



# Environment and Natural Resources Trust Fund

2024 Request for Proposal

## General Information

**Proposal ID:** 2024-250

**Proposal Title:** Water Quality and Robots: Experientially Educating Minnesotan Youth

## Project Manager Information

**Name:** Nikolaos Papanikolopoulos

**Organization:** U of MN - College of Science and Engineering

**Office Telephone:** (612) 625-0163

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## Project Basic Information

**Project Summary:** We propose educational activities for middle school youth on water quality in Minnesota. Youth will gain skills for measuring water quality and communicating results through group study and hands-on projects.

**Funds Requested:** \$353,000

**Proposed Project Completion:** June 30, 2026

**LCCMR Funding Category:** Environmental Education (C)

## Project Location

**What is the best scale for describing where your work will take place?**

Statewide

**What is the best scale to describe the area impacted by your work?**

Statewide

**When will the work impact occur?**

During the Project and In the Future

## Narrative

### **Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.**

While water quality is central to the health of Minnesotan watersheds and the general population, there is a general lack of education on the subject and an absence of inexpensive, accessible tools for water quality sensing. The ubiquity of water bodies across the state, however, and the availability of inexpensive water quality sensors, have created a significant opportunity to expand water quality awareness and to develop monitoring tools accessible to local communities.

We see an opportunity for Minnesota's youth to engage with water quality challenges while investigating innovative ways to measure water quality. Increasingly, young Minnesotans are paying attention to issues of pollution and climate, while educational networks serving youth are well-established statewide. The 4-H program at the University of Minnesota (UMN), for instance, reaches tens of thousands of youth annually, while High Tech Kids, a STEM-focused nonprofit, reaches over 5,000. What is needed is an engaging program delivered through these networks that equips youth to steward Minnesota's water bodies. By combining the networks of our partners in youth outreach with UMN's expertise in water quality sensing and robotics, we are confident that we can help the next generation learn to better understand and care for our natural resources.

### **What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.**

We propose a multi-faceted learning experience for the youth of diverse backgrounds and demographics centered around water quality issues pertinent to Minnesota. We will leverage virtual communication technology and our partners' network and expertise in youth education to create learning communities that will facilitate student-to-student collaboration and expert-to-student coaching and mentoring on water quality sensing topics. Students will apply the ideas they learn by assembling innovative, low-cost robotic systems and using them to measure the water quality of local watersheds. The application of learning activities to the real world will be accomplished by making the measurement data available to local water quality stakeholders. Field experts at UMN's Minnesota Robotics Institute (MnRI) will use on-campus immersion experiences to further demonstrate to youth the value of underwater robotics and sensing in addressing challenging water quality issues.

As a prerequisite to creating this opportunity for youth, we propose developing an inexpensive robotic water quality sensing kit. Feedback gathered from the student's use of the kits will inform improvements. The goal is to design a kit that empowers citizens to collect high-value water quality data using inexpensive, readily available and easily assembled parts.

### **What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?**

By engaging youth in authentic water quality issues through this proposed program, we aim to equip 150 young people as citizen scientists with the skills for (i) building innovative, accessible water quality sensing equipment, (ii) measuring water quality indicators, and (iii) sharing water quality knowledge and data effectively with stakeholder audiences. A by-product of these outcomes is a field-tested design of a low-cost water quality monitoring kit that citizens can build and use. These outcomes promote the democratization of environmental data collection and lower the barriers to entry, enabling the concerned citizen to study and care for Minnesota's watersheds actively.

## Activities and Milestones

### Activity 1: Develop and Plan Educational Hands-on Programs

**Activity Budget:** \$159,583

**Activity Description:**

We will work with statewide youth educator partners to design the program experience’s key topics and themes connecting to current significant water quality challenges. During the design process, we will identify at least 30 viable sampling locations at watersheds statewide as target locations to be visited during hands-on activities. We will then integrate program themes into several topic-specific learning tracks. To prepare for the hands-on part of the program, we will design the water quality sensing kit, select sensor hardware and create software. We will employ feedback from our youth educator partners to balance system sophistication and usability, write supporting documentation on kit assembly, assemble a bank of kits, and develop kit distribution methods that account for team location and access to technology. The kit will include sensors that measure water temperature, turbidity, and pH, among other parameters, and these parameters will be linked to basic concepts of mathematics, physics, and chemistry. We will train local experience coordinators in a series of workshops on water quality content and the essentials of assembling the sensor kits. By UMN policy, background checks for minor safety will be conducted for all parties involved in youth education activities.

