Environment and Natural Resources Trust Fund
2012-2013 Request for Proposals (RFP)

Project Title: **ENRTF ID:** **158-I**

Low Cost Remediation of PAHs from Pond Sediment

Topic Area: I. Water Resources

Total Project Budget: $ 316,000

Proposed Project Time Period for the Funding Requested: 2 yrs, July 2013 - June 2015

Other Non-State Funds: $ 0

Summary:

The project will provide a novel method for inexpensive remediation of polycyclic aromatic hydrocarbons (PAHs) from the sediment of storm water ponds using carbon coated porous magnetic particles.

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Sponsoring Organization: United Science Corp.

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Web Address www.uniscicorp.com

Location

Region: Metro

County Name: Ramsey

City / Township: White Bear Lake

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

PROJECT TITLE: Low Cost Removal of PAHs Found in Drainage Pond Sediment

I. PROJECT STATEMENT

Polycyclic aromatic hydrocarbons (PAH) sourced in part from coal-tar based asphalt sealants have become a major source of non-point source pollution. PAHs accumulate in municipal storm water pond sediment and they are expensive to remediate (~125-200 k USD/pond). The proposed research will develop a remediation technology that allows for more efficient and economical removal of PAHs from storm water pond sediment. Specifically, carbon coated porous magnetic particles (CCPMP) will be developed and examined for their efficacy in *ex situ* PAH remediation from pond sediments.

There are significant ecological and human consequences of PAH contamination such as fin erosion and liver abnormalities in fish and inhibited reproduction and mortality in benthic invertebrates. PAHs are are carcinogenic, mutagenic, and teratogenic to humans. PAH concentrations exceeding Level II sediment quality target of <23000 µg/kg in sediment have been found at hundreds of locations across the Twin Cities metro area. There are approximately 20,000 storm water ponds in the metro area and it is estimated by the MPCA that 30% of them are contaminated at greater than Level I (<1600 µg/kg) with PAHs. The remediation of these ponds is a significant expense for cities, many times overwhelming the budget that is available because the sediment must be disposed in a lined landfill capable of handling hazardous substances. According to Mark Burch (city engineer) at White Bear Lake, tipping fees associated with disposal of sediment as waste instead of cover material can cost up to ~$35 additional costs per cubic yard. With 6,000 ponds at risk and each pond containing approximately 1,500 cubic yards of sediment, an estimated additional $315 million will need to be spent to remediate these ponds over their 15-20 year estimated life. It is clear that research into less expensive technologies to remove PAHs from storm water ponds is necessary.

The goal of this project is to do research and development on a less expensive technique to remove PAHs from storm pond sediment by concentrating them on magnetic carbon particles and removing the particles from the sediment with common magnetic separations equipment during routine dredging, thereby avoiding the need for special disposal. The novel particles are porous magnetic iron oxide coated with pyrolytic carbon. This carbon coating does an excellent job of absorbing PAHs, as our preliminary results have shown. Based on sorptive capacity, we estimate that 1 bobcat bucket of porous magnetic carbon will clean 166 dump truck loads of sediment. Our proposed remediation method is to dredge the contaminated sediment into a skid mounted rotary "cement" mixer with the CCPMP particles continuously added to it. After mixing and PAH adsorption, particles will be conveyed to a commercially available magnetic separator that will remove them from the sediment as is currently accomplished in mining operations. The particles will then be recycled by United Science.

II. DESCRIPTION OF PROJECT ACTIVITIES

Activity 1: Core particle synthesis **Budget:** $80,000

In this activity we will synthesize a number of different formulations of porous magnetic iron oxide particles with varying particle size and porosity. This synthesis will be performed by spray drying of an iron oxide colloid at varying temperatures, flow rates, and colloid nanoparticle size. The goal is to create a highly magnetic porous particle with a surface area of at least 80 m^2/g that is ~20-100 µm in diameter. The particles will be evaluated with BET porosimetry for surface area and pore size, and by light microscopy for particle size.

Outcome	Completion Date
1. Production of porous iron oxide particles	*Oct 31, 2013*

Activity 2: Carbon coat and preliminary PAH testing **Budget:** $ 50,000

This activity will focus on using our patent pending carbon deposition technique to deposit pyrolitic carbon onto the surface of the porous iron oxide particles. The amount of carbon deposited will be

varied and the optimum amount will be determined through preliminary PAH adsorption studies. The goal is to achieve the maximum PAH adsorption across the PAHs listed as health concerns by the EPA. This will be measured by GC/MS or HPLC chromatography.

