Environment and Natural Resources Trust Fund
2019 Request for Proposals (RFP)

Project Title: **ENRTF ID: 091-B**

Quantifying Water Exchange Between Groundwater and Surface Water

Category: B. Water Resources

Sub-Category:

Total Project Budget: $ 478,276

Proposed Project Time Period for the Funding Requested: June 30, 2022 (3 yrs)

Summary:

We will develop a critical tool for accurately quantifying and predicting water exchange between groundwater and surface water. Water exchange will be effectively visualized to aid sustainable water resources management.

Name: Peter Kang

Sponsoring Organization: U of MN

Title: Assistant Professor

Department: Department of Earth Sciences

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Minneapolis MN 55455

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Location

Region: Southeast

County Name: Dakota

City / Township:

Alternate Text for Visual:

A concept of a tool that quantifies groundwater and surface water interaction is shown. The tool will be demonstrated in an outdoor experimental site and transferred to a field site.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%
____ If under $200,000, waive presentation?			

PROJECT TITLE: Quantifying Water Exchange between Groundwater and Surface water

I. PROJECT STATEMENT

Using the increasing quantity of monitoring data from groundwater (GW) and surface water (SW), this project develops a predictive tool that assimilates what is now only indirect data into a hydrogeological model to quantify water exchange between GW-SW. GW-SW interaction controls stream discharge, contaminant and nutrient transport, fish habitat, and aquatic community metabolism, but little is known about these interactions in most rivers and streams. On the other hand, more and more monitoring data from GW and SW is being produced from different sources but the enormous dataset is only indirectly related to water exchange between GW-SW. This project tackles this critical issue by developing a predictive tool to quantify water exchange between GW-SW. The tool will be first implemented and demonstrated in the Outdoor StreamLab at St. Anthony Falls Laboratory (SAFL) and transferred to a field site in southeastern Minnesota (potentially Trout Brook in Dakota County).

The developed tool will accurately quantify water exchange between GW-SW, which is essential information for sustainable water resources management. The estimated water flow between GW-SW will be effectively visualized. For example, we will produce the temporal evolution of a spatial map showing where water flows from stream to groundwater, or vice versa, with colors showing the intensity of the flow rate. The visualized information will greatly aid effective land and water managements that require a clear understanding of temporal and spatial distribution of GW-SW interaction, such as stream restoration and regulation, identification of contamination sources, and estimations of groundwater recharge. Prospective users of the tool will be local and state units of government in charge of water resources such as local watershed districts or the Department of Natural Resources (DNR).

While connections between GW and SW play an integral role in Minnesota's water resources, they are fairly unknown to the public, mainly because the interaction occurs below the bottom of our rivers and is thereby invisible. The importance of GW-SW interaction will be disseminated to Minnesotans through powerful 3D visualization of GW-SW interactions, which will be published online and also actively presented at public events.

This project includes several activities:

- Developing a predictive tool that quantifies water exchange between GW-SW
- Implementing and demonstrating the tool in the Outdoor StreamLab at St. Anthony Falls Laboratory (SAFL)
- Transferring the tool to a field site in southeastern Minnesota (potentially Trout Brook in Dakota County)
- Providing a user's guide for potential users and increasing public awareness with data visualization

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Developing a tool that quantifies water exchange between GW-SW ENRTF BUDGET: $ 149,016

We will develop a hydrogeological model to simulate flow and transport. To quantify water exchange between GW-SW, we will develop a data assimilation tool that integrates the temperature, tracer concentration, and hydraulic head data into the hydrogeological model. The data assimilation tool will refine the hydrogeological model into a predictive model that can quantify and predict water exchange between GW-SW. The developed tool will first be validated in a synthetic problem.

Outcome	Completion Date
1. Develop a hydrogeological model for a synthetic problem	December 2019
2. Develop and validate a data assimilation framework in a synthetic problem	June 2020

Activity 2: Demonstrating the developed tool in the Outdoor StreamLab **ENRTF BUDGET: $ 180,713**

The developed data assimilation tool will be demonstrated in the SAFL Outdoor StreamLab (OSL). The SAFL OSL is a unique field-scale experimental stream within which physical experiments can be carried out in a controlled laboratory environment and under real-life conditions. A real-time monitoring system will be implemented in the OSL to collect thermal, concentration, and hydraulic head data over two consecutive years. Distributed fiber-optic temperature sensing (DTS) has recently received considerable attention as a versatile technique for investigating interactions between GW-SW. We will implement a monitoring network of the DTS and temperature probes for thermal data acquisition, a nested well network to monitor water levels and hydraulic heads, and tracer probes for measuring concentration.

