Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2015 Work Plan

Date of Report: October 15, 2014

Date of Next Status Update Report: December 31, 2015

Date of Work Plan Approval:

Project Completion Date: December 31, 2018

Does this submission include an amendment request? No

PROJECT TITLE: Southeast Minnesota Subsurface Drainage Impacts on Groundwater Recharge

Project Manager: Erik A. Smith

Organization: U.S. Geological Survey

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Location: Goodhue, Wabasha, Dodge, Olmsted, Winona, Mower, Fillmore or Houston counties

Total ENRTF Project Budget:		
	ENRTF Appropriation:	**$488,000**
	Amount Spent:	**$0**
	Balance:	**$488,000**

Legal Citation: M.L. 2015, Chp. 76, Sec. 2, Subd. 04f

Appropriation Language:
$488,000 the first year is from the trust fund to the commissioner of natural resources for an agreement with the United States Geological Survey to assess the relationship between agricultural drainage and water flow within the unique karst geology of southeast Minnesota to characterize the potential impacts of drainage on groundwater recharge and groundwater sustainability in the region. This appropriation is not subject to the requirements in Minnesota Statutes, section 116P.10. This appropriation is available until June 30, 2019, by which time the project must be completed and final products delivered.

I. PROJECT TITLE: Southeast Minnesota Subsurface Drainage Impacts on Groundwater Recharge

II. PROJECT STATEMENT:

Executive Summary: Artificial subsurface drainage is being increasingly utilized on agricultural land in southeast Minnesota. This region is underlain by thinner glacial deposits than are found in the historically drained areas of the State. Due to these thinner deposits, drainage in southeast Minnesota may have a greater impact on the amount of water that recharges underlying bedrock aquifers, a critical resource to many communities in the region. This project will collect field data and use numerical models to assess the potential implications of artificial subsurface drainage on groundwater resources in the region. Results from the field studies and modelling will be extrapolated to produce updated groundwater recharge estimates for southeast Minnesota. Project findings will inform future water resources policy decisions in the region.

Project outcomes:

- Hydrological & meteorological data at three field sites (two drained, one undrained control)
- Field-scale water budgets and groundwater recharge estimates for three field sites
- Numerical models to transfer field study results to areas having different landscape characteristics
- Updated recharge estimates throughout southeast Minnesota

Artificial subsurface drainage is the practice of installing networks of perforated conduit below the land surface to drain the upper soil horizons of excess moisture which can inhibit crop yields and field activities. In Minnesota, this practice has historically been implemented in the south-central and western portions of the state, which are regions underlain primarily by thick impermeable glacial sediments. Due to the impermeable nature of these glacial sediments, it has often been assumed that the natural pre-drained rate of groundwater recharge was so minimal that the net effect of the installation of subsurface drainage networks had a negligible impact on it. Recently, however, due to shifts in climatic and economic factors, installation of subsurface drainage networks has begun to increase in southeast Minnesota. Unlike historically drained regions of the state, much of southeast Minnesota is underlain by thin glacial sediments, often less than 25 feet thick, draped over permeable karstic bedrock aquifers that are the source of much of the region's municipal, domestic, industrial, and agricultural water supplies. Given consideration of the decreased thickness of the glacial sediments overlaying these bedrock aquifers in southeast Minnesota, the prevailing assumption that subsurface drainage has a minimal effect on groundwater recharge may be inappropriate for this portion of the state. Widespread adoption of the practice in this region could alter the amount of water that permeates past the thin glacial sediments ultimately recharging the regions aquifers.

Beyond the 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. The balance between stream water sourced from overland runoff and groundwater is also likely altered by 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. Furthermore, research has also shown that subsurface drain flow can increase the loading of agricultural chemicals such as nutrients and pesticides to surface waters. Collectively, these potential shifts in flow dynamics, sources of flows, and chemical loading to surface waters associated with increased subsurface drainage could impact geomorphological processes, water quality, and stream ecosystems.

