Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-431

Proposal Title: Geologic Hydrogen: Minnesota's Subsurface System and Resource Potential

Project Manager Information

Name: Latisha Brengman

Organization: U of MN - Duluth

Office Telephone: (218) 726-7586

Email: lbrengma@d.umn.edu

Project Basic Information

Project Summary: Minnesota has significant potential for geologic hydrogen. This project aims to create a research framework to address critical knowledge gaps on natural hydrogen gas formation processes and environmental conditions.

ENRTF Funds Requested: $599,000

Proposed Project Completion: June 30, 2028

LCCMR Funding Category: Energy (E)

Project Location

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

Region(s): NE

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

Region(s): NE

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.

Hydrogen is a critical component in industrial transformation but technological development faces many challenges. As an emerging technology, geologic hydrogen (GeoH2) has generated vast global market interest because of its potential to produce clean hydrogen through natural geological processes at lower cost than current technologies. GeoH2 forms in Earth's subsurface through redox and hydration reactions between water and iron minerals; both of which are abundant in northern Minnesota. Therefore, the state is widely considered a high-potential area for GeoH2 and industry is poised to move in. However, significant knowledge gaps exist on the processes and environmental conditions that generate natural hydrogen.

Our proposed work seeks to observe the underground rock-water-microbe system, determine the mechanisms by which it produces hydrogen, and establish baseline subsurface environmental conditions. While microbes might produce or consume hydrogen in surface environments, our multidisciplinary work will determine geological and microbial mechanisms of hydrogen production in the subsurface relevant to GeoH2 in Minnesota. This innovative approach will evaluate evidence of natural processes and environmental conditions associated with GeoH2 production to facilitate technology development and inform state policy.

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 three research activities to solve the problem of incomplete data on geologic processes and environmental conditions that generate hydrogen. First, we will conduct geological and environmental characterization (measuring attributes of rock, water, and microbes) to establish baseline conditions in areas with high potential for GeoH2 production in northeast Minnesota. Then, we will use data collected in activity #1 to determine mechanisms for hydrogen generation, migration, and consumption in Minnesota. Finally, we will integrate datasets and disseminate results. Through these activities, we will establish a research framework to facilitate the development of high-potential hydrogen technology while prioritizing the environment and Minnesota's natural resources.

The proposed work will occur across a region with high potential for GeoH2 generation in northeast Minnesota. We will leverage legacy geological databases, drill cores, and well logs to determine what iron-rich minerals are present in the system, and what pathways are available for water to move through bedrock. We will sample groundwater wells seasonally for complete microbial and geochemical characterization of both the subsurface shallow and deep aquifers that intersect these iron-rich rocks. Our proposed solution integrates capabilities of geologists, microbiologists, aqueous geochemists, water resources scientists, and data scientists across the University of Minnesota system.

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?

To protect, preserve, and enhance Minnesota's natural water and bedrock resources, we anticipate three project outcomes:

(1) Create and publicly disseminate a model of the subsurface GeoH2 system that advances knowledge of natural hydrogen production, migration, and accumulation to facilitate resource exploration.

(2) Generate data that informs baseline environmental conditions in high-potential areas for GeoH2 before exploration takes place to inform state policy for gas exploration.

(3) Initiate a research framework for future resource potential assessment to facilitate the industrial transformation in Minnesota, e.g. iron and steel, mining, fuels and chemicals industries.

Activities and Milestones

Activity 1: Discover subsurface hydrogen generation processes by characterizing bedrock attributes and connectivity, analyzing groundwater geochemistry, and identifying the microbial community.

Activity Budget: $248,861

Activity Description:
Objective 1.1: Characterize bedrock geology attributes necessary for water-rock interaction and GeoH2 gas generation.

Task 1.1.1. Determine bedrock composition at multiple scales.
Task 1.1.2. Identify fluid pathways by measuring porosity and permeability and mapping fracture networks.

Objective 1.2: Analyze groundwater geochemistry to establish baseline conditions and evaluate how the water interacts with local bedrock chemically to produce hydrogen gas.