Outcome	Completion Date
1. Construct a monitoring network in the Outdoor Streamlab	May 2020
2. Demonstrate the developed data assimilation tool in the Outdoor Streamlab	March 2021

Activity 3: Transferring the developed tool to a field site **ENRTF BUDGET: $ 129,760**

The developed monitoring and data assimilation system will be transferred and demonstrated at a field site in southeastern Minnesota (potentially Trout Brook in Dakota County). The data assimilation tool will be designed to be generic, and a hydrogeological model will be developed for a specific site. The developed tool will be released as open-source software and a practical user's guide will be developed to help personnel in charge and interested parties to utilize the tool.

Outcome	Completion Date
1. Establish monitoring system at a field site	October 2021
2. Demonstrate the developed tool at a field site	March 2022
3. Develop a user's guide and give tutorial presentations to interested parties	June 2022

Activity 4: Increasing public awareness in GW-SW interactions **ENRTF BUDGET: $ 18,787**

GW-SW interactions will be visualized and published to increase public awareness of GW-SW interactions.

Outcome	Completion Date
1. Visualize GW-SW interactions and publish through media (newspapers and web)	End of project
2. Present the visualized GW-SW interactions at multiple public events	End of project

III. PROJECT PARTNERS:

A. Partners receiving ENRTF funding

Name	Title	Affiliation	Role
Anthony Runkel	Chief Geologist	Minnesota Geological Survey	Field site identification and hydrogeological assessments
Robert Tipping	Geologist	Minnesota Geological Survey	Field instrumentation and water chemical sampling

IV. LONG-TERM- IMPLEMENTATION AND FUNDING:

This developed predictive tool will assist current practices of water resources management. The tool can be extended to any field site. We will seek collaborations with agencies such as Department of Natural Resources. We will actively apply for further research grants (federal, state and industry) to continue extending our data assimilation tool.

V. TIME LINE REQUIREMENTS:

The proposed project will be completed within three years.

2019 Proposal Budget Spreadsheet

Project Title: Quantifying Water Exchange between Groundwater and Surface water

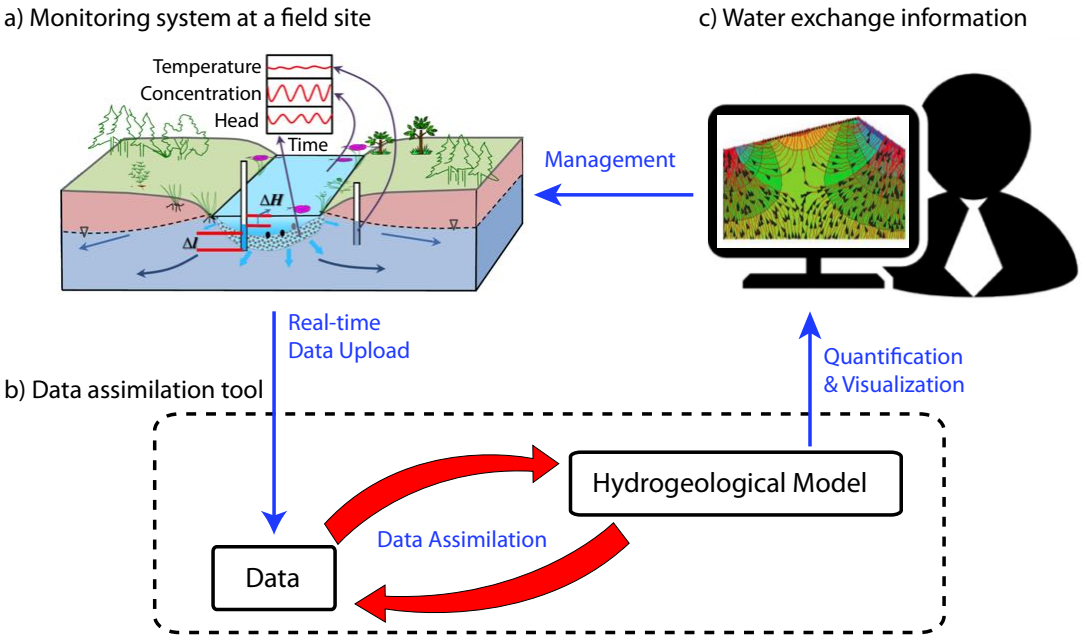
IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM (See "Guidance on Allowable Expenses")	**AMOUNT**
Personnel:	$ 396,326
Dr. Peter K. Kang, PI (75% salary, 25% benefits), 8% FTE; ($29,417)	
Dr. Jessica L. Kozarek, co-PI (75% salary, 25% benefits), 9.47% FTE; ($18,528)	
Dr. Robert Tipping (79% salary, 21% benefits), 8% FTE; ($17,328)	
Dr. Anthony Runkel (79% salary, 21% benefits), 8% FTE; ($18,864)	
Dr. Seonkyoo Yoon, postdoctoral associate (82% salary, 18% benefits), 70% FTE; ($144,574)	
1 Graduate Students (58% salary, 42% benefits), 50% FTE; ($138,751)	
SAFL Technical Staff (79% salary, 21% benefits), 5% FTE; ($6,000)	
Undergraduate Research Assistant (100% salary, 0% benefits), 20% FTE; ($22,866)	
Professional/Technical/Service Contracts:	
Equipment/Tools/Supplies:	$ 78,000
10 CTD-Diver (simultaneously measures conductivity, temperature, hydraulic head) @ 2000 each totalling $20,000	
20 Water level logger @ 500 each totaling $10,000	
20 Temperature logger@ 300 each totaling $6,000	
Distributed fiber optic temperature sensor $40,000	
OSL instrument maintenance and supplies $2,000	
Acquisition (Fee Title or Permanent Easements):	
Travel:	$ 3,950
in-state (2, 2-day trips for 2 reasarchers, yrs 2 and 3, 400 mi at $0.565, $77 lodging, reimburse per the university compensation plan) - $3,950	
Additional Budget Items:	$ -
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 478,276

