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

Project Title: **ENRTF ID: 047-B**

Innovative Assessment of Minnesotas Surface Waters from Space

Category: B. Water Resources

Total Project Budget: $ 458,000

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

Summary:

This project advances statewide assessment of water quality using new satellite sensors to measure major water quality indicators in Minnesota's 10,000 lakes and rivers at high frequency and low cost.

Name: Jacques Finlay

Sponsoring Organization: U of MN

Address: 1987 Upper Buford Circle, 100 Ecology

St. Paul MN 55108

Telephone Number: (612) 624-4672

Email jfinlay@umn.edu

Web Address http://www.cbs.umn.edu/lab/finlay

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

New satellite capabilities enable retrieval of specific water quality indicators from Minnesotas lakes, providing much more detailed and frequent data Minnesotas surface waters than available in the past.

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

PROJECT TITLE: Innovative Assessment of Minnesota's Surface Waters from Space

I. PROJECT STATEMENT

Water quality in Minnesota's water resources is under threat from development, agriculture, and urban and suburban activities. Water clarity, a key water quality indicator, is monitored on thousands of lakes in Minnesota with a simple Secchi disk or remotely using satellites. Nevertheless, neither method distinguishes between the three factors that affect water clarity in our lakes and rivers: algae, colored dissolved organic matter, and suspended solids (e.g., clay minerals). Because they have different impacts on water quality, the ability to measure them directly increases our understanding of the causes and consequences of water quality degradation. Technology now exists to make this advance. **This proposal takes the next step in statewide assessment of water quality using new satellite sensors to remotely measure major water quality indicators in Minnesota's 10,000 lakes at high frequency and low cost.**

The quality of our lakes and rivers directly affects the availability of clean drinking water and habitat for fish and other wildlife. In much of Minnesota, lake and river water quality is influenced mainly by excessive algae (from nutrients), colored organic matter from decaying woody plants in forests and wetlands, and suspended solids from stormwater runoff and invasive carp. These factors thus have distinct causes, and each also requires different management responses in watersheds. Each also has distinct effects on water resources: too much algae decreases water quality and habitat; high levels of colored organic matter decrease fish growth and interfere with natural contaminant degradation processes and drinking water treatment processes; suspended solids destroy fish habitats and clog waterways. The ability to detect these problems in lakes on a regular basis would provide an early warning system for changes and allow management of watersheds and surface waters in ways that are specific to the particular stressors causing the degradation.

Our goals are to: 1) **develop remote sensing methods to permit routine measurement of colored organic matter, algae, and suspended solids levels in Minnesota's waters;** 2) **apply these methods to our 10,000 lakes and large rivers, creating a database and corresponding maps**; and 3) **explore how variations in these water quality indicators influence the fate of contaminants (e.g., pesticides, mercury) and the suitability of water bodies to serve as drinking water supplies**.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: ***Build advanced methods for measuring water quality in surface waters of Minnesota*** **Budget: $225,000**

Physically-based predictive relationships will be developed to determine dissolved organic matter, chlorophyll (algae), and suspended solid levels from available satellite data. The predictive relationships will be developed or "calibrated" using 125 lake and river sites, and then an additional 50 sites will be used for validation. We will evaluate the frequency with which state or region-wide assessments of these water quality indicators are possible within a given year.

Outcome	Completion
1. Measurements of algae, colored organic matter, and suspended solids in 125 selected lake and river sites to obtain a data set for developing predictive relationships	*December 2017*
2. Analysis of field and satellite data to develop predictive relationships to permit routine monitoring of algae, organic matter, and suspended solids in the state's waters	*February 2018*
3. A method for comprehensive water quality monitoring for Minnesota's 10,000 lakes	*June 2018*

Activity 2: ***Relate surface water composition to pollutant levels and drinking water quality*** **Budget $160,000**

Lakes and rivers in the state are influenced by algae, colored dissolved organic matter, and suspended solids but we do not fully understand how these constituents affect drinking water production or the fate of pollutants. We will conduct studies to understand how these features of surface waters, measured for all lakes in the state,

influence formation of disinfection byproducts during drinking water treatment and degradation of pesticides and pharmaceuticals in surface waters. Experiments will be performed in laboratory systems that simulate drinking water treatment and natural processes (the latter leveraged through an active LCCMR project led by Arnold). Information gained in Activity 1 will be related to existing state databases for mercury in fish and information on algae levels will be related to existing state databases of nitrate levels.

Outcome	Completion Date
1. Evaluate the influence of algae and organic matter on formation of disinfection byproducts upon chlorination	*December 2018*
2. Identify waters least and most likely to degrade pesticides by photolysis	*December 2018*
3. Relate results from satellite data to mercury and nitrate distributions in Minnesota surface waters	*December 2018*

Activity 3: *Dissemination and application for surface water monitoring and management* **Budget: $74,000**

Information gained in Activities 1 and 2 will be used to construct a web-accessible statewide database of colored dissolved organic matter, algae, and suspending solid levels that will be available to the public and state agencies. This information will be used to create maps that can illustrate changes in water quality through time, predict levels of pollutants (such as mercury) for specific lakes, and estimate photodegradation rates of emerging contaminants in lakes throughout the state. Results will be disseminated to water resource managers, water utilities, and stakeholders via the Data Repository for the U of MN and presentations at local meetings.

