Environment and Natural Resources Trust Fund
2015 Request for Proposals (RFP)

Project Title: **ENRTF ID: 037-B**

Subsurface Drainage Impacts on Groundwater Recharge: Southeast Minnesota

Category: B. Water Resources

Total Project Budget: $ 488,394

Proposed Project Time Period for the Funding Requested: 3 years, July 2015 - June 2018

Summary:

Groundwater recharge characterization in southeast Minnesota for fields with agricultural drainage. Field-scale results will be upscaled to similar landscape features across the region to quantify drainage impact on groundwater sustainability.

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Location

Region: SE

County Name: Dodge, Fillmore, Goodhue, Houston, Mower, Olmsted, Wabasha, Winona

City / Township:

Alternate Text for Visual:

Potential agricultural land likely to be drained with 25 feet or less to bedrock, Southeast Minnesota

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

PROJECT TITLE: Subsurface drainage impacts on groundwater recharge: Southeast Minnesota

I. PROJECT STATEMENT

Artificial subsurface drainage as a practice to remove excess water from poorly drained agricultural fields has expanded across Minnesota in recent years. Until now, most drainage installation has occurred in south-central and western Minnesota. Due to the impermeable nature of the glacial deposits in these poorly-drained regions, it has often been assumed that the natural pre-drained rate of groundwater recharge was minimal and is therefore unaffected by agricultural subsurface drainage. Recently though, subsurface drainage expansion into southeast Minnesota has begun. Unlike previously drained portions of Minnesota underlain by thick impermeable glacial deposits, much of southeast Minnesota is underlain by karstic bedrock aquifers, often within 25 feet or less of the land surface. **Given the shallow depth from the land surface to bedrock aquifers in southeast Minnesota, the assumption that subsurface drainage has a minimal effect on groundwater recharge may be inappropriate for this portion of the state.**

Beyond potential effects on groundwater recharge, numerous studies have established that subsurface drainage networks significantly alter the timing and magnitudes of flows to local streams. By design, subsurface drainage expedites the movement of water from fields to nearby surface water bodies. Also, the balance between stream water sourced from overland runoff and groundwater is likely altered with additional subsurface drainage in a watershed. For example, possible alterations in the amount of groundwater discharged to regional streams through surficial and bedrock aquifers could occur.

The overall goal of the project is to characterize and measure the inflows and outflows of water from three representative agricultural fields in southeast Minnesota. Two of these will have subsurface drains and a third “undrained” agricultural field will as a control site. Quantification of the effects of subsurface drainage on the flowpaths of water at the field scale will lend insight to the potential effects that subsurface drainage may have on groundwater recharge for the region. The results of the field study will be extrapolated to portions of southeast Minnesota with similar landscape characteristics to quantify the amount of recharge that could be diverted from regional aquifers under various subsurface drainage regimes. Study results will also be compared to the statewide recharge estimates at a 1-kilometer grid spacing, available later in 2014, by the U.S. Geological Survey in cooperation with the Minnesota Pollution Control Agency.

II. PROJECT ACTIVITIES AND OUTCOMES

This project would establish two separate field-scale monitoring sites in agricultural fields with subsurface drains. A third field-scale monitoring site would be established in an “undrained” agricultural field as a control. Each site would include eight observation wells around the perimeter of the field to observe subsurface inflows and outflows. Each of the fields having subsurface drains would contain a focused study area in close proximity to a representative subsurface drain. In this focused study area, four wells to monitor water levels would be installed at increasing distances perpendicular to the subsurface drain. Soil moisture probes would be used to monitor soil moisture conditions at various depths and distances from the subsurface drain. This data along with climate data would be used as input to calibrate a widely used numerical subsurface drainage model, DRAINMOD, which would then be used to calculate the effects of subsurface drainage on recharge rates. Field site selection characteristics will include low slope (limit surface runoff), similarity of agricultural practices, landscape characteristics, logistical feasibility, regional representation, and shallow depth to bedrock.

Activity 1: Installation of equipment and data collection for two growing seasons **Budget: $ 293,036**

Observation well installation and establishment of 12 continuous groundwater level sites at each monitoring site, for a total of 36 continuous groundwater levels. Each site will require the following additional installations: soil moisture probes, weather station including rainfall gage, and drainage flow monitoring.

Outcome	Completion Date
1. Setup of all sites with field equipment to measure the hydrologic budget	November, 2015
2. Water inputs and outputs for each site are measured for two growing seasons	October, 2017

Activity 2: Calculate water budgets (inputs and outputs to the agricultural fields) **Budget: $ 97,679**

This activity will include the data compilation and analysis for all three monitoring sites in order to develop complete field-scale water budgets. Data from the focused areas will be used to construct water budgets for the entire agricultural field using DRAINMOD, based on known characteristics of soil classes, subsurface drainage density, and boundary conditions.

