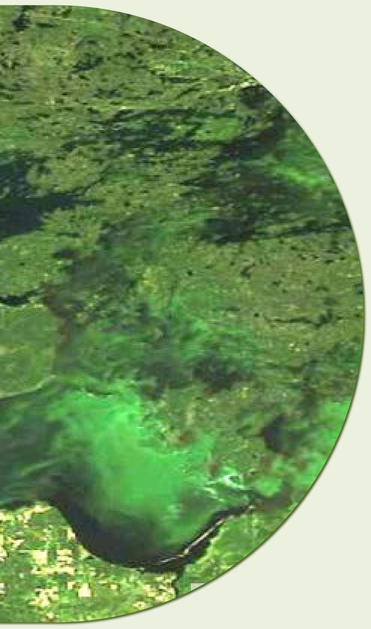
LAKE OF THE WOODS PROGRAM



Water quality and aquatic ecosystem health is of concern in the Lake of the Woods.

The most critical issue affecting Lake of the Woods water quality and aquatic ecosystem health is the persistent and significant algal blooms that occur in summer and fall. Blooms are fed by excess nutrients coming into the lake from various sources, and also from nutrients released from lake sediments.

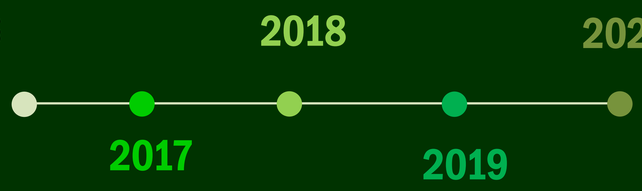
Environment and Climate Change Canada (ECCC) has developed a science program based on the International Joint Commission's recommendations for further study of factors affecting Lake of the Woods.

ECCC has significant expertise in freshwater science from previous and ongoing work in the Rainy River -Lake of the Woods basin and across Ontario and Canada.

OUTCOMES

- Determine the phosphorus load reductions which would be required to achieve environmental outcomes protective of the waters of Lake of the Woods
- Identify Canadian sources and relative contributions of phosphorus

TIMELINE



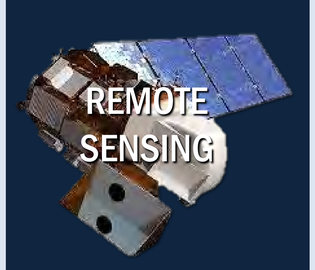
OBJECTIVES

1. ENHANCED MONITORING AND ASSESSMENT OF CURRENT WATER QUALITY CONDITIONS
2. IDENTIFYING CAUSES AND CONSEQUENCES OF NUTRIENT ENRICHMENT AND ALGAL BLOOMS
3. PREDICTING THE LAKE'S REPONSE TO POTENTIAL NUTRIENT LOAD REDUCTION STRATEGIES

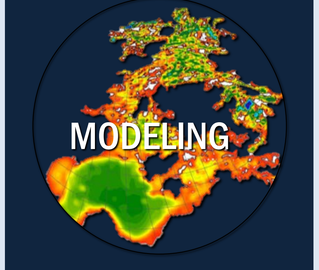
APPROACH

Collect more water quality data for the Lake of the Woods, Rainy River and select tributaries in Canada

Research on the sources of nutrients that fuel algae blooms at local and whole lake scales



Develop tools to identify and monitor algae blooms using satellite-derived information



Integrate land and water-based models to assess lake responses to nutrient reduction strategies

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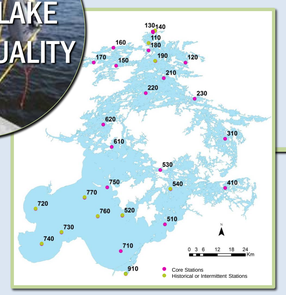
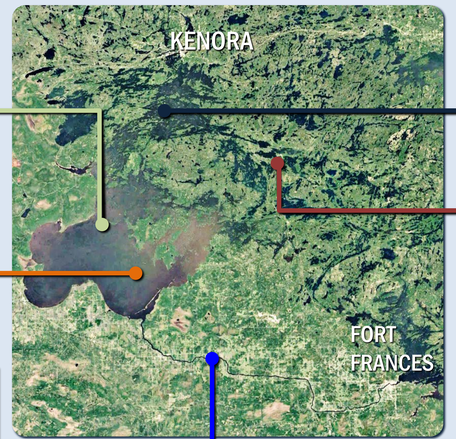
OBJECTIVE 1. ENHANCED MONITORING AND ASSESSMENT OF CURRENT WATER QUALITY CONDITIONS

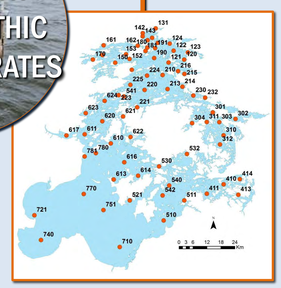
WHY MORE MONITORING?

