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

**Project Title:** **ENRTF ID: 074-B**

Automated Lake and Groundwater Measurements

**Category:** B. Water Resources

**Total Project Budget: $** 368,194

**Proposed Project Time Period for the Funding Requested:** 3.5 years, July 2016 to September 201

**Summary:**

Real-time monitoring of Minnesotas lake-level and groundwater responses to climate and land-use change with new, automated, “smart” sensor technologies; expanding and improving upon volunteer lake-level network; mapping lake contamination susceptibility

**Name:** Andrew Wickert

**Sponsoring Organization:** U of MN

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Minneapolis MN 55455

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**Web Address**

**Location**

**Region:** Statewide

**County Name:** Statewide

**City / Township:**

**Alternate Text for Visual:**

We will fill in the gaps in space (left) and time (right) in monitoring Minnesotas lakes and their interactions with groundwater.

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

**PROJECT TITLE: Automated lake and groundwater measurements**

## I. PROJECT STATEMENT

Minnesota's lake, river, and groundwater levels face an uncertain future due to human water consumption and climate change. Reducing this uncertainty requires new observational tools that:

1. increase the quality and consistency of groundwater and surface water measurements,
2. expand monitoring coverage across the whole of the state, and
3. do so without unsustainable increases in costs.

*We will develop new, automated, **"smart" sensor technologies** to **greatly expand the Minnesota lake-level monitoring program**, and to add **direct measurements of exchange of water between groundwater and surface-water at lake and stream beds**.*

**Lake-level monitoring:** Currently, **lake levels at only 7.6% of Minnesota's 11,842 lakes are monitored**. Nearly all are measured by hand by volunteers. These are accurate but not frequent or regularly-spaced in time enough to connect weather, climate, land-use, and lake conditions. They are also less dependable in the more sparsely populated **northern pine woods and the western prairies that are most vulnerable to climate change.** We will develop automated lake level sensors that can dramatically enhance our ability to monitor the impacts of water resources changes throughout the state. Of particular concern are the impacts of (1) economically-important agricultural activity in western Minnesota; (2) potential changes to the lake tourism industry; (3) possible future mining operations; and (4) connections in the Minnesota, Mississippi, St. Louis, and Red River watersheds between poorly monitored upstream areas and downstream cities.

**Groundwater-surface water interaction monitoring:** Building a strong lake-level data network is a crucial step in understanding Minnesota's overall water budget. However, **this alone cannot tell us whether changes in lake level are from changes at the surface through precipitation and runoff or from changes in how much the lake contributes to (or draws from) groundwater.** We will design and build a sensor that measures water flow into or out of a lake or stream bed. We will deploy these instruments densely around regions of high concern, where they could help us predict (1) the impacts of groundwater pumping on lake levels in high population and irrigation centers and (2) where nitrate and phosphorus may contaminate lakes and streams through groundwater in agricultural areas in central and western Minnesota**.**

**Inexpensive "smart" sensors paired with traditional measurements:** Our design will use new technologies to **reduce the price of monitoring by a factor of 5** when compared to standard commercial alternatives **without sacrificing data quality**. These "smart" sensing technologies will increase measurement frequency and use the physics of subsurface flow to make up-to-date assessments of water transport between lakes and rivers, and groundwater. **Data will be sent instantaneously via text message to an Internet database for immediate use by decision-makers and the public.**

## II. PROJECT ACTIVITIES AND OUTCOMES

**Activity 1:** *Lake-level monitoring* **Budget: $171,134**

We propose to develop an easily-deployable lake-level monitoring station based on technology we have already tested in Alaska and Louisiana. ***This station will record air temperature and water level***, and will be built to allow additional sensors (e.g., for water quality) to be added in the future, thus allowing state agencies or other research groups to "piggy-back" off of our infrastructure. Rugged design will allow this "smart" sensor to increase measurement frequency during inclement weather, when volunteer efforts are less safe and reliable.

| Outcome | Completion Date |
|---|---|
| *1. Develop standardized automated lake monitoring platform* | *July 1, 2017* |
| *2. Test deployment and online data access system; data validated against measurements made by volunteers* | *July 30, 2018* |
| *3. Full deployment* | *September 30, 2019* |

**Budget: $171,635**

**Activity 2:** *Groundwater–surface-water interaction monitoring*

Groundwater and surface water have unique temperature signatures. Therefore, we will build innovative temperature probes that intelligently integrate these measurements to provide up-to-date estimates of water exchange between groundwater and lakes and streams. These "smart" components will be added to our current prototype used in sulfate-impacted streams in northeastern Minnesota. ***These probes can be paired with the lake-level sensors for long-term measurements, and can also be used in on-demand field tests in areas of critical concern.***

| Outcome | Completion Date |
|---|---|
| *1. Develop and test prototype in areas of contaminant concern* | *July 1, 2017* |
| *2. Full test deployment of permanent stations, paired with water level measurements.* | *July 30, 2018* |
| *3. Mobile probes fully-operational for general field work* | *July 30, 2018* |
| *4. Full static co-deployment with lake level sensors* | *September 30, 2019* |

