

**Environment and Natural Resources Trust Fund  
2010 Request for Proposals (RFP)**

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**LCCMR ID: 010-A2**

**Project Title:**

Estrogenic and Pharmaceutical Septic System Discharge to Lakes

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**LCCMR 2010 Funding Priority:**

A. Water Resources

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**Total Project Budget: \$** \$594,500

**Proposed Project Time Period for the Funding Requested:** 3 years, 2010 - 2013

**Other Non-State Funds: \$** \$215,000

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**Summary:**

Minnesota Lakes are vulnerable to septic-system discharge of estrogenic and pharmaceutical compounds. Proposed work assesses septic and watershed influences on levels of contamination and biological responses.

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**Sponsoring Organization:** U.S. Geological Survey

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**Location:**

**Region:** Statewide

**County Name:** Statewide

**City / Township:**

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_____ Knowledge Base	_____ Broad App.	_____ Innovation
_____ Leverage	_____ Outcomes	
_____ Partnerships	_____ Urgency	_____ TOTAL

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## PROJECT TITLE:

### Estrogenic and Pharmaceutical Septic System Discharge to Lakes

#### I. PROJECT STATEMENT

Pharmaceuticals (Phac) and endocrine active compounds (EACs), including estrogenic compounds, were found in water and sediment of 12 Minnesota lakes as part of a recent study by USGS, MPCA, and St. Cloud State University. Lakes with a high density of septic systems (i.e., onsite SSTS) had the most frequent detections of these chemicals (fig.1). Recent work has identified on-site septic systems as sources of emerging contaminants to lakes at concentrations causing ecosystem stress such as reproductive failure of short-lived species of fish. Detailed studies of septic system performance have shown how Phac and EAC compounds survive treatment and discharge into shallow groundwater. ***Given these results, there is a need to know how vulnerable Minnesota lakes are to septic discharge of Phacs and EACs. We propose to survey Minnesota lakes with a high-density of septic systems for water and sediment contamination from Phacs and EACs. We will assess groundwater conditions and watershed characteristics that could influence contaminant distributions and assess adverse biological impacts associated with the presence of these compounds.***

#### II. DESCRIPTION OF PROJECT RESULTS

##### **Result 1: Quantify the occurrence of estrogenic/pharmaceutical compounds in 30 Minnesota lakes that receive groundwater inputs from septic systems**

**LCCMR REQUEST \$215,000. Completion Date: June 2013**

Pharmaceuticals and EACs will be measured in water and sediment from 30 Minnesota lakes. Lakes chosen will have significant numbers of septic systems (>35% shoreline development) and will be distributed among the State's hydrologic and ecological regions. Sampling will follow the general protocol from the recently completed Statewide Survey with MPCA, with site selection and sample distribution designed to follow gradients in groundwater and surface water hydrology within and between lakes. We will combine the results from the proposed study with the results from the preliminary Statewide Survey to develop an EAC contaminant database for MN lakes. The database will be used to analyze for patterns in contaminant occurrence. A report will document results.

##### **Result 2: Assess surface water/groundwater hydrology/watershed characteristics contributing to water/sediment concentrations of estrogenic/pharmaceutical compounds in lakes**

**LCCMR REQUEST: \$104,000. Completion Date: 2013**

Each Minnesota lake sampled under Result 1 will be classified by geologic, hydrologic, and ecological characteristics. Groundwater hydrology, including depth to groundwater and groundwater contribution to lake water balance, will be coupled with surface water hydrology (contributing area, morphometry) and watershed characteristics (land use, land cover; fragmentation) to develop categorical classifications for each lake. Groundwater level data will be collected for each lake in the vicinity of sampling sites, and seasonal (three times per year) groundwater isotope sampling in each lake will provide an estimate of groundwater contribution to water balance. A report will document findings.

