Environment and Natural Resources Trust Fund
2016 Request for Proposals (RFP)

Project Title: **ENRTF ID: 037-B**

Tracking and Preventing Harmful Algal Blooms

Category: B. Water Resources

Total Project Budget: $ 764,300

Proposed Project Time Period for the Funding Requested: 3 years, July 2016 to June 2019

Summary:

Harmful algal blooms, which greatly reduce the ecological and recreational value of many Minnesota lakes, have been increasing in recent years. We will determine their root causes and target solutions.

Name: Daniel Engstrom

Sponsoring Organization: Science Museum of Minnesota - St. Croix Research Station

Address: St. Croix Watershed Research Station, 16910 152nd St. N.
Marine on St. Croix MN 55047

Telephone Number: (651) 433-5953

Email dre@smm.org

Web Address http://www.smm.org/scwrs

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Harmful Algal Blooms graphic

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: **Tracking and Preventing Harmful Algal Blooms**

I. PROJECT STATEMENT

Harmful algal blooms, especially those caused by toxin-producing blue-green algae (Cyanobacteria), significantly reduce the recreational and ecological value of Minnesota lakes. They negatively impact water quality, degrade fisheries, and are a health concern for humans and domesticated animals.

Duration, frequency, and extent of harmful algal blooms are increasing worldwide. New evidence points to similar changes in some Minnesota lakes, yet little information is available on historical trends in blooms or the present-day composition of algae associated with bloom formation and toxin production.

Harmful algal blooms occur as discrete events and are known to relate to phosphorus concentration. However, the seasonality, water-quality conditions, and sediment-water interactions that drive these events are not well understood. A better understanding of the lake characteristics and nutrient-climate interactions that stimulate harmful algal blooms would facilitate new corrective measures and better allocation of management resources.

Previous funding by the LCCMR, which established Minnesota's Sentinel Lakes program, provides a unique opportunity to leverage past water-quality monitoring data and formulate a cooperative sampling campaign across a large area of the state with considerable cost-savings.

Our results will provide new insight into the composition, increase over time, and underlying causes of harmful algal blooms in the state of Minnesota.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Finger the culprits: Identify species composition and timing of harmful algal blooms

Budget: $179,900

We will assess the relationship between algal communities and water quality in a representative group of Minnesota lakes to determine the distribution, abundance, and seasonality of bloom-forming species.

- Current water quality monitoring of 10 Sentinel Lakes (carried out by the MN DNR and MPCA) will be amended to include a monthly algae sampling during the ice-free period over 2 years that will be analyzed by the St. Croix Watershed Research Station's CHARM Laboratory (Center for Harmful Algal Research in Minnesota), established with prior LCCMR support.
- Research Station personnel will collect water-quality and algae samples monthly during the ice-free period from five additional Sentinel Lakes over 2 years.
- Harmful algae that are detected will be quantified in terms of biomass (bloom vs. non-bloom), danger to public health (toxin producing vs. non-toxin producing), and provenance (invasive vs. historically occurring).

Outcome	Completion Date
1. *A quantification of the seasonality of harmful algal blooms across a representative sampling of Minnesota lakes*	June 2018
2. *The identification of bloom-forming species, the associated risk for toxin production, and the occurrence of invasive blue-green algae*	June 2018

Activity 2: Use history: Uncover increased frequency of algal blooms relative to natural conditions
Budget: $254,400

We will determine where and when bloom-forming algae have increased in Minnesota lakes over the last century to better understand the causes and susceptibility of individual lakes to bloom development.

- We will perform a historical reconstruction of the frequency and severity of blue-green algae blooms on the 15 lakes monitored in Activity 1 using paleolimnological methods.
- Sediment cores will be collected from each lake and dated using radioisotopes at the St. Croix Watershed Research Station to establish a continuous history of lake condition over the last 150 years.
- Dated sections will be analyzed for fossil algal pigments, including those unique to blue-green algae, to determine presence, abundance, and frequency of harmful algal blooms in a historical context.

Outcome	Completion Date
1. *A comparison of historical changes in harmful algae among a large suite of Sentinel lakes to determine the geographic extent and timing of the problem*	January 2018
2. *An assessment of the likely drivers of increasing harmful algae by comparison of trends in lake sediment cores with changes in landscape, land-use, and climate over the period of record*	December 2018

Activity 3: Isolate the causes: Determine how nutrients and climate interact to favor harmful algae
Budget: $330,000

We will quantify phosphorus inputs and cycling in a contrasting set of lakes to determine the critical factors leading to bloom development including watershed inputs, recycling from sediments, and changing lake temperatures.

- We will investigate a subset of 4 lakes included in Activities 1 and 2 to pair monitoring of harmful algae blooms with mechanistic models that describe watershed inputs and internal recycling of nutrients.
- We will measure potential for in-lake recycling of legacy nutrients (phosphorus) by determining the fraction of bio-available phosphorus in the lake sediment.
- We will monitor bloom formation by quantifying harmful algae in sediment traps and water column samples, along with potential environmental controls, including water chemistry, lake temperatures, and oxygen depletion of bottom waters.

