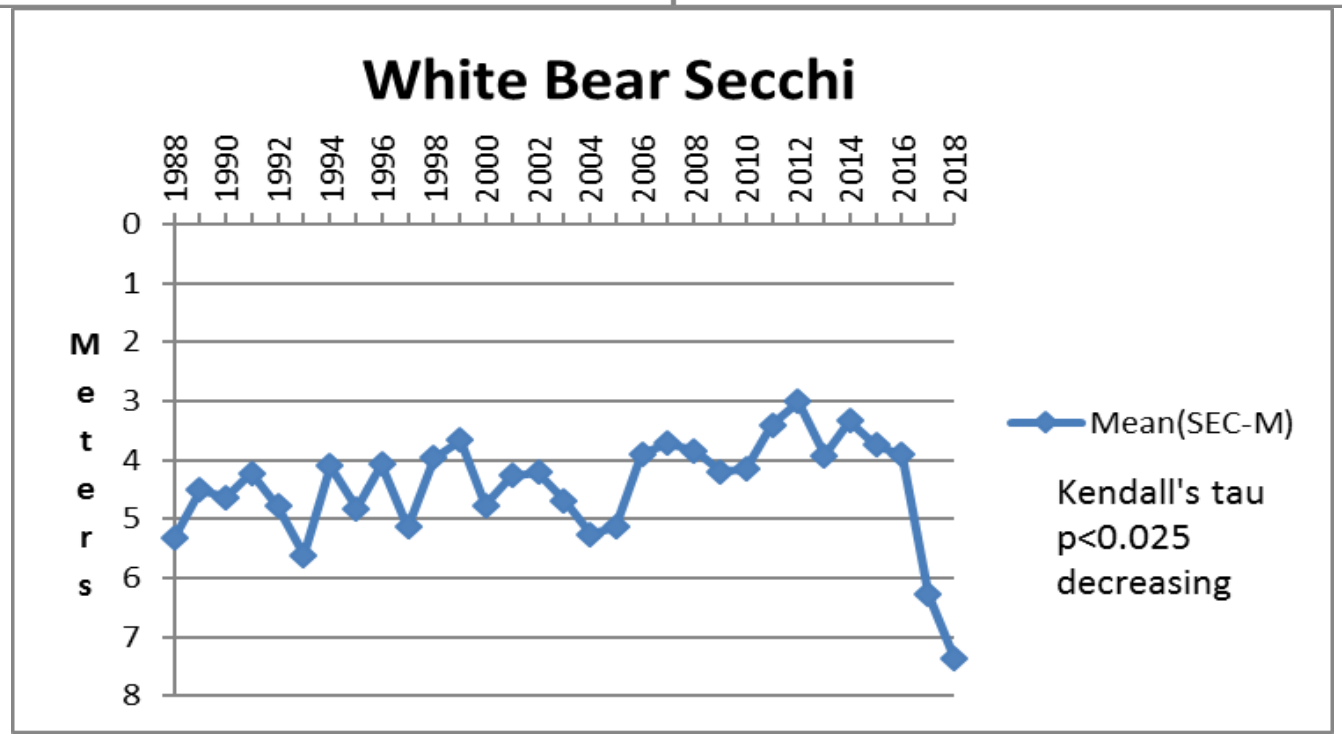


Note:2014 + 2016 Alum treatments

[Link to Alum Treatment Project Page]







Note: 2014 Zebra Mussel infestation confirmed

RAMSEY COUNTY LAKE MANAGEMENT WINTER MONITORING PROGRAM

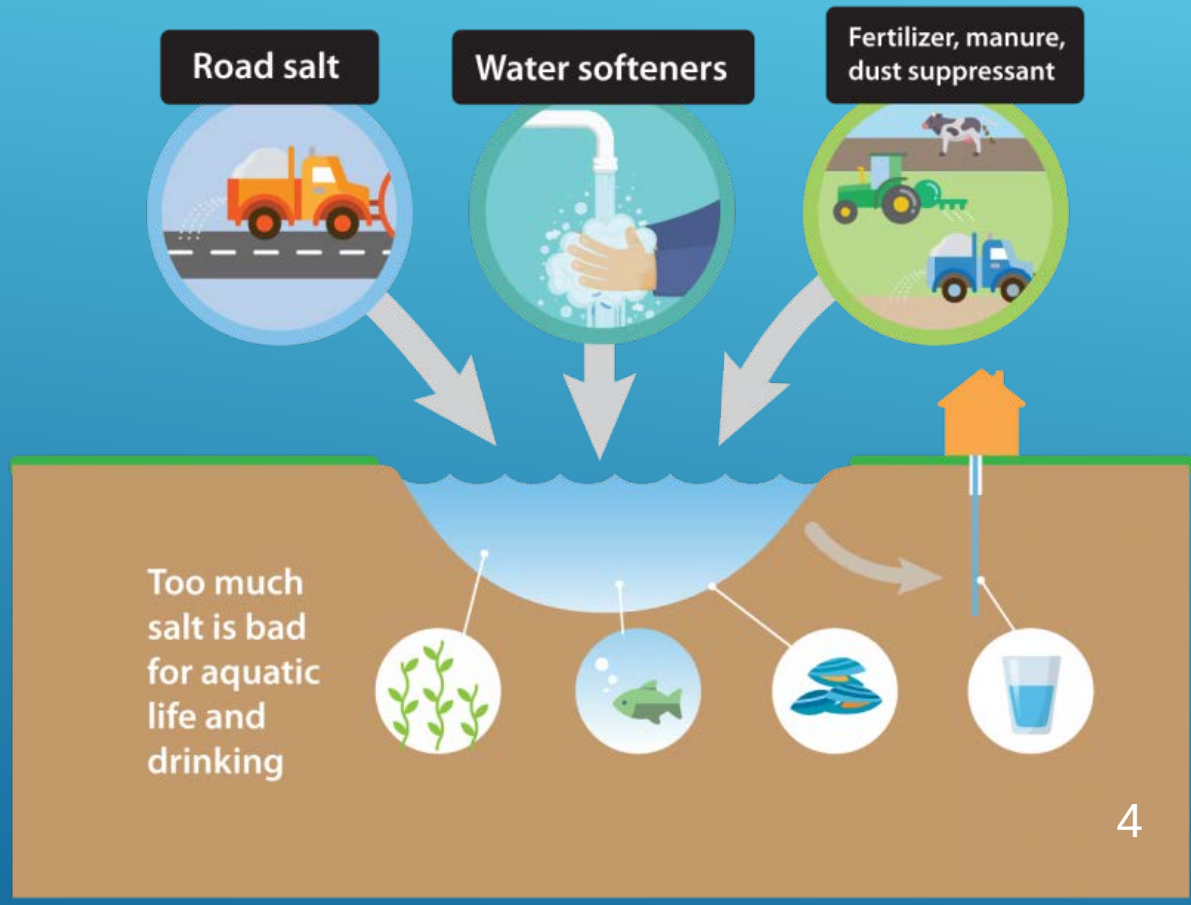
- Dissolved oxygen monitoring/aerating
  - Como, Owasso, Island, Otter, Silver East, Beaver
- Chloride monitoring
  - Worked with MPCA to establish a state water quality standard for chloride. TCMA Chloride Project Link
  - A large number of lakes were categorized as impaired for aquatic life, or at high risk of becoming impaired.

WHERE DOES CHLORIDE COME FROM ?

- Ramsey County uses 16,000,000 lbs/year to deice roads
- 700,000,000 lbs/year used in the Twin Cities Metro Area (1)
- 78% of this chloride is transported to surface or ground water in the TCMA

Table 1. Summary of annual road salt application amounts

User	Use (Tons)	Use %
MNDOT	80,797	23%
Counties	70,284	20%
Cities	114,314	33%
Commercial Bulk	66,349	19%
Packaged	17,460	5%
Total	349,204	100%



WHY IS CHLORIDE SO BAD?

- It takes only one teaspoon of salt to permanently pollute five gallons of water.
- There's no easy way to remove salt from water.
- Causes osmotic stress to organisms
- Decreases the biodiversity of sediment organisms and plants(2)
- Increases the release and transport of heavy metals(3)
- 30% of wells in TCMA had chloride concentrations above the chronic water quality standard.
- Corrosive to most surfaces

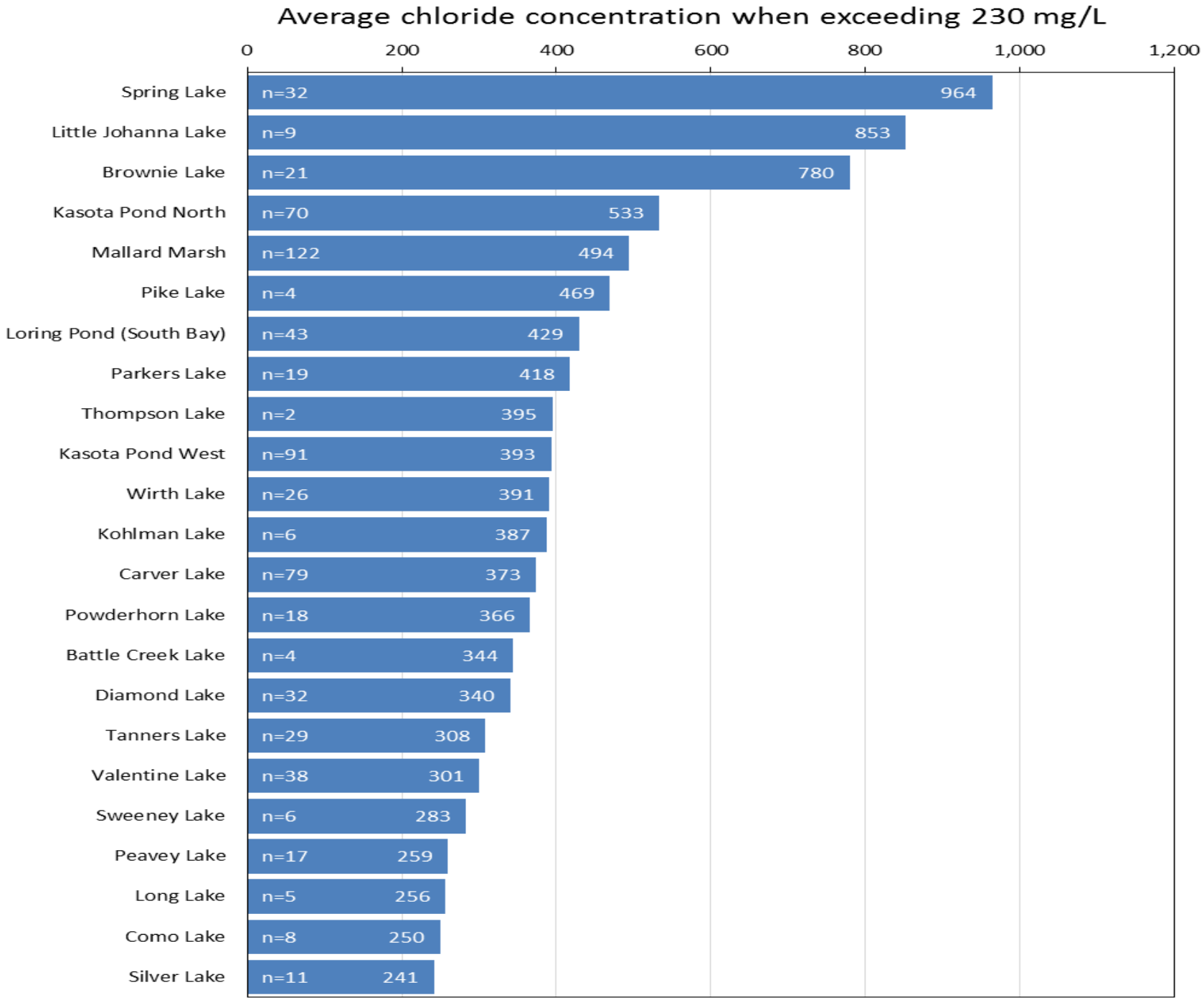
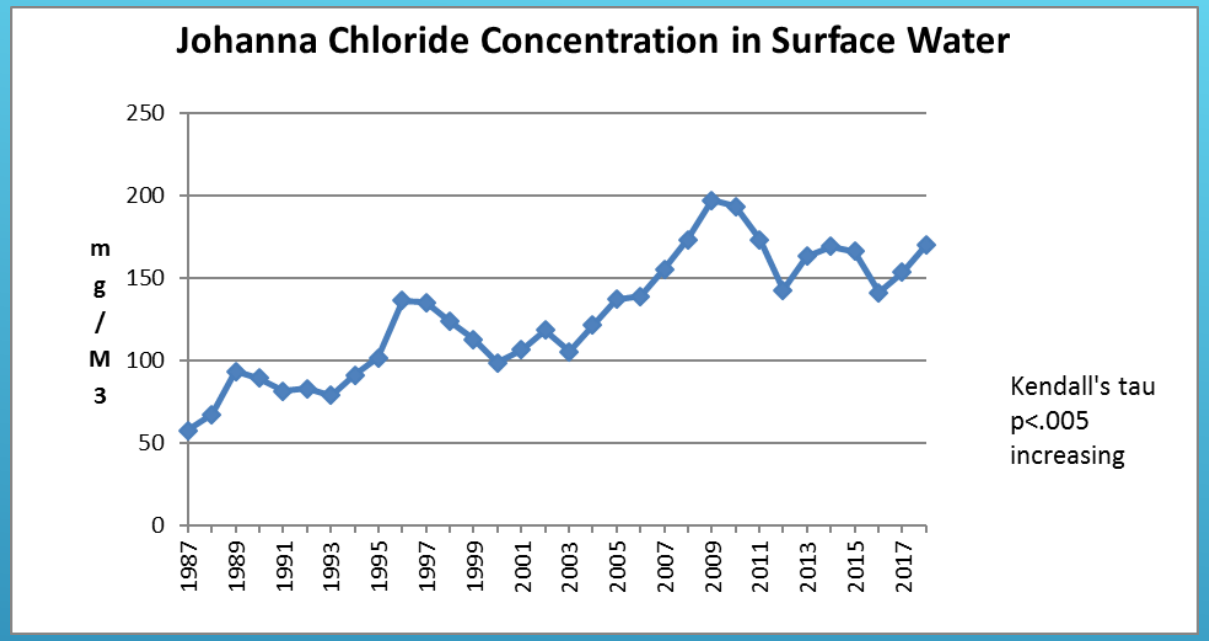
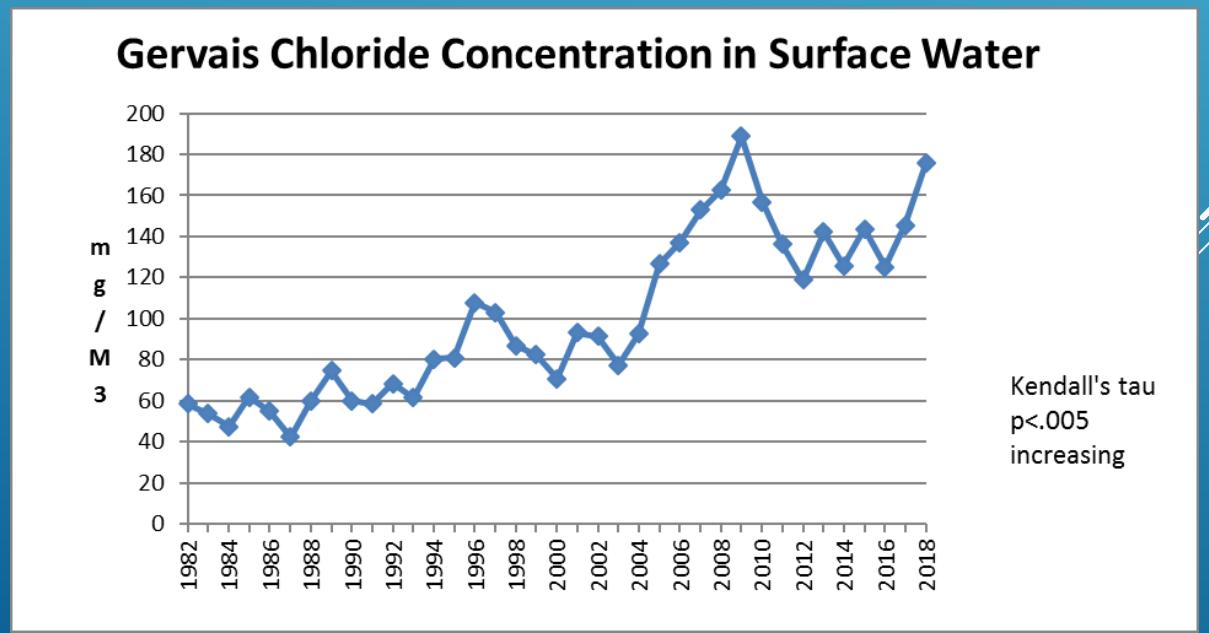


