Environment and Natural Resources Trust Fund
2017 Request for Proposals (RFP)

Project Title: **ENRTF ID: 019-A**

Mapping Heavy Metal Contamination Using Geophysics and Chemistry

Category: A. Foundational Natural Resource Data and Information

Total Project Budget: $ 91,945

Proposed Project Time Period for the Funding Requested: 1 year, July 2017 - June 2018

Summary:

This pilot project uses field-based geophysics and chemistry to create high-resolution maps of heavy metal abundances in urban soils. Analysis of microbial communities will determine remediation potential for contaminated sites.

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Sponsoring Organization: U of MN

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Location

Region: Metro

County Name: Hennepin

City / Township: Minneapolis

Alternate Text for Visual:

Satellite image of proposed study areas in western Minneapolis

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

PROJECT TITLE: Mapping heavy metal contamination using geophysics and chemistry

I. PROJECT STATEMENT

There are serious health risks associated with exposure to elevated levels of heavy metals such as lead (Pb) and arsenic (As). Recent media attention regarding the ongoing water crisis in Flint, Michigan highlights the need for state governments and local municipalities to have quality information about the concentration of heavy metals in urban soil and water resources. **Here, we propose to use a combination of geophysical, chemical, and biological techniques to perform a pilot survey of heavy metal contamination in surface soils at selected brownfield sites in the Minneapolis metropolitan area.** Our study will focus on the Basset Creek Irving Avenue Dump superfund site, nearby Bryn Mawr Meadows Park, and Theodore Wirth Park in western Minneapolis the closest comparatively undisturbed urban area. By conducting a pilot survey in these locations we aim to highlight the utility of geophysical techniques in mapping heavy metal contamination and create a basis for addressing how microbial communities change with regards to metal concentrations. This work will have important implications for how heavy metals are surveyed and will lead to future efforts in understanding how microbial communities can be used in bioremediation.

Activity 1. Heavy metal concentrations and the geophysical properties of soils

Our proposed study will tie discrete measurements of heavy metal abundance to geophysical measurements of magnetic susceptibility for each study site. Heavy metals are known to accumulate in surface soils by sorption to the surfaces of iron oxide and iron-bearing clay minerals. By measuring the magnetic susceptibility of a soil it is possible to quantify the relative abundance of iron oxides, which ultimately is related to heavy metal abundance. The Department of Earth Sciences at the University of Minnesota has instrumentation available to make rapid, field-based measurements of both magnetic susceptibility and heavy metal concentration that will enable us to create a rich data set with which to test the efficacy of the geophysical survey. After sufficient sampling, we will use this paired data to convert high-resolution magnetic susceptibility transects collected using a magnetic gradiometer into heavy metal abundance. The final products of this phase will be high-resolution geophysical and geochemical maps of the study sites that will highlight areas of contamination for heavy metal abundance.

Activity 2. Microbial community diversity in surface soils with high and low metal abundance

A crucial step in understanding the fate and distribution of heavy metals in the environment is an understanding of the microbial communities that are able to gain energy associate with the reduction and oxidation of these metals. In some instances, it may be possible to use naturally occurring microbial communities to help transform metal contamination into forms that are more easily and economically remediated. This pilot project integrates microbiological analysis into the chemical and geophysical mapping in order to advance our understanding of how microbial community structure changes with heavy metal concentration. The results of this activity will have important implications for understanding microbial metabolisms that have the potential to mobilize or transform metals in ways that may aide in bioremediation efforts. Specific sampling sites for activity 2 will be determined using the geophysical and geochemical maps generated by activity 1 and will focus on assessing microbial communities in samples with high and low concentrations of heavy metals.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Heavy metal concentrations and the geophysical properties of soils **Budget: $41,345**

Outcome	Completion Date
1. Transects at field sites collecting discrete chemical and geophysical data	*August 2017*
2. Geophysical survey of entire field areas using magnetic gradiometer	*September 2017*
3. Map of heavy metal abundance	*October 2017*

Activity 2: Microbial community diversity in surface soils with high and low metal abundance **Budget: $ 50,600**

Outcome	Completion Date
1. Discrete sampling for microbial community analysis	*October 2017*
2. Sequencing and analysis of microbial communities	*June 2018*

III. PROJECT STRATEGY

A. Project Team/Partners

Project Leader: Dr. Joshua Feinberg (University of Minnesota – Department of Earth Sciences) is an Associate Professor and the Assistant Director of the Institute for Rock Magnetism. He is an expert in geophysics, magnetism, and mineralogy. Feinberg will participate and supervise Maxbauer on Activity 1.