Outcome	Completion Date
1. *A mechanistic understanding of drivers of harmful algal blooms based on intensive monitoring of algae phenology and in-lake processes*	June 2019
2. *A determination of the relative importance of external loading vs. the internal recycling of phosphorus in terms of driving harmful algal blooms across lakes*	June 2019
3. *A predictive framework linking internal and external nutrient loads to the occurrence of harmful algal blooms in Minnesota lakes*	June 2019

III. PROJECT STRATEGY

A. Project Team/Partners

USGS will receive $100,000 to develop in-lake models of internal processes controlling harmful algae blooms and integrate them with watershed loading models developed by the St. Croix Watershed Research Station as part of this project. The DNR will contribute monthly algal and water sampling of Sentinel lakes.

B. Project Impact and Long-Term Strategy

This project will reveal how phosphorus and lake temperatures interact to cause algal blooms in a range of Minnesota lakes. The development and implementation of corrective measures will require long-term strategies and resources beyond the scope of this project.

C. Timeline Requirements

The project will require three years to complete.

2016 Detailed Project Budget

Project Title: Tracking and Preventing Harmful Algal Blooms

IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM	AMOUNT
Personnel: (all funded on research grants) Engstrom, Project management, 0.08 %FTE 3 Years $32,400 Almendinger, SWAT (GIS) modeling, 0.5 %FTE 2 Years $100,200 Edlund, BG algae & diatom analysis, 0.5 %FTE 3 Years $146,800 Heathcote, BG algae & diatom analysis, 0.5 %FTE 3 Years $110,000 Technicians (2), Field sampling, 0.5 %FTE 2 Years $88,000	$ 477,400
Professional/Technical/Service Contracts: US Geological Survey: Modeling of in-lake phosphorus cycling and field monitoring of watershed inflow/ lake outflow over 3 years $100,000 Algal pigment analyses at specialized external lab (232 samples @ $125) $29,000	$ 129,000
Equipment/Tools/Supplies: YSI mulit-parameter sonde (field meter) for water-column measurements $20,000 ELISA microplate reader for analysis of algal toxins (microscystins) $10,000 Field supplies (sample bottles, vials, and jars, sediment traps, core tubes) $5,000	$ 35,000
Travel: Field travel to 15 Sentinel lakes for sediment coring $15,000 Field travel to 5 Sentinel lakes for collection of phytoplankton and water quality samples 5x/year for 2 years $7,500	$ 22,500
Other - Analytical Services at SCWRS: TN/TP : 360 water samples @ $35 = $12,600 NOx/SRP : 360 water samples @ $35 = $12,600 DIC/DOC : 180 water samples @ $35 = $6,300 Loss-on-Ignition : 15 sediment cores @ $800 = $12,000 Lead-210 dating: 15 sediment cores @ $2400 = $36,000 Cesium-137 dating: 4 sediment cores @ $1400 = $5,600 Sediment Total-P : 15 sediment cores @ $540 = $8,100 Sediment P-fractions : 4 sediment cores @ $1050 = $4,200 Sediment Metals : 4 sediment cores @ $750 = $3,000	$ 100,400
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 764,300

V. OTHER FUNDS

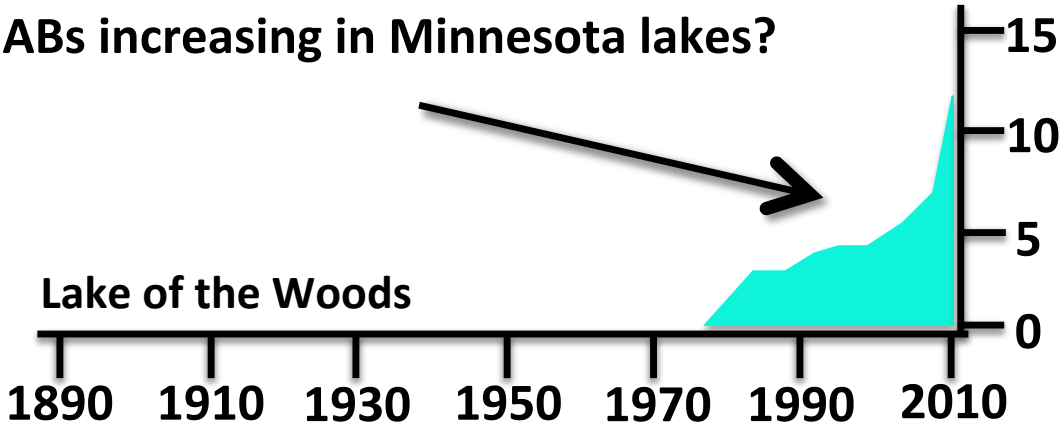
SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: Science Museum of Minnesota: Unrecovered support services (lab & equipment maintenance, infrastructure, support staff, project administration) 43% of direct costs (less analytical services and subcontracts)	$ 230,007	Pending
Other State $ To Be Applied To Project During Project Period: *None*	$ -	
In-kind Services To Be Applied To Project During Project Period: MN DNR will provide support in collecting water and phytoplankton samples from Sentinel Lakes during routine monthly visits pending renewed funding for Sentinel Lakes monitoring project	$ 105,000	Pending
Funding History: (ENRTF) M.L. 2009, Chap 143, Sect 2, Subd 05c "Cooperative Habitat Research in Deep Lakes" (MN DNR subcontract to SMM)	$ 90,000	
Remaining $ From Current ENRTF Appropriation: M.L. 2014, Chap 226, Sect 2, Subd 3g "Watershed-scale Monitoring of Long-term Best Management Practice Effectiveness"	$ 700,000	