Through field data collection, analysis, and process based numerical modelling this study will assess the impact of subsurface drainage on field-scale water budgets and groundwater recharge in southeast Minnesota. Greater insights on the potential impacts of subsurface drainage on groundwater recharge are necessary to plan for long-term water sustainability within regions like southeast Minnesota. Results of this study will advance

scientific understanding of comprehensive water budgets for agricultural fields with subsurface drainage, specifically for areas with similar geology to southeast Minnesota. This study will also provide important information for agricultural producers to design water management infrastructure that both adequately drains for crop production yet provides important ecosystem services such as groundwater recharge. Accurate quantification of potential groundwater recharge through this study will also benefit regional groundwater flow models, as recharge is an important calibration parameter for these models. Because accurate field estimates of potential recharge rates are lacking, current model analyses must largely rely on inferred data or the results of other modeling studies.

This proposed study will produce regional maps of recharge differences between the study's results and the statewide recharge estimates available at a one-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 subsurface drainage on groundwater recharge under various build-out scenarios. The proposed study will increase the Minnesota Department of Natural Resources understanding of groundwater recharge, resulting in more sustainable groundwater appropriations in the affected areas. The Minnesota Pollution Control Agency and the Minnesota Department of Health will benefit from the study by gaining a better understanding of how changes in the water budget could affect the flux of agricultural chemicals to the bedrock aquifers. The Minnesota Department of Agriculture and the Minnesota Board of Water and Soil Resources will benefit from the study by reconsidering recommended agricultural best management practices (BMPs) if there is a net decrease in groundwater recharge by subsurface drainage. Generally, the study results will provide the colleges, universities, and the scientific community with basic knowledge important to educating the public on basic science.

Scope and Objective: This project will establish two separate field-scale monitoring sites in agricultural fields with subsurface drains in southeast Minnesota. A third field-scale monitoring site would be established in a non-drained agricultural field as a control. Study sites will be selected in areas with a shallow depth to bedrock and low surface slope to limit surface runoff. Other considerations will include choosing fields with similar agricultural practices (for example, tillage practices, nutrient management, and crop rotation), landscape characteristics, and include no supplemental irrigation. The overall goal for each of the three study sites is to quantify the field-scale water budget. A comprehensive water budget requires a full quantification of the water balance in the soil, where any change in the water storage in the soil can be quantified by the following:

$$\Delta S = (P + I + U) - (ET + PR + D + R_o),$$

where P represents the total precipitation across the monitoring site, I is irrigation, U is the upflux or capillary rise of water from shallow groundwater, ET is evapotranspiration, PR is deep infiltration or potential groundwater recharge, D is subsurface drainage, and R_o is surface runoff. By choosing a site with low surface slope, R_o will be limited or completely eliminated (depending on the site). For inputs other than U, P will be measured at each site and I will be zero. ET will be quantified for each study area by a Penman-Monteith or similar calculation. D will be measured by monitoring drainage outflow for one or more tiles at each field site, and using DRAINMOD or a similar modelling program to estimate subsurface drainage for the entire field site (modelling component will be part of Activity 2). Depending on the characteristics of the field sites, a smaller isolated plot within the field might be used in lieu of the entire field to limit poorly defined inputs or outputs. All aspects of the controlled study area will be quantified and compared against the water budgets of the other sites. Furthermore, comparisons will be made against the water budgets from another study being conducted by the University of Minnesota at two sites in southwestern Minnesota.

The overall goal of the project is to characterize and measure the water budgets for these three agricultural fields. 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 one-kilometer grid spacing, available in early 2015, by the U.S. Geological Survey in cooperation with the Minnesota Pollution Control Agency.

III. OVERALL PROJECT STATUS UPDATES:

Project Status as of January 1, 2016:

Project Status as of July 1, 2016:

Project Status as of January 1, 2017:

Project Status as of July 1, 2017:

Project Status as of January 1, 2018:

Project Status as of July 1, 2018:

Overall Project Outcomes and Results:

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Site selection, installation of field instrumentation, data collection, and field characterization activities.
Description: Initially, site reconnaissance will need to be carried out to find three different field sites for carrying the project. In order to narrow down the potential search field, the following counties in southeast Minnesota will be considered: Goodhue, Wabasha, Dodge, Olmsted, Winona, Mower, Fillmore or Houston counties. Based on preliminary conversations in fall 2014, all three county Soil and Water Conservation Districts (SWCDs) have indicated interest in assisting the U.S. Geological Survey (USGS) in carrying out the search. Further targeting within each county will be done by utilizing a map similar to fig. 1, which illustrates the preferred study areas for Goodhue County. Similar maps have been created for both Olmsted and Fillmore Counties. Fig. 1 considers three different categories of study suitability: preferred, acceptable, and marginal. The category score was calculated by an algorithm which considers the land slope, land cover type based on the National Land Cover Dataset classifications, depth to bedrock, and distance to a Department of Natural Resources (DNR) designated trout stream or protected tributary to designated trout stream. The ideal site has characteristics which would include a favorable combination of low slope, shallow depth to bedrock, and a short distance (< 1 kilometer) to a trout stream or tributary to a trout stream. Also, two of the three fields will have active subsurface drainage, preferably at a known configuration in order to improve the accuracy of the water budgets. The third agricultural field will not have subsurface drainage. Once candidate fields have been identified, relationships will be established with the agricultural producers to coordinate field installation activities in the fall 2015 and active data collection through fall 2017. Agricultural producers will be appropriately compensated for any impact on crop production caused by the project, in particular any portions of the field which have been taken out of production for field equipment installations.

Field installation at each of the field sites will proceed in fall 2015, mainly in the months of October, November, and December, if necessary. The USGS will carry out approximately two weeks of installation activities at each of the three sites, for a total of six weeks in fall 2015. This will include the installation of the piezometer network, weather stations, soil moisture probes, and subsurface drain flow monitoring. Each field installation at a

drainage site will look similar to fig. 2, which shows a preliminary plan of field installation including an active weather station for measuring rainfall and collecting all data necessary for an evapotranspiration calculation, piezometer network for measuring continuous water levels, soil moisture probes, and subsurface drain flow. One subsurface drain per field site will have two different measuring points for subsurface drainflow. The piezometer network will include a series of piezometers around the perimeter of an established intensive monitoring area within the field, with additional piezometers within the field to characterize the subsurface drainage effect on the water table with respect to lateral distance from the drain. The field installation of the undrained site will look similar to fig. 2, with the exception of no subsurface drainage flow monitoring and few infield piezometers. In addition to subsurface drain flow, continuous specific conductance and temperature monitoring within the subsurface drain will assist with flowpath characterization. Soil coring activities with the usage of the USGS Geoprobe will take place during site installations to determine the various soil and glacial till horizons, in addition with confirming the depth to bedrock for the field site.

Summary Budget Information for Activity 1:

ENRTF Budget: $ 266,600
Amount Spent: $ 0
Balance: $ 266,600

Outcome	Completion Date
1. *Site selection of the three field sites and selection of partner Soil and Water Conservation District (SWCD).*	September 30, 2015
2. *Installation of piezometer network with pressure transducers.*	November 30, 2015
3. *Installation of other field instrumentation, including soil moisture probes, weather station, and drainage flow monitoring.*	December 31, 2015
4. *Field characterization activities completed for the first field season, including tracer studies and soil coring activities.*	October 31, 2016
5. *Continuous data collection completed for the first field season.*	December 31, 2016
6. *Field characterization activities completed for the second field season, including further tracer studies and soil coring activities.*	October 31, 2017
7. *Continuous data collection completed for the second field season.*	December 31, 2017

Activity Status as of January 1, 2016:

Activity Status as of July 1, 2016:

Activity Status as of January 1, 2017:

Activity Status as of July 1, 2017:

Activity Status as of January 1, 2018:

Activity Status as of July 1, 2018:

Final Report Summary:

ACTIVITY 2: Data Compilation, Analysis and Field-Scale Water Budgets

Description: This activity will include the compilation and analysis of continuous soil, water, and climate data for all three monitoring sites. All data will be verified for integrity and completeness on an annual basis. Verified data will then be utilized as input parameters to mathematical relationships to derive water budget components or, when appropriate, explicitly quantify water budget components. In cases where water budget components are derived from mathematical relationships, several generally accepted methods will be evaluated in their

derivation. Field-scale water budgets will be determined using these individual water budget components. Uncertainty and sensitivity analyses will be performed on calculated water budgets with respect to measurement precision, method of calculating individual water budget components, and the time step used in calculating water budgets and individual components. Finalized water budgets will be analyzed to assess the influence of subsurface drains, climate, and other environmental factors on water budgets at all three monitoring sites over a spectrum temporal scales (for example, single precipitation events to seasonal variations).