Outcome	Completion Date
1. Integrate project results into an annually updated, publically accessible web accessed database and mapping tool	*February 2019*
2. Four peer reviewed publications, and numerous presentations on methods & applications	*May 2019*
3. New comprehensive techniques, and data for local-to-regional assessment	*Spring 2019*

III. PROJECT STRATEGY

A. Project Team/Partners

The project team consists of the Principal Investigator (PI) Jacques Finlay and co-PIs Patrick Brezonik, Leif Olmanson, William Arnold and Raymond Hozalski, all based at the University of Minnesota.

B. Timeline Requirements. The project will be completed in three years.

C. Long-Term Strategy and Future Funding Needs

This project directly addresses LCCMR funding priorities in *Water Resources* and *Foundational Natural Resource Data and Information.* Our project brings together expertise in remote sensing, aquatic ecology, contaminant cycling, and water treatment to advance our abilities to detect and understand spatial and temporal patterns in water quality. Our past development of remote sensing methods for water clarity, funded in part by LCCMR, has allowed routine monitoring of >10,000 Minnesota lakes. Expansion of these capabilities to include specific organic matter sources, algal abundance, and suspended sediments using new satellite capabilities will allow development of cost-effective methods to monitor, understand and manage Minnesota's freshwater resources. With increasing GIS expertise in local and state natural resource agencies, increasing availability at no cost of high-quality satellite imagery, and greater ability to process such imagery, the tools that we will develop will be widely accessible for use by state and local agencies to help address water quality monitoring needs. In collaboration with USGS scientists, we are seeking funding from the NSF and USGS for a complementary project to explore how landscape conditions control organic matter across the upper Midwest. Because water quality affects fisheries, drinking water, emerging contaminants, and mercury, our project will be of immediate use to MPCA and DNR in decision making and prioritization of resources.

2016 Detailed Project Budget

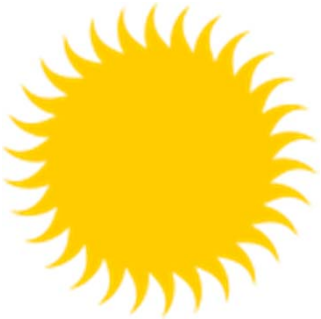
Project Title: Innovative Assessment of Minnesota's Surface Waters from Space

IV. TOTAL ENRTF REQUEST BUDGET - 3 years

BUDGET ITEM	AMOUNT
Personnel:	
Jacques Finlay, PI (75% salary, 25% benefits); 0.5 months per year	$ 21,000
Ray Hozalski, Co-PI (75% salary, 25% benefits); 0.5 months per year	$ 29,000
Patrick Brezonik, Co-PI (95% salary, 5% benefits); 0.5 months per year	$ 18,000
William Arnold, Co-PI (75% salary, 25% benefits); 0.5 months per year	$ 32,000
Leif Olmanson, Co-PI (75% salary, 25% fringe); Year 1 = 42% FTE, Year 2 = 25% FTE, Year 3 = 25% FTE	$ 75,000
2 Graduate Students - (52% salary, 48% fringe during the academic year-includes tuition; 85% salary, 15% fringe during the summer); Year 1 = 31% FTE, Year 2 = 50% FTE, Year 3 = 19% FTE	$ 177,000
2 Undergraduate Students (100% salary, 0% fringe) - 23% FTE for year1 and 2. Students will gain in depth research experience and training while assisting with research.	$ 22,000
Junior Scientist (79% salary, 21% fringe) - 30% FTE for year 1 and year 2 to oversee analyses.	$ 32,000
Equipment/Tools/Supplies:	
YSI Sensor package - A YSI sonde capable of measuring and data logging multiple parameters including algal pigments and DOM fluorescence is requested. This instrument will be used to verify the correspondence between remotely sensed parameters and field observed values. The equipment will be used throughout the project for collection of data to needed to ensure that sampling sites are representative, to examine assumptions related to effects of shoreline and water depth effects on satellite data, and to monitor pH, oxygen and organic matter levels in laboratory experiments. We will continue to use the equipment for purposes related to the proposed research throughout the life of the instrument as new satellite sensors added to the ones currently available. All other equipment needed for the project is currently available for the use of the research team in on-campus laboratories or in shared (core) facilities.	$ 20,000
Lab/Field Supplies - The materials and supplies budget will be used to purchase chemicals, glassware, and disposable items needed to perform the proposed research. Examples of laboratory supplies required for this research include glassware, sample bottles, filters, pipette tips, chemicals, and reagents needed for analyses of water samples. Other supply funds are requested for bottles, gloves, and filters required for collection, transport, and storage of samples, and for preparation for lab manipulations. Costs of analyses of a suite of basic parameters in our labs for each site sampled in the field sampling, and for lab experiments are included. The lab analyses cost includes instrument time, gases, reference standards and reagents for colored organic matter concentration and spectral properties/EEMS, total phosphorus and nitrogen, suspended sediments, particulate organic carbon and chlorophyll a.	$ 12,000
Travel:	
Travel funds are requested for travel to field sites in year 1 and 2. This includes vehicle rental, mileage, hotel, and meals, estimated according to UMN guidelines, for PIs, graduate students, and undergraduates during year 1 and for the field sampling campaign in the second year. In addition, funds are requested for travel to meetings with collaborators and state agencies, and for registration at the Minnesota Resources Conference in years 2 and 3.	$ 9,000
Additional Budget Items:	
Sponsored Publications - Publication costs to disseminate the work.	$ 2,000
Lab Services - Lab services includes costs of sample analyses at external labs for metals and major ions via ICP and IC in the Dept. of Earth Sciences at the University of Minnesota ($31.50 per sample x 126 samples), and charges for FT-ICR-MS analyses ($100 per sample x 50 samples) to characterize DOC/DOM properties.	$ 9,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 458,000