Table 2.TCMA Chloride Management Plan - MPCA 2015

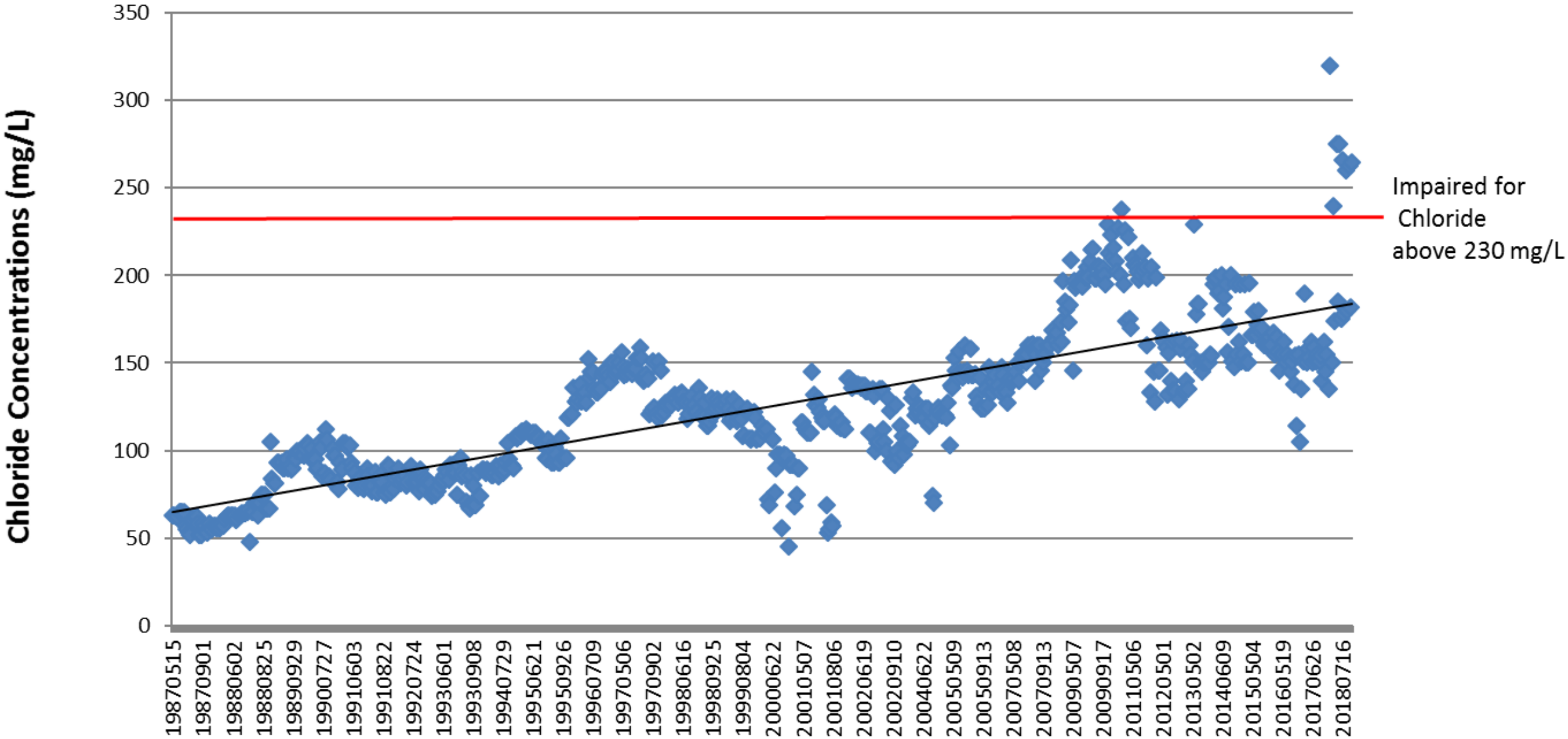
LAKES WITH A HIGH RISK OF CHLORIDE IMPAIRMENT

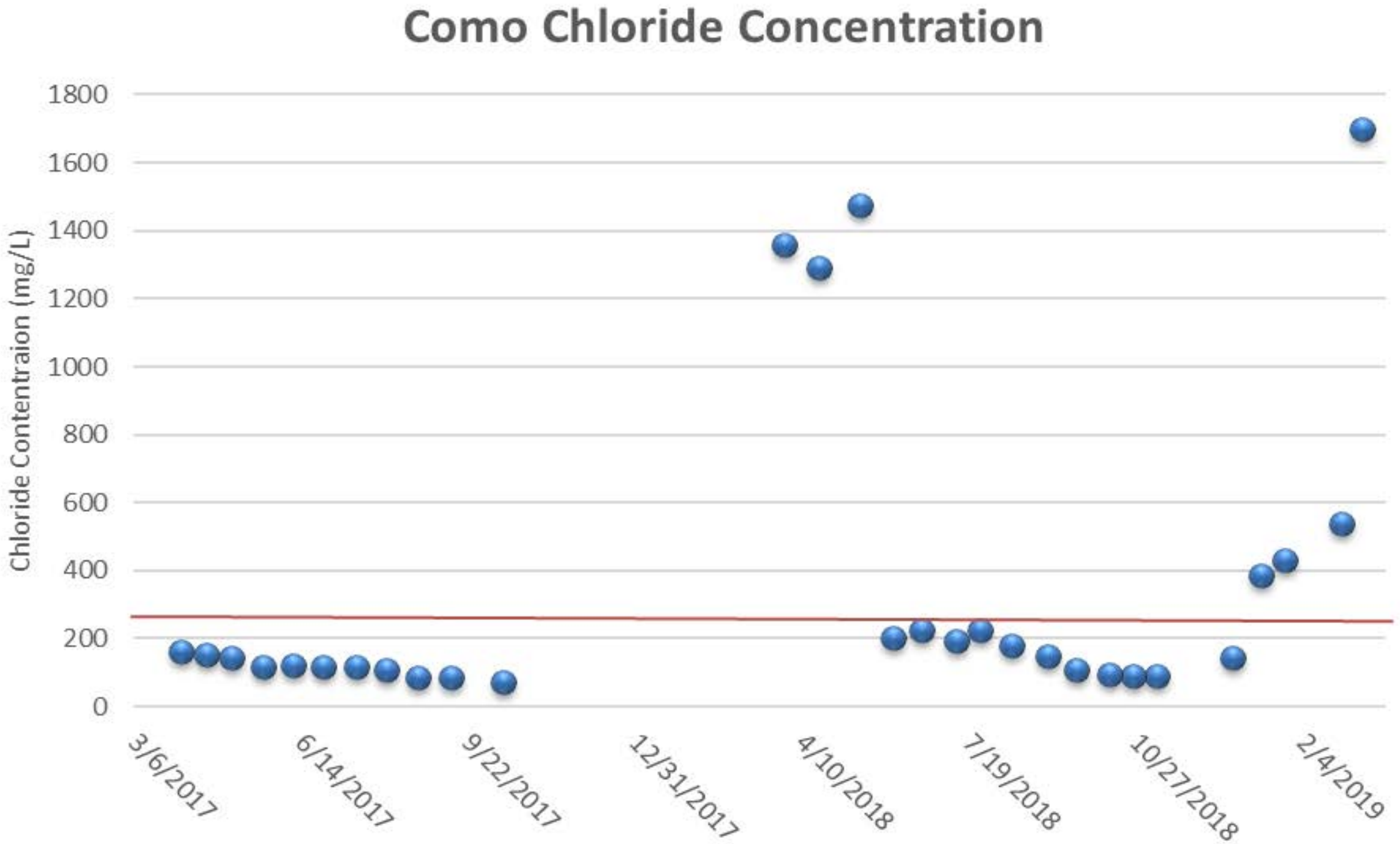
- Beaver
- Bennett
- Crosby ★
- Gervais ★
- Johanna ★
- Keller
- McCarrons
- Wabasso
- Wakefield ★





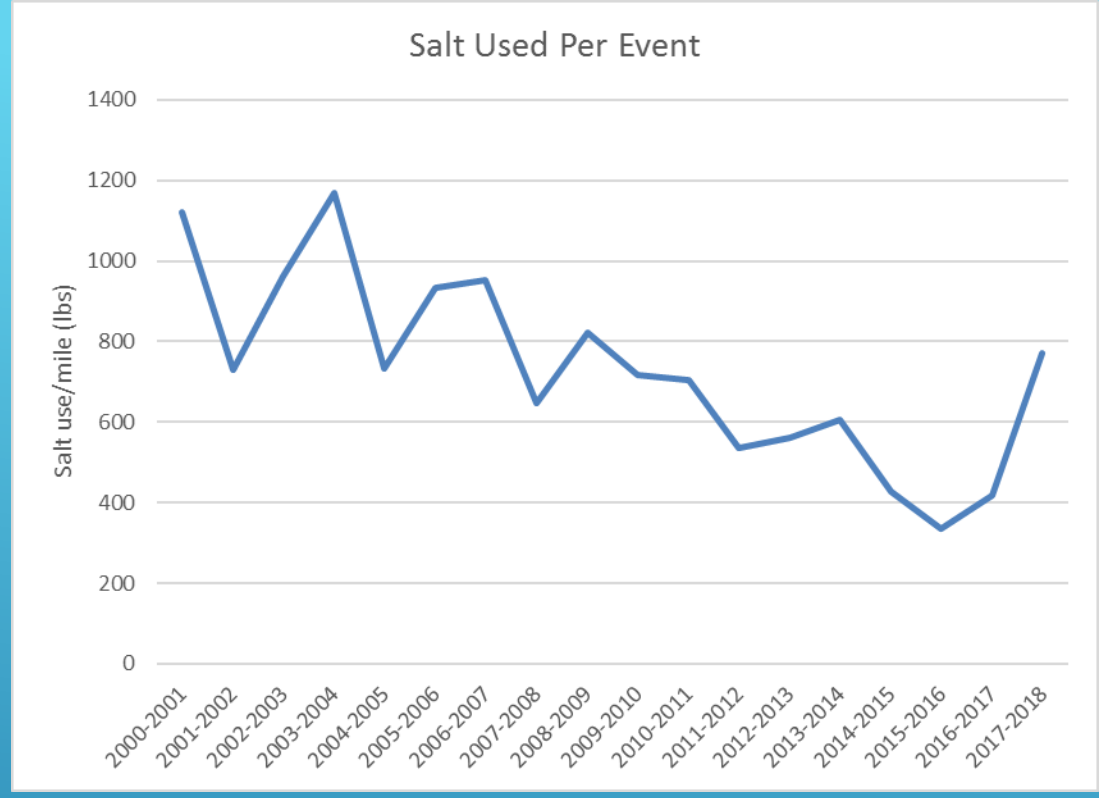
Johanna Lake Chloride Concentraion 1987 - 2018




Como Chloride Concentration
Chloride Contentraion (mg/L)
1800
1600
1400
1200
1000
800
600
400
200
0
3/6/2017
6/14/2017
9/22/2017
12/31/2017
4/10/2018
7/19/2018
10/27/2018
2/4/2019

WHAT IS RAMSEY COUNTY DOING

- Set goals to decrease salt usage
- Track usage of salt with calibrated dispensers
- Prevent ice buildup by shoveling and plowing more often, or with better equipment.
  - Ramsey County recently purchased tungsten carbide plow blades for our trucks to improve ice and snow removal ($145,000)
- **MPCA Smart Salt Applicating Training and Tools**
- Use Salt brine when conditions allow
- Sweep up excess salt and reuse



Great Online Resources

Improved Winter Maintenance: Good Choices for Clean Water

MN Key Water Info List

http://es.metc.state.mn.us/KeyWaterList/#SurfaceWater

Surface Water Data – MPCA

http://cf.pca.state.mn.us/water/watershedweb/wdip/index.cfm

Road Salt and Water Quality - MPCA

https://www.pca.state.mn.us/water/chloride-salts

https://www.pca.state.mn.us/water/salt-applicators

REFERENCES

1. Sander, A., E. Novotny, O. Mohseni, H.G. Stefan, (2007)"Inventory of Road Salt Uses in the Minneapolis/St. Paul Metropolitan Area". University of Minnesota, St. Anthony Falls Laboratory, Minneapolis, MN, Report No. 503, December 2007, 46 pp.

2. Talmage P J, Lee K E, Goldstein R M, Anderson J P, Fallon J D. Water Quality, Physical Habitat, and Fish-Community composition in Streams in the Twin Cities Metropolitan Area, Minnesota 1997-98. 1999; 18.

3. Novotny V, Muehring D, Zitomer D H, Smith D W, Facey R. Cyanide and metal pollution by urban snowmelt: impact of deicing compounds. Water Science and Technology 1998; 38: 223-230.

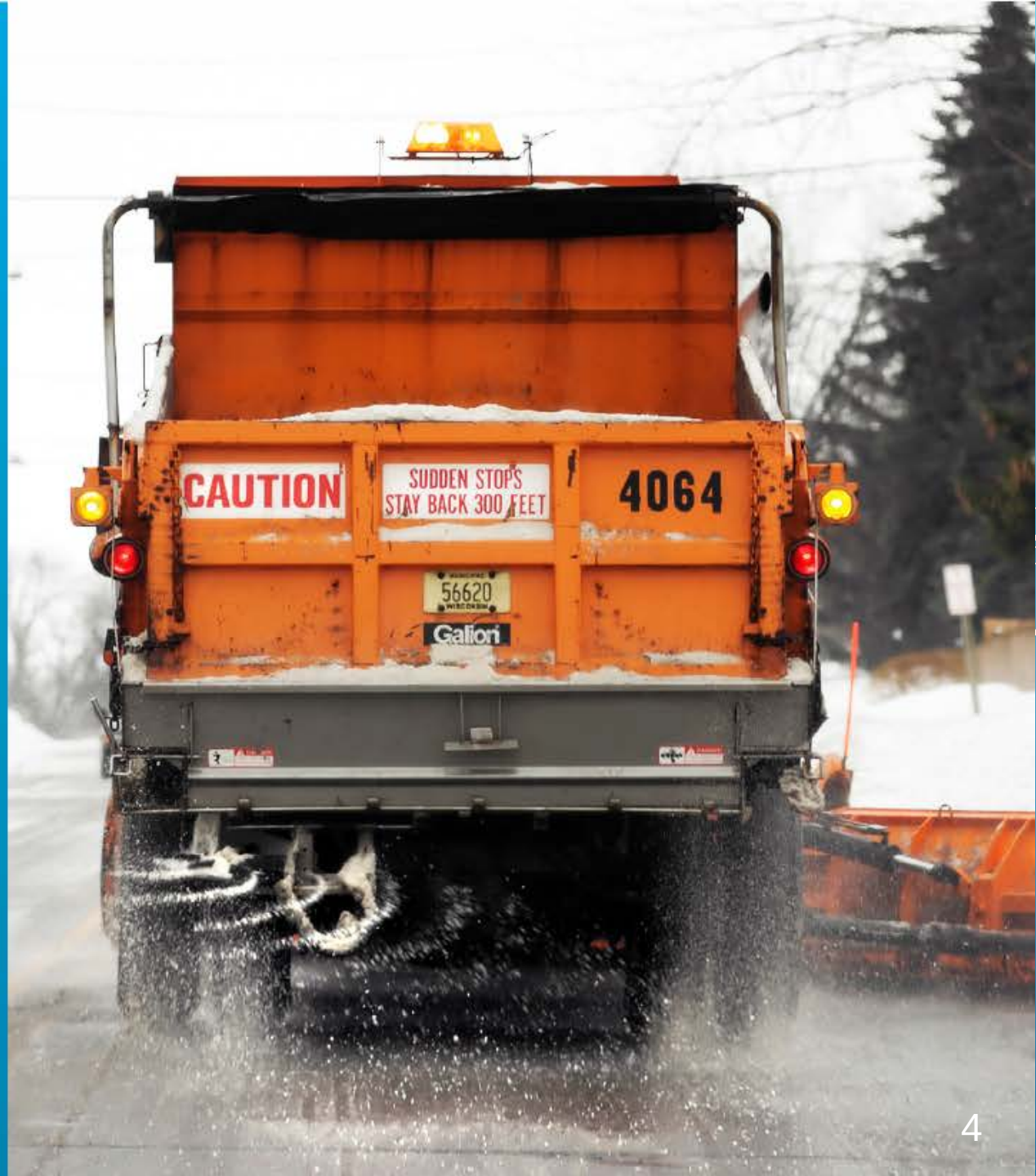
4. https://www.pca.state.mn.us/water/chloride-101

5. Heiskary, S. and M. Lindon. 2009. Microcystin in Minnesota Lakes. *LakeLine* 24(4):25-30

Salt pollutes.

When snow and ice melts, the salt goes with it, washing into our lakes, streams, wetlands, and groundwater. Once in the water, there is no way to remove the chloride, and it takes only one teaspoon of road salt to permanently pollute five gallons of water. Less is more when it comes to applying salt because at high concentrations, chloride can harm the fish and plant life in our waters.

MINNESOTA POLLUTION CONTROL AGENCY



RAMSEY COUNTY

Thank You Plow Drivers!

Ramsey County plow truck drivers work tirelessly to not only keep us mobile in the worst weather, but also focus on smart salt use using innovative equipment, technology, and know how to reduce chloride use on the roads

Preventing New Infestations and Their Effect on Water Quality

March 2019 Forum

RAMSEY COUNTY

Justin Townsend
Aquatic Invasive Species Coordinator
Ramsey County
Parks and Recreation-Soil and Water Division
1425 Paul Kirkwold Drive
Arden Hills, MN 55117
651-266-7277
Justin.Townsend@co.Ramsey.MN.US

Friendly public service announcement: Not all aquatic plants or animals are bad. They require care like any landscape. Please take care of them.

RAMSEY COUNTY

Photos 1 & 2: Sole juvenile zebra mussel found on a settlement plate by a lake resident on August 18, 2018 in Bald Eagle Lake, Ramsey County.

Figure 1. Zebra mussels found in Lake Johanna, collected in 2018. Two distinct year classes were found (top numbers on ruler are in mm).

Photo Courtesy of Steve McComas or Bluewater Science

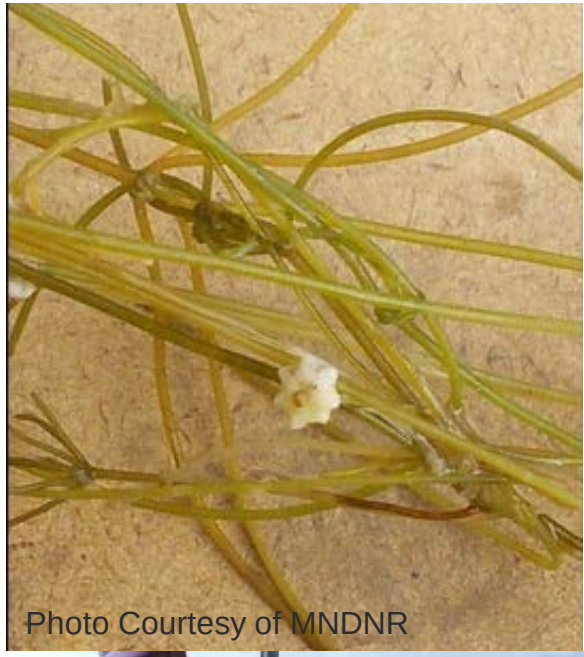


Photo Courtesy of MNDNR

Photo Courtesy of St. Cloud Times

RAMSEY COUNTY

Why Should I Care?