1. TO ASSESS CURRENT WATER QUALITY CONDITIONS
2. TO IMPROVE ESTIMATES OF NUTRIENT LOADING FROM CANADIAN SOURCES
3. TO SUPPORT RESEARCH AND MODELING EFFORTS

MONITORING IS DESIGNED TO IDENTIFY THE CONTRIBUTION OF NUTRIENTS BY SOURCE TYPE







LAKE OF THE WOODS

SEDIMENT

RAINY RIVER

LAKE TRIBUTARIES

	LAKE OF THE WOODS	SEDIMENT	RAINY RIVER	LAKE TRIBUTARIES
WHAT	NUTRIENTS MAJOR IONS METALS OTHER PARAMETERS	NUTRIENTS MAJOR IONS METALS INVERTEBRATES	NUTRIENTS MAJOR IONS METALS OTHER PARAMETERS	NUTRIENTS MAJOR IONS OTHER PARAMETERS
HOW MANY	26-30 STATIONS	72 STATIONS	4 LOCATIONS ALONG RAINY RIVER AND PINEWOOD RIVER	5 TRIBUTARIES; LAKE OUTLET
HOW OFTEN	TWICE ANNUALLY – JUNE AND SEPTEMBER	SAMPLED IN 2009-2014	BIWEEKLY DURING OPEN WATER; MONTHLY DURING ICE-ON	EVENT BASED 10 -15 SAMPLES
WHO	ECCC	ECCC	ECCC AND LOCAL CONTRACTORS	MOECC

OUTCOMES

1. IDENTIFICATION OF THE CONTRIBUTION OF CANADIAN SOURCES OF NUTRIENTS
2. IDENTIFICATION OF AREAS WITH ELEVATED NUTRIENTS
3. IDENTIFICATION OF CONDITIONS THAT CAN LEAD TO ELEVATED NUTRIENTS
4. LONG-TERM BASELINE DATASET TO TRACK SUCCESS OF ACTION

NUTRIENTS
Phosphorus (multiple forms)
Nitrogen (multiple forms)
Carbon (multiple forms)

MAJOR IONS
Chloride
Sulfate
Sodium
Magnesium
Calcium
Potassium
Fluoride

METALS
Arsenic
Cadmium
Chromium
Copper
Iron
Lead
Mercury
Manganese
Nickel
Zinc
And many more

OTHER
Chlorophyll-a
Conductivity
Alkalinity
pH
Reactive Silicate
Total Suspended Solids
Turbidity
Temperature
Dissolved Oxygen
Secchi Depth

WHAT IS BEING DONE?

- More tributaries sampled
- Greater number of sampling events
- New tools used to collect samples
- New data on atmospheric inputs
- Building new local partnerships

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OBJECTIVE 2. IDENTIFYING THE CAUSES AND CONSEQUENCES OF NUTRIENT ENRICHMENT AND ALGAL BLOOMS

THE ALGAE PROBLEM IN LAKE OF THE WOODS IS COMPLEX

1. BLOOMS ARE MOBILE AND CAN REACH AREAS FAR FROM THEIR ORIGIN
2. NOT ALL ALGAE PRODUCE TOXINS AND THOSE THAT CAN, DON'T ALWAYS DO SO
3. BLOOMS ARE FUELLED BY DIFFERENT NUTRIENT SOURCES AND UNDER A VARIETY OF CONDITIONS
4. BLOOMS CAN COVER LARGE AREAS AND ARE DIFFICULT TO MONITOR FROM THE WATER
5. A ONE SIZE FITS ALL APPROACH TO MANAGING THE PROBLEM MAY NOT SOLVE THE ISSUE

