Environment and Natural Resources Trust Fund
2015 Request for Proposals (RFP)

Project Title: **ENRTF ID:** **036-B**

Biological Consequences of Septic Pollution in Minnesota Lakes

Category: B. Water Resources

Total Project Budget: $ 364,427

Proposed Project Time Period for the Funding Requested: 3 years, July 2015 - June 2018

Summary:

Septic systems are likely sources of Contaminants of Emerging Concern (CEC) to Minnesota lakes. Their potential contribution as CEC sources and subsequent effects on lake fish health will be assessed.

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

(left) Map of Minnesota Lakes that have been sampled for CECs previously with number of detects indicated by the size of the circle. (right) Conceptual drawing of the flow of CECs from on-site septic systems to ground water and shallow lake spawning habitat.

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

PROJECT TITLE: Biological Consequences of Septic Pollution in Minnesota Lakes

I. PROJECT STATEMENT

Contaminants of Emerging Concerns (CECs), which include hormones, pharmaceuticals and compounds found in personal care products, have the potential to harm lake fish populations. We will link the established presence of CECs in Minnesota Lakes to observed biological effects in lake fish and provide the foundation needed for subsequent remediation efforts. The ENRTF has been instrumental in establishing that CECs are present and cause biological effects in Minnesota rivers and lakes. Riverine research has progressed to identifying sources and assessing the feasibility of remediation. However, for Minnesota lakes, only the presence has been established: the actual **sources of CECs** to the lakes have yet to be conclusively elucidated. **Understanding the sources of CECs is a crucial and necessary step to remedying the problem of CECs in Minnesota lakes.** Lake environments respond to pollution very differently than rivers as the sources of pollution are usually more diffuse (non-point sources) and as the long residence time of lake water (months to years) prevents the dilution of incoming pollution often observed in riverine environment. As a consequence, biological effects already observed in riverine fish exposed to CECs are likely more pronounced in lake fish and are more difficult to assess. In many lakes, obvious point sources of pollution are usually lacking. Among potential CEC sources to Minnesota Lakes, onsite septic systems stand out for three reasons: (i) they are commonly used around Minnesota lakes; (ii) they are not designed to remove CECs from household waste water; and (iii) CEC composition and concentrations measured in Minnesota Lakes in previous studies had distinct human "signatures" with many compounds present that are usually only associated with human household consumption (for example mood altering drugs, fragrances). The goal of this project is, therefore, to validate the presence and biological effects of CECs in representative lake-types in Minnesota and conduct detailed analysis of potential sources with particular focus on onsite septic systems. The outcome of the proposed study is the identification of specific sources of CECs to Minnesota lakes and the documentation of the hydrologic pathways that result in discharge to lakes. As part of this approach, we will examine several types of onsite septic system to assess their potential to treat CECs more effectively than is the case with traditional septic systems. This knowledge will aid natural resource managers in water conservation districts, watershed associations, and county zoning offices in identifying sources of CECs in their aquatic resources and will provide the information needed for water treatment specialists to assess potential remediation and/or preventative actions.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Integrated Surface and Ground Water Sampling for CECs **Budget: $125,000**

To identify sources of CECs in Minnesota Lakes, both surface and ground water needs to be sampled continuously and across seasons in lakes with varying infrastructure characteristics. The USGS has developed a passive sampling technology that allows for continuous sampling of surface and ground water for a month at a time. This technology will be used to explore the continuous input of CECs through ground water and surface water runoff in Minnesota lakes (with known concentrations of CECs) that are characterized by different discharge pathways (surface water runoff; sewered vs on-site septic systems) and septic technologies (traditional systems, advanced aeration). Samples will be screened using inexpensive high-throughput assay technology and augmented with detailed analytical chemistry (Activity 2) when warranted by assay results. Due to the potential high temporal variability in water quality of some potential CEC sources (i.e., septic tank leachate), detailed temporal grab samples will also be collected to verify the validity of the passive sampling approach (Activity 2). These results will inform the biological effects testing (Activity 3).

Outcome	Completion Date
1. CEC concentrations in seasonal ground water from 4 lakes	June 30, 2017
2. CEC concentrations in seasonal surface water from 4 lakes	June 30, 2017

3. Resource management tool to connect CEC presence and septic characteristics	June 30, 2018

Activity 2: Analysis of samples for CECs **Budget: $142,125**

Identifying the sources of CECs to Minnesota lakes will require looking for both CECs that are expected to be released to surface waters (i.e., from storm water runoff) and CECs that might leach from on-site septic systems (i.e., pharmaceuticals and personal care products). State of the art liquid chromatography tandem mass spectrometry will be employed for known CEC analysis of selected samples (Activity 1). In addition, these samples will be screened for non-target compounds using high throughput LC-time-of-flight MS, which will enable the identification of a broad range of contaminants. This non-target screening is essential, as many known CECs can be biologically or chemically transformed in the environment to often unknown transformation products that retain substantial biological activity, and may confound the biological assays (Activity 3).