**Activity 3:** *Interactive internet database* **Budget: $25,425**

We will equip our "smart" sensors with text-messaging technology that will automatically and instantaneously transmit measurements to an Internet database. Information will be available ***to decision-makers and the public as up-to-date raw numbers, graphs, and an interactive Google Earth KML file.*** This online resource can be connected with the Minnesota volunteer lake-level monitoring network, which is an excellent way to engage the public in science. Coordinating with the network will provide a consistent interface to all work and a way to extend and cross-check the self-measured and automatically-measured records.

| Outcome | Completion Date |
|---|---|
| *1. Develop and test text-message transmission of measurements throughout state* | *July 1, 2017* |
| *2. Create easy-to-use interfaces and formats for presenting measurements* | *July 30, 2018* |
| *3. Design website to post information for resource managers and the public* | *July 30, 2018* |

## III. PROJECT STRATEGY

### A. Project Team/Partners

The University of Minnesota project team will be jointly led by Principal Investigators Andy Wickert and Crystal Ng; co-PI Scott Alexander will participate in the instrument construction and field-testing. Wickert will direct the mechanical instrument and electronics components designs. Ng will direct the software development for estimating hydraulic properties. All will field-test and deploy the designs.

### B. Project Impact and Long-Term Strategy

- Locally-developed water sensors will be available to interested agencies.
- A new network of automated lake-level gauges will be installed, laying the groundwork for streamlined future installations by state agencies.
- A new easy-to-use interface will provide Minnesotans access to the real-time status of lakes.
- Scientists and state water managers will be able to better link the causes and effects of water shortages and contaminant transport, and to connect impacts on surface water and groundwater resources.

Funds for the electronics laboratory exist, so all anticipated material costs will be supplies related directly to the proposed sensors.

### C. Timeline Requirements

The project requires three full field seasons, and thus ends at the end of September 2019. Initial designs will be developed during the 2016–2017 academic year, installed in summer 2017, and retrieved during summer 2018. The web interface will be developed during the 2017–2018 academic year. During the 2018–2019 academic year, any problems with the designs will be resolved, and the final stations will be deployed in Summer 2019.

# 2016 Detailed Project Budget

**Project Title:** Automated lake and groundwater measurements

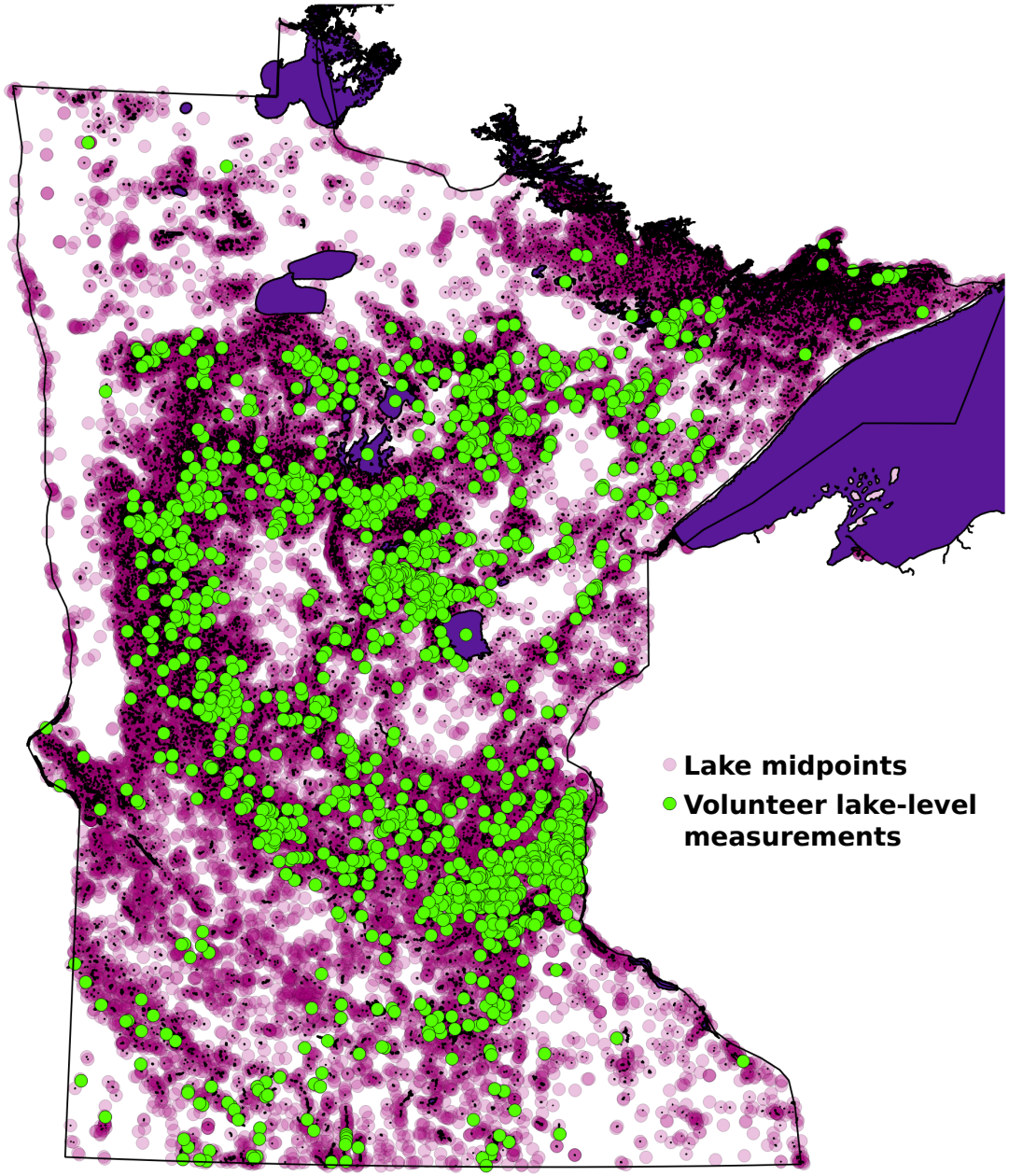
**IV. TOTAL ENRTF REQUEST BUDGET** *3* **years**