INTEGRATIVE APPROACH

RESEARCH OBJECTIVES	DETERMINE THE ORIGIN, MOVEMENT AND MAKE UP OF BLOOMS	IDENTIFY THE SOURCES OF ALGAE TOXINS	UNDERSTAND THE EXTENT OF INTERNAL NUTRIENT LOADINGS ON ALGAE	ASSESS THE EXTENT THAT NEARSHORE NUTRIENT SOURCES FUEL BLOOMS	DEVELOP TOOLS TO MONITOR BLOOM SIZE, COMPOSITION AND SEVERITY
WHY?	Knowing where blooms form and how and where they move will direct management efforts most efficiently	Toxins enter water when algae cells break open. Knowing how and under what conditions this occurs will help develop management solutions	Knowing the extent that sediments contribute to blooms is an important consideration for moving forwards on management	Local nutrient sources may contribute to blooms in select areas. Studying this will contribute to developing a well-rounded solution	Monitoring blooms at a lake-wide scale will help to assess water quality conditions , communicate the issue and track the success of action
WHAT?	Lake-wide spatial surveys to identify bloom species and movement patterns	Molecular, physiological and analytical methods to determine toxin production	Sediment and bottom water quality sampling throughout the year	Study the quality of ground and surface waters in 3 developed areas that experience blooms	Map bloom size, intensity and species. Use archived images to determine historical trends

From satellite to microscope, understanding the algae problem requires research spanning multiple scales in space and time

OUTCOMES & CONTRIBUTIONS

- DOCUMENT STATUS, TRENDS AND DRIVERS OF BLOOMS
- DETERMINE THE RISK THAT BLOOMS POSE
- INFORM MANAGEMENT AND MITIGATION STRATEGIES

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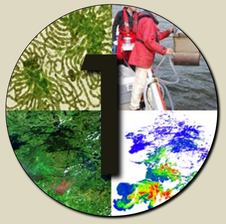
OBJECTIVE 3. PREDICTING THE LAKE'S RESPONSE TO POTENTIAL NUTRIENT LOAD REDUCTION STRATEGIES

HOW DO YOU PREDICT LAKE RESPONSES?



INTEGRATE LAKE AND LAND MODELS

CALIBRATE AND VALIDATE MODEL USING PAST AND PRESENT WATER QUALITY CONDITIONS

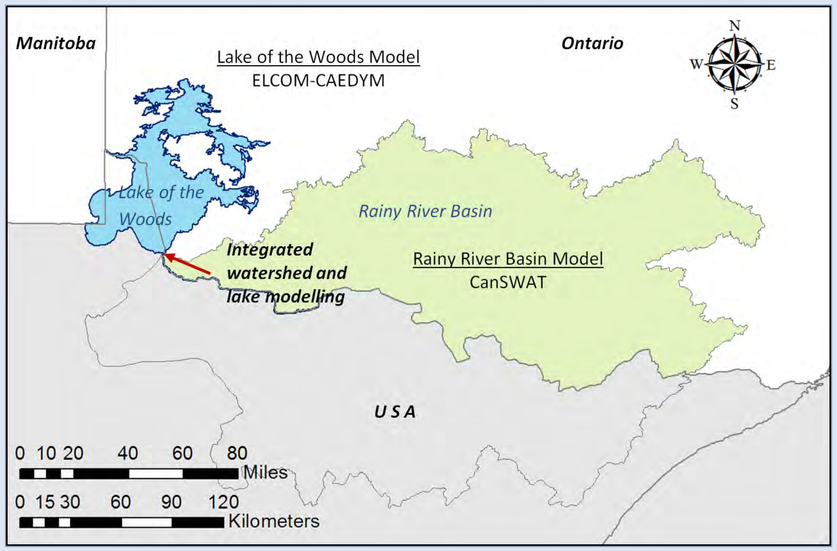
ASSESS THE LAKE'S RESPONSE TO DIFFERENT NUTRIENT LOADING AND CLIMATE CHANGE SCENARIOS