Outcome	Completion Date
1. Accurate quantitation of known CECs in passive sampler extracts and grab samples	June 30, 2017
2. Screening of grab samples and extracts for non-target analytes	June 30, 2018

Activity 3: Analysis of Fish for Effects and Causal Linkage to CEC Exposure **Budget: $97,302**

CECs are diverse in their presence, concentrations and chemical nature. To establish a causal relationship between CECs measured through chemical analysis and biological effects observed in resident fish, two assumptions have to be tested: (i) fish in lakes with CEC occurrence present pathologies consistent with CEC exposure and (ii) laboratory reared fish exposed to the mixture of CECs measured in surface and ground water will develop similar pathologies. We will collect fish and nests in the vicinity of the sampling sites and assess for a comprehensive range of pathological indications consistent with exposure to CECs. By including nests we can quantify fecundity and health of embryos and juveniles and use the information in population models established as part of previous ENRTF funded research. In addition, we will expose eggs and adult fish in the laboratory to mixtures of CECs based on analytical findings from Activities 1 & 2 and assess similar endpoints.

Outcome	Completion Date
1. Collect & analyze 3 fish species from study lakes (Activity 1) for CEC exposure effects	Dec 31, 2016
2. Establish causality between lake CEC exposure and biological effects through laboratory fish exposures based on measured environmental concentrations (Activity 2)	June 30, 2018

III. PROJECT STRATEGY

A. Project Team/Partners

The project team consists of the Principal Investigator (PI) Heiko Schoenfuss (St. Cloud State University) and co-PIs Richard W. Kiesling (USGS, Mounds View, MN) and Christopher Higgins (Colorado School of Mines). Kiesling will guide the lake sampling and characterization effort. Higgins will lead the analytical characterization of selected samples. Schoenfuss will guide the biological impact research and organize the entire project effort.

B. Project Impact and Long-Term Strategy

The proposed research fits into a larger research agenda centered at St. Cloud State University and the USGS focused on contaminants of emerging concern and protection of lake ecosystems. The addition of Dr. Higgins at the Colorado School of Mines will provide specific knowledge to the analytical component of the study not currently available to us. The proposed research complements current and prior research in this area. When taken together, this research will provide a more complete picture of how to assess the environmental impact of on-site septic system, improve treatment, and safeguard our fish populations.

C. Timeline Requirements

The proposed project will be completed in the allotted three-year period.