##### **Result 3: Assess biological exposure and response to known estrogenic/pharmaceutical compound contamination in Minnesota lakes**

**LCCMR REQUEST: \$165,500. Completion Date: 2013**

A subset of the 30 lakes sampled for ECs will be chosen for detailed biological analysis based on the severity of contamination. Adult bluegill sunfish will be sampled during the spring reproductive period from active nesting areas in each lake. Nesting areas will be associated with developed and undeveloped shorelines. Adult male and female fish will be evaluated using a variety of biomarkers, including condition factors, blood-chemistry (e.g., plasma vitellogenin) and histo-pathological indices of abnormal gonad development (e.g., intersex). Nesting sites will be evaluated for selected Phac and EAC residues in food-web components at the time of active reproduction. Samples from major trophic levels including adult bluegill will also be collected for stable isotope analysis to determine bluegill food web structure during the nesting period.

#### **Result 4: Enhance EAC analytical capabilities at the Minnesota Department of Health (MDH).**

##### **LCCMR REQUEST: \$110,000, Completion Date: 2013**

MDH currently has the capability to quantify a number of Phacs and organic compounds including the EACs bisphenol A, nonyl phenol (NP), and octyl phenol (OP). As part of this project, MDH will enhance its existing Phacs and EAC methods while implementing advanced laboratory techniques to quantify NP precursors. All MDH Phac and EAC analytical capabilities will be used to analyze water samples from the 30 Minnesota lakes in this study.

### **III. PROJECT STRATEGY AND TIMELINE**

#### **A. Project Partners**

This project is a continuing partnership between the United States Geological Survey (USGS) and the State of Minnesota to document the occurrence and effects of emerging contaminants in lakes. Team members from the USGS include Dr. Richard Kiesling (project Leader), Kathy Lee (project co-leader; USGS Biologist), and Dr. Mindy Erickson (USGS Groundwater Specialist). USGS will manage project planning, sampling, and sample analysis. Dr. Heiko L. Schoenfuss, Professor and Director of the Aquatic Toxicology Laboratory, Department of Biological Sciences, St. Cloud State University, will participate in this project by performing histo-pathology analysis of fish tissues and data analysis and interpretation. Minnesota Department of Health laboratory team members include Paul Swedenborg, (MDH organics lab supervisor) and Dr. Carin Huset (MDH organics lab research scientist). Mark Ferrey from the Minnesota Pollution Control Agency will provide external peer review of project plans and deliverables. All team members will participate in writing the final report and communicating results to state user groups.

#### **B. Project Impact**

##### **1. Project provides details on what pharmaceutical and estrogenic compounds are present in lakes with high numbers of SSTS systems.**

Most EACs are found at very low concentrations in water but reach higher concentrations in sediment. Despite these low concentrations, research has identified developmental and reproductive effects on fish species at environmentally relevant concentrations. The proposed work will determine if lakes under the influence of septic systems are at risk for significant contamination from Phacs and EACs.

##### **2. Project provides an estimate of the importance of groundwater hydrology and watershed characteristics in predicting the frequency and magnitude of pharmaceutical and estrogenic contamination in MN lakes.**

In Minnesota, pharmaceuticals and EACs have been observed in a range of lake types from a diverse set of background conditions. This study will provide a comprehensive analysis of the frequency and magnitude of contamination relative to important factors including hydrology and geology.

##### **3. Project provides an estimate of how pharmaceuticals and estrogenic compounds affect biological communities, and whether effects are limited in space and time.**

Three recent studies in Minnesota indicate river and lake fish communities are vulnerable to reproductive impacts from EACs. The proposed project uses a representative fish (bluegill) to determine how vulnerable adult fish are to pharmaceutical and estrogenic compounds exposure during spawning. The study assesses the role of food-web structure and function when measuring the ecological characteristics that might mitigate EAC exposure.

#### **C. Time**

**This is a three-year proposal.** Activities in year one will include the sampling design for lake sites, the preliminary water quality sampling, and the development of the lake watershed database. The second and third year will complete the lake water quality sampling, the watershed characterizations, the site-specific sediment sampling, and the fish community study. Year three will consist of completing the sampling, analyzing data and writing the final report. Results will be communicated to state and national peer groups through presentations at regional and national meetings including state resource management meetings.

