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

Project Title: **ENRTF ID: 049-B**

Understanding Bedrock Fracture Flow to Improve Groundwater Quality

Category: B. Water Resources

Total Project Budget: $ 183,627

Proposed Project Time Period for the Funding Requested: 3 years, July 2016 to June 2019

Summary:

We will use new techniques of borehole testing and rock fracture mapping in the Twin Cities to achieve a better understanding of groundwater flow through fractured bedrock, improving groundwater management.

Name: Anthony Runkel

Sponsoring Organization: Minnesota Geological Survey

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Location

Region: Metro, SE

County Name: Anoka, Dakota, Fillmore, Goodhue, Hennepin, Houston, Olmsted, Wabasha, Washington, Winona

City / Township:

Alternate Text for Visual:

Illustration of fractured Platteville Formation and contaminated groundwater beneath the Twin Cities.

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

I. PROJECT STATEMENT

Using new borehole testing and rock fracture mapping techniques we will gain a better understanding of groundwater flow through fractured bedrock in the Twin Cities that will support better management of water quality and quantity. Groundwater flow in bedrock occurs mostly through fractures in a manner that remains difficult to predict, hampering efforts to protect and remediate groundwater. This problem is particularly acute across southeastern Minnesota, including the Twin Cities, where fractured limestone bedrock is a source of baseflow to streams, and also a source of drinking water. Contaminated water from point (e.g. petroleum products and solvents) and non-point (e.g. nitrate) sources in these limestones is well-known. Point-source contamination plumes are a particular problem in the Twin Cities, with a large number of actively monitored and remediated sites, including Superfund sites in Minneapolis, St. Louis Park, Oakdale, and Edina.

Results/Benefits. In combination with ongoing County Geologic Atlas program mapping, the results will provide a better understanding of fracture-controlled flow that can be used to more effectively remediate contamination sites, and improve management strategies to better protect fractured rock aquifers from further degradation. In addition to contamination issues, the results will provide guidance for water management engineering inherent to many of the construction projects in central Twin Cities, and for groundwater-surface water modeling, such as within the Minnehaha Creek Watershed.

Project design The project will focus on the Platteville Formation in the Twin Cities, which is one of the most heavily contaminated bedrock layers in the state. It is also hosts a large number of springs, such as Camp Coldwater spring, that discharge to the Mississippi River, and is the bedrock foundation for infrastructure in the urban core. At a site along the Mississippi River in Minneapolis, we will use recently developed techniques of borehole geophysical testing and installation of pressure and temperature sensors in two monitor wells, and detailed mapping of fractures at nearby rock exposures. Pressure and temperature measurements collected from the wells, interpreted in the context of nearby fracture mapping, will allow us to link hydraulic (water) properties to rock (fracture) properties to provide a greater understanding of fracture flow.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Test monitor wells to identify fractures and measure flow, and install sensors **Budget: $115,672**
Utilize geophysical and video tools to identify and measure fractures, and measure water flow, in two monitor wells on University of Minnesota campus. Install flexible borehole liners (1 each well) and sensors (15 each well)

Outcome	Completion Date
1. Depiction of fracture patterns in the wells that can be compared with outcrop fractures	9/1/16
2 Measurements of groundwater flow in two monitor wells	9/1/16
3. Borehole liners and sensors in two wells installed for temperature and pressure data	11/1/16

Activity 2: Collect groundwater pressure and temperature data from wells for 2 years **Budget: $18,572**
Extract sensors from wells at 4 month intervals to download temperature and pressure data, and re-insert sensors for additional data collection

Outcome	Completion Date
Acquisition of two years of continuous data showing temperature and pressure variability that provide an understanding of groundwater flow conditions.	11/1/18

Activity 3: Map fractures in bedrock along Mississippi River near the tested monitor wells **Budget: $21,524**
Fractures will be mapped by photo-based trace mapping of rock exposures along east bank of Mississippi River, about 500 yards from monitor wells tested as part of Activity 1.

Outcome	Completion Date
An understanding of the distribution of fractures that control groundwater flow	11/1/17

Activity 4: Synthesize information, disseminate results to groundwater managers. **Budget: $27,858**
Compile and interpret data, produce reports and presentations that will be disseminated to organizations that have a role in managing groundwater quality and quantity, such as MPCA, DNR, County environmental managers, and environmental consulting industry.