Outcome	Completion Date
1. Full hydrologic budgets for each monitoring site (total of three sites)	November, 2017
2. Comparisons of field-derived recharge rates to previously calculated recharge estimates	December, 2017

Activity 3: Data analysis and upscaling calculated recharge rates to agricultural lands across the region with similar landscape characteristics **Budget: $ 97,679**

Field-scale water budget components, such as groundwater recharge, will be extrapolated to areas with similar site characteristics and to quantify an impact for these areas. Data will be analyzed and reported in peer-reviewed literature, in addition to regional impact maps showing the changes in groundwater recharge rates as a result of various potential subsurface drainage scenarios.

Outcome	Completion Date
1. Upscaling groundwater recharge rates to the regional scale using currently available geographic information systems (GIS) coverages	June, 2018
2. Final peer-reviewed journal article and regional maps	June, 2018

III. PROJECT STRATEGY

A. Project Team/Partners

- Erik Smith, Ph.D., Hydrologist, U.S. Geological Survey. Dr. Smith will be a co-primary investigator and administrator of the project. The USGS will be contributing 30% to project funds. Dr. Smith will also manage and complete all activities, and contribute to the final report.
- Jason Roth, Hydrologist, U.S. Geological Survey. Mr. Roth will be a co-primary investigator of the project. Mr. Roth will also assist with completing all activities and contribute to the final report.
- Joel Groten, Hydrologist, U.S. Geological Survey. Mr. Groten will be providing support to the project's data collection and is a project science advisor.

B. Long-Term Strategy and Future Funding Needs

This project will produce regional maps of recharge differences between the study's results and the statewide recharge estimates available at a 1-kilometer grid spacing. The regional maps will be produced by delineating areas of southeast Minnesota with similar site characteristics to the study's fields. The study's findings applied to these maps will illustrate the potential effects of drainage on groundwater sustainability. The data could also be used to validate existing models or to calibrate and validate new models.

C. Timeline Requirements

The project would run from July 2015 through June 2018. The field-site establishment and preliminary installations would be completed by November 2015. Two field seasons in 2016 and 2017 will be necessary to establish adequate data collection. Analysis of the data will occur as data is collected, and prepared for peer-review publication by the end of June 2018.