Daniel Maxbauer (University of Minnesota – Department of Earth Sciences) will be a Postdoctoral Scholar in the Department of Earth Sciences at UMN. He is an expert in magnetism and mineralogy of soils and sediments. Will perform the majority of analyses and sampling for Activities 1 and 2.

Dr. Jeff Gralnick (University of Minnesota – BioTechnology Institute) is an Associate Professor of Microbiology and an expert in bacterial genetics and bio-mediated metal reduction. Will advise and provide expertise on Activity 2.

Associates:

Dr. Nic Jelinski (University of Minnesota – Department of Soil, Water, and Climate) is an Assistant Professor and has an ongoing independent research project on lead concentrations in residential soils across the Twin-Cities metropolitan area. Dr. Jelinski will be involved in providing support and logistical assistance for this project.

B. Project Impact and Long-Term Strategy

This project has the potential to substantially impact how heavy metals are detected by state agencies and private environmental and geotechnical consulting firms. First, proving the efficacy of geophysical techniques for surveying heavy metal abundance has considerable potential to increase the ease and cost-effectiveness of acquiring high-resolution information about metal contamination across the state. Second, linking information about metal abundance and associated microbial communities will serve as a basis for future work into effective and novel measures of bioremediation at metal contaminated sites. We expect future iterations of these efforts to involve collaborations with the Minnesota Pollution Control Agency and the Minnesota Department of Health to expand upon the scope of this pilot study. Further, this work is supported through ongoing collaborative efforts between the UMN Department of Earth Sciences and private firms such as Braun Intertec and Barr Engineering. Funding for future efforts will be targeted at national sources through the National Science Foundation and the Environmental Protection Agency.

No other funds have been acquired to specifically support this research.

C. Timeline Requirements

The timeline required to complete this pilot-study is 1 calendar year.

2017 Detailed Project Budget

Project Title: Mapping heavy metal contamination using geophysics and chemistry

IV. TOTAL ENRTF REQUEST BUDGET: *1 y* **ear**

BUDGET ITEM	AMOUNT
Personnel:	
Joshua Feinberg, Project Manager (75% salary, 25% benefits); 8% FTE for year 1	$ 8,745
Daniel Maxbauer, Geophysicist/Soil Specialist/Data Analyst (82% salary, 18% benefits); 100% FTE for year 1	$ 61,200
Graduate Research Assistant, microbial community analysis (50% salary, 50% benefits); 20% FTE for year 1	$ 10,000
Professional/Technical/Service Contracts:	
University of Minnesota Genomics Center: Microbial community analysis for 50 samples at 1,000,000 reads per sample.	$ 10,000
Equipment/Tools/Supplies:	
Consumables for portable X-Ray Fluorescence spectrometer (pXRF): cups, films, standards	$ 1,000
Consumables for magnetic gradiometry: cables, measuring tapes, notebooks	$ 1,000
Acquisition (Fee Title or Permanent Easements):	N/A
Travel:	N/A
Additional Budget Items:	N/A
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST	= $ 91,945

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: This is a pilot study and no non-state funds have been secured previously.	$ -	Pending
Other State $ To Be Applied To Project During Project Period: This is a pilot study and no state funds have been secured previously.	$ -	Pending
In-kind Services To Be Applied To Project During Project Period: University of Minnesota: Procurement of Instrumentation (X-Ray Spectrometer & Magnetic Gradiometer)	$ 75,000	Secured
Funding History: This is a pilot study and no additional funds have been secured previously.	$ -	
Remaining $ From Current ENRTF Appropriation: N/A	$ -	Unspent