Outcome	Completion Date
1. Carbonization of porous iron oxide particles	*Dec. 31, 2013*
2. Optimization of carbon coating load for maximum PAH adsorption	*Jan. 31, 2014*

Activity 3: Perform lab scale PAH remediation **Budget:** $80,000

Lab scale PAH remediation with real world sediment samples that are spiked with PAHs will be performed in this activity. Different geometries of mixers will be explored to determine the most efficient way to remove PAHs from the contaminated sediment. Different magnet types and geometries will also be explored to obtain rapid and complete separation of the CCPMP particles after they have completed PAH adsorption. The goal of this activity is to obtain a laboratory scale mixer and lab scale magnetic separator that will accomplish PAH removal from sediment using CCPMP particles.

Outcome	Completion Date
1. Lab scale PAH remediation using CCPMP	*May 30, 2014*

Activity 4: Perform scale up and field pilot study **Budget:** $125000

The activity will focus on scaling up the production of the CCPMP particles and the establishment of a field pilot study. Scaling up both the spray drying process, the carbonizing process and the mixing and separation processes will be the first portion of this activity. The goal is to be able to produce 10s of kilograms of final product per week. Next, in collaboration with the city engineers of White Bear Lake, a suitable site for a field pilot study will be chosen and full scale processing will occur. The goal is to build a skid system from standard magnetic separations equipment that will remove all detectable PAHs from the pond sediment and to separate the contaminated particles out and recycle them.

Outcome	Completion Date
1. Particle Synthesis is scaled up and 10s of kg of week can be produced	*Jun. 30, 2014*
2. Full scale PAH remediation process at field pilot trial	*Nov. 30, 2014*

III. PROJECT STRATEGY

A. Project Team/Partners

The research and development will be lead by project manager Dr. Conor Smith, a chemist with a Ph.D. in inorganic chemistry and multiple years of experience with porous particles and the carbonization of them. Most of the funding will be used by United Science LLC in performing the basic research and development for this project. Dr. Jon Thompson, will provide support in analytical chemistry. City Engineer of White Bear Lake Mark Burch will contribute his expertise with stormwater ponds and pond sediment, as well as providing access to sediment and stormwater ponds in the city of White Bear Lake. Professor of civil and environmental engineering at Stanford University Richard Luthy will provide support with method development of mixing and separations of the CCPMP particles, and will receive funds for a graduate student to perform this work. Dale Thompson, former MPCA environmental engineer involved in PAH remediation, will also consult on this project.

B. Timeline Requirements

This project is expected to take 17 months. The initial research portions of the timeline, such as particle production, carbonization, and lab scale PAH remediation are expected to be unaffected by seasonality, and to occur over 10 months. The field pilot study must be performed during the summer season, so it is targeted for summer 2014 and should take approximately 6 months.

C. Long-Term Strategy and Future Funding Needs

The long term strategy for this product is to offer local municipalities a lower cost and lower waste alternative to current PAH contaminated sediment processing. Funding for this ongoing project will be pursued from MPCA 319 grants as well as private investors.

2012-2013 Detailed Project Budget

INSTRUCTIONS AND TEMPLATE (1 PAGE LIMIT)

Attach budget, in MS-EXCEL format, to your "2012-2013 LCCMR Proposal Submit Form".