Outcome	Completion Date
1. Peer reviewed report(s) and public presentations of results will lead to more effective remediation of contamination sites, and improve management strategies to better protect fractured rock aquifers from further degradation.	7/1/19

III. PROJECT STRATEGY

A. Project Team/Partners

- **Minnesota Geological Survey (MGS)**: Anthony Runkel , project leader, with expertise on fractured rock properties and groundwater flow, will manage logistics, and together with MGS geologists will conduct fracture mapping, and participate in testing and installing sensors in monitor wells. MGS staff also responsible for monitor well data collection, synthesis of results, report writing, and dissemination.
- **Centre for Applied Groundwater Research** , University of Guelph, Ontario, led by Beth Parker. Geophysical testing and installation of pressure and temperature sensors as a contracted collaboration. This Centre is uniquely capable of acquiring temperature logs that measure flow direction through fractures, and in installation of the nested pressure and temperature sensors, a procedure developed by their group. Contribution to interpretation of results and publication will be an unpaid contribution.
- **Braun Intertec,** Bloomington, Minnesota. Kelton Barr, Principal Hydrogeologist, providing unpaid consultation at all stages of the investigation. Mr. Barr has over 40 years of experience remediating fractured limestone contamination sites in the Twin Cities.

B. Project Impact and Long-Term Strategy

Application of our results will improve the efficiency and effectiveness of remediation and monitoring at a large number of contamination sites across the Twin Cities. The results will also be applicable to water management at construction (tunneling, building foundation, roadwork) sites, and to modeling groundwater-surface water interaction in areas such as the Minnehaha Creek Watershed. The results will provide a better understanding of fracture controlled flow through limestones regionally across southeastern Minnesota, and therefore link to the mapping of these limestones as part of ongoing County Geologic Atlas mapping progam, such as the in-progress Hennepin County Atlas. The borehole equipment purchased for this project, and the investigative methods, can be subsequently deployed in both wells and springs at other sites in southeastern Minnesota.

C. Timeline Requirements

The timeline of 3 years is required to acquire an adequate time interval of hydraulic and temperature data from the boreholes, and to map fractures. Two years of borehole data will provide a continuous record of pressure and temperature changes that occur from seasonal impacts to groundwater. The third year of the project will be used for data assimilation, continued monitoring, report writing, and dissemination.

2016 Detailed Project Budget

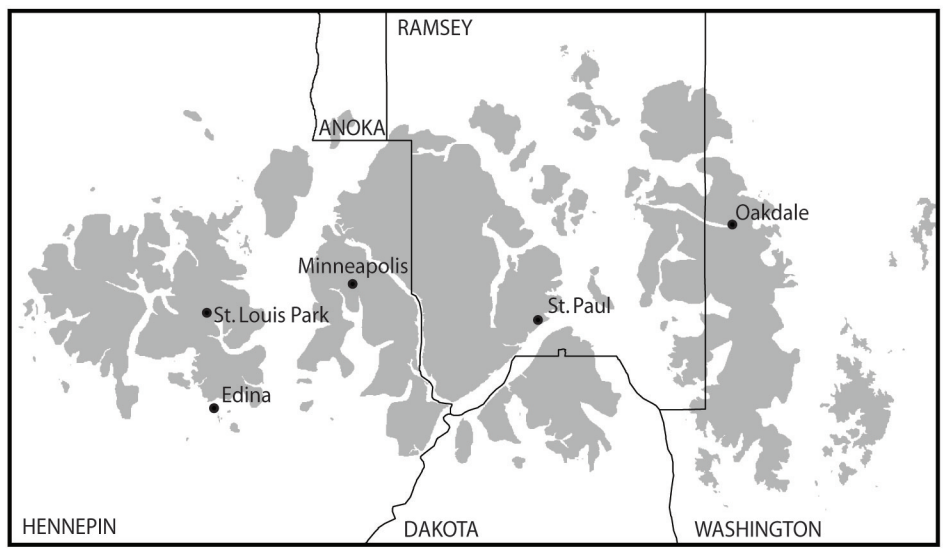
Project Title: Understanding Groundwater Flow in Fractured Bedrock