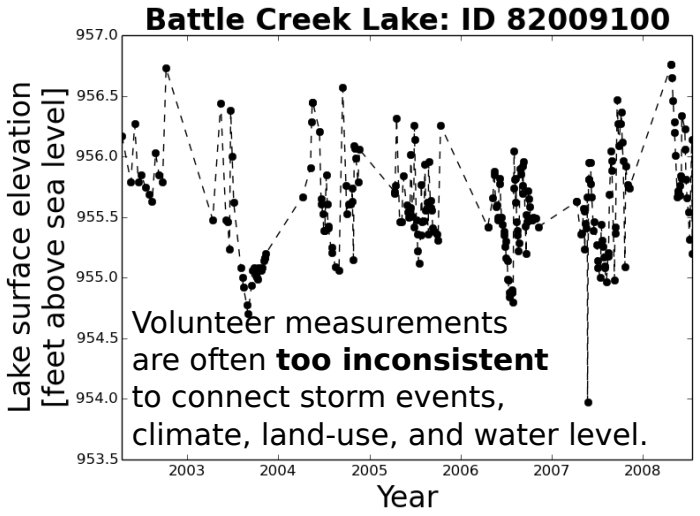
| BUDGET ITEM | AMOUNT |
|---|---|
| **Personnel:** | |
| Andrew Wickert, instrumentation hardware, measurement systems, software: 75% salary, 25% benefits, 6 summer months total | $ 63,263 |
| G.-H. Crystal Ng, hydrologist and software developer: 75% salary, 25% benefits, 3 summer months total | $ 32,053 |
| Scott Alexander, monitoring hardware and field deployment lead: 79% salary, 21% benefits, 3 years, 0.33 FTE time position | $ 65,400 |
| graduate student: 55% salary, 45% benefits (includes tuition), 0.5 time position (begins 9/2016) | $ 126,938 |
| **Professional / technical / service contracts:** | |
| Circuit board mass construction contracting ($50/board) | $ 2,500 |
| 50 Cell phone plans on data-loggers for telemetry ($10/month/site x 24 months) | $ 12,000 |
| Web service for data dissemination ($50/month * 24 months) | $ 1,200 |
| **Equipment/Tools/Supplies:** | |
| 50 custom printed circuit boards ($25/each) | $ 1,250 |
| Electrical components ($100/board) | $ 5,000 |
| 30 GPS units for timing and location ($80/each) | $ 2,400 |
| 50 look-down ultrasonic sensors and temperature-correction probes ($150/each) | $ 7,500 |
| Wire, solder, other electrical consumables | $ 500 |
| 500 High-precision thermistors for temperature profile probes ($5/each) | $ 2,500 |
| Temperature profile probe fabrication (after our initial prototypes) | $ 4,000 |
| 50 Pressure transducers for standalone temperature (groundwater) probes ($60/each) | $ 3,000 |
| 50 Cell phone chips and SIM cards for telemetry ($80) | $ 4,000 |
| 25 PVC housings for subsurface temperature (groundwater) probe: $50/each | $ 1,250 |
| 25 PVC housings for lake level probes | $ 1,250 |
| 25 solar radiation shields for temperature correction measurements ($60/each) | $ 1,500 |
| Waterproofing consumables: PVC cement, caulking, seals | $ 1,000 |
| Data logger waterproof housings ($50/each) | $ 2,500 |
| 50 Data transmission antennas ($10/each) | $ 500 |
| Fence posts, hose clamps, pipe and other attachment hardware | $ 2,000 |
| Prototyping equipment and supply costs | $ 2,500 |
| **Travel:** | |
| Field-testing of sensors throughout state ($0.54/mi, $83 GSA lodging for outstate MN, $30 partial per diem): ~6000 miles, 150 person-days | $ 20,190 |
| **Additional Budget Items:** | |
| Publication and dissemination of instruction sheets for toolkit usage by resource managers | $ 2,000 |
| **TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =** | $ 368,194 |