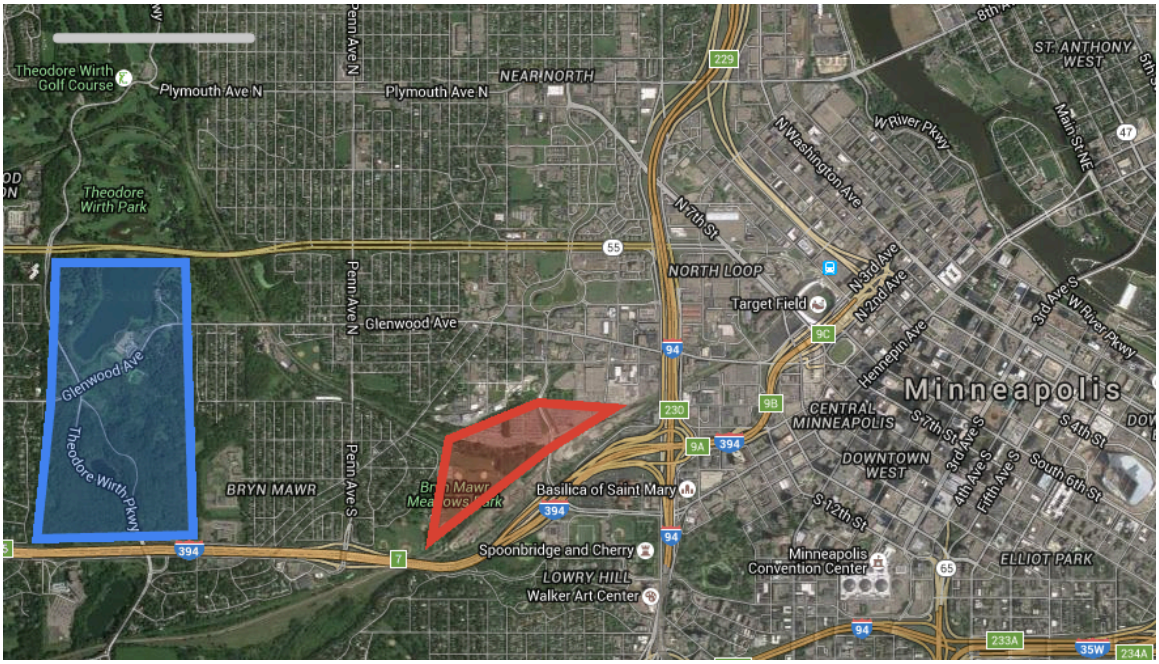

Figure 1. Satellite image of proposed study areas in western Minneapolis. Red polygon shows the Basset Creek Irving Avenue Dump superfund site and Bryn Mawr Meadows Park. Green polygon outlines targeted study area near Theodore Wirth Park, a relatively undisturbed urban area. Image modified from Google Earth. Scale bar in upper left is 1 km.

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Project Manager Qualifications & Organization Description

The proposed Project Manager, Joshua Feinberg, has over 19 years of experience working as a geoscience professional for state and federal natural resource agencies, for private environmental consulting corporations, and as a university professor overseeing federally funded scientific research. This project will require (1) oversight of Postdoctoral Scholar Daniel Maxbauer and a graduate student, (2) training on the responsible and efficient operation of the portable X-Ray Fluorescence Spectrometer and Magnetic Gradiometer, (3) instruction on how to synthesize and report the raw geochemical and geophysical data, (4) guidance and collaboration with our scientific partners Jeff Gralnick (on the genetics of microbial communities) and Nic Jelinski (on regional urban soils and Pb abatement), (5) coordination with our state partners at the Minnesota Pollution Control Agency and the Minnesota Department of Health, (6) obtaining and maintaining proper permits for non-intrusive survey work at the Bassett Creek Irving Avenue Dump superfund site, Bryn Mawr Meadows Park, and Theodore Wirth Park, and (7) overseeing all reporting and scientific dissemination responsibilities.

Feinberg is currently a tenured Associate Professor in the Department of Earth Sciences at the University of Minnesota and the Associate Director of the Institute for Rock Magnetism (IRM), which is a National Multi-User Facility funded primarily by the National Science Foundation. The main activities of both the Earth Sciences Department and the IRM are scientific research, education, and community service, all of which are directly addressed in this LCCMR proposal. Feinberg is well positioned to manage the research team, oversee Maxbauer and the graduate student (TBD), and ultimately convert this pilot project into a survey methodology that would be of interest to private companies and federal research agencies tasked with characterizing heavy metal contaminants and their risk to public health and water resources.