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: *All the satellite imagery is available from federal sources at no cost*	$ -	
Other State $ To Be Applied To Project During Project Period: *N/A*	$ -	
In-kind Services To Be Applied To Project During Project Period: *Indirect costs (52% MTDC) associated with this proposal*	$ 189,000	*Secured*
Funding History: "Solar Driven Destruction of Pesticides, Pharmaceuticals, Contaminants in Water" Arnold is currently investigating pesticide/pharamceutical fate in wetlands and the role of DOM plays in photolysis. The techniques developed will be used on the lake and river samples in this project.	$ 291,000	Secured
Remaining $ From Current ENRTF Appropriation: *N/A*	$ -	



Water clarity is currently measured for all MN lakes with satellites, providing a major resource for water resource management and education

New satellite technology enables measurement of the ***causes*** of decreased water clarity. **This project develops methods to measure water color, algae and sediment on all lakes and large rivers**

Water Color

Algae

Sediment

Why? Chemical properties of lakes have **different causes** and **distinct consequences** for surface water quality.

Recreation

Water treatment

Contaminants

Fish growth and health

The ability to routinely monitor specific water quality drivers in all lakes as well as large rivers provides a resource that can **be used by managers, scientists and the public to understand and improve water quality**

Project Manager Qualifications and Organization Description

Jacques Finlay, Project PI. Associate Professor and Director of Graduate Studies, Department of Ecology, Evolution and Behavior, University of Minnesota. B.S., Natural Resources, 1990. University of New Hampshire, Durham, NH. Ph.D., Integrative Biology, 2000. University of California Berkley.

Dr. Finlay studies how watersheds influence carbon, nitrogen, phosphorus, and mercury processing in aquatic ecosystems. His work has concentrated on linking terrestrial and aquatic ecosystems with research focusing on the environmental controls of mercury bioavailability and the hydrologic and biogeochemical factors influencing carbon and nitrogen availability in rural watersheds. He has been involved in multiple projects tracing the sources and fates of nutrients in urban and rural ecosystems. He has published over 70 peer reviewed articles and is a Fellow at the Institute on the Environment.

Patrick Brezonik, Prof. Emeritus, Department of Civil, Environmental, and Geo- Engineering. Dr. Brezonik is a leader in applications of remote sensing to water quality monitoring, and has done work in this area since 1998. He will provide scientific guidance and participate in all aspects of the project.

Leif Olmanson, Research Assoc., Remote Sensing Lab, Dept. of Forest Resources, has worked for 17 years on developing remote sensing techniques for water quality. He will process imagery, participate in data analysis, and help disseminate results via http://water.umn.edu, presentation and publications.

Raymond M. Hozalski, Professor, Department of Civil, Environmental, and Geo- Engineering. Dr. Hozalski's research focuses on water treatment systems including filtration, biofiltration, sorption, and chemical oxidation as well as water distribution system issues. He is well connected in the drinking water community in Minnesota via his involvement with the Minnesota Section of the American Water Works Association.

William Arnold, Professor, Department of Civil, Environmental, and Geo- Engineering. Dr. Arnold has studied the fate of pharmaceutical and pesticide compounds in aquatic environments for sixteen years. Work has focused on the phototransformation of pesticides in wetlands, pesticides losses in soils, and antibiotic fate in surface waters. He has published over twenty peer-reviewed papers on pesticide and pharmaceutical fate since 2003, and he is the co-author of a textbook on water chemistry published in 2011Dr. Arnold's LCCMR funded work on photodegradation will be leveraged in this project.

Lake selection and sampling will be done in collaboration with PCA and DNR scientists studying organic matter and mercury contamination and the lake assessment and monitoring programs. UMN undergraduates and two graduate students will be trained during the project, mentored by all PI's; Finlay's lab manager Michelle Rorer will oversee lab analyses.

Organization Description

All personnel are based at the University of Minnesota, one of the largest, most comprehensive, and most prestigious public universities in the US (http://www1.umn.edu/twincities/01_about.php). The labs and offices of the investigators and collaborators are equipped with the necessary space and facilities needed for the proposed studies.