## Project Budget

### IV. TOTAL PROJECT REQUEST BUDGET for 3 years

<b>BUDGET ITEM</b> (See list of Eligible & Non-Eligible Costs, p. 13)	<b>AMOUNT</b>
<b>Personnel:</b> USGS Hydrologist: 0.15 FTE per year for three years USGS Biologist: 0.12 FTE per year for three years USGS Hydrology Tech: 0.35 FTE per year for three years USGS Biology Tech: 0.35 FTE per year for two years	\$ 195,400
SCSU GRA: 0.5 FTE per year for one year	\$ 22,000
SCSU Full Professor eligible for summer salary: 3 months summer salary for one year	\$ 18,000
<b>Equipment/Tools/Supplies:</b> Triple quadrupole mass spectrometer for the Public Health Laboratory, Minnesota Department of Health	\$ 110,000
Supplies for sample collection, storage, and shipping	\$ 26,000
<b>Travel:</b> In-state travel to the the 30 lakes over the three years of the project. Request covers 45 trips by teams of two or three people lasting 2-3 days.	\$ 24,600
<b>Additional Budget Items:</b> USGS analytical costs for water, biota, and sediment samples from 30 lakes	\$ 198,500
<b>TOTAL PROJECT BUDGET REQUEST TO LCCMR</b>	<b>\$ 594,500</b>

### V. OTHER FUNDS

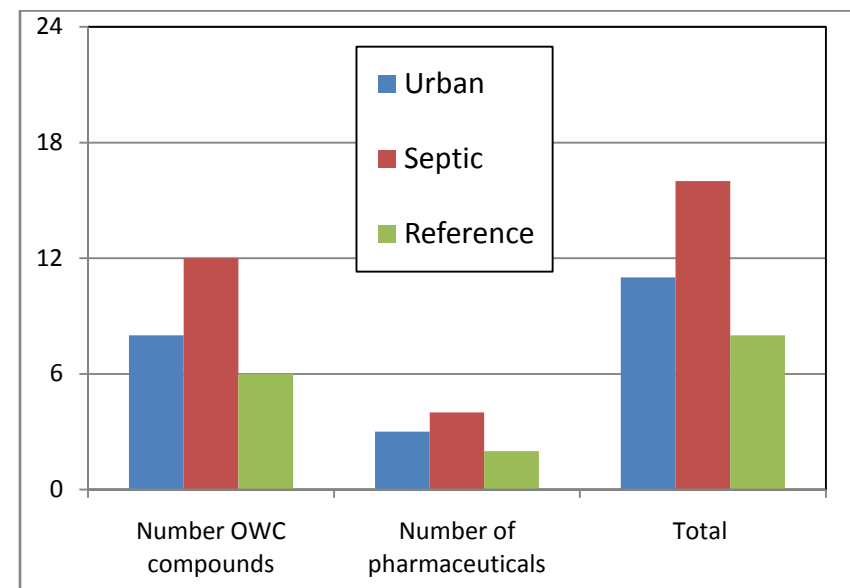
<b>SOURCE OF FUNDS</b>	<b>AMOUNT</b>	<b>Status</b>
<b>Other Non-State \$ Being Applied to Project During Project Period:</b> USGS Cooperative Funding Match	\$ 215,000	<i>Secured</i>
<b>Other State \$ Being Applied to Project During Project Period:</b> Minnesota Department of Health Equipment Funding Match	\$ 110,000	<i>Secured</i>
<b>In-kind Minnesota Department of Health Equipment Utilized During Project Period:</b> LC/MS/MS (purchased in 2007) - \$367,000.00		<i>In service</i>
<b>In-kind Services During Project Period:</b> Minnesota Department of Health In Kind Funding ( Staff: \$51,300 per year for three years)	\$ 153,900	<i>Secured</i>
<b>Remaining \$ from Current Trust Fund Appropriation (if applicable):</b> Pending LCCMR funding of \$297,000 to R. Kiesling (USGS) to investigate reproduction of lake fish exposed to endocrine disruptors in mesocosms. Start date is July 1, 2009.	\$ 297,000	<i>Pending</i>
<b>Funding History:</b> Funding from MPCA to SCSU and USGS for Statewide survey of pharmaceuticals and endocrine disruptors in Minnesota lakes and streams	\$ 285,000	