- Zebra mussel shells are extremely sharp
- At scale they foul equipment (clogged engine intakes)
- Eat the base of the food chain fish species rely on
- Change water clarity increasing nuisance plants

https://bugwoodcloud.org/mura/mipn/assets/File/UMISC-2016/Tuesday/2/Fieldseth_McComas_ZebraMusselsWaterQualLakeMinnetonkaMN.pdf

PHOTO BY BRAD HENLEY

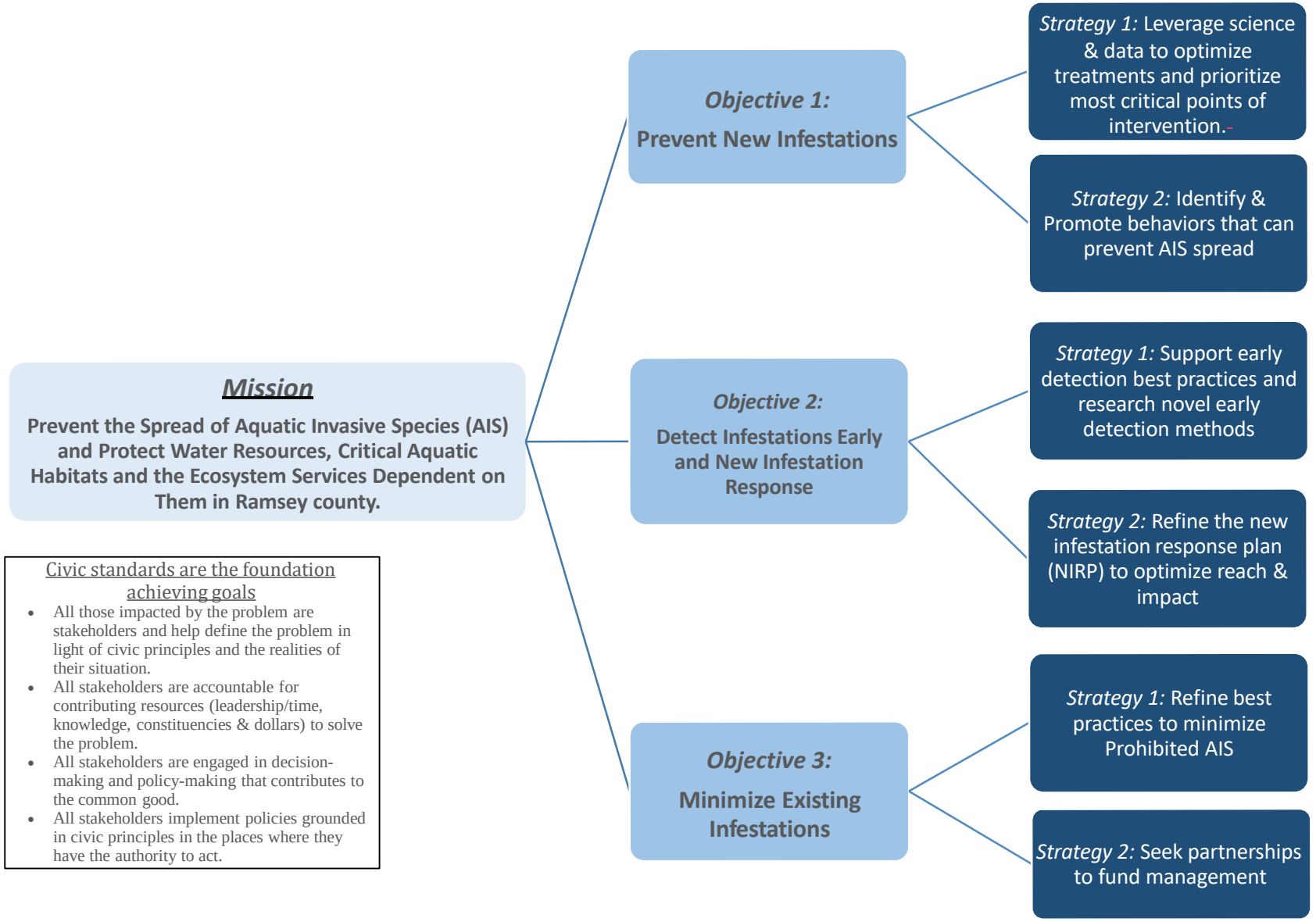
RAMSEY COUNTY

Why Should I Care?

- Eurasian Milfoil, Starry Stonewort, Brittle Niad, Phragmites, and Flowering Rush are aggressive plants
- They diminish the recreational value of lakes
- Decrease or interrupt spawning habitat for fish
- May have allelopathic (kills other plants) tendencies

https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=1688

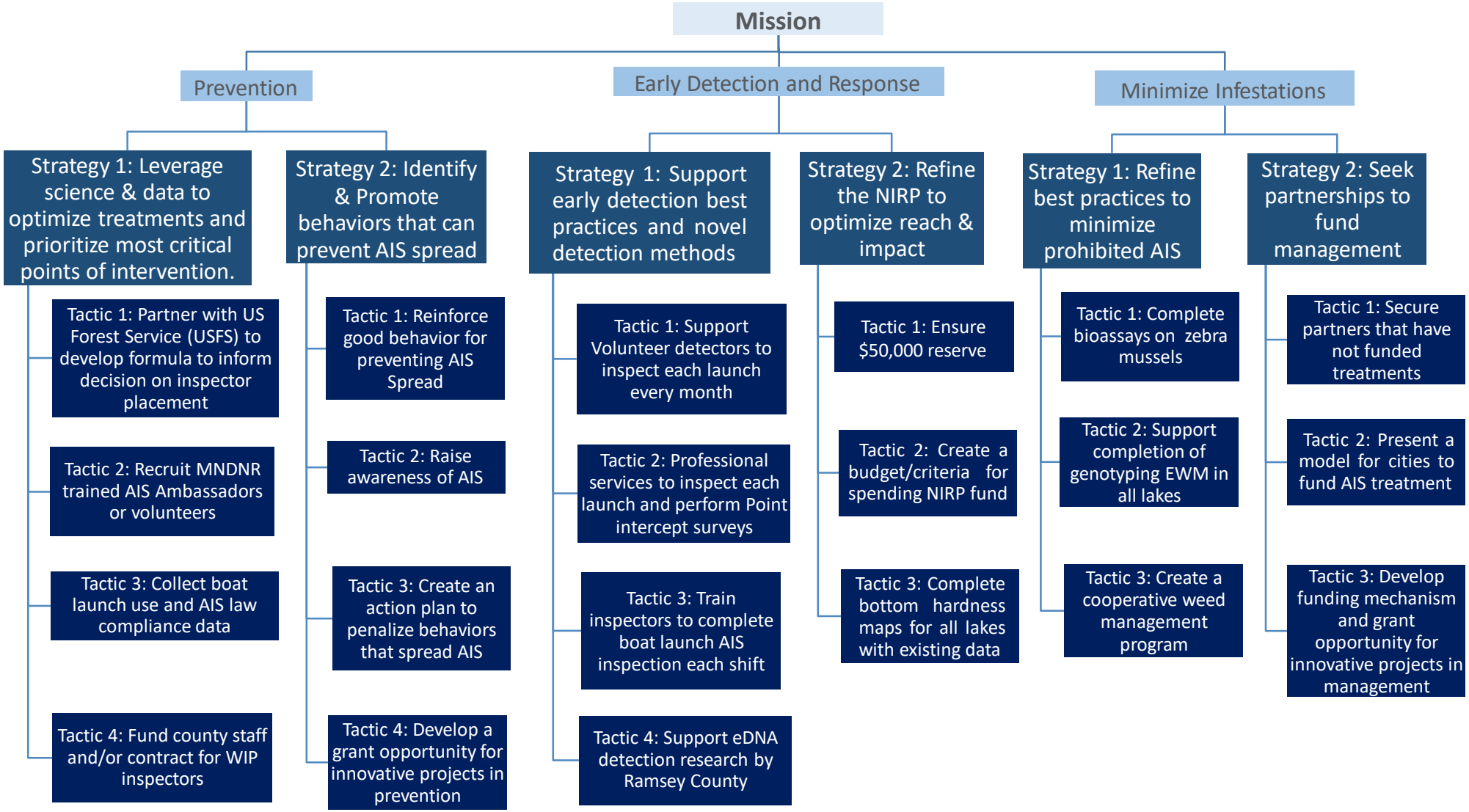
2019-2024 Five Year Strategic Plan



Civic standards are the foundation achieving goals

- All those impacted by the problem are stakeholders and help define the problem in light of civic principles and the realities of their situation.
- All stakeholders are accountable for contributing resources (leadership/time, knowledge, constituencies & dollars) to solve the problem.
- All stakeholders are engaged in decision-making and policy-making that contributes to the common good.
- All stakeholders implement policies grounded in civic principles in the places where they have the authority to act.

2019 Work Plan



RAMSEY COUNTY

We Inspect to:
- Raise awareness
- Gather data
- Educate

We analyze to:
- Refine inspections
- Reach more people
- Reduce the risk

$$\max_{x_{ik}, y_{jk}} Z = \sum_{j \in J} \sum_{i \in I} \sum_{k \in K} n_{ijk}(a_{ijk} + b_{ijk})$$

Subject to:

$$a_{ijk} \leq x_{ik} \qquad \forall i, j, k$$

$$b_{ijk} \leq y_{jk} \qquad \forall i, j, k$$

$$a_{ijk} + b_{ijk} \leq 1 \qquad \forall i, j, k$$

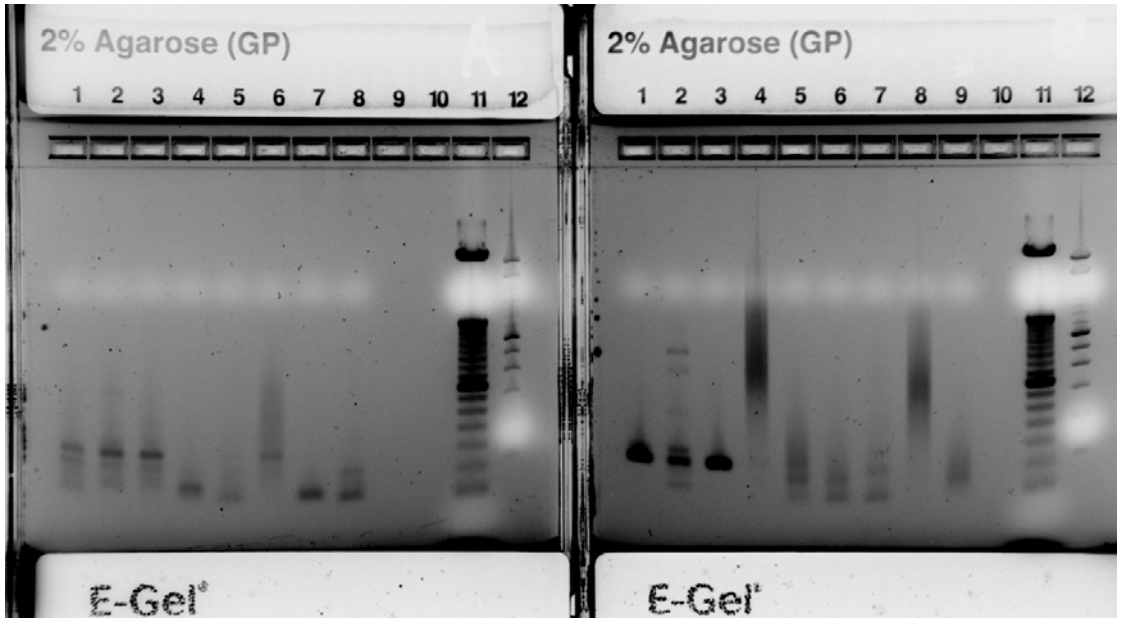
We reduce the barriers to clean boats
- Provide the Knowledge
- Provide the tools
- Increase the social pressure to clean, drain, dispose

RAMSEY COUNTY

Early Detection

- Inspectors search daily
- Volunteer detectors search monthly
- Veliger Tows
- Contracted diver searches at each boat launch
- Cutting edge eDNA detection

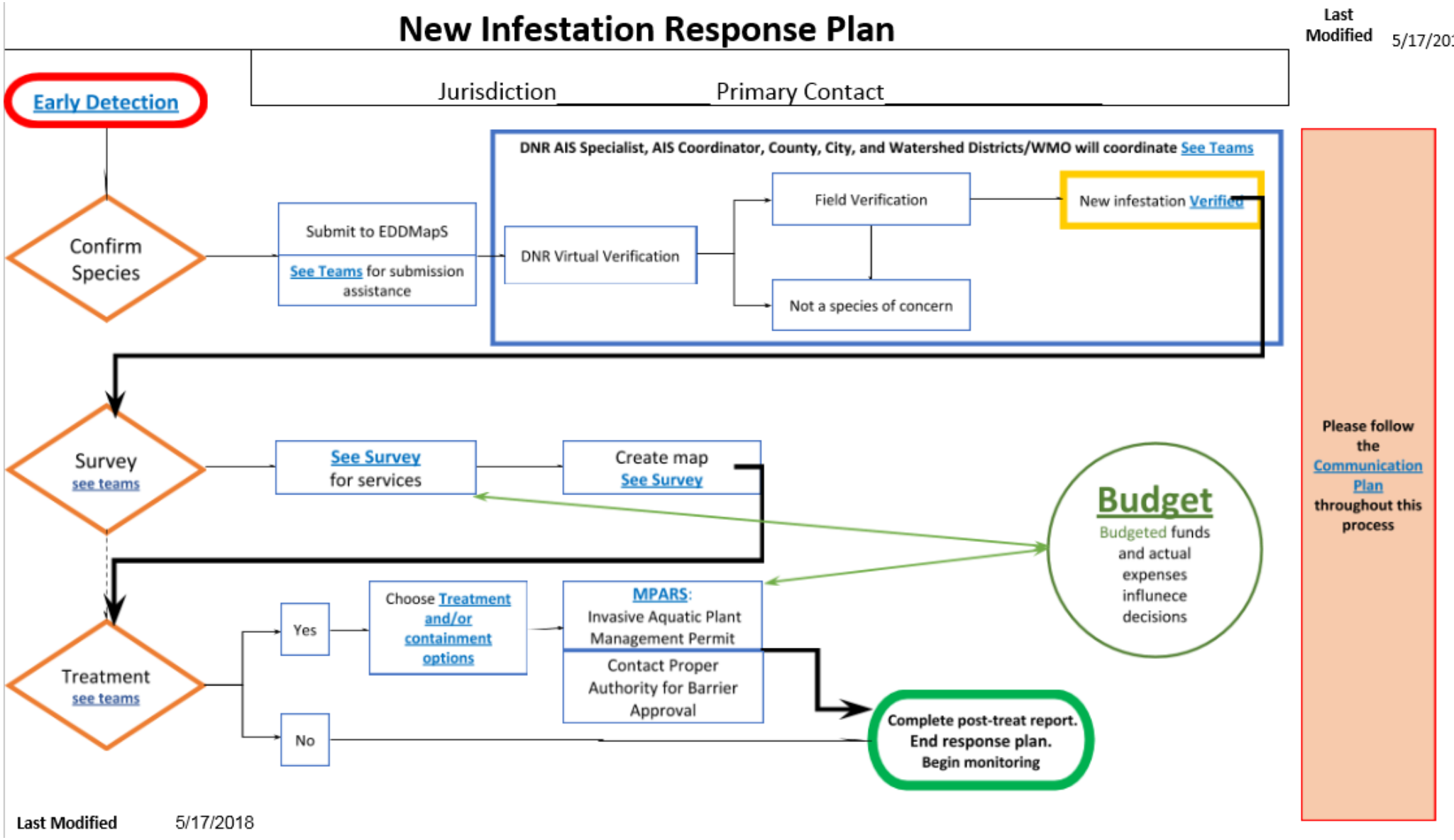
Figure 3. [left] Blue Water Science staff searching nearshore areas for zebra mussels. [right] Example of organisms found on a rock that are not zebra mussels.



RAMSEY COUNTY

Response

- Planning-developed the new infestation response plan
- Funding- contingency dollars via county prevention aid
- Collaborating-working proactively with lake associations, cities, and all stakeholders
- Bioassays to study chemical efficacy for zebra mussel treatment
- Working with the Minnesota Aquatic Invasive Species Research Center (MAISRC) on Eurasian Milfoil genotyping


New Infestation Response Plan
Last Modified 5/17/2018
Jurisdiction
Primary Contact
Early Detection
DNR AIS Specialist, AIS Coordinator, County, City, and Watershed Districts/WMO will coordinate See Teams
Confirm Species
Submit to EDDMapS
See Teams for submission assistance
DNR Virtual Verification
Field Verification
New infestation Verified
Not a species of concern
Survey
see teams
See Survey for services
Create map
See Survey
Budget
Budgeted funds and actual expenses influnece decisions
Treatment
see teams
Yes
Choose Treatment and/or containment options
MPARS: Invasive Aquatic Plant Management Permit
Contact Proper Authority for Barrier Approval
No
Complete post-treat report. End response plan. Begin monitoring
Last Modified 5/17/2018
Please follow the Communication Plan throughout this process

RAMSEY COUNTY

Bottom Line

Invasions are hard to predict.
Watch your boats and lifts! Report new sightings.

Ramsey County will work with you to be a county of excellence in AIS prevention

RAMSEY COUNTY

Save The Date: May 17th 2019

Soil and Water Conservation Division Forum

Composting

Get Active. Become an AIS Detector.

Contact Justin if interested

Justin.Townsend@co.ramsey.mn.us

RAMSEY COUNTY

More Questions? Contact Us

Harmful Algal Blooms

- Shahram Missaghi
  - miss0035@umn.edu
  - 952-221-1333

Salt

- John Manske
  - John.manske@co.ramsey.mn.us
  - 651-266-7277

Aquatic Invasive Species

- Justin Townsend
  - Justin.townsend@co.ramsey.mn.us
  - 651-266-7277

RAMSEY COUNTY

Please Let us Know What is Working

Please take 3 minutes on Wednesday March 20th for a survey

https://www.surveymonkey.com/r/DCDN2NH

- How did you like this forum?
- Was the venue comfortable?
- What would you like to see at the next forum?