Summary Budget Information for Activity 2:

ENRTF Budget: $ 105,700
Amount Spent: $ 0
Balance: $ 105,700

Outcome	Completion Date
1. *Data compilation and validation for growing season 1*	February 28, 2017
2. *Preliminary analysis and water budget calculations for growing season 1*	April 30, 2017
3. *Uncertainty and sensitivity analysis of water budget determinations for growing season 1*	July 31, 2017
4. *Data compilation and validation for growing season 2*	October 31, 2017
5. *Preliminary analysis and water budget calculations for growing season 2*	December 31, 2017
6. *Uncertainty and sensitivity analysis of water budget determinations for growing season 2*	February 28, 2018
7. *Finalized water budget with statistical and trend analyses of water budgets and water budget components at each site for two growing seasons*	June 30, 2018

Activity Status as of January 1, 2016:

Activity Status as of July 1, 2016:

Activity Status as of January 1, 2017:

Activity Status as of July 1, 2017:

Activity Status as of January 1, 2018:

Activity Status as of July 1, 2018:

Final Report Summary:

ACTIVITY 3: Modelling and Extrapolation of Estimated Recharge Rates

Description: An established hydrologic model (examples include DRAINMOD, APEX, GSFLOW, GSSHA) will be calibrated and validated to accurately reproduce overall water budgets and individual water budget components observed at field monitoring sites. These calibrated models will then be used to evaluate the effects of variations of subsurface drain configurations, soil characteristics and climatic variability on the field-scale water budgets. Specific scenarios to be modelled will include a series of model runs incrementally varying the depth of the glacial sediments, soil hydraulic properties, and subsurface drain configuration. The appropriate depths of glacial sediments and values for soil properties will be acquired from local and national repositories. The results from these series of model runs will enable the transfer of the previously calculated site-specific water budget and recharge calculations to other portions of the landscape within the region where landscape and drainage properties differ from those at the monitoring sites. Results from field-scale modelling will be used to inform a larger regional modelling effort to update groundwater recharge estimates across the entire southeast portion

of Minnesota. The SWB regional model will be used to demonstrate the effects of subsurface drainage on regional groundwater recharge under various subsurface drainage build-out scenarios. Findings will be reported in a peer-reviewed USGS SIR, in addition to regional impact maps showing the changes in groundwater recharge rates as a result of various potential subsurface drainage scenarios.

Summary Budget Information for Activity 3:

ENRTF Budget: $ 115,700
Amount Spent: $ 0
Balance: $ 115,700

Outcome	Completion Date
1. *Field-scale hydrologic model selection based on initial calibration to field data from season 1*	July 31, 2017
2. *Field-scale hydrologic model calibration and validation based on two growing seasons of field data*	March 31, 2018
3. *Field-scale modelling scenarios showing effect of changes in depth of glacial sediments, soil properties, and subsurface drain configuration on groundwater recharge and other water budget components*	April 30, 2018
4. *Incorporation of field-scale model outcomes into region model and evaluation of effects of several subsurface drainage build-out scenarios on regional groundwater recharge*	May 31, 2018
5. *Final peer-reviewed USGS Scientific Investigations Report (SIR) and regional maps*	December 31, 2018

Activity Status as of January 1, 2016:

Activity Status as of July 1, 2016:

Activity Status as of January 1, 2017:

Activity Status as of July 1, 2017:

Activity Status as of January 1, 2018:

Activity Status as of July 1, 2018:

Final Report Summary:

V. DISSEMINATION:
Description:
Project milestone results will be communicated to LCCMR staff with semi- annual written results. The results of USGS continuous data collection will be stored in the USGS National Water Information System (NWIS) database and made available to the public via the USGS Minnesota Water Science Center web site at http://mn.water.usgs.gov/index.html. Additionally, the final results from the project will be presented through the publication of a peer-reviewed USGS Scientific Investigations (SIR) report and will be available at the end of the study. All of the approved continuous climate, water level, soil moisture, and subsurface drainage flow data will be provided in an attached appendix either in the SIR and/or in a separate final report to the LCCMR. Also, these data will be presented at various forums such as the Minnesota Water Resources Conference and the annual Soil and Water Conservation Society meetings.