V. OTHER FUNDS *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

SOURCE OF FUNDS	**AMOUNT**	**Status**
Other Non-State $ To Be Applied To Project During Project Period:	NA	
Other State $ To Be Applied To Project During Project Period:	NA	
In-kind Services To Be Applied To Project During Project Period: Unrecovered F&A calculated at 54%	$ 212,018	*secured*
Past and Current ENRTF Appropriation: Conserving Minnesota's Native Mussels (PI: J. Kozarek): M.L. 2014, Subd. 05k	$ 350,000	complete June 2018
Evaluate Temperature, Streamflow and Hydrogeology Impact on Brook Trout Habitat (PI: B. Tipping): M.L.2016, Subd. 03k	$ 115,000	complete June 2019
Other Funding History:	N/A	

Quantifying Water Exchange between Groundwater and Surface water



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SAFL Outdoor StreamLab

Trout Brook in Dakota County

- The tool will be demonstrated in an outdoor experimental site and transferred to a field site in southeastern Minnesota (potentially Trout Brook in Dakota County).

Peter K. Kang
Assistant Professor
Gibson Chair of Hydrogeology
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Professor Kang is a hydrogeologist and computational geoscientist whose research focuses on the physics of flow and reactive transport in subsurface. Kang will join the Department of Earth Sciences at the University of Minnesota in August 2018, following a research scientist position at Korea Institute of Science & Technology (KIST) in South Korea. Prior to his research scientist position, Kang was a postdoctoral associate in the Earth Resources Laboratory (ERL) at MIT, received his Ph.D. in hydrology from MIT (2014), and obtained his BSc in Civil, Urban & Geosystem engineering at Seoul National University with *summa cum laude* (2008).

Kang has diverse and in-depth research experiences in groundwater related topics including subsurface contaminant transport, subsurface characterization, and aquifer storage and recovery. Kang and his research group combines theoretical, numerical and field methods to develop models that can predict flow and reactive transport in subsurface. Kang made several major contributions in that area, developing new models and novel field experiments both to advance physical understanding and to address important, real-world applications.

During his postdoc period at MIT ERL, he developed a predictive model for fluid flow and tracer transport through fractured media, and also collaborated with geophysicists to develop data assimilation methods for characterizing fractured reservoirs. As a research scientist at KIST, he collaborated with geochemists and microbiologists to understand the coupling between fluid flow and biogeochemical activities. He also conducted a large-scale managed aquifer recharge project in a confined aquifer to secure sustainable water resources for a metropolitan city.

Kang is also passionate about teaching, mentoring and increasing public awareness in water related issues. Kang teaches computational hydrogeology, field hydrogeology, and computational methods in Earth Science.

Department of Earth Sciences, University of Minnesota - Twin Cities

The University of Minnesota is a highly ranked public research university offering a wide range of undergraduate and graduate programs. Dr. Kang belongs to the Department of Earth Sciences in the College of Science and Engineering. The department includes about 25 full faculty members and it awards bachelors, masters, and doctorate level degrees in Earth Sciences and various sub-disciplines, including hydrogeology. A number of on-going research projects in the department focus on water resources issues in Minnesota.