Don’t like computers? Contact Justin Townsend

justin.townsend@co.ramsey.mn.us or 651-266-7277 to take the survey via phone or email.

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Environmental Services, Lake Management

RAMSEY COUNTY

Working with you to enhance our quality of life

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Phosphorus (All forms)

Nitrogen (All forms)

Chloride

Chlorophyll A

Turbidity

Phytoplankton

Zooplankton

Zebra Mussel Veliger

Total Hardness

Total Alkalinity

Total Nonfilterable Residue

Volatile Nonfilterable Residue

E. coli

eDNA

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BENNETT	C	C	C	C	C	D	D
COMO	D	D	D	D	D	D	D
CROSBY	C	C	C	C	D	C	C
GERVAIS	B	B	B	B	C	C	C
ISLAND NORTH	C	C	C	C	B	B	N/A
ISLAND SOUTH	C	B	B	B	B	B	B
JOHANNA	B	B	B	A	B	B	B
JOSEPHINE	C	B	B	B	B	B	B
KELLER	B	B	B	B	C	B	C
KOHLMAN	C	B	B	B	C	C	C
LITTLE CROSBY	C	B	B	C	D	B	B
LOEB	A	A	A	B	B	A	A
LONG NORTH	D	D	D	D	D	D	D
LONG SOUTH	C	B	B	C	C	C	C
MCCARRON	A	A	A	A	B	A	A
OTTER	A	A	A	A	A	A	A
OWASSO	B	B	B	B	B	C	C
PHALEN	A	A	A	A	B	B	B
ROUND(NR PHALEN)	B	A	A	B	C	B	B
SILVER E	C	C	C	C	C	D	D
SILVER W	C	C	C	B	C	C	C
SNAIL	A	A	A	A	A	A	A
TURTLE	A	A	A	A	A	A	A
TWIN	B	B	B	B	C	B	B
WABASSO	A	A	A	A	A	A	A
WAKEFIELD	D	C	C	D	C	C	C
WHITE BEAR	A	A	A	A	A	A	A

April 16, 2018

By the Numbers at MSP

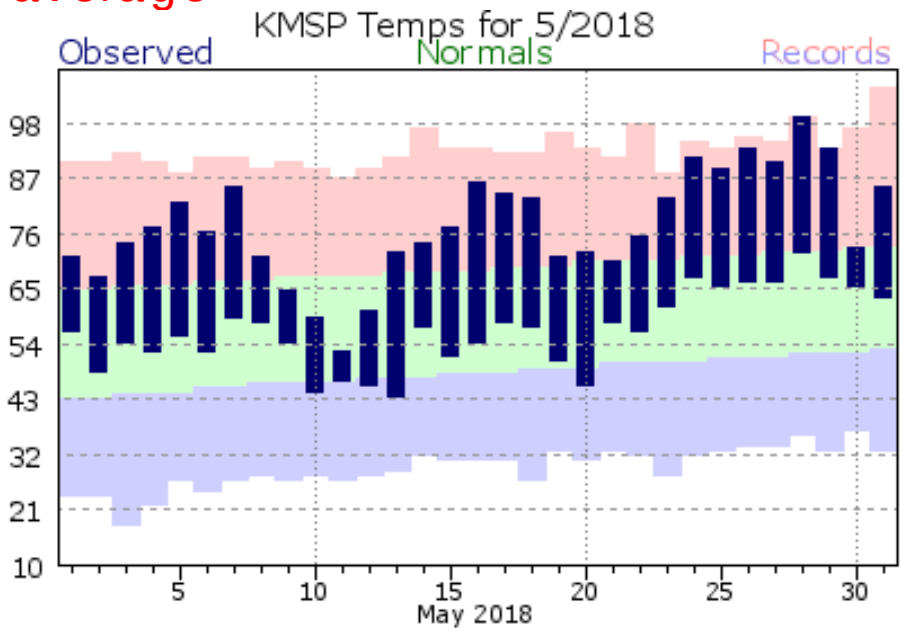
0	Number of days that have been above normal so far this April
15.8	Storm total snowfall at MSP
15.9	Monthly temperature departure below normal
26.1	April monthly snowfall at MSP, new record (21.8” 1983)
37.0	Today’s forecast high temperature
58.0	Today’s normal high temperature
78.3	Inches of snow so far this season

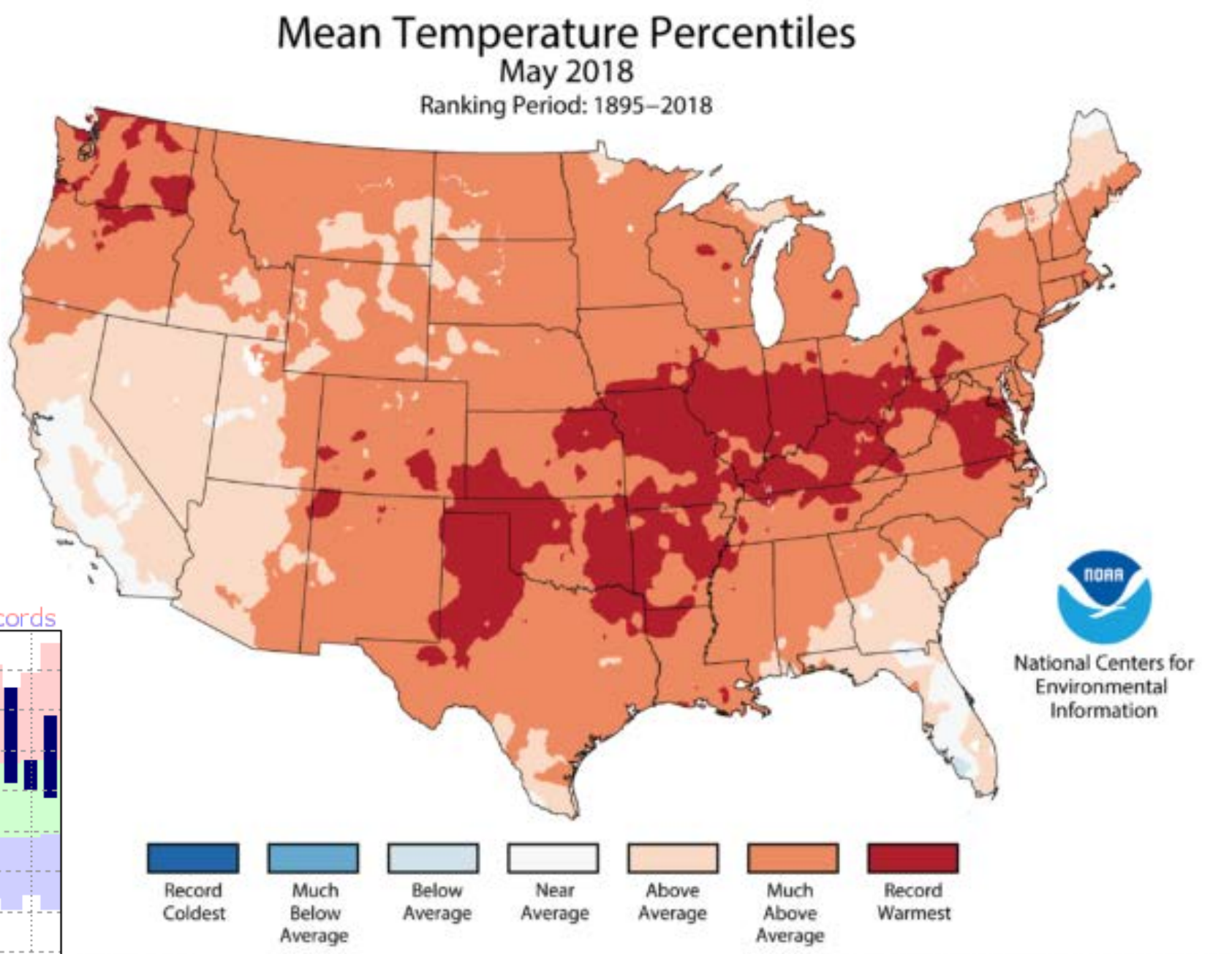
Created by NWS Twin Cities – April 16, 2018

Records set in May 2018

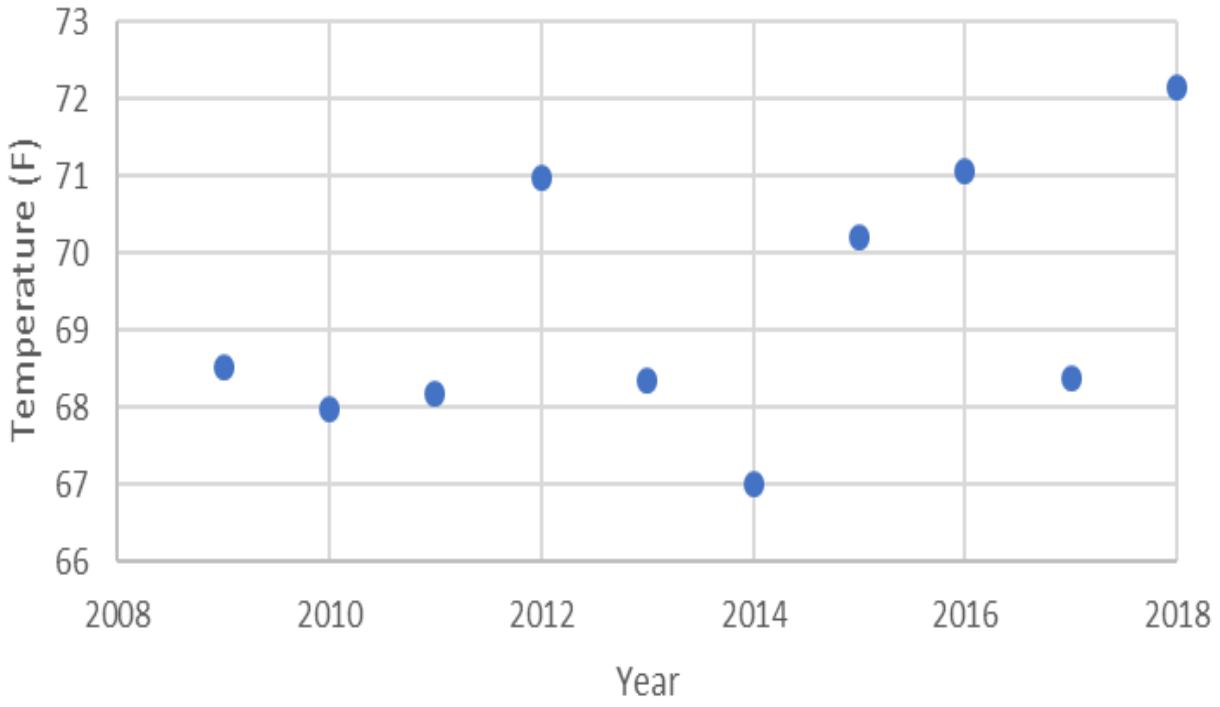
- Warmest Mean Temperature in USA
- 6 days above 90°F in the Twin Cities
- Earliest 100°F day in the Twin Cities (May 28th)