Task 1.2.1. Measure physical (pH, temperature, conductivity), and chemical (concentrations of hydrogen, ammonium, nitrate, sulfide, cations, anions, trace elements, rare earth elements, dissolved inorganic and organic carbon concentrations, carbon, hydrogen, and oxygen isotopes) parameters of groundwater at wells to evaluate how water interacts with bedrock.
Task 1.2.2. Analyze chloride isotope ratios of a subset of groundwater samples to evaluate water reservoir residence time.

Objective 1.3: Identify what microbes are present in the subsurface groundwater-rock system and evaluate if they consume or produce hydrogen gas.

Task 1.3.1. Collection of microbes from groundwater wells.
Task 1.3.2. Analyze hydrogen production and consumption potential of key microbes.

Key Outcome: A model of geologic hydrogen production, migration, and accumulation pathways to facilitate resource exploration in Minnesota.

Activity Milestones:

Description	Approximate Completion Date
Assess, compile, and evaluate existing data to inform sampling and characterization plans	August 31, 2026
Digitize historical drill core logs and other non-digital geological information.	January 31, 2027
Characterize key geologic units to establish groundwater: rock interaction.	September 30, 2027
Sample 10 groundwater wells for aqueous geochemistry and microbial analyses.	September 30, 2027
Build a preliminary schematic model of the system by integrating geological, chemical, and biological datasets.	December 31, 2027

Activity 2: Establish baseline environmental conditions for the hydrogen-generating subsurface system to inform policy decisions on future geologic hydrogen resource exploration

Activity Budget: $226,484

Activity Description:
Objective 2.1: Evaluate seasonality of hydrogen signals in the subsurface and determine variation in baseline conditions across a year.

Task 2.1.1. Repeat aqueous geochemical and biological measurements listed in tasks from Activity 1, Objectives 2 and 3 at the same wells during two different seasons.
Task 2.1.2. Compare groundwater geochemical and biological data from warm vs. cold seasons to assess variation.

Objective 2.2: Scale and integrate geologic, geochemical, and microbial datasets from rock, water, and microbe samples to construct a research framework for full GeoH2 system evaluation.

Task 2.2.1. Combine micro-scale mineral composition, volume, porosity, and permeability datasets with geophysical data, meso-scale drill core data, and macro-scale map data to characterize the geologic system and its suitability to generate and store hydrogen gas.
Task 2.2.2. Model groundwater: microbe: bedrock interaction in warm vs. cold seasons to assess annual variation in natural hydrogen consumption or production rates.

Key Outcome: Generate data that informs baseline environmental conditions in high-potential areas for GeoH2 before exploration takes place to inform state policy for gas exploration.

Activity Milestones:

Description	Approximate Completion Date
Sample 10 groundwater wells for aqueous geochemistry and microbial analyses in warm vs. cold seasons.	December 31, 2027
Integrate and scale all geological, chemical, and biological data sets.	February 28, 2028
Refine schematic model of the system using seasonal datasets.	April 30, 2028

Activity 3: Data synthesis, reporting, and dissemination.

Activity Budget: $123,655

Activity Description:
We will disseminate project information to Minnesota energy resource professionals, government entities, and scientific communities by creating two deliverables. The primary deliverable will be a publicly available technical report written for economists, government representatives, and interested community members in Minnesota. It will include comprehensive results, maps, and interpretation. The second deliverable will be a peer-reviewed publication in a scientific journal. Results will be presented at appropriate state meetings or conferences, such as the annual meeting of the Institute on Lake Superior Geology. Additional dissemination will be facilitated through the marketing and communications tools of the Natural Resources Research Institute, University of Minnesota Duluth, and University of Minnesota.

Objective: Deliver critical data on processes that generate geologic hydrogen in the subsurface to the public.

Task: Share project results with the community in the form of one technical report, and one scientific paper.

Key outcome: Initiate a research framework for future hydrogen resource assessment and environmental considerations.