2015 Detailed Project Budget

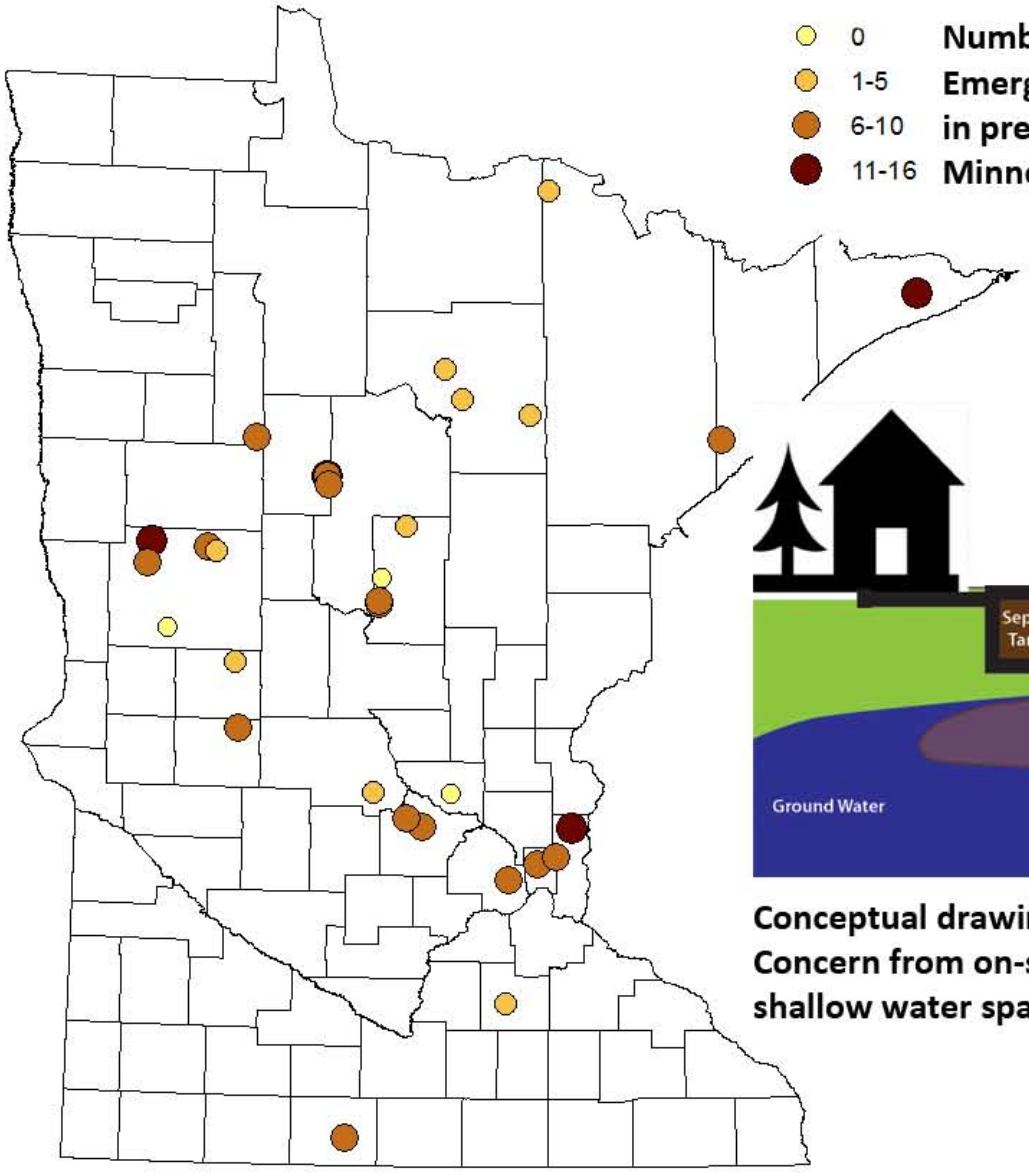
Project Title: *Biological Consequences of Septic Pollution in Minnesota Lakes*

IV. TOTAL ENRTF REQUEST BUDGET 3 years

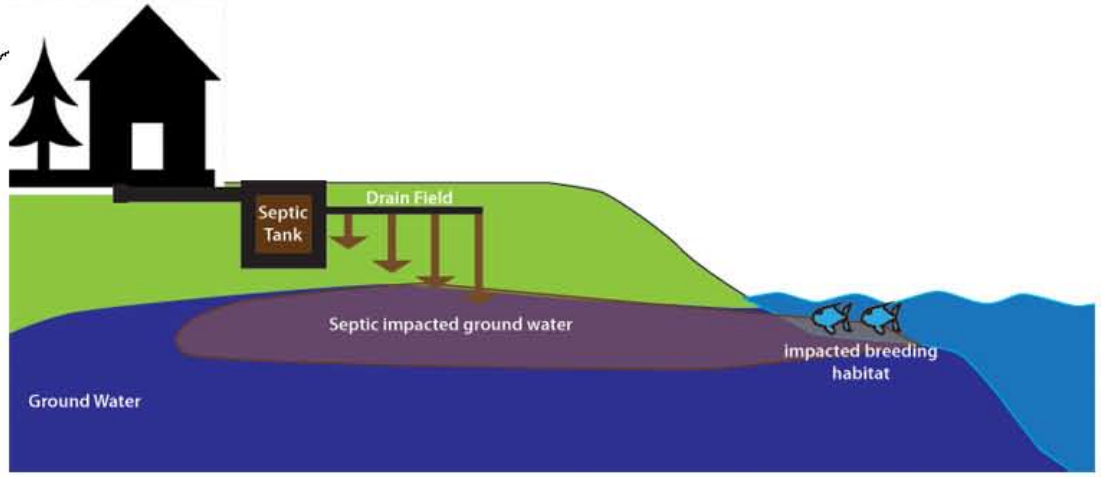
BUDGET ITEM	AMOUNT
Personnel:	
Heiko L. Schoenfuss, Project Manager (74% salary, 26% benefits); 10% FTE per year for 3 years	$ 27,846
Graduate Research Assistant, conduct and analyze experiments (75% salary, 25% benefits, including $6114 tuition/year); 50% FTE per year for 2 years	$ 48,628
Contracts:	
Subcontract: Some of the work will be conducted at the US Geological Survey (Activity 1). The subcontract amount will include characterization of groundwater flow into lakes; acquisition and deployment of groundwater and surface water passive sampling devices ($89,800), and bi-weekly sample collection and analysis of water samples for common contaminants of emerging concern using ELISA kits ($35,200). The subcontract costs include salary and benefits for a Hydrologist for 3 years at 12% effort ($53,800) and salary and benefits for Co-PI Kiesling for three years at 6% effort ($34,700).	$125,000
Subcontract: Some of the work will be conducted at the Colorado School of Mines (Activity 2). The subcontract amount will include salary and benefits for a postdoctoral fellow ($22,500 salary and $11,475 benefits per year for 3 years at 50% effort) and one day of summer salary for Co-PI Higgins ($517 in salary and $237 in benefits per year for three years). In addition, supplies for experiments and measurements (chemicals, analysis time, etc.) will be $13,400 per year for three years. No travel funds are requested.	$ 142,125
Equipment/Tools/Supplies: Fish acquisition and maintenance ($1,000/year for 3 years), gene expression assays ($2,500/year for 3 years), histopathology ($1,200/year for 3 years), exposure experiment setup and execution ($1,500/year for 3 years).	$ 18,600
Travel: *Travel to field sites located on four Minnesota lakes for three consecutive summers (1,500 miles/year @ $0.495/mile for three years).*	$ 2,228
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 364,427