Twin Cities were 8.7°F above average

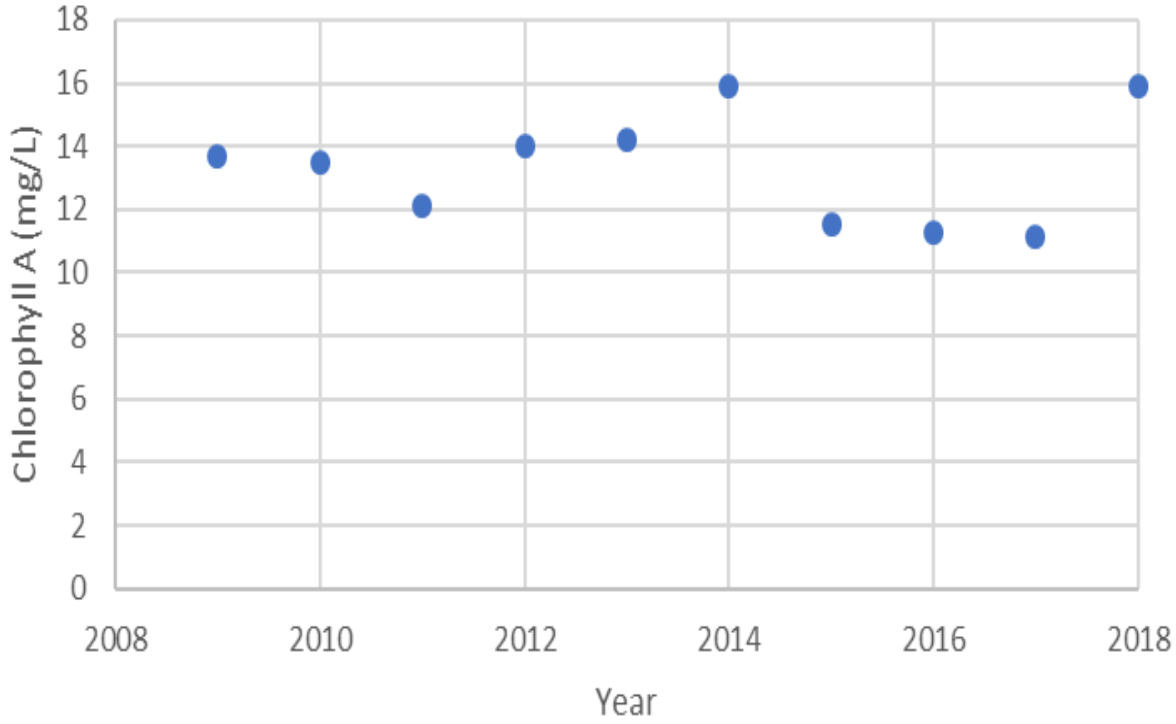


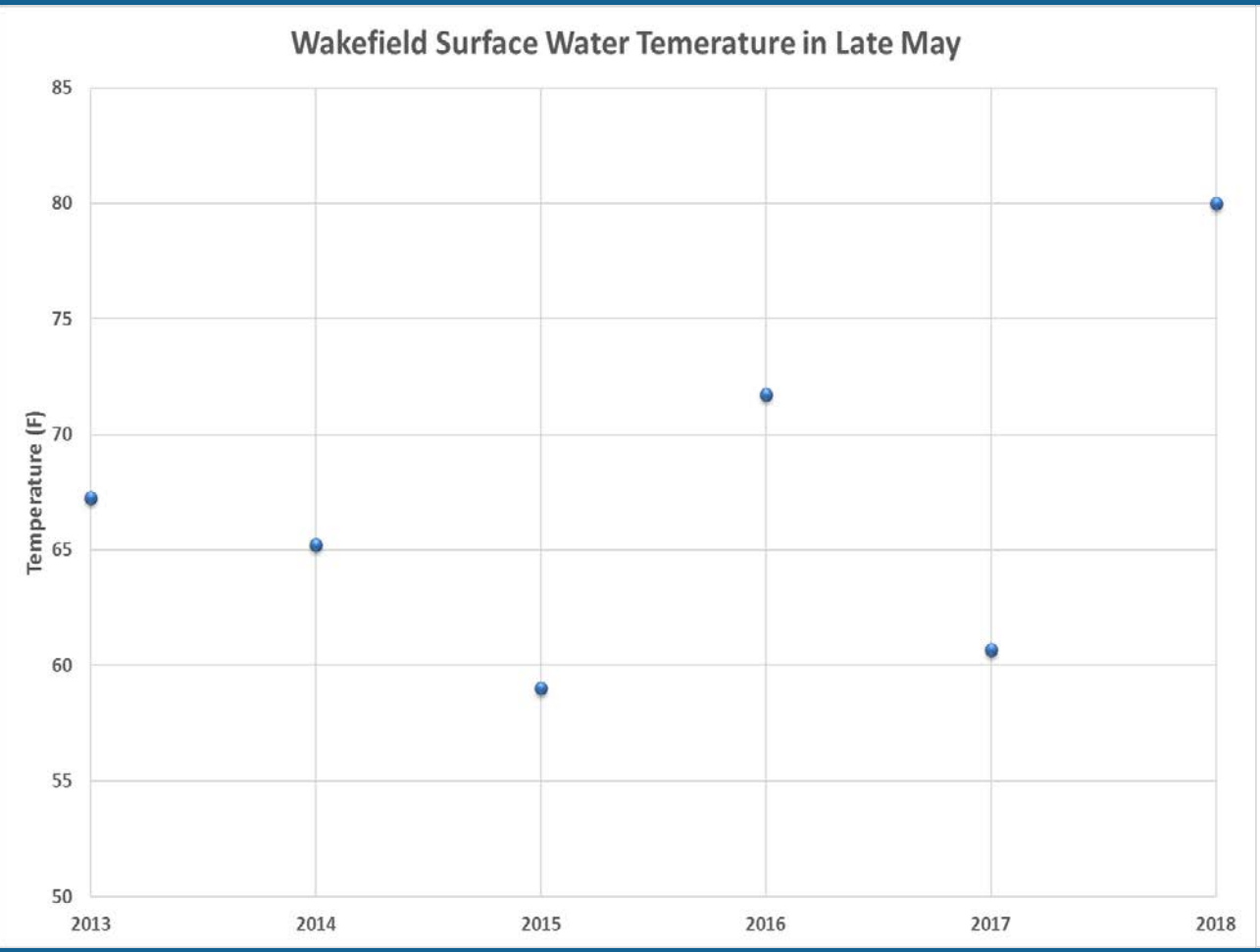


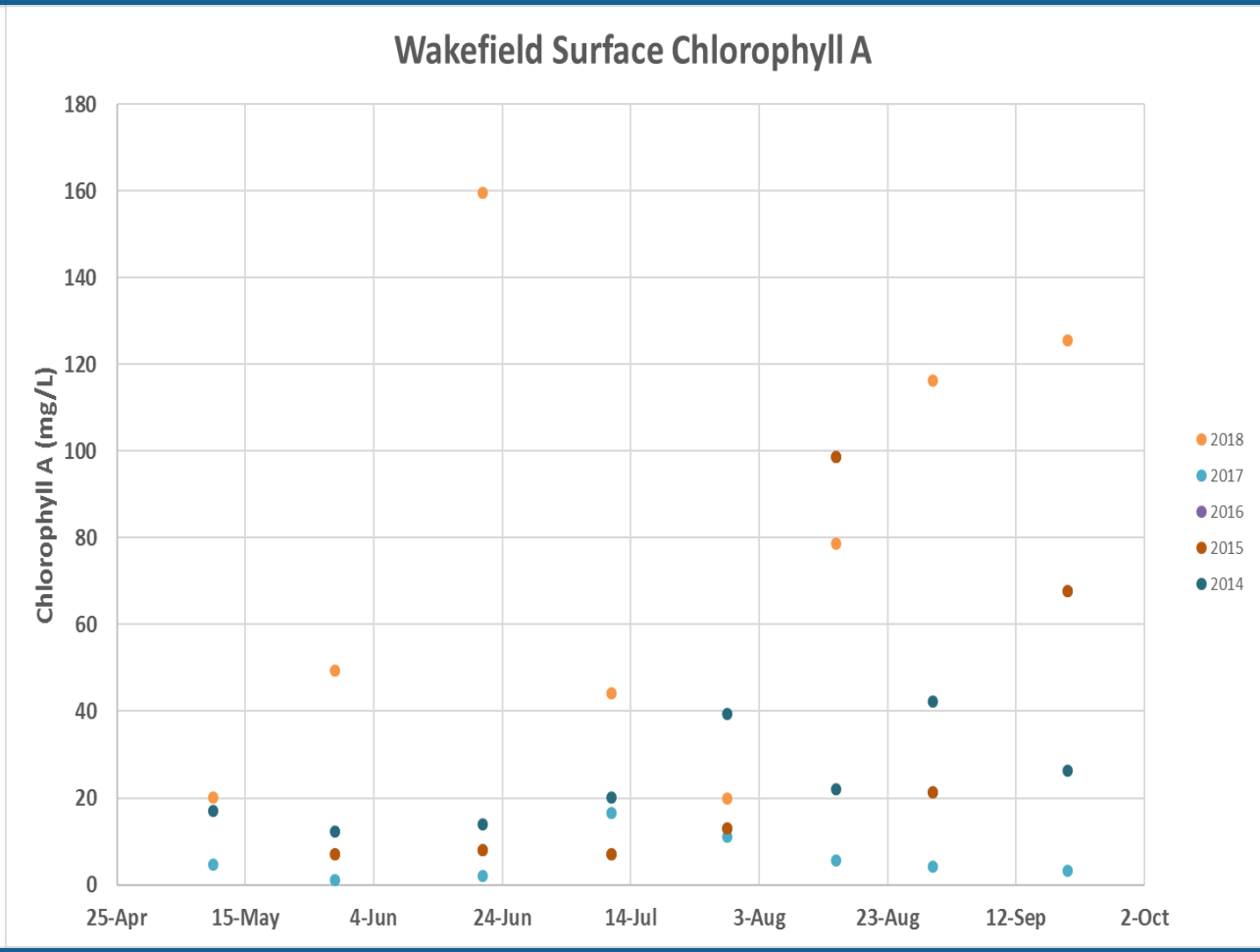
Average Temperature in the epilimnion of all Ramsey County lakes monitored May-Sept



Average Chlorophyll A in the epilimnion of all RC lakes May-Sept




Wakefield Surface Water Temerature in Late May
Temperature (F)
85
80
75
70
65
60
55
50
2013
2014
2015
2016
2017
2018


Wakefield Surface Chlorophyll A
Chlorophyll A (mg/L)
180
160
140
120
100
80
60
40
20
0
25-Apr
15-May
4-Jun
24-Jun
14-Jul
3-Aug
23-Aug
12-Sep
2-Oct
2018
2017
2016
2015
2014