IV. TOTAL ENRTF REQUEST BUDGET: 3 years

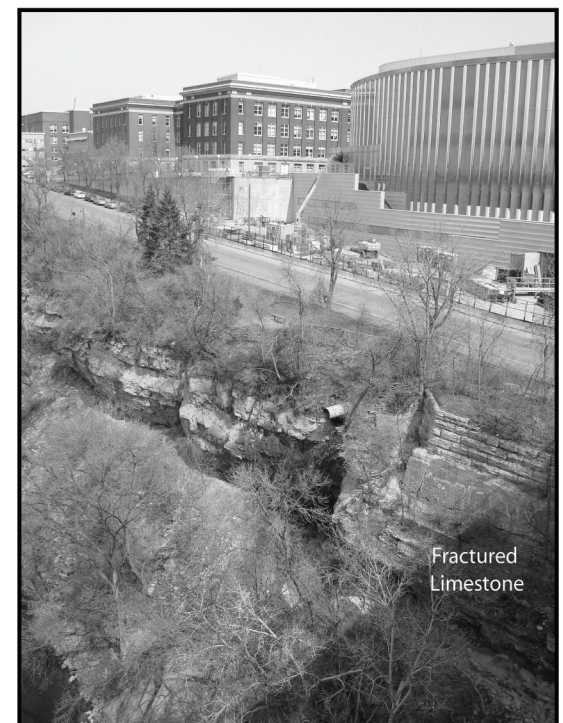
BUDGET ITEM	AMOUNT
Personnel:	
1 senior scientist, MGS; 16.6% time per year for 3 years, 74% salary, 26% benefits	$ 46,512
1 senior scientist, MGS 8.3% time per year for 3 years, 74% salary, 26% benefits	$ 21,403
1 scientist MGS 4.2% time per year for 3 years, 74% salary, 26% benefits	$ 8,592
1 assistant scientist MGS 4.2% time per year for 3 years, 74% salary, 26% benefits	$ 7,068
Professional/Technical/Service Contracts:	
Centre for Applied Groundwater Research (CAGR) , University of Guelph, Ontario: Acquisition of borehole data from two monitor wells that will provide recognition of rock fractures in the wells, and where and in what direction natural groundwater flow occurs. Includes directional temperature logs (CAGR is sole source provider), acoustic and optical televiewer logs, and full waveform sonic logs. Design and installation of a borehole liner and 15 sensors (a technique developed and deployed only by CAGR) in each of two monitor wells (total 2 borehole liners and 30 sensor arrays designed and installed)	$ 40,000
Equipment/Tools/Supplies	$ -
Data logger sensors that measure pressure and temperature (to be installed in two boreholes): Total 30 sensors @ $1827.50 ea	$ 54,825
Borehole liners to be installed in two monitor wells. FLUTe brand flexible liners, Total of 2 liners @ $1541 ea	$ 3,082
Equipment rental (truck) for monitor well liner installation, retrieval, re-installation (to retrieve data 4 times during course of project) (truck rental, 5 weeks @ $269/week)	$ 1,345
Equipment for outcrop fracture tracing (camera and accessory rental, scaffolding)	$ 800
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 183,627