**V. OTHER FUNDS**

| SOURCE OF FUNDS | AMOUNT | Status |
|---|---|---|
| **Other Non-State $ To Be Applied To Project During Project Period:** N/A | $ - | - |
| **Other State $ To Be Applied To Project During Project Period:** N/A | $ - | - |
| **In-kind Services To Be Applied To Project During Project Period:** The University of Minnesota's Facilities and Administrative rate is 52% of modified total direct costs (total direct less graduate student fringe, capital equipment, subawards over $25,000 and on-site facilities rental). The amount, if F&A expenses would have been allowed on the project, would be $163,427. The University will provide office space, IT services, and administrative / financial services in support of the project. | $ 163,427 | *secured* |
| **Funding History:** co-PI Ng received a USGS grant through UMN's Water Resources Center to investigate impacts of groundwater-surface water interactions on sulfate and wild rice. The work includes the design of a temperature profile probe that will serve as an early prototype for the proposed project. Of the $29,592 grant total, about $4,000 is applied toward supplies, personnel, and travel for temperature probe development | $ 4,000 | *secured* |
| **Remaining $ From Current ENRTF Appropriation:** N/A | $ - | - |

# Automated lake and groundwater measurements




**Top:** High-quality scientific predictions require consistent and frequent data that lets us connect storm events, climate, and land-use to lake levels. **We propose to couple new automated sensors with groundwater probes that tell us how lakes provide water to or draw from groundwater aquifers.**

**Left:** We need more water level data in the agriculturally-impacted southwest and the climate-change- and mining-impacted north. Currently, <10% of Minnesota's lakes are monitored.

Project Title: *Automated lake and groundwater measurements*

**Project Manager Qualifications & Organizational Description:**

Andrew Wickert, Assistant Professor of Earth-Surface Processes, Department of Earth Sciences, University of Minnesota

Andrew Wickert is joining the faculty of the University of Minnesota in August 2015, where he will build on his past and present experience in characterizing water at the Earth's surface over time and its relationship to climate and the landscape. He received his BS from MIT in 2008, and his PhD from the University of Colorado in 2014. During this time, he worked to understand how floods change river channels, how the Mississippi River evolved since the last glaciation, and how modern hillslopes respond to climate and wildfire disturbance. During his PhD, he overcame budget difficulties during the recession by designing and building all of his own field equipment. So many colleagues were interested in the modern, inexpensive, and lightweight designs that he founded a Minnesota-based small company, Northern Widget LLC, to distribute his data loggers and instrumentation with the goal that all of the designs would be open-access for anyone to modify and improve. This started a collaboration with Chris Paola's group at Minnesota, in which Wickert is helping a master's student to measure water levels for a Mississippi River delta restoration project. He is currently at the University of Potsdam, Germany, working to understand climate change impacts on hydrology and rapid change in river channels in northwestern Argentina. He is enthusiastic to connect his expertise with instrumentation and water science to his lifelong love of the lakes and rivers of his home state of Minnesota.

Department of Earth Sciences, University of Minnesota (Twin Cities)

The Department is part of the Newton Horace Winchell School of Earth Sciences and belongs to the College of Science and Engineering at the University of Minnesota. Its includes 25 full faculty members and it awards bachelor's, master's, and doctoral degrees in Earth Sciences and various sub-disciplines, including hydrogeology. A number of ongoing research projects in the department have focused on Minnesota water resources issues, including the karst region of southeastern Minnesota, wild rice producing lakes in the north, and in watersheds and surface waters with high sulfate and mercury.