BALD EAGLE ALUMINUM SULFATE TREATMENT

Project Engineer: Wenck Engineers • Scientists Business Professionals

Contractor: HAB AquaticSolutions

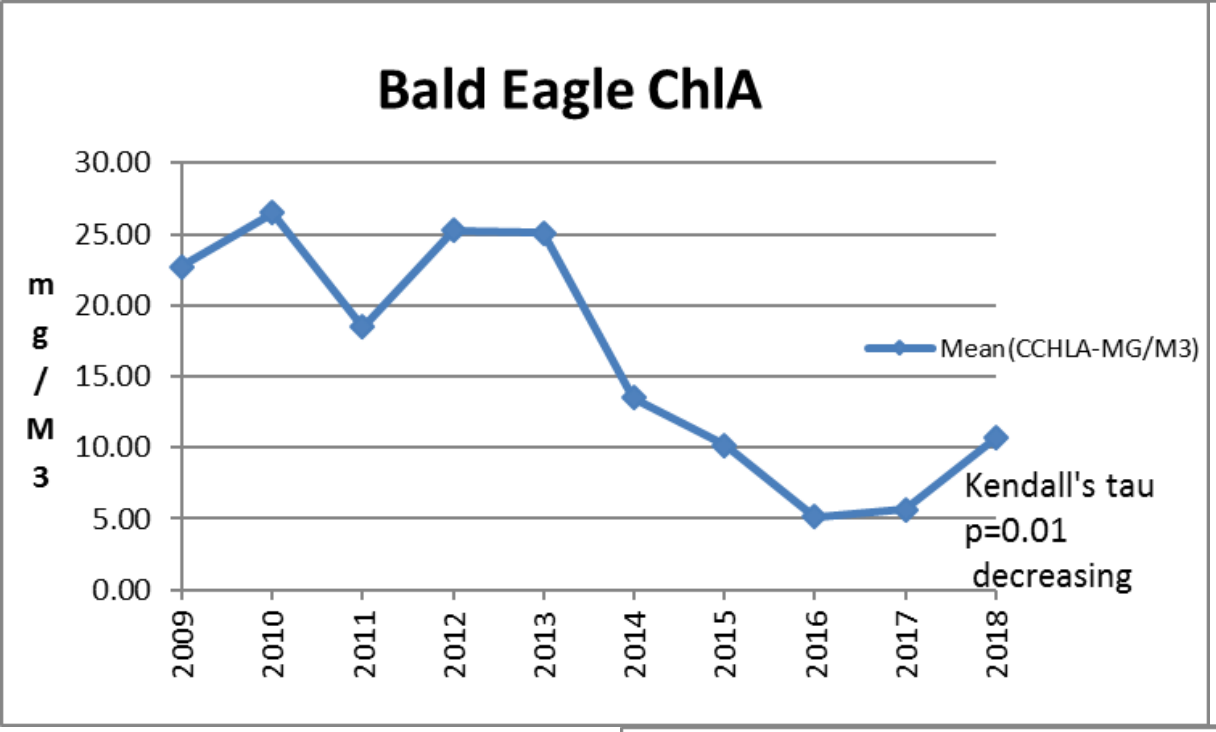
Treatment 1: 2014

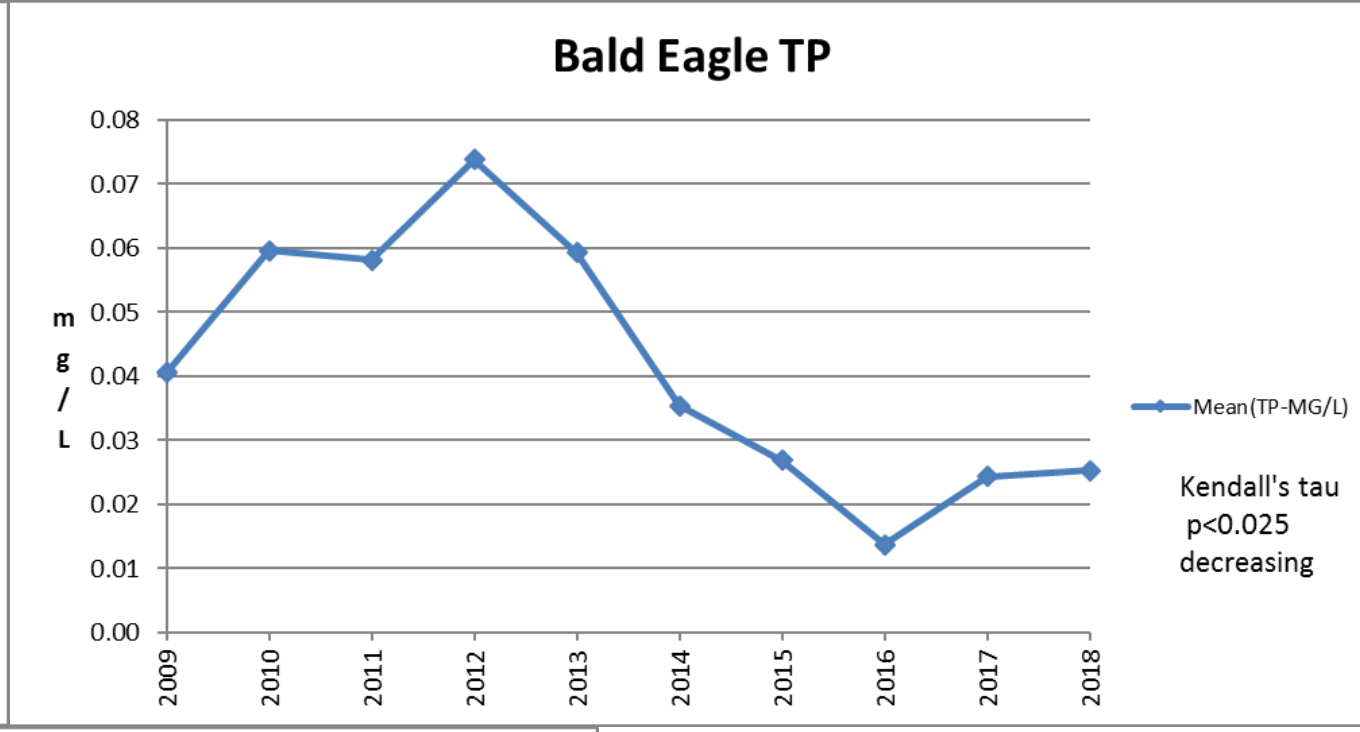
Treatment 2: 2016

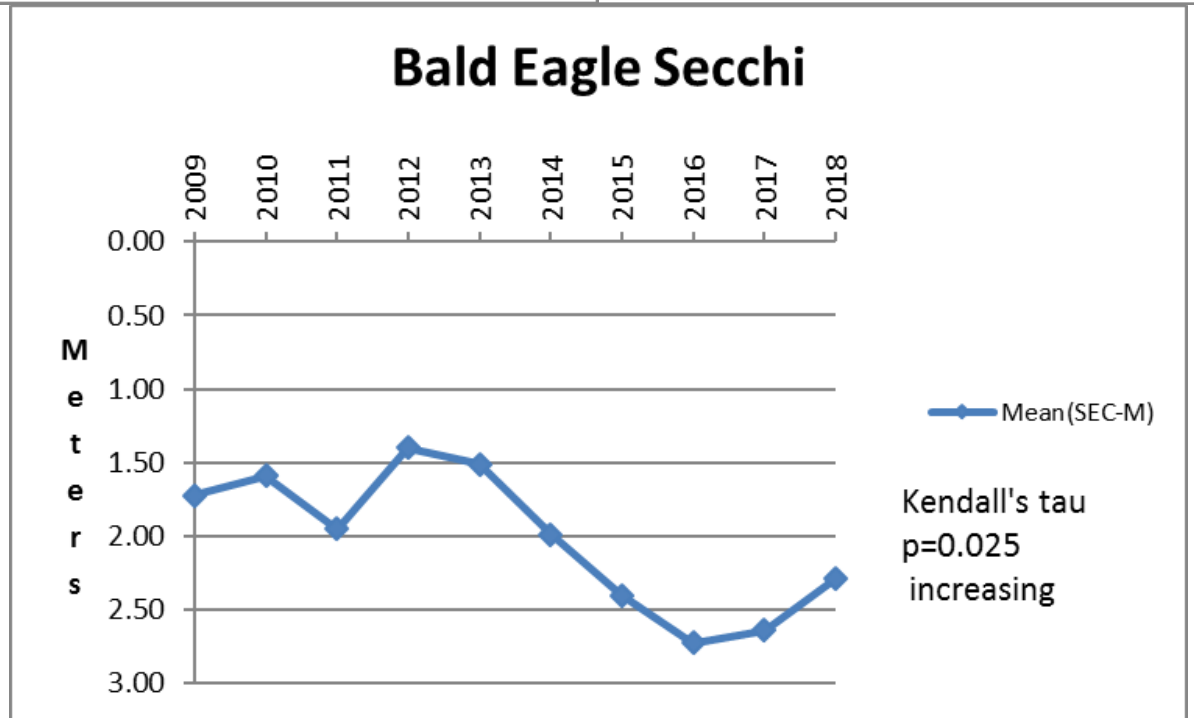
The largest alum treatment in MN

RCWD RICE CREEK WATERSHED DISTRICT

RCWD
RICE CREEK WATERSHED DISTRICT

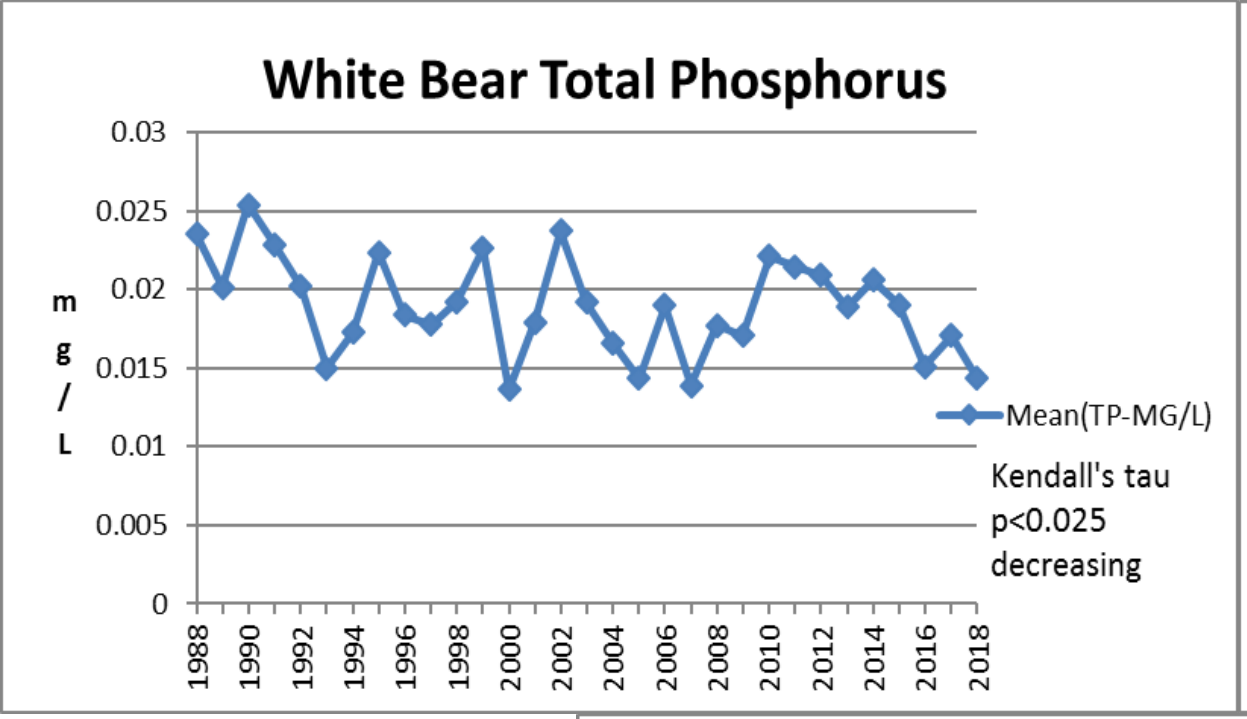


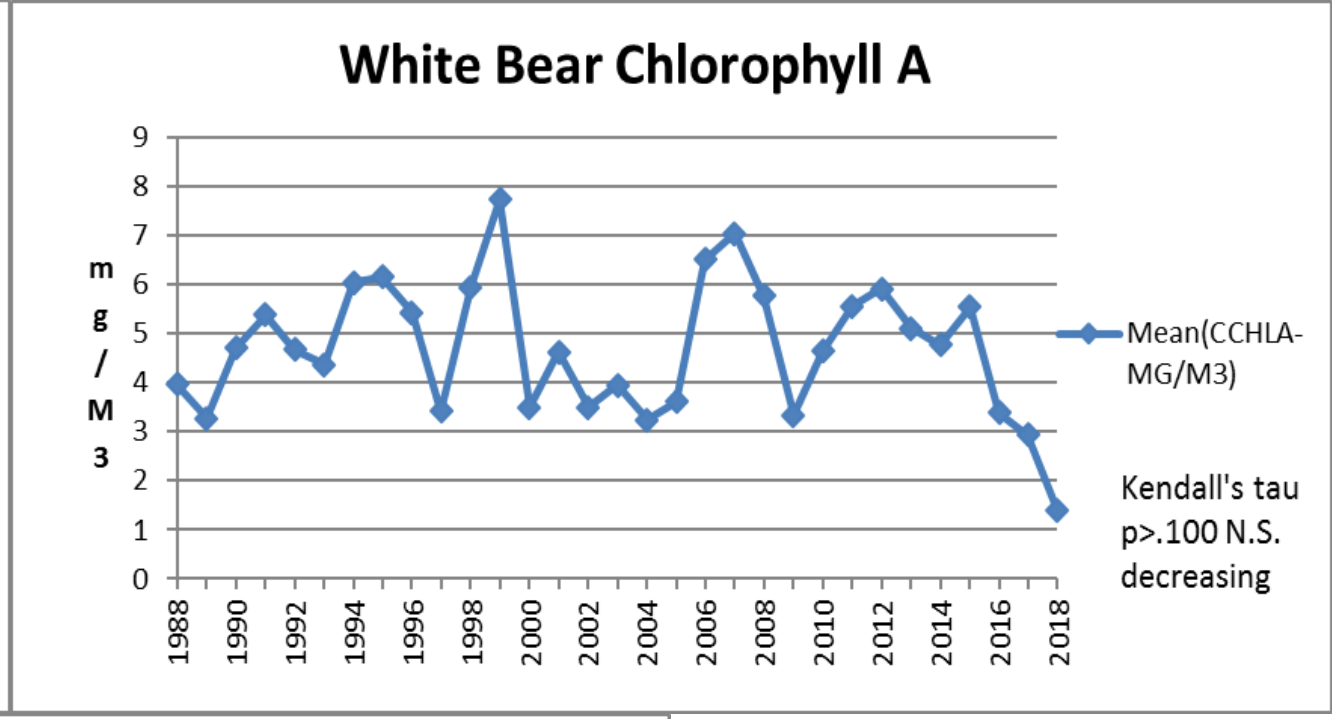


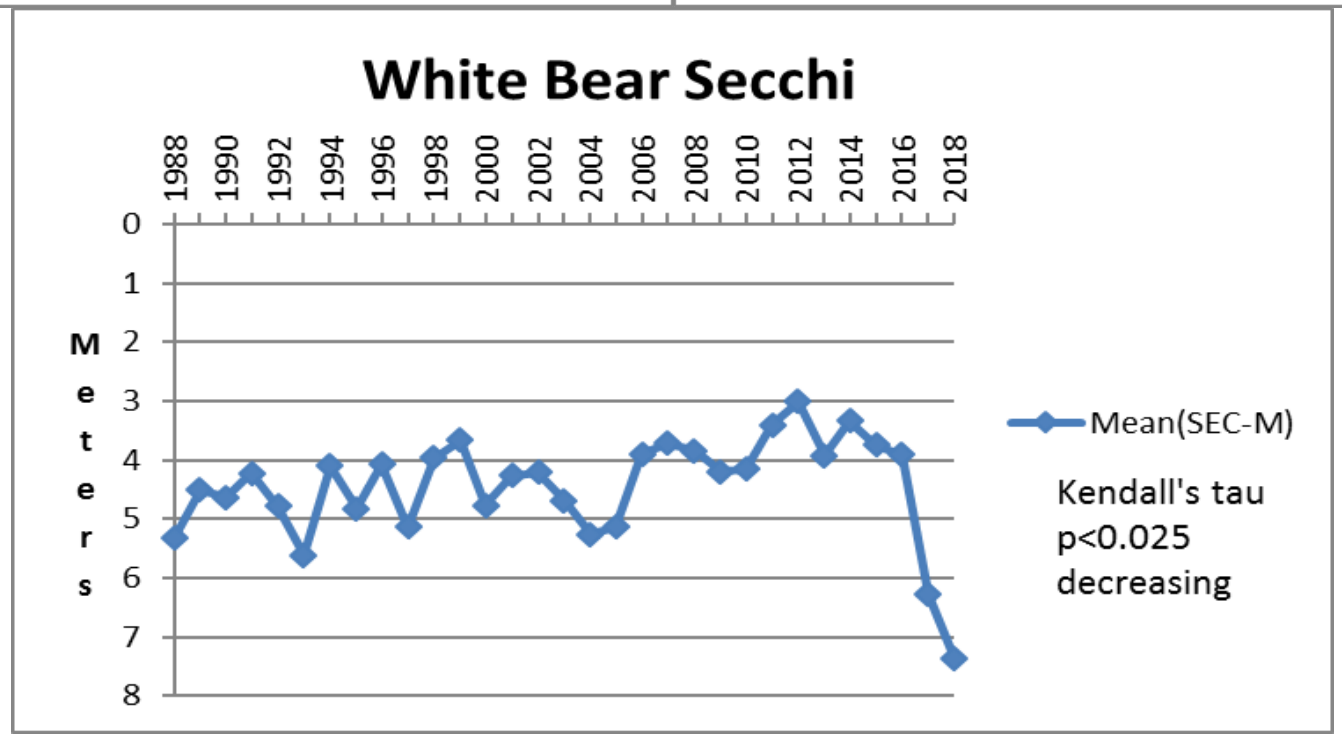


Note:2014 + 2016 Alum treatments

[Link to Alum Treatment Project Page]







Note: 2014 Zebra Mussel infestation confirmed

RAMSEY COUNTY LAKE MANAGEMENT WINTER MONITORING PROGRAM

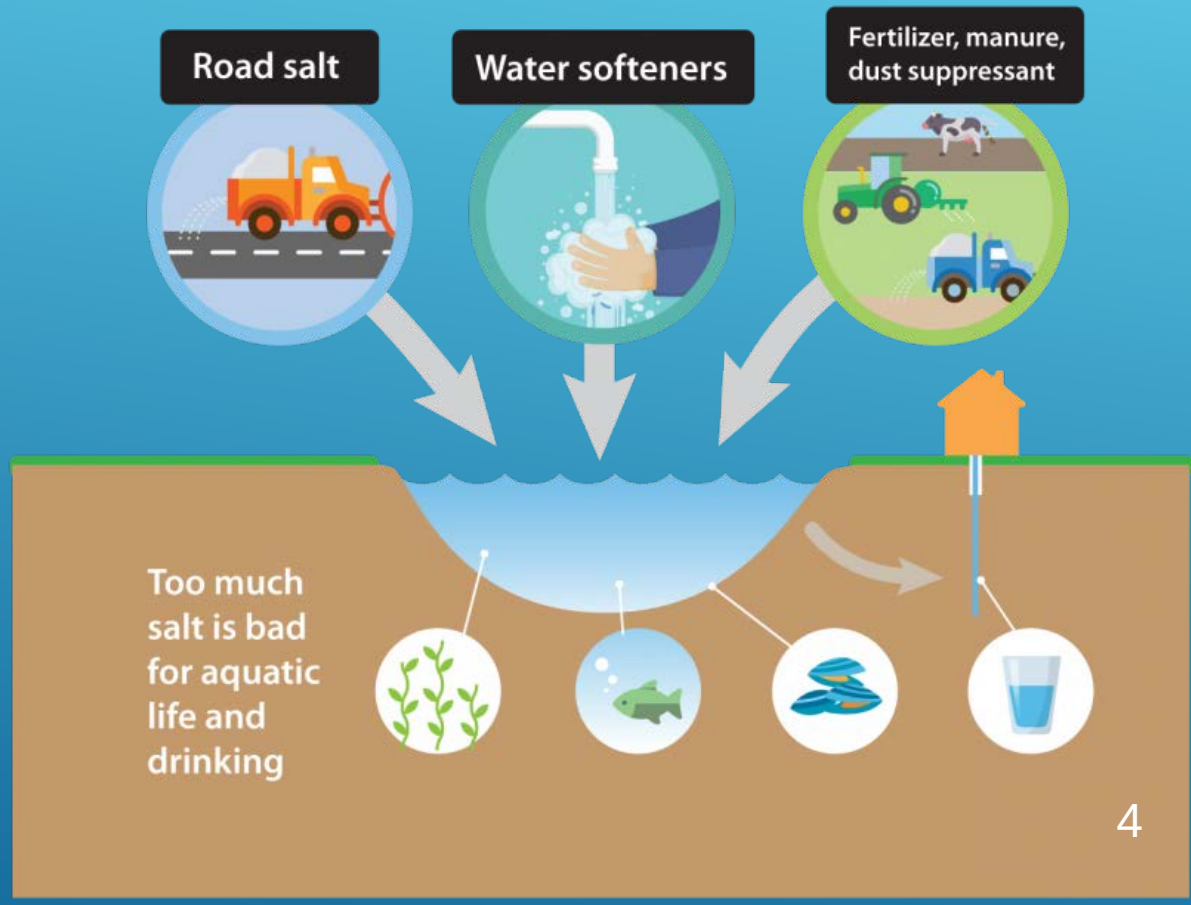
- Dissolved oxygen monitoring/aerating
  - Como, Owasso, Island, Otter, Silver East, Beaver
- Chloride monitoring
  - Worked with MPCA to establish a state water quality standard for chloride. TCMA Chloride Project Link
  - A large number of lakes were categorized as impaired for aquatic life, or at high risk of becoming impaired.

WHERE DOES CHLORIDE COME FROM ?

- Ramsey County uses 16,000,000 lbs/year to deice roads
- 700,000,000 lbs/year used in the Twin Cities Metro Area (1)
- 78% of this chloride is transported to surface or ground water in the TCMA

Table 1. Summary of annual road salt application amounts

User	Use (Tons)	Use %
MNDOT	80,797	23%
Counties	70,284	20%
Cities	114,314	33%
Commercial Bulk	66,349	19%
Packaged	17,460	5%
Total	349,204	100%



WHY IS CHLORIDE SO BAD?

- It takes only one teaspoon of salt to permanently pollute five gallons of water.
- There's no easy way to remove salt from water.
- Causes osmotic stress to organisms
- Decreases the biodiversity of sediment organisms and plants(2)
- Increases the release and transport of heavy metals(3)
- 30% of wells in TCMA had chloride concentrations above the chronic water quality standard.
- Corrosive to most surfaces

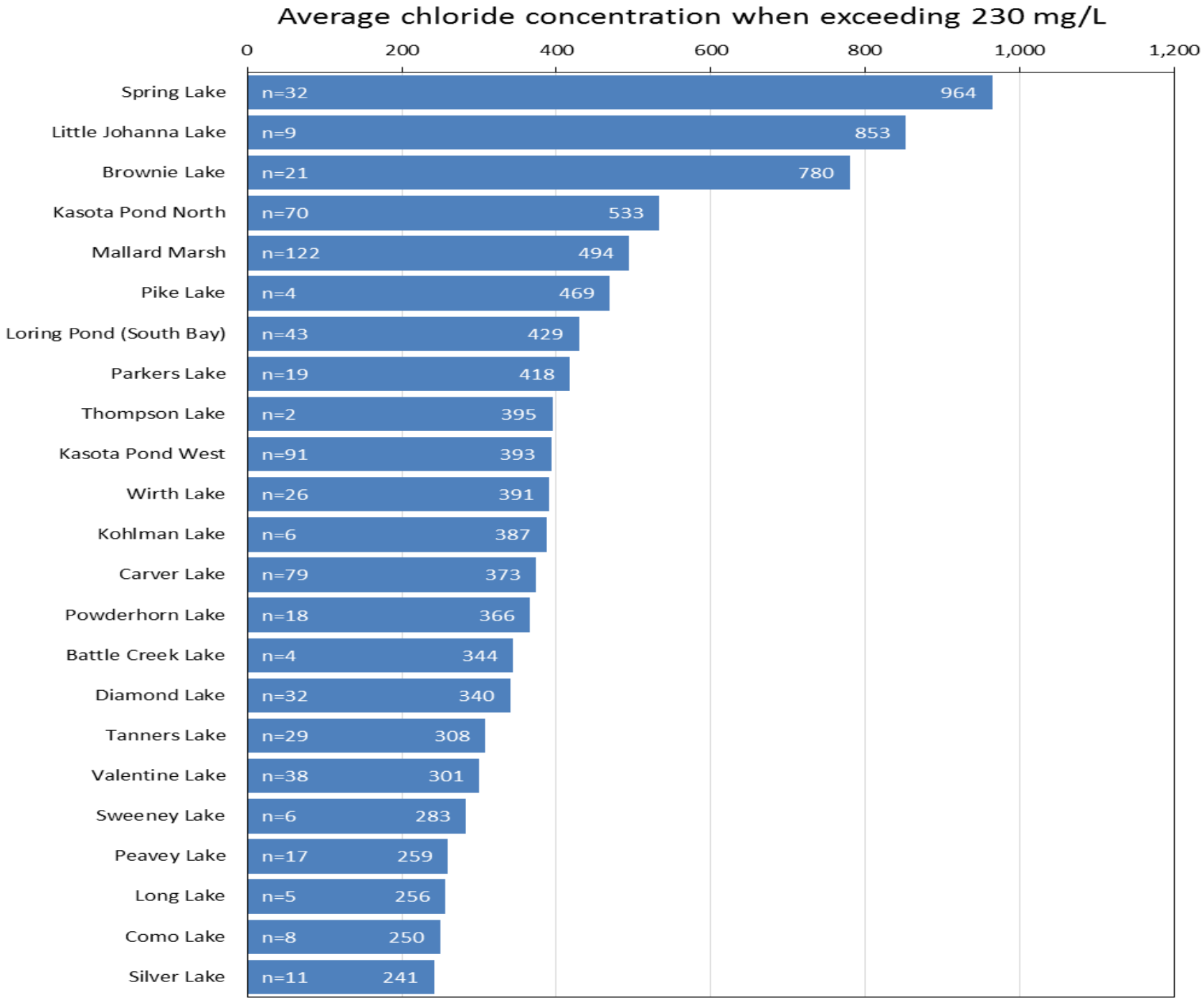
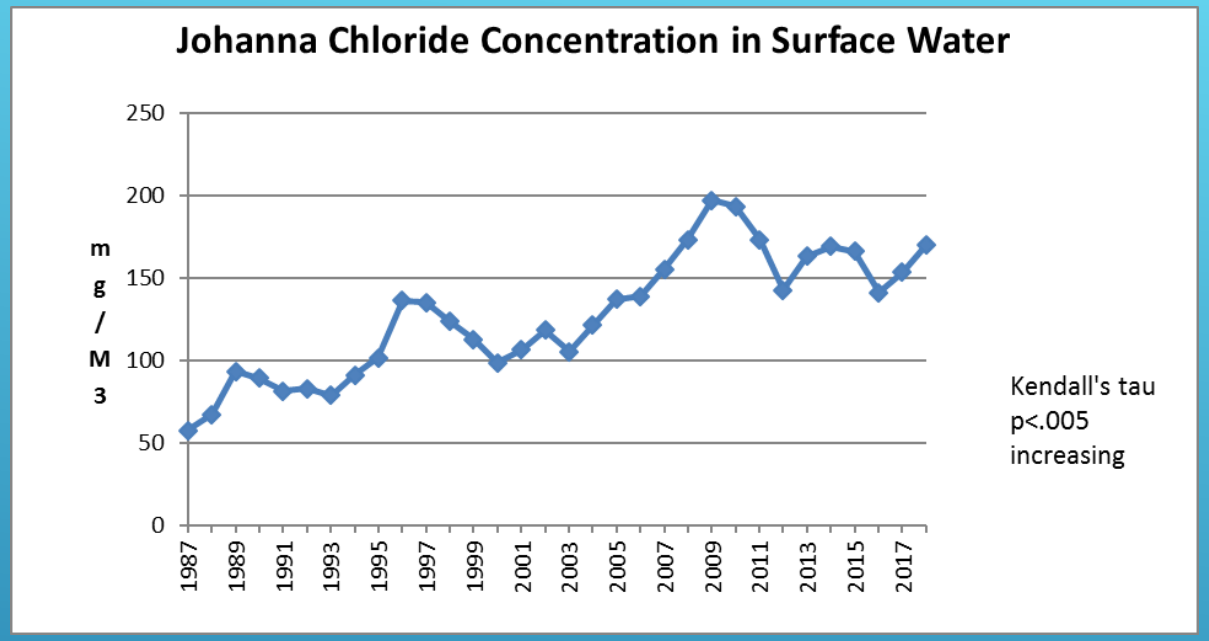
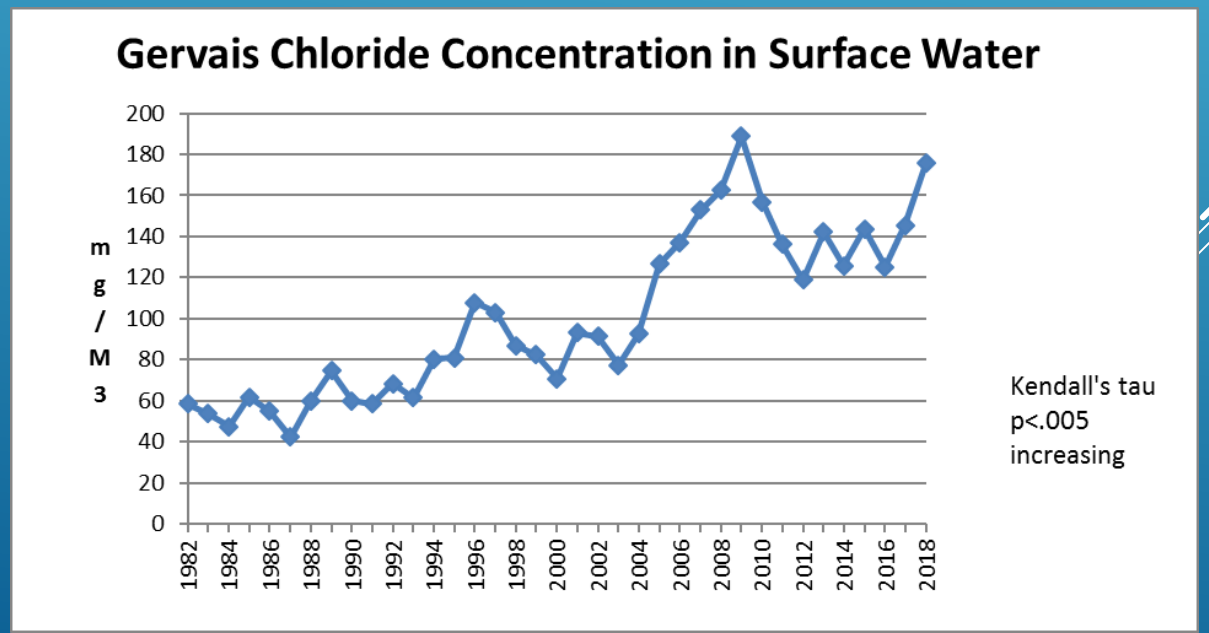