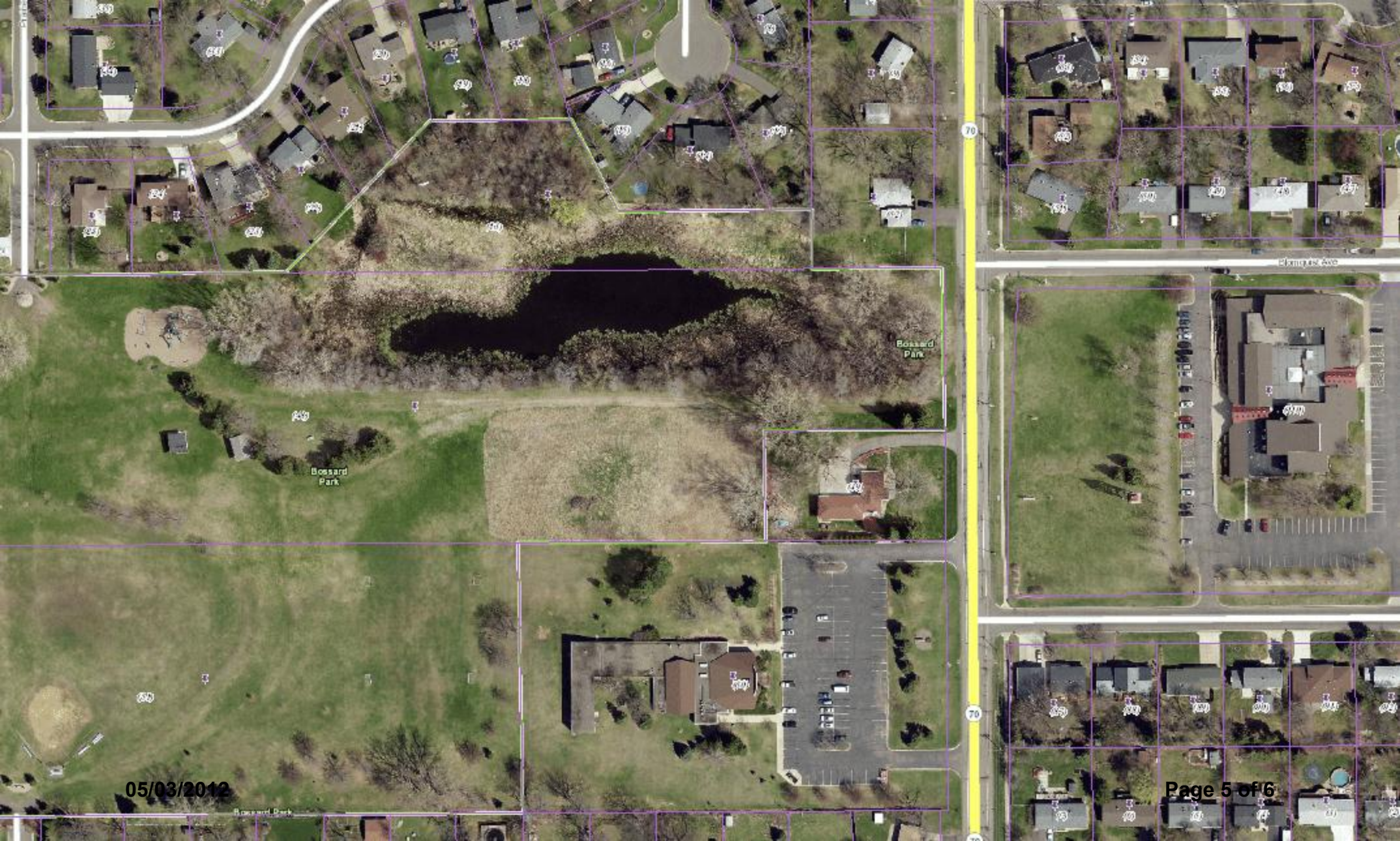
(1-page limit, single-sided, 10 pt. font minimum. Retain bold text and DELETE all instructions typed in italics. ADD OR DELETE ROWS AS NECESSARY. If a category is not applicable write "N/A" , leave it blank, or delete the row.)

IV. TOTAL ENRTF REQUEST BUDGET *[Insert # of years for project]* **years**

BUDGET ITEM *(See list of Eligible and Non-Eligible Costs, p. 11)*	**AMOUNT**
Personnel: Conor Smith, Full time, Project Manager, 50% toward salary, 20% benefits, *In this column, list who is getting paid to do what and what is the % of full-time employment for each position. List out by position or position type - one row per position/position type. For each, provide details in this column on the inputs: i.e., % dollars toward salary, % dollars toward benefits, time period for position/position type, and number of people in the position/position type.*	$ -
Conor Smith, Full Time, Project Manager, 50% toward salary, 15% Benefits, 2 yrs, 1	$ 60,000
Jon Thompson, Full Time, Analytical Chemist, 25% toward salary,15% Benefits, 5 yrs, 1	$ 50,000
Doug Fryer, Full Time, Lab Technician, 100% salary, 15% benefits	$ 50,000
Contracts: *In this column, list out proposed contracts. Be clear about whom the contract is to be made with and what services will be provided. If a specific contractor is not yet determined, specify the type of contractor sought. List out by contract types/categories - one row per type/category.*	$ -
Prof. Dick Luthy, Environmental Engineering, Stanford, Analytical	$ 16,000
Dale Thompson, Environmental Engineering Consultant	$ 10,000
Equipment/Tools/Supplies: *In this column, list out general descriptions of item(s) or item type(s) and their purpose - one row per item/item type.*	$ -
Spray dry equipment	$ 30,000
Reactor Upgrade	$ 5,000
Lab scale mixing and separations appratus	$ 30,000
Skid scale mixing and separations equipment	$ 65,000
Acquisition (Fee Title or Permanent Easements): *In this column, indicate proposed number of acres and and name of organization or entity who will hold title.*	$ -
Travel: *Be specific. Only in-state travel essential to completing project activities can be included.*	$ -
Additional Budget Items: *In this column, list any additional budget items that do not fit above categories. List by item(s) or item type(s) and explain how number was reached. One row per type/category.*	$ -
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 316,000