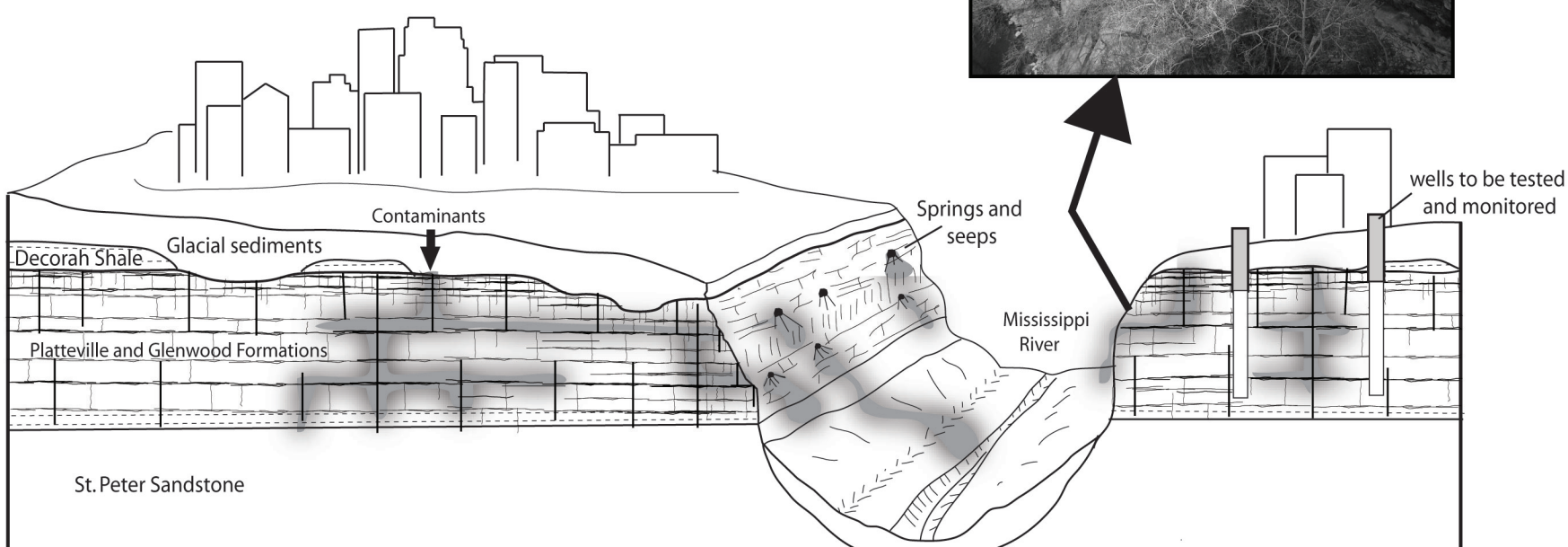
V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other State $ To Be Applied To Project During Project Period: The proposed project is in part an outgrowth of knowledge about the importance of flow through fractured limestone attained through the ongoing Minnesota Geological Survey and DNR County Geologic Atlas progam, funded through ENRTF. If funded, the project will also coincide with completion of the Hennepin County Geologic Atlas, which will provide the map products necessary to apply our project results across larger areas.	NA	*secured*
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 this project, would be $95,486	$ 95,486	
Funding History: Proposed project builds on over 5 years of research by MGS staff on fractured rock groundwater flow in the Platteville Formation, funded through Minnesota Geological Survey base funding, and a 2010 Met Council grant.	~60,000	completed
Remaining $ From Current ENRTF Appropriation:	$ -	



Gray shading indicates where fractured limestone of the Platteville Formation is present beneath the land surface





Depiction of the fractured limestone and contamination plumes beneath the Twin Cities

Understanding bedrock fracture flow to improve groundwater quality

Project Manager: Anthony (Tony) Runkel

Qualifications:

Education

PhD in Geology, University of Texas, 1989

MS in Geology, University of Montana, 1986

BA in Geology University of Minnesota, Minneapolis, MN, 1983

Professional Experience

Geologist, Minnesota Geological Survey, 1989-2015
Chief Geologist, Minnesota Geological Survey 2005-2015

As geologist responsible for geologic mapping in southeastern Minnesota, and investigative projects involving groundwater flow in the karstic and fractured bedrock across the same region

As Chief Geologist responsible for quality of all MGS products (maps, reports) and scientific direction.

Geologic interests and experience include:

- 25 years of geologic mapping and groundwater research on the bedrock of southeastern Minnesota, including the Twin Cities Metro region
- the relationship of geologic settings and ground water sensitivity.
- the influence of geologic settings on groundwater and surface water

Organization Description:

The Minnesota Geological Survey is the geologic mapping agency for the State of Minnesota, as directed by its enabling legislation. Its primary goal is to produce comprehensive geologic mapping and related databases statewide at a scale of 1:100,000 or more detailed. This mapping supports informed land use management and decision-making that protects and wisely allocates resources. The MGS is part of the N.H. Winchell School of Earth Sciences in the College of Science and Engineering at the University of Minnesota. It has existed since 1872 and has a current staff of approximately 32.