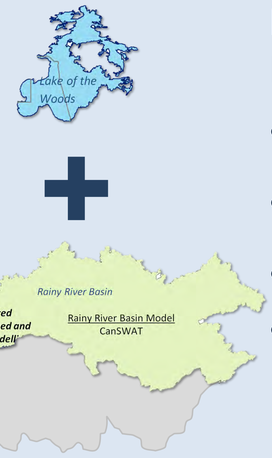
MODELING APPROACH

DEVELOP MODEL THAT CAN LINK NUTRIENT SOURCES FROM THE WATERSHED TO CONDITIONS IN THE LAKE

INCORPORATE WHAT WE LEARN FROM STUDYING ALGAE AND NUTRIENTS

CONSIDER OTHER POTENTIAL FUTURE CHANGES INCLUDING CLIMATE CHANGE





LAKE AND WATERSHED MODELS WILL PREDICT:

- nutrient loadings
- water movement
- water quality conditions
- lake responses to reducing nutrients

IDENTIFY THE relative importance of Canadian sources of nutrients

CONTRIBUTE TO developing future water quality goals

INFORM THE DESIGN of nutrient reduction strategies

WHY PREDICT LAKE RESPONSES?

IMPROVING WATER QUALITY WILL REQUIRE ACTION TO REDUCE NUTRIENTS

TO SET REALISTIC EXPECTATIONS FOR FUTURE CONDITIONS

TO ACCOUNT FOR THE POTENTIAL EFFECTS OF CLIMATE CHANGE ON WATER QUALITY

COLLABORATION

THIS PROJECT WILL INCORPORATE DATA FROM CANADIAN AND U.S. SOURCES AND IMPROVE LAKE RESPONSE PREDICTIONS. RESULTS AND DATA SHARING WITH U.S. PARTNERS IS ONGOING AND CRITICAL TO PROGRAM SUCCESS.

Minnesota Pollution Control Agency

Lake of the Woods water sustainability foundation

Ontario

Many agencies and organizations have provided data to this project. We recognize the contributions of our partners.