**Activity Milestones:**

Description	Approximate Completion Date
Build partnerships, promote program design meetings, identify 30 local data collection sites.	September 30, 2024
Design program structure, identify key topics and learning tracks.	October 31, 2024
Design and validate sensor kit, develop distribution options, procure and assemble kit components.	January 31, 2025
Promote and perform training sessions for local Coordinators.	March 31, 2025

### Activity 2: Create Learning Communities

**Activity Budget:** \$105,147

**Activity Description:**

We will identify and train Learning Community Facilitators who will monitor the interactions between students and domain experts (faculty and staff). Their role is critical since they must manage the student’s learning needs, sensors, and system constraints. They also need to have an in-depth understanding of the students’ backgrounds. We will provide materials and resources to the Facilitators explaining how to direct the learning communities on water quality and robotic sensing topics. We will also create learning tracks that break down issues and encourage student-to-student knowledge sharing and collaboration.

Robotics is a powerful tool for experiential learning, but there are several constraints associated with its use: (i) students from underrepresented groups often do not have easy access to robotics resources; (ii) designing robotic experiments for science-based water quality topics is complex; and (iii) system affordability and accessibility to all students has not always been a priority. Our Learning Communities will have the flexibility to transition into online content delivery (given the experience during the 2020 coronavirus pandemic) and allow groups to be reconfigured into subgroups that will execute the different tasks to maintain social distancing.

**Activity Milestones:**

Description	Approximate Completion Date
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Identify, train learning community Facilitators for the five emphasis regions; deliver materials and resources.	December 31, 2024
Provide learning tracks to students throughout the five emphasis regions.	April 30, 2025
Provide virtual correspondence between learning track groups and domain experts.	June 30, 2025
Facilitate cross-track sharing of studies.	September 30, 2025

### Activity 3: Program Implementation and Evaluation

**Activity Budget:** \$88,270

**Activity Description:**

We will carry out water quality education programs for the target participation of 150 students conducting sampling experiments at 30 sites across the state. We will send education materials and sensor kits to team coordinators. MnRI robotics and sensing experts will provide coaching on sensory system design and assembly via a flexible combination of face-to-face and virtual communication, according to team location. Before site visits, training will be administered regarding all Minnesota Department of Natural Resources compliance safety procedures and standardized data collection methods. MnRI will provide students with on-campus opportunities to interact with domain experts and to use the students’ sensor kit designs onboard a research laboratory underwater robot. Water quality data collected throughout the program will be aggregated, processed, and made available for documenting water quality.

An essential component of the whole effort is evaluating the methods used. Online surveys of students and other stakeholders will be conducted to provide feedback on the concepts or sensors that excite the students and on the ones that fail. A revised set of activities and sensors will be created and shared with the broader community under open-source guidelines.

**Activity Milestones:**

Description	Approximate Completion Date
Supply sensor kit, provide build session coaching, provide training for watershed visit protocols.	June 30, 2025
Provide on-campus immersion, AUV interaction, and on-site data collection.	August 31, 2025
Aggregate and process measurement data, re-publish to teachers and stakeholders for environmental education.	September 30, 2025
Collect post-experience feedback from students and coordinators.	February 28, 2026
Collect final on-site data.	June 30, 2026

## Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Prof. David Mulla	Department of Soil, Water, and Climate, UMN	David is a world-renowned scientist in water quality issues and precision agriculture. Since January 2004, he has been the Director of the Precision Agriculture Center at UMN. He will oversee the project efforts in water quality by selecting the parameters and sensors used by the students.	Yes
Prof. Junaed Sattar	Department of Computer Science and Engineering, UMN	Junaed is an associate professor of Computer Science and Engineering and the founding director of UMN's Interactive Robotics and Vision Laboratory. He specializes in all aspects of autonomous underwater robotics. His underwater robotics student camps gather hundreds of students annually. He will coordinate the underwater robotics aspects of the project.	Yes
Margo A. Bowerman	UMN Extension Center for Youth Development	Margo is the Co-Chair of the Minnesota State 4-H STEM Team, and oversees STEM programming in the northwest region of MN. She has expertise in creating high quality, scaffolded learning experiences for youth from kindergarten to one year past high school. She will review the education activity design.	Yes
Cheryl Moeller	High Tech Kids	Cheryl has worked for nearly 20 years in informal STEM education. She is the Executive Director at High Tech Kids, a Minnesota nonprofit offering K-12 STEM programs in robotics to over 5,000 Minnesota students each year. High Tech Kids will coordinate students and volunteers to participate in the proposed.	Yes
Travis Henderson	Minnesota Robotics Institute, Department of Computer Science & Engineering, University of Minnesota (UMN)	Travis is a research engineer and STEM outreach program coordinator at MnRI. His experience combines work on designing and building robots for environmental monitoring with outreach to youth through developing and leading STEM education efforts. He will have the same roles in this project.	Yes