Table 2.TCMA Chloride Management Plan - MPCA 2015

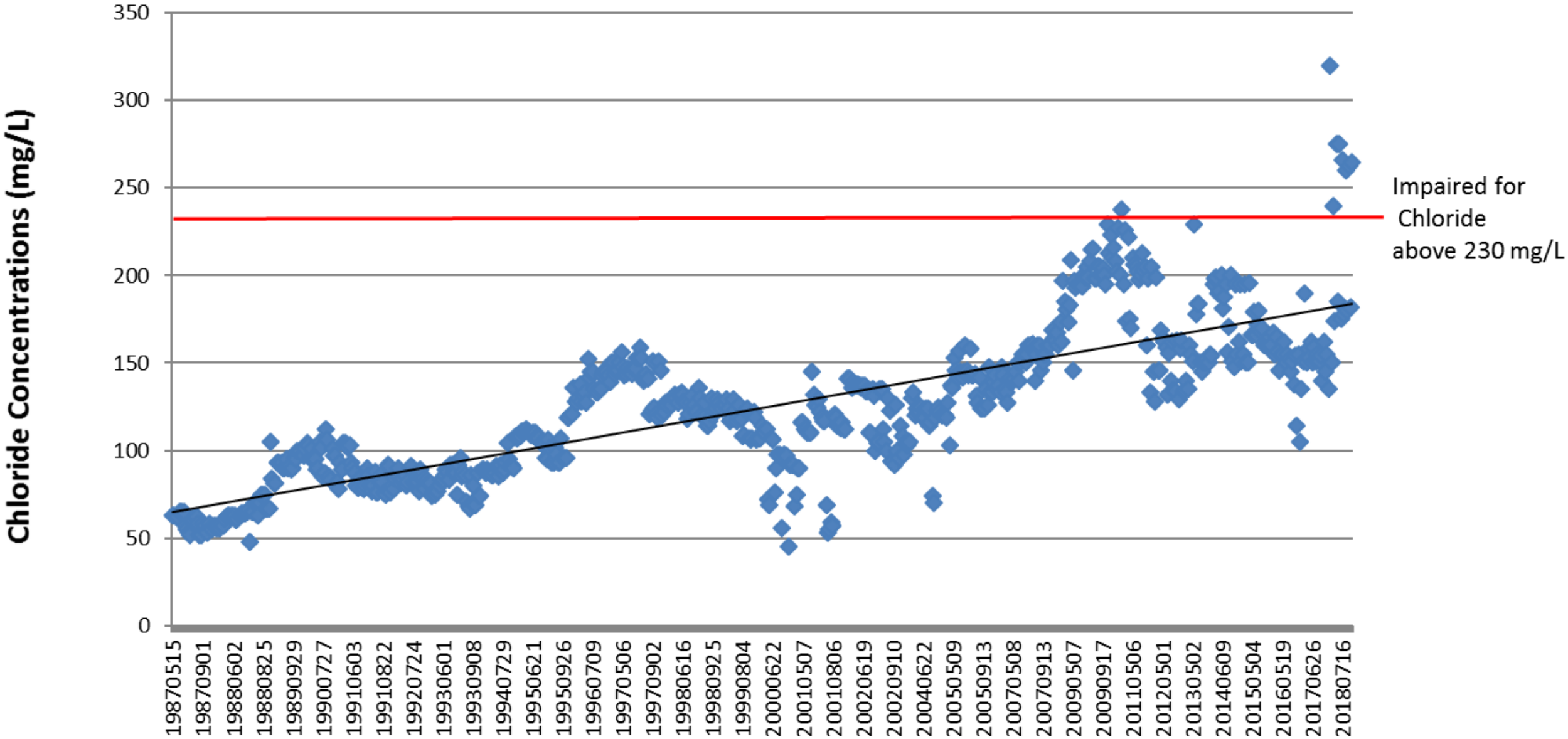
LAKES WITH A HIGH RISK OF CHLORIDE IMPAIRMENT

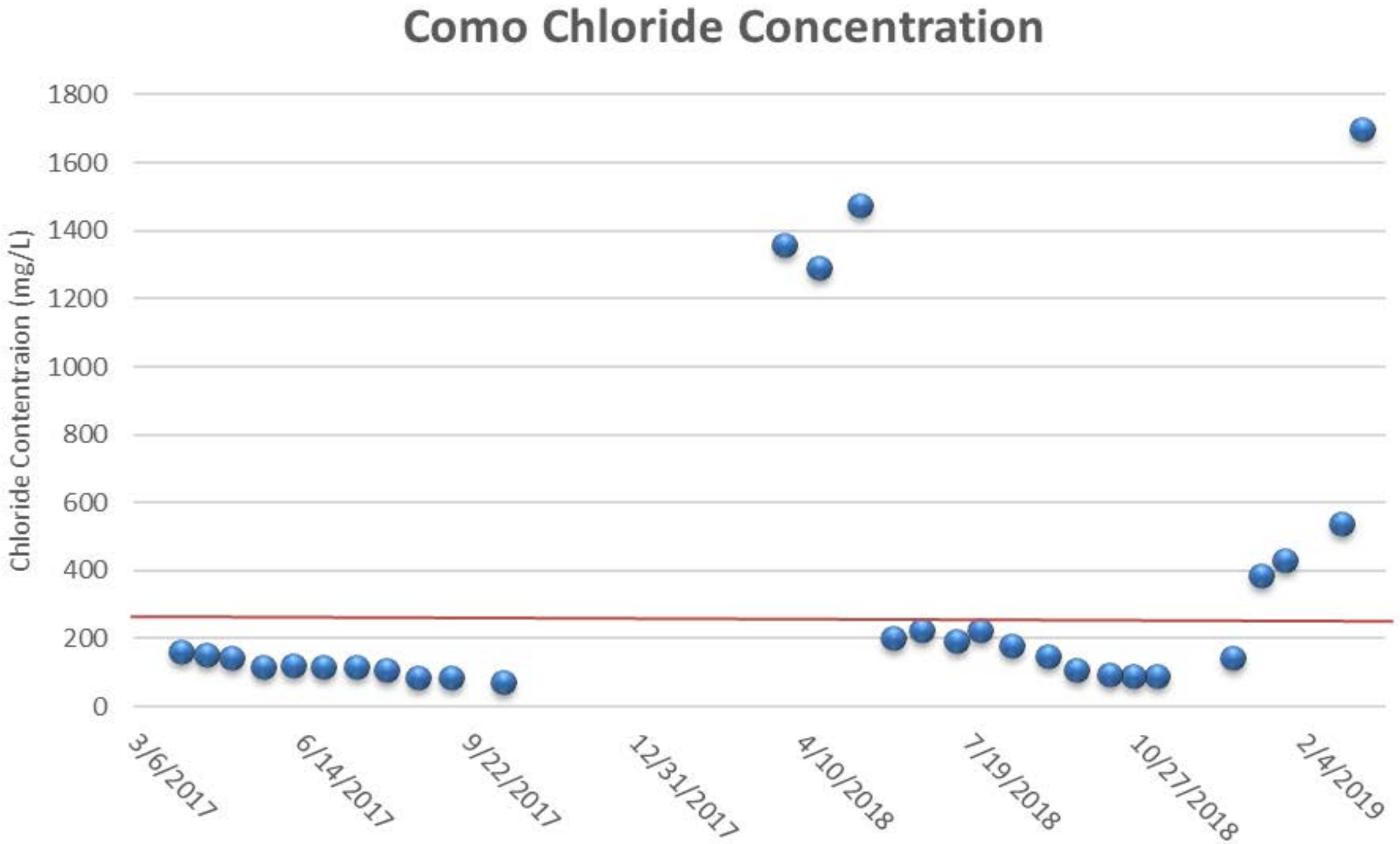
- Beaver
- Bennett
- Crosby ★
- Gervais ★
- Johanna ★
- Keller
- McCarrons
- Wabasso
- Wakefield ★





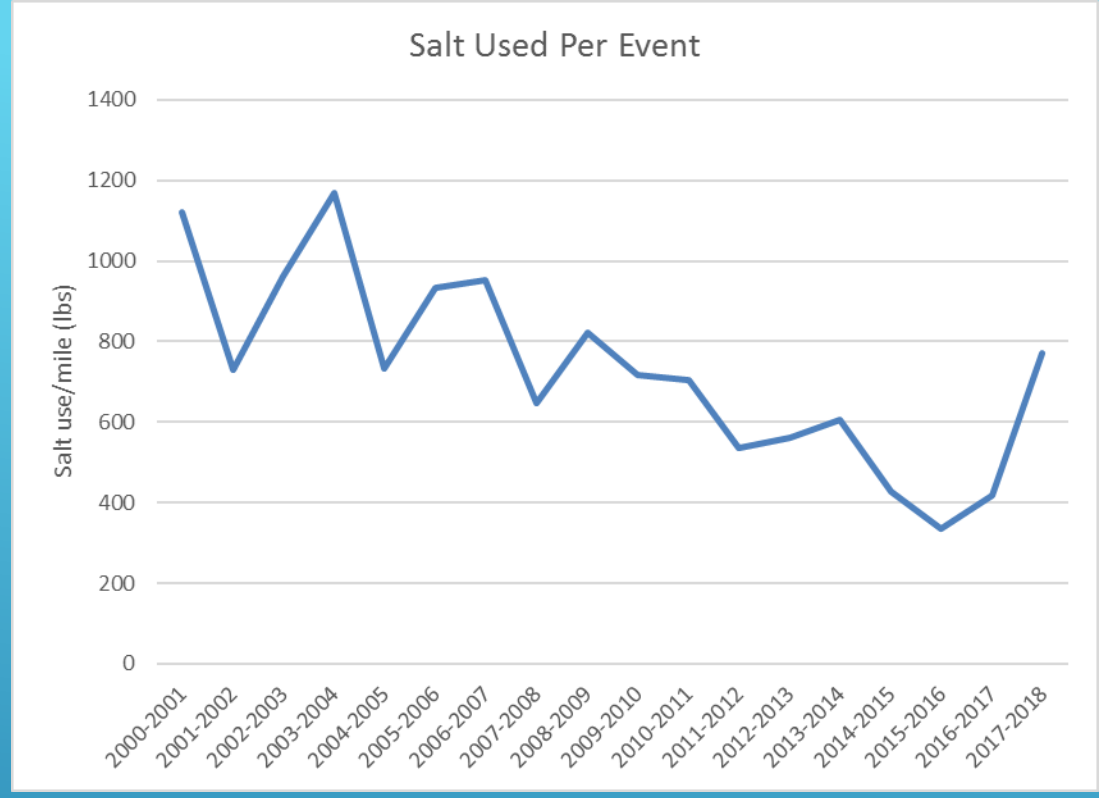
Johanna Lake Chloride Concentraion 1987 - 2018




Como Chloride Concentration
Chloride Contentraion (mg/L)
1800
1600
1400
1200
1000
800
600
400
200
0
3/6/2017
6/14/2017
9/22/2017
12/31/2017
4/10/2018
7/19/2018
10/27/2018
2/4/2019

WHAT IS RAMSEY COUNTY DOING

- Set goals to decrease salt usage
- Track usage of salt with calibrated dispensers
- Prevent ice buildup by shoveling and plowing more often, or with better equipment.
  - Ramsey County recently purchased tungsten carbide plow blades for our trucks to improve ice and snow removal ($145,000)
- **MPCA Smart Salt Applicating Training and Tools**
- Use Salt brine when conditions allow
- Sweep up excess salt and reuse



Great Online Resources

Improved Winter Maintenance: Good Choices for Clean Water

MN Key Water Info List

http://es.metc.state.mn.us/KeyWaterList/#SurfaceWater

Surface Water Data – MPCA

http://cf.pca.state.mn.us/water/watershedweb/wdip/index.cfm

Road Salt and Water Quality - MPCA

https://www.pca.state.mn.us/water/chloride-salts

https://www.pca.state.mn.us/water/salt-applicators

REFERENCES

1. Sander, A., E. Novotny, O. Mohseni, H.G. Stefan, (2007)"Inventory of Road Salt Uses in the Minneapolis/St. Paul Metropolitan Area". University of Minnesota, St. Anthony Falls Laboratory, Minneapolis, MN, Report No. 503, December 2007, 46 pp.

2. Talmage P J, Lee K E, Goldstein R M, Anderson J P, Fallon J D. Water Quality, Physical Habitat, and Fish-Community composition in Streams in the Twin Cities Metropolitan Area, Minnesota 1997-98. 1999; 18.

3. Novotny V, Muehring D, Zitomer D H, Smith D W, Facey R. Cyanide and metal pollution by urban snowmelt: impact of deicing compounds. Water Science and Technology 1998; 38: 223-230.

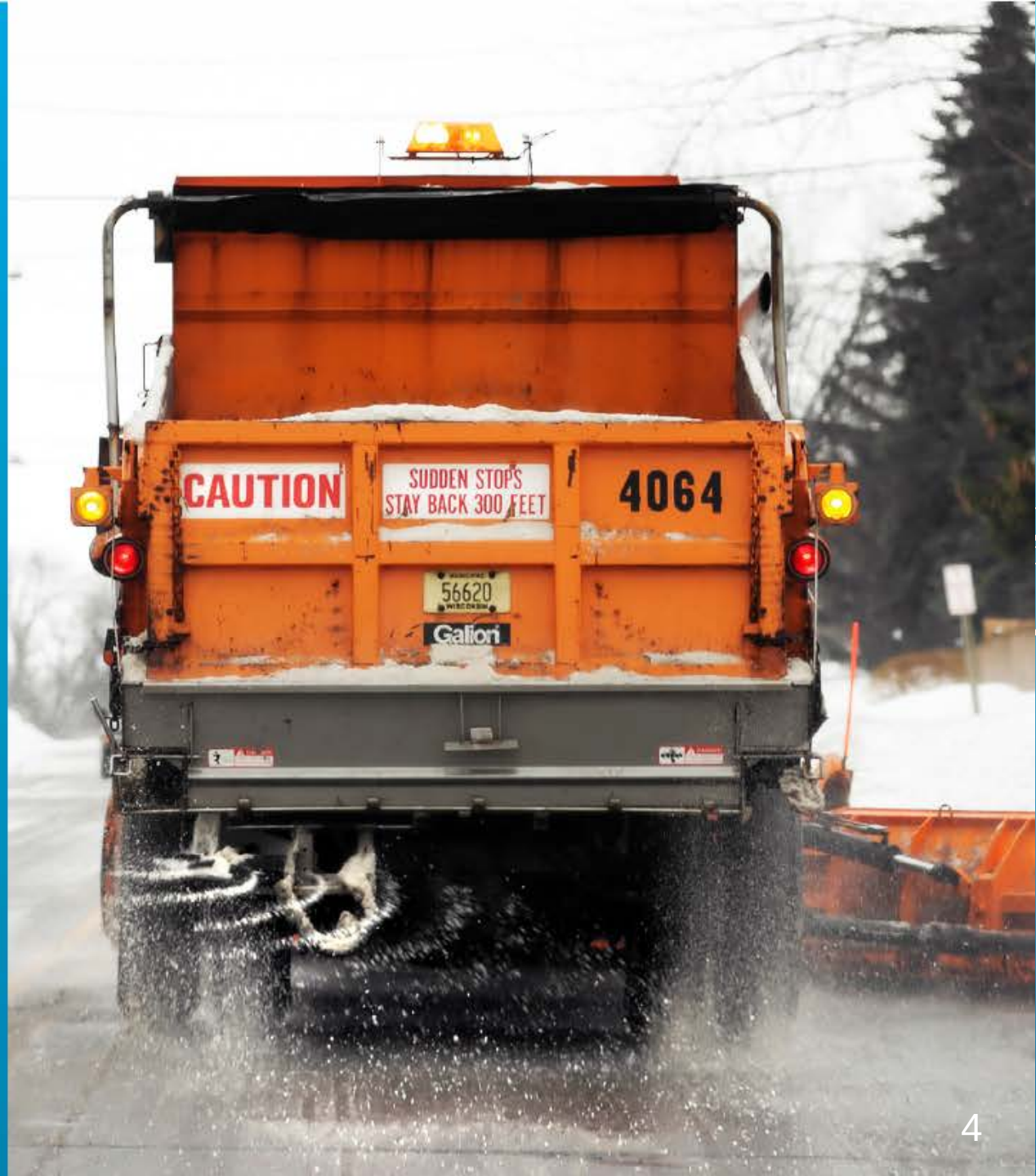
4. https://www.pca.state.mn.us/water/chloride-101

5. Heiskary, S. and M. Lindon. 2009. Microcystin in Minnesota Lakes. *LakeLine* 24(4):25-30

Salt pollutes.

When snow and ice melts, the salt goes with it, washing into our lakes, streams, wetlands, and groundwater. Once in the water, there is no way to remove the chloride, and it takes only one teaspoon of road salt to permanently pollute five gallons of water. Less is more when it comes to applying salt because at high concentrations, chloride can harm the fish and plant life in our waters.

MINNESOTA POLLUTION CONTROL AGENCY



RAMSEY COUNTY

Thank You Plow Drivers!

Ramsey County plow truck drivers work tirelessly to not only keep us mobile in the worst weather, but also focus on smart salt use using innovative equipment, technology, and know how to reduce chloride use on the roads

Preventing New Infestations and Their Effect on Water Quality

March 2019 Forum

RAMSEY COUNTY

Justin Townsend
Aquatic Invasive Species Coordinator
Ramsey County
Parks and Recreation-Soil and Water Division
1425 Paul Kirkwold Drive
Arden Hills, MN 55117
651-266-7277
Justin.Townsend@co.Ramsey.MN.US

Friendly public service announcement: Not all aquatic plants or animals are bad. They require care like any landscape. Please take care of them.

RAMSEY COUNTY

Photos 1 & 2: Sole juvenile zebra mussel found on a settlement plate by a lake resident on August 18, 2018 in Bald Eagle Lake, Ramsey County.

Figure 1. Zebra mussels found in Lake Johanna, collected in 2018. Two distinct year classes were found (top numbers on ruler are in mm).