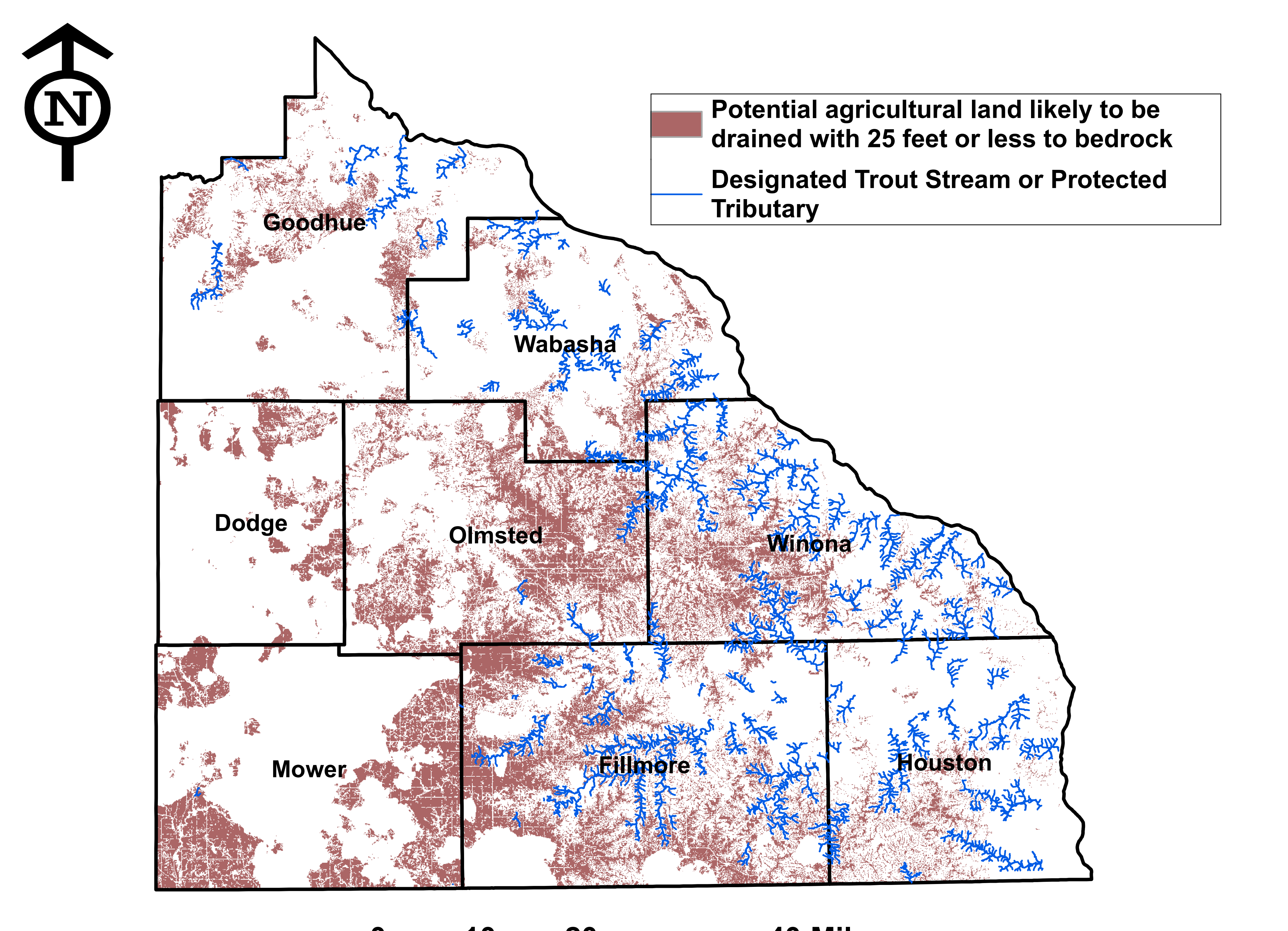
2015 Detailed Project Budget

IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM	AMOUNT
Personnel: 1 hydrologist, USGS project management and groundwater specialist, 25% time for 3 years, 75% salary, 25% benefits,	$ 92,645
1 hydrologist, USGS groundwater specialist, 25% time for 3 years, 75% salary, 25% benefits,	$ 79,393
1 hydrologic technician, USGS groundwater specialist, 15% time for 3 years, 75% salary, 25% benefits,	$ 25,580
1 hydrologic technician, USGS surface-water specialist, 15% time for 3 years, 75% salary, 25% benefits,	$ 25,580
Contracts: USGS groundwater hydrograph collection and processing: 36 sites; drill-rig installation of shallow piezometers	$ 147,403
National QA/QC and database support: USGS headquarters technical services	$ 48,840
Equipment: Water inflow and outflow equipment, with total requested in parantheses: pressure transducers (22, $1,350 each), soil moisture probes (36, $150 each) with loggers (9, $500 each), Onset weather station (3), drainage flow equipment (6), etc.	$ 61,058
Travel: to and from field area in southeast Minnesota, 40 person days, field staff, food and lodging, $149/day.	$ 5,960
Vehicle fuel, based on travel estimate, 300 miles per trip, 20 trips	$ 1,935
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 488,394

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ Being Applied to Project During Project Period: USGS cooperative program matching funds. Portion of budget items not funded by this request. 14 pressure transducers will be provided in-kind for project usage.	$ 209,312	Secured


N
Potential agricultural land likely to be drained with 25 feet or less to bedrock
Designated Trout Stream or Protected Tributary
Goodhue
Wabasha
Dodge
Olmsted
Winona
Mower
Fillmore
Houston
0
10
20
40 Miles

Erik Smith

Erik Smith has been a hydrogeologist with the U.S. Geological Survey (USGS) since 2004. Erik started as a student while finishing a Master's Degree in Geology from the University of Minnesota. In 2005, Erik transferred to the Iowa Water Science Center (USGS) to work as a supporting scientist and full-time hydrologic technician on the NAWQA program's Agricultural Chemicals Transport (ACT) team. During the ACT tenure, Erik assisted in all aspects of the South Fork Iowa River's ACT project, including the management of an extensive groundwater monitoring network, groundwater and surface water sampling, and instrumentation of an in-field subsurface drainage monitoring site. In 2008, Erik moved back to Minnesota to complete work on a Ph.D. tied into the Iowa ACT project. Erik's research during this period focused on the spatial and temporal variability of preferential flow in a subsurface-drained landscape. Since graduating from the University of Minnesota in 2011, Erik has been a full-time hydrologist with the Minnesota Water Science Center. His current research focuses on CE-QUAL-W2 modeling of Sentinel Lakes, SWB modeling to estimate recharge across Minnesota, and groundwater sustainability.

Jason Roth

Jason Roth is a hydrologist with the USGS Minnesota Water Science Center. He has a Master's Degree in Civil Engineering and a Certificate in Stream Restoration Science from the University of Minnesota. Jason's past research has involved the investigation of the impact of surface drain inlets on nutrient and sediment transport in agricultural areas, modelling of the effects of Agricultural BMPs on hydrologic cycle and sediment transport, and developing a temporal water table model to model short duration water table fluctuations in areas with subsurface drains. Recently he has been involved with the development of a county-scale groundwater model which will lend insight to questions of groundwater sustainability for the city of Rochester, the state's largest groundwater consumer.