USGS science for a changing world

Agriculture and Agri-Food Canada

NRC·CNRC

Ducks Unlimited Canada Conserving Canada's Wetlands

U.S. Fish & Wildlife Service

United States Environmental Protection Agency

Environment and Climate Change Canada

Environnement et Changement climatique Canada

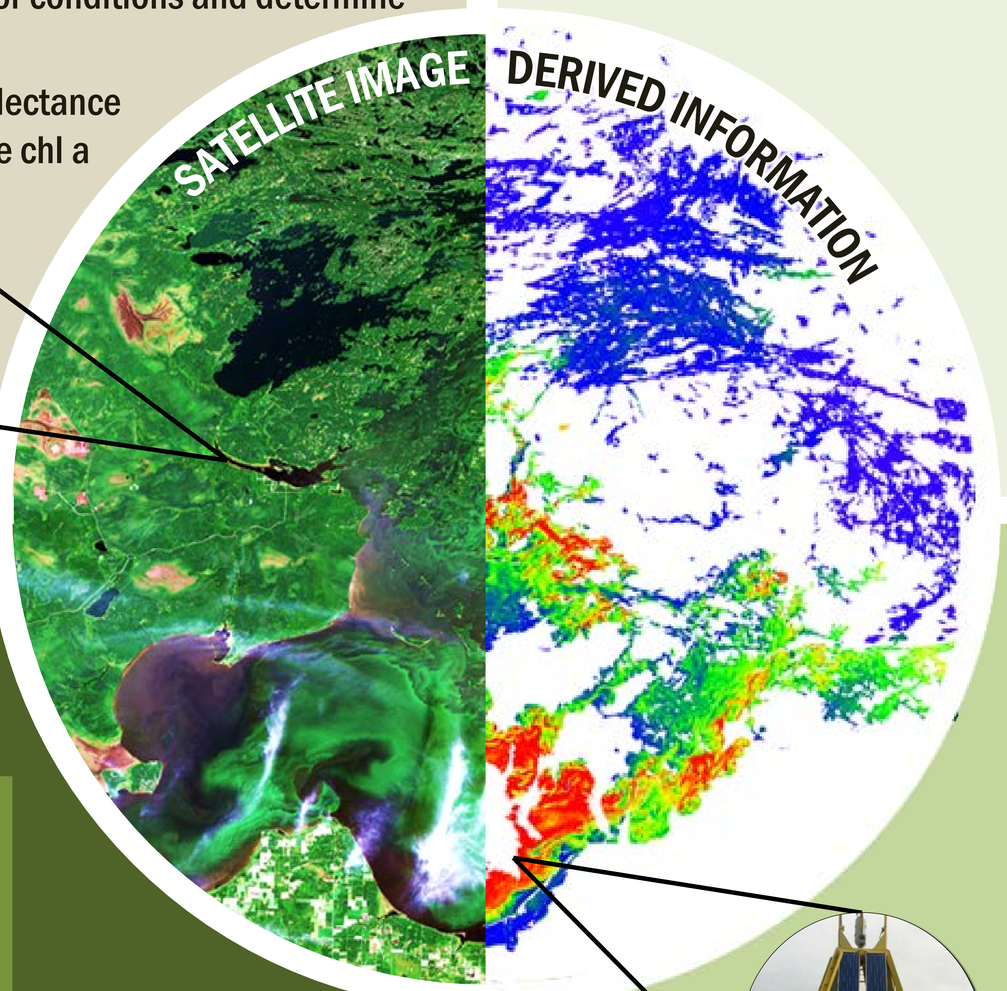
Canada

FOCUS AREA REMOTE SENSING OF ALGAE BLOOMS

WHY USE SATELLITES?

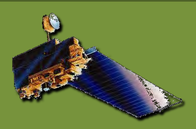
- Remotely sensed information can be acquired for large areas and is ideal for studying issues like large algae blooms visible from space
- Information can be collected repeatedly to monitor conditions and determine trends over time
- Scientists can develop tools that correlate the reflectance information in images to conditions in the lake like chl a

Satellite images are made up of pixels. Each pixel represents the reflectance of light at that location.



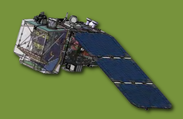
WHICH SATELITES WILL WE USE?

- Satellites contain sensors that collect information
- We use a variety of satellites to fit our needs



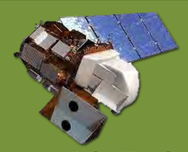
MODIS

Coarse resolution for whole lake monitoring



SENTINEL - 3

Moderate resolution for nearshore and bloom species detection



LANDSAT - 8

Moderate resolution for nearshore and bloom species detection

HYPERSPECTRAL SENSORS

Measure wavelengths of light beyond the visible spectrum

APPROACH

The goal of this research area is to develop tools to enhance monitoring of blooms as well as contribute bloom information for modeling and other research efforts.

1 MONITOR BLOOMS AT A MULTIPLE SCALES AND OVER TIME

To communicate and quantify the extent of the algae problem

2 REPORT ON TRENDS IN BLOOM SIZE , SEVERITY AND DURATION

To better understand bloom characteristics and to inform management

3 DEVELOP TOOLS TO IDENTIFY BLOOM CONSTITUENTS

Knowing blooms species will help to determine potential health risks

4 CONTRIBUTE NFORMATION ON BLOOMS NEEDED FOR MODELING AND RESEARCH

Information of blooms at a large spatial scale will assist modeling and research efforts

A scientific buoy has been deployed in Big Traverse Bay near the outlet of the Rain River. It collects information on weather, water quality and optical properties of the water.

The buoy was deployed in early summer to collect information in pre-bloom conditions. It will:

- provide continuous bloom measurements
- Provide optical information to develop and validate mapping tools
- Provide information of use for other research areas of the program

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FOCUS AREA NEARSHORE

WHAT IS THE NEARSHORE?