What's going on with Harmful Algal Blooms (HABs) in Minnesota lakes?

- **What algae are present, when do they bloom, and are they harmful?**

HABs to the public:
a soupy green mess

- **HABs increasing in Minnesota lakes?**



Harmful algae preserved in lake sediment

- **Excess phosphorus causes HABs, but which is the bigger problem?**
  - ? **Watershed inputs**
  - ? **In-lake recycling**

The Ghost of Phosphorus Past

Project Manager Qualifications

DANIEL R. ENGSTROM

1. Education

Ph.D.	1983	University of Minnesota, Minneapolis (Ecology)
M.S.	1975	University of Minnesota, Duluth (Zoology, minor: Botany)
	1971-73	University of Wisconsin, Madison (Zoology: Limnology)
B.A.	1971	University of Minn., Duluth (Zoology, minor: chemistry) Magna cum Laude

2. Positions

1999-	Director, St. Croix Watershed Research Station, Science Museum of Minn.
1995-99	Sr. Scientist, St. Croix Watershed Research Station, Science Museum of Minn.
1990-	Adjunct Professor, Dept. of Earth Sciences, University of Minnesota
2004-	Adjunct Professor, Water Resources Science, Univ. of Minnesota
1983-95	Research Associate, Limnological Research Center, Univ. of Minnesota

3. Research Expertise

Environmental chemistry, geochemistry, and radiometric dating; human impacts on water quality, atmospheric chemistry, and biogeochemical processes; understanding long-term environmental change from lake sediment records mechanistically linked to modern-day processes.

Current Research:

- Atmospheric mercury deposition and cycling in temperate, tropical, and arctic regions
- Agricultural impacts on nutrient and sediment loading to the upper Mississippi River
- The effects of climate change on boreal lake ecosystems

4. Recent Publications (of more than 130)

Engstrom, D.R., W.F. Fitzgerald, C.A. Cooke, C.H. Lamborg, P.E. Drevnick, E.B. Swain, S.J. Balogh, and P.H. Balcom. 2014. Atmospheric Hg emissions from preindustrial gold and silver extraction in the Americas: a reevaluation from lake-sediment archives. *Environ. Sci. & Technol.* 48: 6533-6543.

Smith, V.H., W.K. Dodds, K.E. Havens, **D.R. Engstrom**, H.W. Paerl, B. Moss, and G.E. Likens. 2014. Comment: cultural eutrophication of natural lakes in the United States is real and widespread. *Limnology and Oceanography* 59: 2217-2225.

Anger, C.T., C. Sueper, D.J. Blumentritt, K. McNeill, **D.R. Engstrom**, and W.A. Arnold. 2013. Quantification of triclosan, chlorinated triclosan derivatives, and their dioxin photoproducts in lacustrine sediment cores. *Environmental Science & Technology* DOI 10.1021/es3045289

Anderson, N.J., R.D. Dietz, and **D.R. Engstrom**. 2013. Land-use change, not climate, controls organic carbon burial in lakes. *Proceedings of the Royal Society B* 280: 20131278.

Organization Description

The Science Museum of Minnesota (SMM) is a private, non-profit 501(c)3 institution dedicated to encouraging public understanding of science through research and education. The St. Croix Watershed Research Station the environmental research center of the SMM with the mission to foster, through research and outreach, "a better understanding of the ecological systems of the St. Croix River basin and watersheds worldwide." The SCWRS supports an active year-round program in environmental research and graduate-student training, guided by a dedicated in-house research staff with direct ties to area universities and colleges. It collaborates closely with federal, state, and local agencies with responsibility for managing the St. Croix and upper Mississippi rivers and is a full partner with the National Park Service for resource management in parks of the western Great Lakes region. Its research has played a central role in setting management policy for the St. Croix and Mississippi rivers, for establishing water-quality standards for Minnesota lakes and for developing long-term monitoring plans for the National Park Service.