Activity Milestones:

Description	Approximate Completion Date

Complete comprehensive technical report.	June 30, 2028
Complete draft for peer-reviewed publication.	June 30, 2028
Disseminate information through presentations and NRRI, UMD, and U of MN outreach channels.	June 30, 2028
Make data available through the Data Repository of the University of Minnesota.	June 30, 2028

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Michael Braunagel	University of Minnesota Duluth	Co-Investigator, Fracture network analysis and rock mechanics analyses	Yes
Jeff Havig	University of Minnesota	Co-Investigator, Aqueous Geochemistry and associated field work	Yes
Will Bartsch	Natural Resource Research Institute	Co-Investigator, Data Science	Yes
Joyashish Thakurta	Natural Resource Research Institute	Geological Characterization	Yes
Cory Paliewicz	NRRI	Geologic Characterization	Yes
Sara Post	NRRI	Geologic characterization, field work, water sampling	Yes
Amber Ulseth	NRRI	Field work and water sampling	Yes
Kristi Nixon	NRRI	Mapping/GIS	Yes
Trinity Hamilton	University of Minnesota	Co-Investigator, Microbiology and associated field work	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?

The research framework developed from this state investment is foundational to evaluating the feasibility of geologic hydrogen as an energy resource in Minnesota and sets the stage for future environmental considerations. Findings, results, and products developed will be documented in a comprehensive technical project report tailored for economists and government representatives in Minnesota. Science outcomes will be published in a peer-reviewed journal to ensure wide dissemination, broad awareness, and critical community evaluation of the work. We will pursue future funding from the National Science Foundation and Department of Energy to support additional efforts towards commercial development of natural hydrogen resources.

Project Manager and Organization Qualifications

Project Manager Name: Latisha Brengman

Job Title: Associate Professor

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

As an Associate professor in the Department of Earth and Environmental Sciences at the University of Minnesota Duluth, Dr. Brengman is an expert in quantifying and mapping redox and hydration reactions in iron-rich lithologies relevant to geologic hydrogen resource discovery and generation. In addition, she has over ten years experience tracking mineral reactions and silicification mechanisms in Precambrian terranes like that of Minnesota. The work proposed here directly expands from Brengman's current National Science Foundation grant on geologic hydrogen generated from iron formations. As a part of her current National Science Foundation grant, the UMD-led team is developing a cross-disciplinary scalable, quantitative workflow specific to hydrogen resource discovery in iron-rich lithologies of the Midwest. The research outlined in this LCCMR builds on Brengman's current NSF grant, proposing the integrative and innovative approach of characterizing fluids, minerals, and the subsurface microbial ecosystem in place, at multiple

scales across key units with the potential to generate hydrogen in Minnesota. The LCCMR proposal UMD-UMTC-NRRI team expertise and system-specific knowledge will help set the stage for future applied research of direct interest to industry as interest in hydrogen as an energy source grows. Collectively, the team has the multidisciplinary expertise required to characterize the subsurface system, making them well-poised to directly contribute to discovery of this potential new natural hydrogen gas resource.

Organization: U of MN - Duluth

Organization Description:
UMD is recognized as a Research University that actively engages with the region to contribute to the "economic, cultural, social, and environmental sustainability of Northeast Minnesota and the development of resilient communities in the Northland and beyond." With a mission to "inspire the next generation of STEM professionals to solve complex problems" and a vision to "lead in building interdisciplinary, inclusive communities to create a sustainable future," Swenson College of Science and Engineering delivers a student-centered experience through class and research experiences, with a focus on growth, community, creativity, and stewardship.

The cross- disciplinary proposed work aligns with UMD and SCSE's mission and vision, and would contribute directly to SCSE's goal of "Expand[ing] scholarly efforts, leverag[ing] shared knowledge and resources, and positively impact[ing] the Northland, Minnesota, and the world through mutually beneficial partnerships and collaborations."

The proposed outcomes of the work would aid in achieving NRRI's mission and vision of "discover[ing] the economy of the future" by "deliver[ing] integrated research solutions that value our resources, environment and economy for a sustainable and resilient future" while "improv[ing] student skills and training for the workforce by advancing industry, agency, nonprofit and community partnerships on SCSE projects."