Photo Courtesy of Steve McComas or Bluewater Science

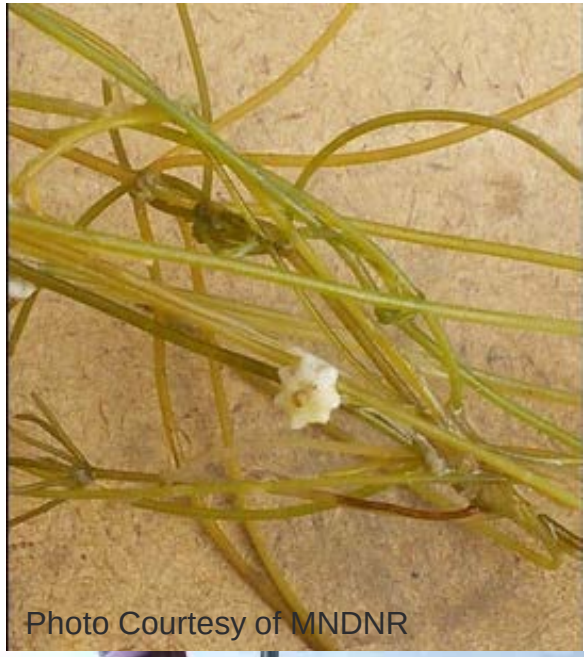


Photo Courtesy of MNDNR

Photo Courtesy of St. Cloud Times

RAMSEY COUNTY

Why Should I Care?

- Zebra mussel shells are extremely sharp
- At scale they foul equipment (clogged engine intakes)
- Eat the base of the food chain fish species rely on
- Change water clarity increasing nuisance plants

https://bugwoodcloud.org/mura/mipn/assets/File/UMISC-2016/Tuesday/2/Fieldseth_McComas_ZebraMusselsWaterQualLakeMinnetonkaMN.pdf

PHOTO BY BRAD HENLEY

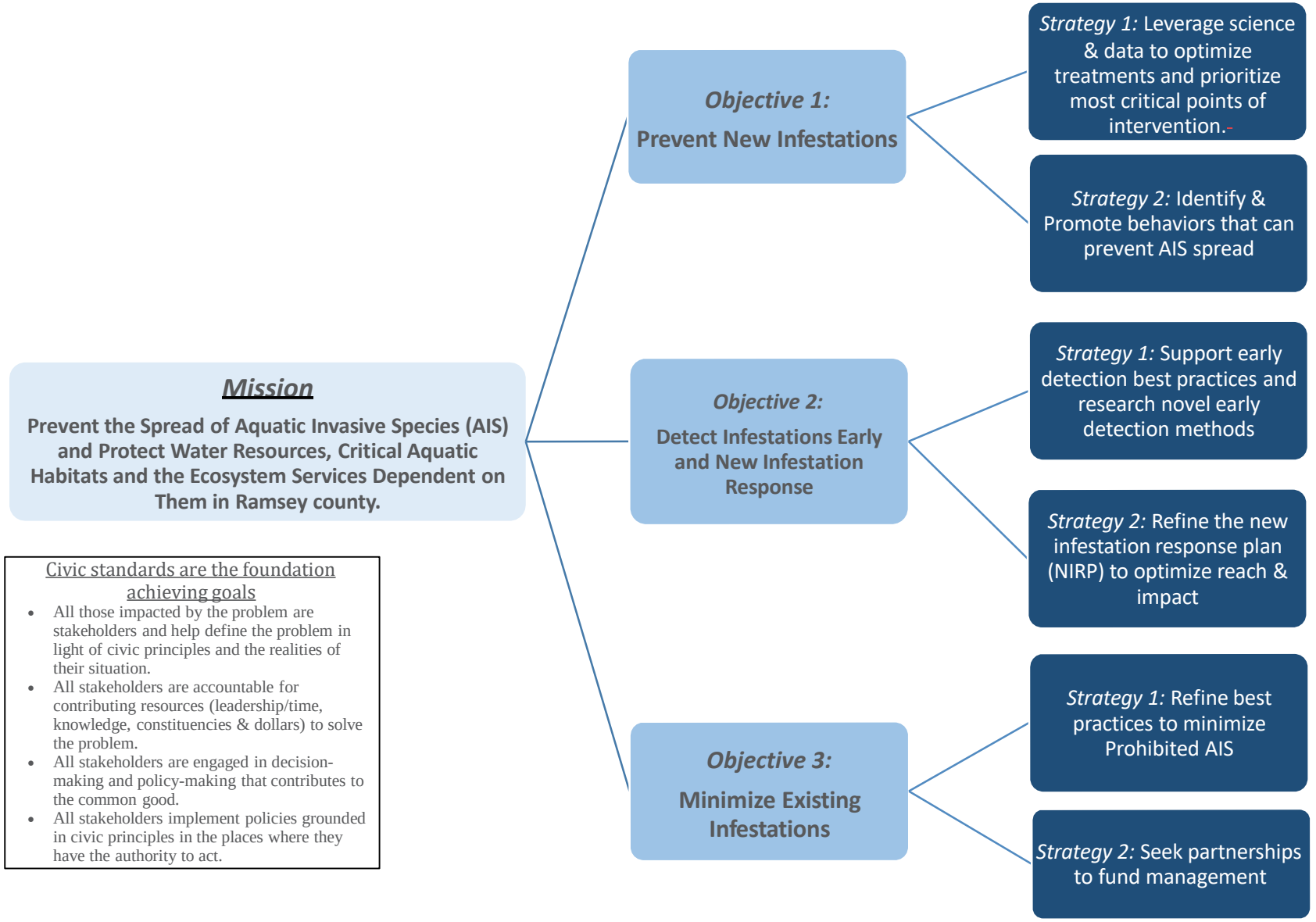
RAMSEY COUNTY

Why Should I Care?

- Eurasian Milfoil, Starry Stonewort, Brittle Niad, Phragmites, and Flowering Rush are aggressive plants
- They diminish the recreational value of lakes
- Decrease or interrupt spawning habitat for fish
- May have allelopathic (kills other plants) tendencies

https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=1688

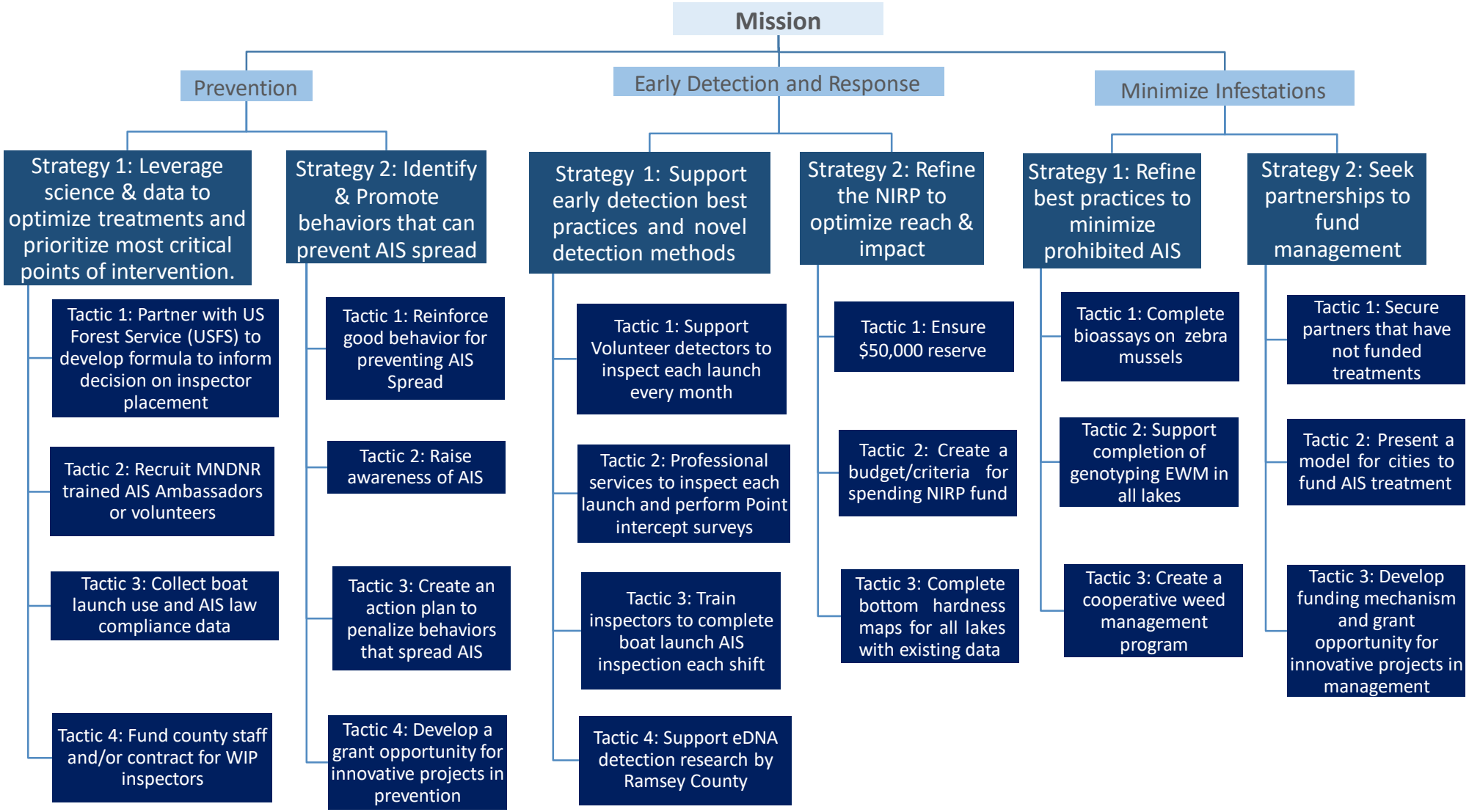
2019-2024 Five Year Strategic Plan



Civic standards are the foundation achieving goals

- All those impacted by the problem are stakeholders and help define the problem in light of civic principles and the realities of their situation.
- All stakeholders are accountable for contributing resources (leadership/time, knowledge, constituencies & dollars) to solve the problem.
- All stakeholders are engaged in decision-making and policy-making that contributes to the common good.
- All stakeholders implement policies grounded in civic principles in the places where they have the authority to act.

2019 Work Plan



RAMSEY COUNTY

We Inspect to:
- Raise awareness
- Gather data
- Educate

We analyze to:
- Refine inspections
- Reach more people
- Reduce the risk

$$\max_{x_{ik}, y_{jk}} Z = \sum_{j \in J} \sum_{i \in I} \sum_{k \in K} n_{ijk}(a_{ijk} + b_{ijk})$$

Subject to:

$$a_{ijk} \leq x_{ik} \qquad \forall i, j, k$$

$$b_{ijk} \leq y_{jk} \qquad \forall i, j, k$$

$$a_{ijk} + b_{ijk} \leq 1 \qquad \forall i, j, k$$

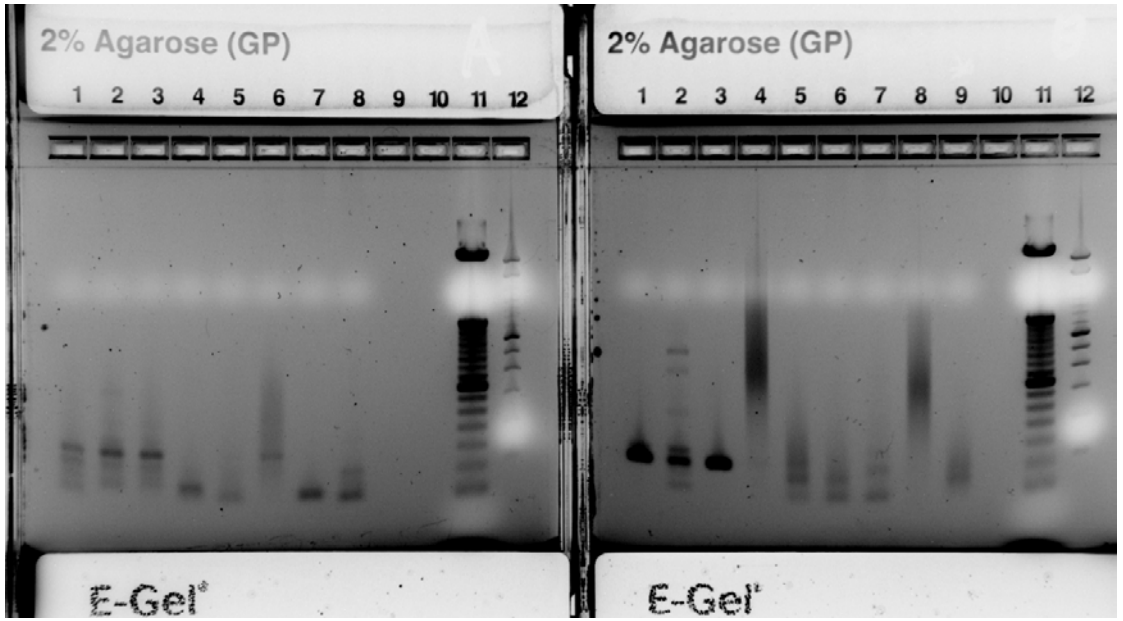
We reduce the barriers to clean boats
- Provide the Knowledge
- Provide the tools
- Increase the social pressure to clean, drain, dispose

RAMSEY COUNTY

Early Detection

- Inspectors search daily
- Volunteer detectors search monthly
- Veliger Tows
- Contracted diver searches at each boat launch
- Cutting edge eDNA detection

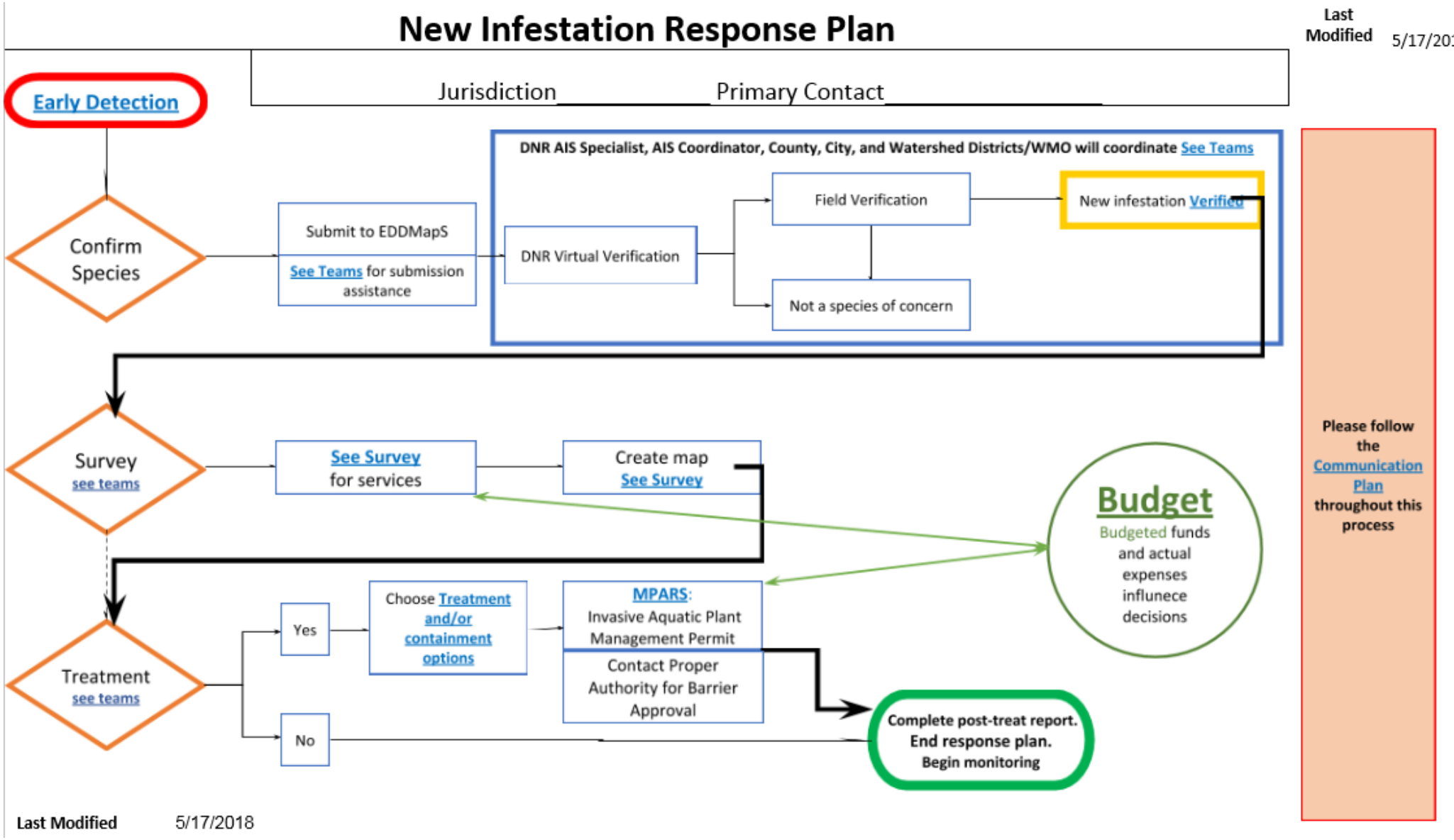
Figure 3. [left] Blue Water Science staff searching nearshore areas for zebra mussels. [right] Example of organisms found on a rock that are not zebra mussels.



RAMSEY COUNTY

Response

- Planning-developed the new infestation response plan
- Funding- contingency dollars via county prevention aid
- Collaborating-working proactively with lake associations, cities, and all stakeholders
- Bioassays to study chemical efficacy for zebra mussel treatment
- Working with the Minnesota Aquatic Invasive Species Research Center (MAISRC) on Eurasian Milfoil genotyping


New Infestation Response Plan
Last Modified 5/17/2018
Jurisdiction
Primary Contact
Early Detection
DNR AIS Specialist, AIS Coordinator, County, City, and Watershed Districts/WMO will coordinate See Teams
Confirm Species
Submit to EDDMapS
See Teams for submission assistance
DNR Virtual Verification
Field Verification
New infestation Verified
Not a species of concern
Survey
see teams
See Survey for services
Create map
See Survey
Budget
Budgeted funds and actual expenses influnece decisions
Treatment
see teams
Yes
Choose Treatment and/or containment options
MPARS: Invasive Aquatic Plant Management Permit
Contact Proper Authority for Barrier Approval
No
Complete post-treat report. End response plan. Begin monitoring
Please follow the Communication Plan throughout this process
Last Modified 5/17/2018

Bottom Line

Invasions are hard to predict
Watch your boats and lifts! Report new sightings

Ramsey County will work with you to be a county of excellence in AIS prevention