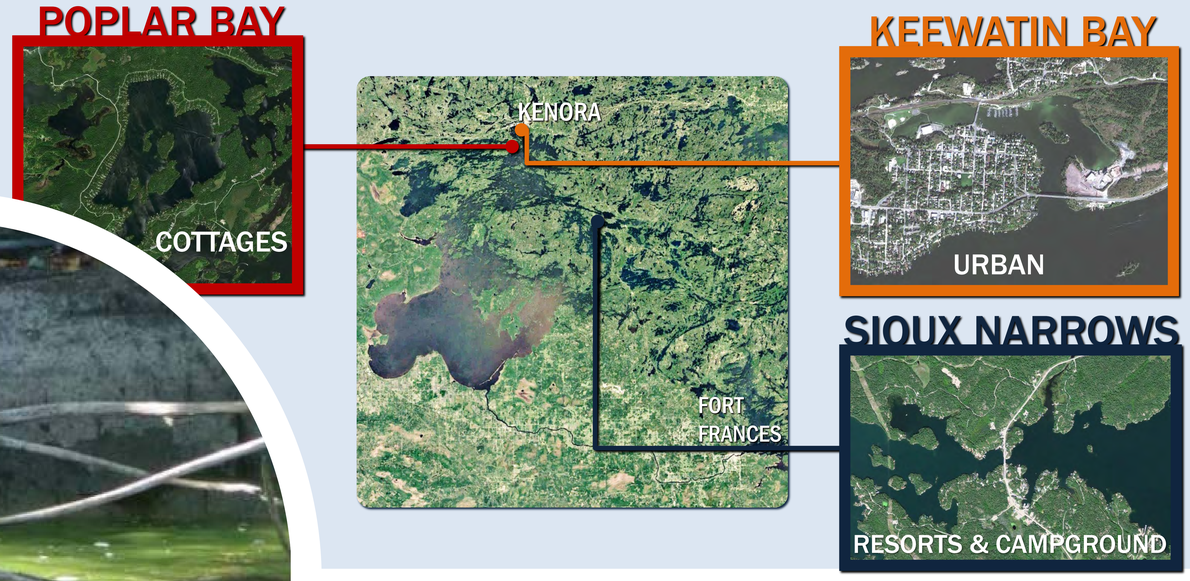
- Lands and waters near shore where maximum biological and human activity typically take place

WHY STUDY THE NEARSHORE?

- Much of the focus of past and present research has focused on the role of the large tributaries to the lake and sediments as sources of nutrients that fuel blooms
- The nearshore zone represents a potentially critical source of nutrients and could greatly improve our understanding of bloom formation and dynamics

APPROACH

Study three developed areas with different land uses to study local sources of nutrients



SAMPLING

- Nearshore surface water sampling
- Groundwater sampling including septic plumes
- Contextual sampling to compare water quality of the three focus areas to reference conditions
- Nutrients can also exist in a particulate form that can be transported to the lake via erosion – studying the nearshore will include assessing the extent that erosion contributes nutrients at a local scale

CONSIDERATIONS

- Developing management strategies to reduce nutrients and algae blooms needs to consider all nutrient sources
- Studying the nearshore will provide information on the role that local factors play in bloom formation and growth
- Results from this focus area will contribute to the programs modeling efforts and help inform development of management strategies

OUTCOME

- Inclusion of factors that affect local sources of nutrients that may contribute to algae development and blooms when designing management strategies

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PARTNERSHIPS AND ENGAGEMENT

MANAGEMENT OF FRESHWATER RESOURCES IS A SHARED RESPONSIBILITY

WE WORK WITH:

- THE PUBLIC & OTHER STAKEHOLDERS
- INDIGENOUS ORGANIZATIONS
- CANADIAN & U.S. AGENCIES
- INTERNATIONAL JOINT COMMISSION
- BINATIONAL SCIENCE COORDINATION GROUPS
- NON-GOVERNMENT RESEARCHERS

HOW ARE WE ENGAGING STAKEHOLDERS AND THE PUBLIC?

- JOINT WEBINARS WITH MINNESOTA POLLUTION CONTROL AGENCY
- UPDATES DURING STAKEHOLDER MEETINGS
- DEVELOPMENT OF A QUARTERLY NEWSLETTER
- PARTICIPATION AT CONFERENCES/FORUMS
- WORKING TO IMPROVE WEB CONTENT
- PARTICIPATION AT PUBLIC MEETINGS / OPEN HOUSES

BINATIONAL COOPERATION AND COORDINATION

Total Maximum Daily Load

We are working closely with Minnesota Pollution Control Agency (MPCA) as they prepare a plan to improve U.S. waters. Our work will supply updated information on Canadian sources of nutrients

International Multi-Agency Arrangement

Is a binational group of government agencies and local organizations coordinating science in the region.

We are jointly launching a new work group with MPCA to focus on nutrient and algae science in Lake of the Woods.

PARTNERS ARE CRITICAL TO MOVE FROM SCIENCE TO ACTION AT LOCAL, REGIONAL AND BINATIONAL SCALES

HERE IS A SMALL SAMPLE OF GROUPS WE WORK WITH

Minnesota Pollution Control Agency

International Joint Commission · Commission Mixte Internationale

Lake of the Woods water sustainability foundation

Ontario

Zhaagimaa Waabo

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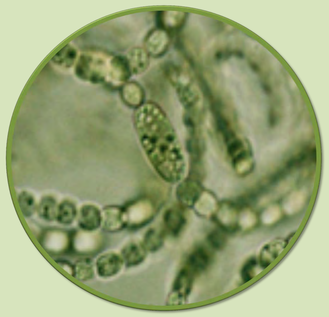
UNDERSTANDING ALGAE

DID YOU KNOW?