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Latisha Brengman		Principal Investigator, Project Manager			27%	0.08		$14,568
Michael Braunagel		Co-Investigator, Structural Geology and rock mechanics			27%	0.08		$11,846
TBD Graduate Student Researcher, UMD		Geology and geochemistry characterization			44%	0.82		$88,038
Undergraduate Researcher 1, UMD		Sampling, mineral characterization, data analysis			0%	0.38		$12,200
Undergraduate Researcher 2, UMD		Sampling, mineral characterization, data analysis			0%	0.38		$12,200
Will Bartsch		Co-Investigator, Data science			27%	0.12		$16,721
Kristi Nixon		Mapping/ GIS			24.4%	0.08		$6,645
Cory Paliewicz		Geologic characterization			24.4%	0.24		$22,399
Sara Post		Field work, water sampling, geological characterization			24.4%	0.2		$17,226
Joyashish Thakurta		Geologic characterization			27%	0.12		$17,109
Amber Ulseth		Field work and water sampling			27%	0.1		$12,990
Undergrad Researcher, NRRI		Geologic characterization			0%	0.16		$5,384
TBD Graduate Student Researcher, NRRI		Geologic characterization			18.8%	0.02		$1,467
TBD Technician, Temp/Casual, NRRI		Geologic characterization			7%	0.18		$8,057
TBD Technician,		Geologic characterization			24.4%	0.02		$1,768

Bargaining Unit, NRRI								
Trinity Hamilton		Co-Investigator, Microbiology			27%	0.08		$19,627
Jeff Havig		Co-Investigator, Aqueous Geochemistry			27%	0.16		$22,894
TBD Post Doctoral Researcher, UMN		Microbiology and aqueous geochemistry			21%	2		$166,943
							Sub Total	**$458,082**
Contracts and Services								
University of Minnesota Duluth	Internal services or fees (uncommon)	Lab analyses at UM, SEM $40/hr, 120hrs, SEM training $168, n=3, SEM staff assistance $44/hr, 20hrs. carbon coating $13, n=16, coater training $46, n=3, XRD $ 14/hr, 200hrs, EPMA $800/24hrs, n=5, XCT $120/hr, 75hrs. Thin sections $60 each, 200 total.				0.02		$34,669
University of Minnesota system	Internal services or fees (uncommon)	Cost for groundwater anion and nutrient analysis at UMTC and NRRI; rock thin section preparation; electron microprobe fees at UMTC; Xray diffraction fees at UMD.				0.02		$11,260
Quantitative Bio-element Imaging Center (QBIC) at Northwestern University, UC-Davis Stable Isotope Facility (SIF), and the PRIME Lab at Purdue University, and the University of Minnesota Genomics Center (UMGC)	Service Contract	Characterize aqueous and particulate matter geochemistry in well water samples. Analysis for stable isotopes, trace elements, nutrients, Cl isotopes by the QBIC at Northwestern University, UC-Davis SFI, the PRIME Lab at Purdue University. Characterize microbial community composition by sequencing metagenomes at UMGC. Sequencing costs are standard costs at the UMGC.				0.02		$30,000
							Sub Total	**$75,929**

Equipment, Tools, and Supplies								
	Tools and Supplies	Lab consumables - low speed saw blade $ 500 2 1 Lab consumables - polishing supplies $ 150 8 6 Lab consumables - mount cups $ 50 2 1 Lab consumables - epoxy resin $ 200 2 1 Lab consumables - pXRF/ XRF mount cups and supplies $ 100 1 1Field supplies - Gas analyzer sampling (tubing, depth samplers) $ 100 Field supplies - sampling supplies (baggies, markers, notebooks, flagging) $ 50 Field supplies - field supplies (bug protection, sun protection, baggies, flagging, notebooks) $ 50	Cost of supplies for geologic sample preparation for thin section preparation, EPMA analyses and XRD analyses; Cost of consumables for collecting field gas measurements and core samples					$4,950
	Tools and Supplies	Laboratory supplies	Cost of sample containers and other consumables for collecting and preparing groundwater for anion and nutrient analysis					$1,550
	Tools and Supplies	Supplies include nucleic acid extraction kits, DNA quality reagents, filter pipette tips and lab consumables, probes and reagents for assessing water quality, tubes, bottles and filters for collecting water.	Funds in Years 1 and 2 to support lab and field costs associated with sampling water from wells.					$10,000
							Sub Total	**$16,500**
Capital Expenditures								
		Ex TEC HS680 CH4, CO, CO2, H2S, O2 detector	This portable, field gas analyzer is critical to measuring in situ at the field sites, concentrations of methane, carbon monoxide, carbon dioxides, hydrogen sulfide, and oxygen. Without measuring these gases, we cannot determine if hydrogen present is actually methane, and we also cannot tell if it is associated with any other gases.	X				$10,634
		Variotec H2 tracergas	This portable, field gas analyzer is critical to measuring hydrogen concentrations in situ at the field sites.	X				$10,276