## Long-Term Implementation and Funding

**Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?**

We are determined to ensure that the effects of this effort extend far beyond the funding window. The data collected from watersheds across the state will be processed and made available to environmental educators and researchers in relevant institutions for the purposes of developing data-informed educational materials and strengthening watershed scientific models. In addition, the feedback gathered from the program evaluations will be used to improve the sensor kit hardware, software, and system documentation. To encourage statewide democratization of environmental data collection, plans and bills of materials will be made available to the educational community under open-source guidelines.

## Project Manager and Organization Qualifications

**Project Manager Name:** Nikolaos Papanikolopoulos

**Job Title:** McKnight Presidential Endowed Professor Minnesota Robotics Institute Director

**Provide description of the project manager's qualifications to manage the proposed project.**

Nikolaos P. Papanikolopoulos, an IEEE Fellow, received a diploma in electrical and computer engineering from the National Technical University of Athens in 1987 and an MSEE in electrical engineering from Carnegie Mellon University in

1988, a Ph.D. in electrical and computer engineering from Carnegie Mellon University in 1992. He is currently the McKnight Presidential Endowed Professor in Computer Science at UMN, a Distinguished McKnight University Professor in the Department of Computer Science, and Director of MnRI. His research interests include robotics, computer vision, sensors for transportation applications, and control. He has authored or co-authored more than 350 journal and conference papers in these areas, including more than 80 refereed journal papers. NSF, NIH, DHS, DARPA, MnDOT, DOT, Kansas DOT, FHWA, Honeywell, Minnesota Corn Growers, 3M, Johnson Controls, Sentera. and Wisc has funded his work. He has advised more than 30 Ph.D. students and holds eight patents. He has been General and Program Chair for the two largest international robotics conferences (IEEE International Conference on Robotics and Automation and IEEE/RSJ International Conference on Intelligent Robots and Systems). He has received the IEEE Robotics and Automation Distinguished Service and George Saridis awards. Along with his students, he founded ReconRobotics Inc., which has deployed more than 6,000 robots worldwide. His UMN service ranges from working with a donor to secure a \$10M donation for the robotics effort to chairing the MnDRIVE Robotics, Sensors, and Advanced Manufacturing planning committee, which established MnRI and the MS in Robotics program. He has also organized and supported robotics summer camps for middle schoolers from underrepresented groups for the last 18 years. More than 1,000 students participated in these events.

**Organization:** U of MN - College of Science and Engineering

**Organization Description:**

The Minnesota Robotics Institute (MnRI, a unit of the UMN College of Science and Engineering) will manage the project. MnRI is an outcome of UMN's Discovery, Research, and Innovation Economy (MnDRIVE) initiative, which brings interdisciplinary researchers together to solve grand challenges and increase Minnesota's position as a global robotics research and education leader. MnRI is housed in the world-class Gemini-Huntley Research Laboratory, made possible by a generous gift from Jim & Sharon Weinel and Fred & Siri Oss. The laboratory includes a 20,000-square-foot state-of-the-art robotics research space, nine flexible robotics labs, and various workspaces for faculty and graduate students—including a two-story drone lab and rooms for research on underwater robots. MnRI offers several outreach programs, ranging from robotics summer camps to support of high school robotics teams throughout the state. MnRI has also started a Master of Science program in Robotics, with more than 70 students currently enrolled. This project will be done with the College of Food, Agricultural and Natural Resource Sciences (CFANS), the nonprofit High Tech Kids, and UMN Extension.

## Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
<b>Personnel</b>								
Nikos Papanikolopoulos- Principal Investigator/Project Manager		Management of the Project and related activities			36.8%	0.04		\$38,528
Junaed Sattar- Co-Investigator- Robotics Lead		Coordinate the robotics activities.			36.8%	0.08		\$41,434
David Mulla- Co-Investigator - Water Quality Leader		Coordinate the water quality activities.			36.8%	0.04		\$26,839
Travis Henderson- Project Coordinator		Assist with robotic hardware design/prototyping; coordinate activity development.			36.8%	0.16		\$43,936
Margo Bowerman - Youth Development		Consult for youth-oriented activity development.			36.8%	0.04		\$1,087
One Graduate Research Assistant at 25% from CS&E		Assist with water quality sensing kit design.			24.1%	0.3		\$54,229
One Graduate Research Assistant at 25% from CFANS		Assist with water quality parameter selection & data processing.			24.1%	0.3		\$56,821
							<b>Sub Total</b>	<b>\$262,874</b>
<b>Contracts and Services</b>								
High Tech Kids	Sub award	Fund the cost of High Tech Kids' Youth Coordination responsibilities in this proposed work.				0.3		\$15,295
							<b>Sub Total</b>	<b>\$15,295</b>
<b>Equipment, Tools, and Supplies</b>								

	Tools and Supplies	Robot Kits and sensors	Robot kits for 150 students. These will be used by the participating students for data collection.					\$60,000
							<b>Sub Total</b>	<b>\$60,000</b>
<b>Capital Expenditures</b>								
							<b>Sub Total</b>	-
<b>Acquisitions and Stewardship</b>								
							<b>Sub Total</b>	-
<b>Travel In Minnesota</b>								
	Miles/ Meals/ Lodging	Travel costs associated with milestones in Activity 3: Build session training (one-day event) - 35 volunteer participants On-campus immersion (one-day event) - 5 volunteer and 20 youth participants Allocations (per person-day): Miles: \$50 Meals: \$50 Lodging: \$100	Funds for youth participants and adult volunteers to travel the the UMN Twin Cities campus for two separate one-day events					\$11,583
							<b>Sub Total</b>	<b>\$11,583</b>
<b>Travel Outside Minnesota</b>								
							<b>Sub Total</b>	-
<b>Printing and Publication</b>								
							<b>Sub Total</b>	-
<b>Other Expenses</b>								
		Computer Services – CSE ISO Charges – Network and Computer Services	CS&E Network and Computer Services - Networking and computer charges are expenses charged to sponsored and non-sponsored accounts to support the portion of networking and computer infrastructure used by sponsored and non-sponsored research projects.					\$3,248



							<b>Sub Total</b>	<b>\$3,248</b>
							<b>Grand Total</b>	<b>\$353,000</b>

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
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Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	-
Non-State				
			Non State Sub Total	-
			Funds Total	-

## Attachments

### Required Attachments

#### *Visual Component*

File: [9494020c-e82.pdf](#)

#### *Alternate Text for Visual Component*

The visual highlights the overarching theme of the proposal, the stakeholders, the water quality challenges, and the project objectives....

### Optional Attachments

#### *Support Letter, Photos, Media, Other*

Title	File
Approval to Submit Proposal- 1101631 Papanikolopoulos LCCMR	<a href="#">495bd7ba-173.pdf</a>
Budget Justification	<a href="#">482f1bce-7f1.pdf</a>
ECL Letter of Support	<a href="#">7005a3d3-25f.pdf</a>
Northarvest Support Letter	<a href="#">773666cb-436.pdf</a>
4-H State STEM Team Support Letter	<a href="#">e4d78e69-dcf.pdf</a>

## Administrative Use

**Does your project include restoration or acquisition of land rights?**

No

**Does your project have potential for royalties, copyrights, patents, or sale of products and assets?**

No

**Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?**

N/A

**Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?**

N/A

**Does your project include original, hypothesis-driven research?**

No

**Does the organization have a fiscal agent for this project?**

Yes, Sponsored Projects Administration

**Does your project include the design, construction, or renovation of a building, trail, campground, or other capital asset costing \$10,000 or more?**

No

**Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services, as defined in Minnesota Statutes section 299C.61 Subd.7?**

Yes

**Do you certify that background checks are performed for background check crimes, as defined in Minnesota Statutes, section 299C.61, Subd. 2, on all employees, contractors, and volunteers who have or may have access to a child to**

**whom children's services are provided by your organization?**

Yes