- Algae are some of the oldest organisms on earth
- They exist as unicells, filaments or colonies
- Algae are an essential component of aquatic ecosystems
- Algae are photosynthetic like plants

Phosphorus has long been considered a key driver for growth of aquatic plants and algae. Other nutrients such as **nitrogen** (e.g. nitrates or ammonia) can intensify this fertilizing effect.

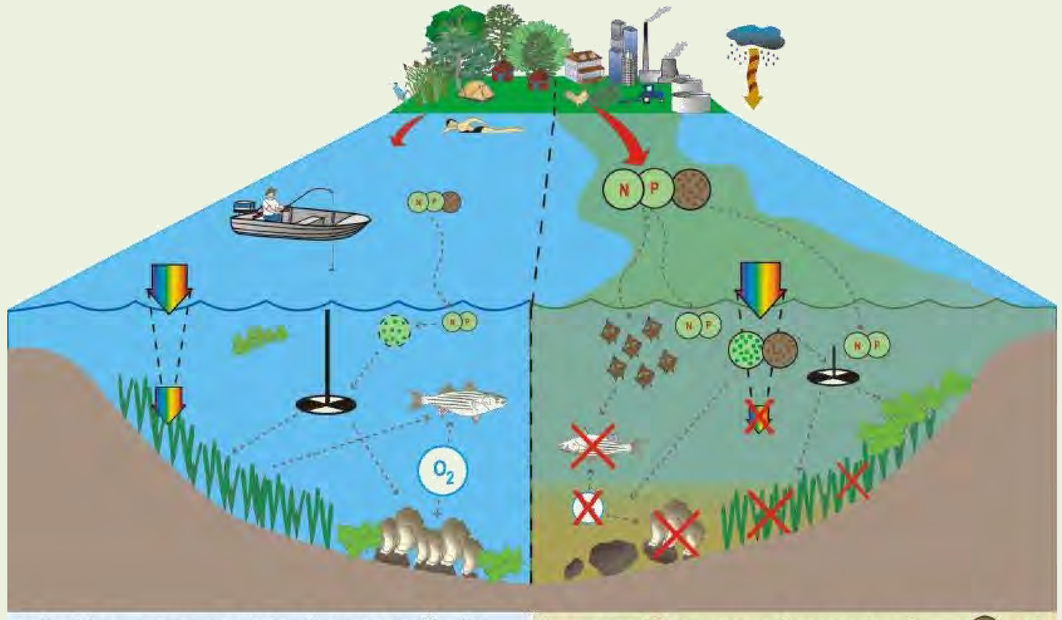
Phosphorus in water occurs via natural and human inputs:

- **runoff** from agriculture (e.g. excess fertilizers and manure)
- runoff from forestry and urban expansion
- industrial **emissions** (e.g. pulp and paper)
- wastewater **discharge**, including septic systems
- **wind blown dust** from bare soils

In the absence of human development, phosphorus exists only in phosphate-bearing rock and is introduced into water through soil and rock erosion.

Water bodies in regions with a lot of soil, such as the Prairies, naturally have high phosphorus levels compared to water bodies in areas with little soil like the Canadian Shield.