							Sub Total	**$20,910**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Site/core travel, travel for EPMA and XCT analyses	For site travel, costs include mileage for 10 trips to Hibbing, MN in Years 1 and 2. For analyses, Year 1 - 2 EPM, A days, 1 XCT day, 2 travel days, lodging for 3 nights, 2 different teams, Year 2 - 3 EPMA days, 2 XCT days, 2 travel days, lodging for 5 nights, 2 different teams.					$6,192
	Miles/ Meals/ Lodging	Mileage (75%) and lodging (25%) for travel to well sampling locations, DNR drill core library, U of MN analytical labs on the Twin Cities campus, and a scientific conference in Minnesota.	Costs will follow federal mileage, per diem, and lodging rate guidelines (3% inflation rate).					$5,587
	Miles/ Meals/ Lodging	Each trip will require rental vehicle, lodging, meals.	Funds in Years 1 and 2 of the project to support field sampling trips for Hamilton, Havig and the postdoc.					$11,000
							Sub Total	**$22,779**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	Publication costs, UMD team	Funds for open access publication fees.					$1,000
	Publication	Publication costs, UMN team	Funds in Year 2 for open access publication fees.					$3,000
							Sub Total	**$4,000**
Other Expenses								

		Shipping, UMD	Costs to send rock samples for thin section preparation and to UMTC for analysis.					$100
		Shipping, NRRI	Cost to send rock samples out for thin section preparation and bulk geochemical analysis and to send groundwater samples to UMTC for anion analysis.					$700
							Sub Total	**$800**
							Grand Total	**$599,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Capital Expenditures		Ex TEC HS680 CH4, CO, CO2, H2S, O2 detector	We need this gas analyzer (cost is a direct quote price) to determine gas composition to complete stated project goals. After project completion, gas exploration work, and associated assessment of gas composition across multiple different environments in the state will continue in the region, and we will continue to leverage this instrument for that purpose. **Additional Explanation :** Hydrogen exploration is of great interest in the region, and with this instrument, we will be able to measure gas composition at any field site of interest as our understanding of hydrogen generation processes expands. We will continue to use the equipment for the same purpose of gas measurements in subsurface systems for its useful life.
Capital Expenditures		Variotec H2 tracergas	We need this gas analyzer (cost is a direct quote price) to be able to determine how much hydrogen gas is present at field sites to complete stated project goals. After project completion, hydrogen gas exploration work, and associated assessment of gas composition across multiple different environments in the state will continue in the region, and we will continue to leverage this instrument for that purpose. **Additional Explanation :** This portable, field gas analyzer is critical to measuring hydrogen concentrations in situ at the field sites. Hydrogen exploration is of great interest in the region, and with this instrument, we will be able to measure hydrogen gas at any field site of interest as our understanding of hydrogen generation processes expands. We will continue to use the equipment for the same purpose of gas measurements in subsurface systems for its useful life.

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
In-Kind	UMN unrecovered indirect costs are calculated at the UMN negotiated rate for research of 54% modified total direct costs.	Indirect costs are those costs incurred for common or joint objectives that cannot be readily identified with a specific sponsored program or institutional activity. Examples include utilities, building maintenance, clerical salaries, and general supplies. (https://research.umn.edu/units/oca/fa-costs/direct-indirect-costs)	Secured	$297,587
			Non State Sub Total	**$297,587**
			Funds Total	**$297,587**

Total Project Cost: $896,587

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 7945a70d-bb6.pdf

Alternate Text for Visual Component

A schematic figure that display the driving research question: Does Minnesota bedrock plus groundwater plus microbes yield hydrogen gas that we can use as a new energy resource?...

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
UMN Authorization Letter	a9f47db8-1e1.pdf
Letter of Support from National Renewable Energy Laboratory	e32f27d0-7ec.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I understand the UMN Policy on travel applies.

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

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?

Yes

Does the organization have a fiscal agent for this project?

No

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

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 as "the provision of care, treatment, education, training, instruction, or recreation to children")?

No

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:

None.

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

Yes, I understand