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Matching Funds: USGS Cooperative Water Program Match Funding	$ 56,000	*pending*
Funding History: ML 2009, Chap.142, Sec. 2, Subd. 5b "Vulnerability of Lakes to Endocrine Disruption"	$ 297,000	*completed*
Funding History: M.L. 2010, Chp. 362, Sec. 2, Subd. 5c "Ecological Impacts of Effluent in Surface Waters and Fish"	$ 340,000	*completed*
Funding History: M.L. 2010, Chp. 362, Sec. 2, Subd. 5e "Assessing Septic System Discharge to Lakes"	$ 594,500	*in progress*
Funding History: "Cost-benefit Analysis of Wastewater Treatment and Fish Abundance" (Novak, PI)	$ 500,000	*pending*
Remaining $ From Current ENRTF Appropriation: ***M.L. 2010, Chp. 362, Sec. 2, Subd. 5e***	$ 6,540	*unspent*



0 Number of Contaminants of
1-5 Emerging Concerns detected
6-10 in previously sampled
11-16 Minnesota Lakes



Conceptual drawing on the movement of Contaminants of Emerging Concern from on-site septic systems into Minnesota Lakes. Note that shallow water spawning habitats are most impacted by the septic flow.

Project Manager Qualifications and Organization Description

Heiko L. Schoenfuss
Professor, Director of the Aquatic Toxicology Laboratory, St. Cloud State University

B.S., Biology, 1991, University of Bayreuth, Germany.
M.S., Veterinary Anatomy, 1997, Louisiana State University, Baton Rouge, LA.
Ph.D., Evolutionary Morphology, 1997, Louisiana State University, Baton Rouge, LA..

Dr. Heiko Schoenfuss will be responsible for overall project coordination. He has been studying the biological effects of contaminants of emerging concern for the past 15 years years. His laboratory has pioneered exposure systems at environmentally relevant concentrations in the ng/L range and has integrated field and laboratory studies over multiple levels of organsimal complexity. Recent work has focused on the presence and biological effects of estrogenic compounds in lakes. Dr. Schoenfuss was the 2006 recipient of an EPA STAR (Science to Achieve Results) grant award for his work on contaminants of emerging concern. He subsequently served on the US EPA Science Advisory Board and a National Institute of Environmental Health review committee. Dr. Schoenfuss has been the recipient of the "Advisor of the Year" and "Researcher of the Year" awards from St. Cloud State University. He has published over 60 peer reviewed manuscripts on the effects of environmental disturbances on fish populations. He and Dr. Richard Kiesling have collaborated on two LCCMR-funded project to assess sources and biological effects of contaminants of emerging concerns. Several manuscripts have been published and more will be submitted for publication from this work.

Dr. Richard Kiesling (US Geological Survey, Mounds View, MN) has been studying the biological effects of environmental estrogens for the past 15 years. He combined expertise in hydrology and limnology which will be critical to the success of the proposed study.

Dr. Christopher Higgins (Colorado School of Mines) is an analytical environmental chemist with extensive expertise in assessing sources and fate of contaminants of emerging concerns in the environment with a recent focus on those emitted from on-site septic systems. His analytical experience with septic system and ground water samples as well as his available instrumentation are unmatched within the State of Minnesota.

Organization Description
St. Cloud State University, the largest of the Minnesota State Colleges and Universities system as well as the second largest university in Minnesota, with 18,300 students enrolled in 2012 and approximately 600 faculty members. St. Cloud State University has developed an extensive expertise in supporting externally funded research in the field of aquatic toxicology. The laboratories and offices of the PI and co-PIs contain all of the necessary fixed and moveable equipment and facilities needed for the proposed studies.