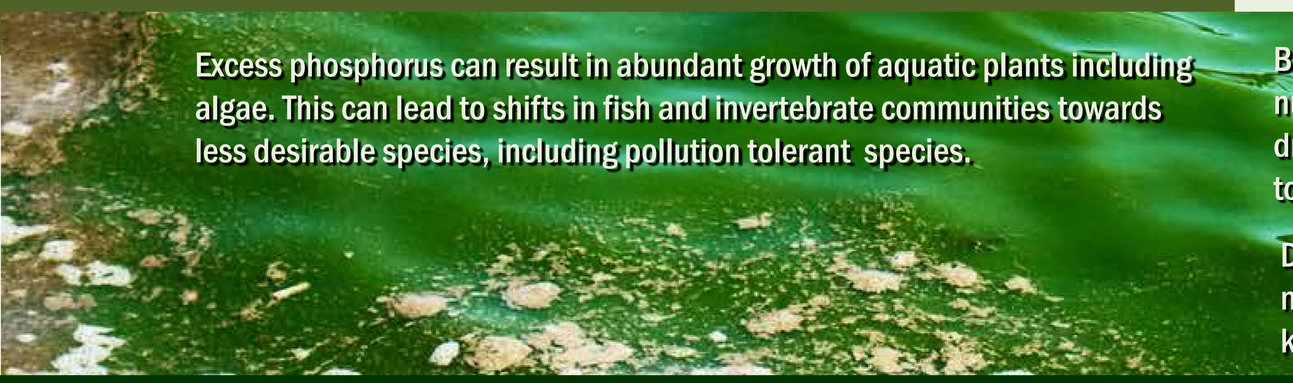
HEALTHY ECOSYSTEM VS EUTROPHIC ECOSYSTEM



In healthy ecosystems, nutrient inputs, specifically nitrogen and phosphorus (N P), occur at a rate that stimulates a level of macroalgal and phytoplankton (chlorophyll *a*) growth in balance with grazer biota. A low level of chlorophyll *a* in the water column helps keep water clarity high, allowing light to penetrate deep enough to reach submerged aquatic vegetation. Low levels of phytoplankton and macroalgae result in dissolved oxygen (O_2) levels most suitable for healthy fish and shellfish so that humans can enjoy the benefits that a coastal environment provides.

In a eutrophic ecosystem, increased sediment and nutrient loads (N P) from farming, urban development, water treatment plants, and industry, in combination with atmospheric nitrogen, help trigger both macroalgae and phytoplankton (chlorophyll *a*) blooms, exceeding the capacity of grazer control. These blooms can result in decreased water clarity, decreased light penetration, decreased dissolved oxygen, loss of submerged aquatic vegetation, nuisance/toxic algal blooms and the contamination or die off of fish and shellfish.

SOURCE: Bricker, S.B., Longstaff, B., Dennison, W., Jones, A., Boicourt, K., Wicks, C., Woerner, J., 2007. Effects of nutrient enrichment in the nation's estuaries: a decade of change. In: NOAA Coastal Ocean Program Decision Analysis Series No. 26, National Centers for Coastal Ocean Service, Silver Spring, MD, 328 pp.



Excess phosphorus can result in abundant growth of aquatic plants including algae. This can lead to shifts in fish and invertebrate communities towards less desirable species, including pollution tolerant species.

Blue green algae (cyanobacteria) can form blooms under certain conditions, such as high nutrient loadings and warm temperatures, and cause unpleasant taste and odour problems in drinking water. Some of these bacteria can release toxins in the water which can pose health risk to humans and animals.

Decaying and unsightly Algae and aquatic plant growths can also clog intake pipes and impair navigation reducing the aesthetic and recreational value of aquatic ecosystems. Additionally, fish kills can occur as a result of concurrent declines in dissolved oxygen.

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MINNESOTA'S LAKE OF THE WOODS NUTRIENT TOTAL DAILY MAXIMUM LOAD APPROACH

THE TMDL PROCESS

Assess the state's waters

↓

List those that do not meet standards

↓

Identify sources and reductions needed (TMDL Study)

↓

Implement restoration activities (Implementation Plan)

↓

Evaluate water quality

TMDL ANALYSIS

- A TMDL is the sum of the individual waste loads from point sources, nonpoint sources and natural background, with an additional loading allowance for a margin of safety

- Once established it can be the basis for regulatory and non-regulatory measures to reduce loadings

TIMELINES AND PRODUCTS

- Project expected to run from 6/30/15 - 6/30/18
- Updated BATHTUB and HSPF models by 11/15/15 (Completed)
- TMDL summary tables, calculations of existing P loads by source, and expected reductions from BMPs – Fall 2017
- Draft TMDL report – Fall 2017
- Draft Restoration Strategy by June 30 2018

RESTORATION STRATEGY

- The Watershed Restoration Strategy will:
  - address the nutrient TMDL load reductions;
  - identify pollutant sources; and
  - build on current watershed planning efforts and past conservation accomplishments in the Lake of the Woods Basin
- The restoration strategy will strive to complement watershed restoration and water quality efforts previously completed or currently underway by the several local, state, federal, international, and tribal agencies