V. OTHER FUNDS

SOURCE OF FUNDS	**AMOUNT**	**Status**
Other Non-State $ Being Applied to Project During Project Period: *Indicate any additional non-state cash dollars to be spent on the project during the funding period. For each individual sum, list out the source of the funds, the amount, and indicate whether the funds are secured or pending approval.*	$ -	*Indicate: Secured or Pending*
Other State $ Being Applied to Project During Project Period: *Indicate any additional state cash dollars (e.g. bonding, other grants) to be spent on the project during the funding period. For each individual sum, list out the source of the funds, the amount, and indicate whether the funds are secured or pending approval.*	$ -	*Indicate: Secured or Pending*
In-kind Services During Project Period: *Indicate any in-kind services to be provided during the funding period. List type of service(s) and estimated value. In-kind services listed must be specific to the project.*	$ 100,000	Secured
Remaining $ from Current ENRTF Appropriation (if applicable): *Specify dollar and year of appropriation from any current ENRTF appropriation for any directly related project of the project manager or organization that remains unspect or not yet legally obligated at the time of proposal submission. Be as specific as possible. Describe the status of funds in the right-most column.*	$ -	*Indicate: Unspent? Not Legally Obligated? Other?*
Funding History: *Indicate funding secured prior to July 1, 2013, for activities directly relevant to this specific funding request. State specific source(s) of funds.*	$ -	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Project Manager

Dr. Conor Smith

Dr. Conor Smith is Carbon R&D Manager at United Science and will act as project manager on the proposal. He recently received his doctorate in Inorganic Chemistry from the UMN Dept. of Chemistry in the area of metal oxide oxygen sensing and has been working on carbon based coatings as a consultant for United Science since its launch in May 2009. Dr. Smith has been a key innovator in the area of manufacturing scale up and reactor design. He has extensive experience with the production and development of carbon coatings on solid phase extraction media based on metal oxides. He has performed preliminary work with PAH remediation from sediments and has interfaced with multiple municipalities including White Bear Lake about the same. Dr. Smith is proficient with the synthetic (colloid synthesis, spray drying) and analytical (GC/MS HPLC) techniques that are necessary for the proposed project.

Organization Description

United Science, a recent Minnesota green-tech startup, is focused on creating products that meet critical environmental sensing and remediation needs. Since inception, the company has produced several environmentally significant experimental products that have been shown to eliminate tons of toxic emissions from copper and gold mine effluents. The projects have been conducted in collaboration with the University of MN, National Science Foundation, Newmont Mining, FLSmidth, and Freeport McMoran. The federal grants associated with these sensors have been completed successfully and the sensors are now in commercial trials. Furthermore, in collaboration with Agilent and Gustavus Adolphus College (no federal or state funding to date), United Science has developed novel and selective and porous solid phase extraction carbon media for pesticide, herbicide, PAH, and heavy metal extraction from analytical solutions. The products are under evaluation at over 10 major analytical companies for use in pesticides and heavy metals analysis. In response to the Gulf oil spill, United Science extended this work to create a novel remediation media comprising nonporous carbon magnetic sorbents for tar ball contamination and demonstrated severe and immediate coagulation and removal of tar balls from brine solutions. Our mining partner FLSmidth manufactures magnetic separations equipment for the iron ore market that we plan to adapt to allow large scale skid-based magnetic separations systems that could enable *ex situ* environmental remediation right here in our neighborhoods.