Figure 1. USGS LCCMR Lakes

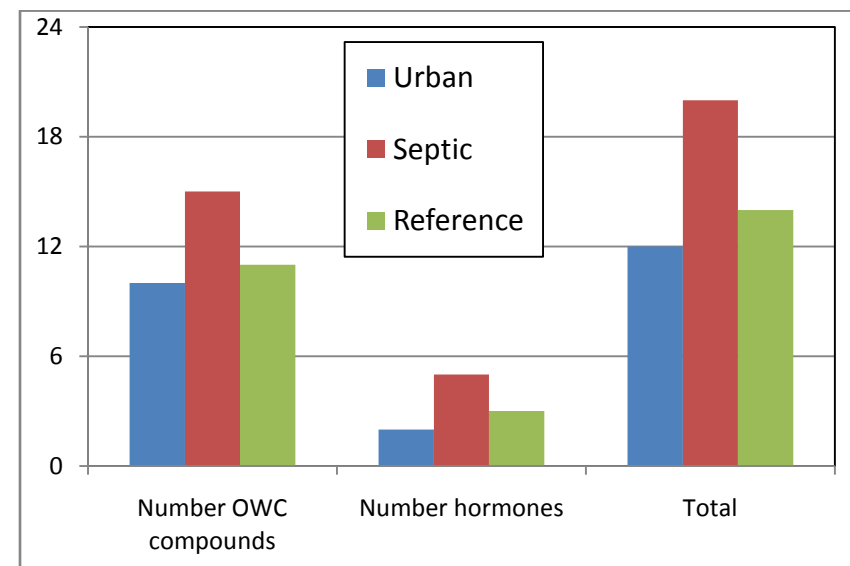
Sampling Sites for Statewide Survey of Endocrine Disruptors and Pharmaceuticals in Lakes



Number of compounds detected in sediment by lake type.



Number of compounds detected in surface water by lake type.



*Curriculum Vitae*

**RICHARD L. KIESLING, Ph. D.**

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**Education:**

University of Michigan: 9/83-7/90, Ph. D. in Biological Sciences awarded 12/90; specialized in ecology and limnology

University of Minnesota: 9/75-6/80, majored in biology and history, BS awarded 6/80

**Professional Experience:**

US Geologic Survey

Hydrologist and Limnology Specialist, 9/05 to present

Hydrologist and Water Quality Specialist, 8/01 to present

University of Minnesota

Research Associate. Dept. of Fisheries, Wildlife, and Conservation Biology, 2/2006 to 2/2008

University of Texas

Research Fellow, Environmental Science Institute, 1/02 to present.

**Recent Publications:**

Baker, J.W., J.P. Grover, B.W. Brooks, F. Ureña-Boeck, D.L. Roelke, R.M. Errera, R. Kiesling. 2007. Growth and toxicity of *Prymnesium parvum* (Haptophyta) as a function of salinity, light and temperature. *Journal of Phycology*. 43:219-227.

Grover, J.P., J.W. Baker, F. Ureña-Boeck, B.W. Brooks, R. Errera, D.L. Roelke, R.L. Kiesling. 2007. Laboratory tests of ammonium and barley straw extract as agents to suppress abundance of the harmful alga *Prymnesium parvum* and its toxicity to fish. *Water Research*. 41: 2503-2512.

Roelke D.L., R. Errera, R. Kiesling, B.W. Brooks, J.P. Grover, L. Schwierzke, F. Ureña-Boeck, J. Baker, J.L. Pinckney. 2007. Effects of nutrient enrichment on *Prymnesium parvum* population dynamics and toxicity: Results from field experiments, Lake Possum Kingdom, USA. *Aquatic Microbial Ecology*. 46:125-140.

Kiesling, R.L. 2003. Applying Indicators of Hydrologic Alteration to Texas Streams- overview of methods with examples from the Trinity River basin. U.S. Geological Survey Publication FS 128-03.