Status as of January 1, 2016:

Status as of July 1, 2016:

Status as of January 1, 2017:

Status as of July 1, 2017:

Status as of January 1, 2018:

Status as of July 1, 2018:

Final Report Summary:

VI. PROJECT BUDGET SUMMARY:

A. ENRTF Budget Overview:

Budget Category	$ Amount	Overview Explanation
Personnel:	$ 342,600	1 USGS Studies Chief at 4% FTE each year for 3 years; 1 USGS Project Chief at 33% FTE each year for 3 years; 1 USGS Hydrologist at 33% FTE each year for 3 years; 1 USGS Geographer at 7% FTE each year for 3 years; 1 USGS Hydrologic Technician at 11.5% FTE each year for first 2 years; 1 Admin Support at 4.5% FTE each year for 3 years; 2 USGS Groundwater/Surface Water Specialists at 4% FTE each year for 3 years; 2 Database/IT Support Specialists each year for years
Professional/Technical/Service Contracts:	$ 59,900	Reimbursement to agricultural producers (TBD) for agricultural field out-of-production; Soil and Water Conservation District (TBD) to assist in selection of field site locations; USGS groundwater network for processing 12 reference continuous water-levels; USGS Geoprobe for drilling piezometers and coring activities; publication of USGS Scientific Investigations Report
Equipment/Tools/Supplies:	$ 66,300	Submersible pressure transducers, soil moisture probes, data loggers, storage modules, power supply, weather station housing, drain flow and water chemistry instrumentation, supplies for piezometer installation and coring activities
Travel Expenses in MN:	$ 19,200	Mileage (0.55/mile), lodging, meals
TOTAL ENRTF BUDGET:	**$488,000**	

Explanation of Use of Classified Staff: N/A

Explanation of Capital Expenditures Greater Than $5,000: N/A

Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation: 3.17 FTEs

Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation: 0.04 FTEs for each year for first two years

B. Other Funds:

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
Non-state			
U.S. Geological Survey	$209,312	$0	Personnel, travel, supplies
State			
N/A	$0	$0	
TOTAL OTHER FUNDS:	**$209,312**	**$0**	

VII. PROJECT STRATEGY:

A. Project Partners: There are no current agreements with partners to collaborate with this project. However, as part of Activity 1, project partners will be identified.

Project Partners Receiving Funds:

- Soil and Water Conservation District (TBD), either for Goodhue, Wabasha, Dodge, Olmsted, Winona, Mower, Fillmore or Houston counties: $5,000 to assist in selection of field site locations and work as a potential intermediary for facilitating relationships with agricultural producers.
- Agricultural producers (TBD), based on site location: $6,000 to reimburse agricultural producers for agricultural field out-of-production

B. Project Impact and Long-term Strategy:

It is anticipated that this project will provide important data on the potential impacts of subsurface drainage on groundwater recharge in southeast Minnesota, as a current data gap exists for this type of information. With the continuous data collection at all three field sites, the calculated field-scale water budgets will help ascertain the overall groundwater recharge for these field sites. Further modelling efforts will be conducted to extrapolate estimated recharge rates to agricultural lands across the region with similar landscape characteristics. Calibrated models will be used to evaluate the effects of variations of subsurface drain configurations, soil characteristics and climatic variability on the field-scale water budgets. The results from these series of model runs will enable the transfer of the previously calculated site specific water budget and recharge calculations to other portions of the landscape within the region where landscape and drainage properties differ from those at the monitoring sites. Results from field-scale modelling will be used to inform a larger regional modelling effort to update groundwater recharge estimates across the entire southeast portion of Minnesota. The long term strategy for this project is to maintain the sites, if possible, with future partner funds acquisition to continue monitoring activities for calculating annual hydrologic budgets and to expand data collection to nutrients and pesticides to attribute the potential changes in loads due to the presence of subsurface drains.

C. Funding History: N/A

VIII. FEE TITLE ACQUISITION/CONSERVATION EASEMENT/RESTORATION REQUIREMENTS:

A. Parcel List: N/A

B. Acquisition/Restoration Information: N/A

IX. VISUAL COMPONENT or MAP(S): See attached figures.

X. RESEARCH ADDENDUM:

The U.S. Geological Survey will conduct internal peer reviews of this detailed proposal and will be revised based on those USGS peer review comments. The proposal will then be approved by the USGS and added to this document. The expected date of proposal approval is June 30, 2015.

XI. REPORTING REQUIREMENTS:

Periodic work plan status update reports will be submitted no later than January 1, 2016; July 1, 2016; January 1, 2017; July 1, 2017; January 1, 2018; and July 1, 2018. A final report and associated products will be submitted no later than December 31, 2018.

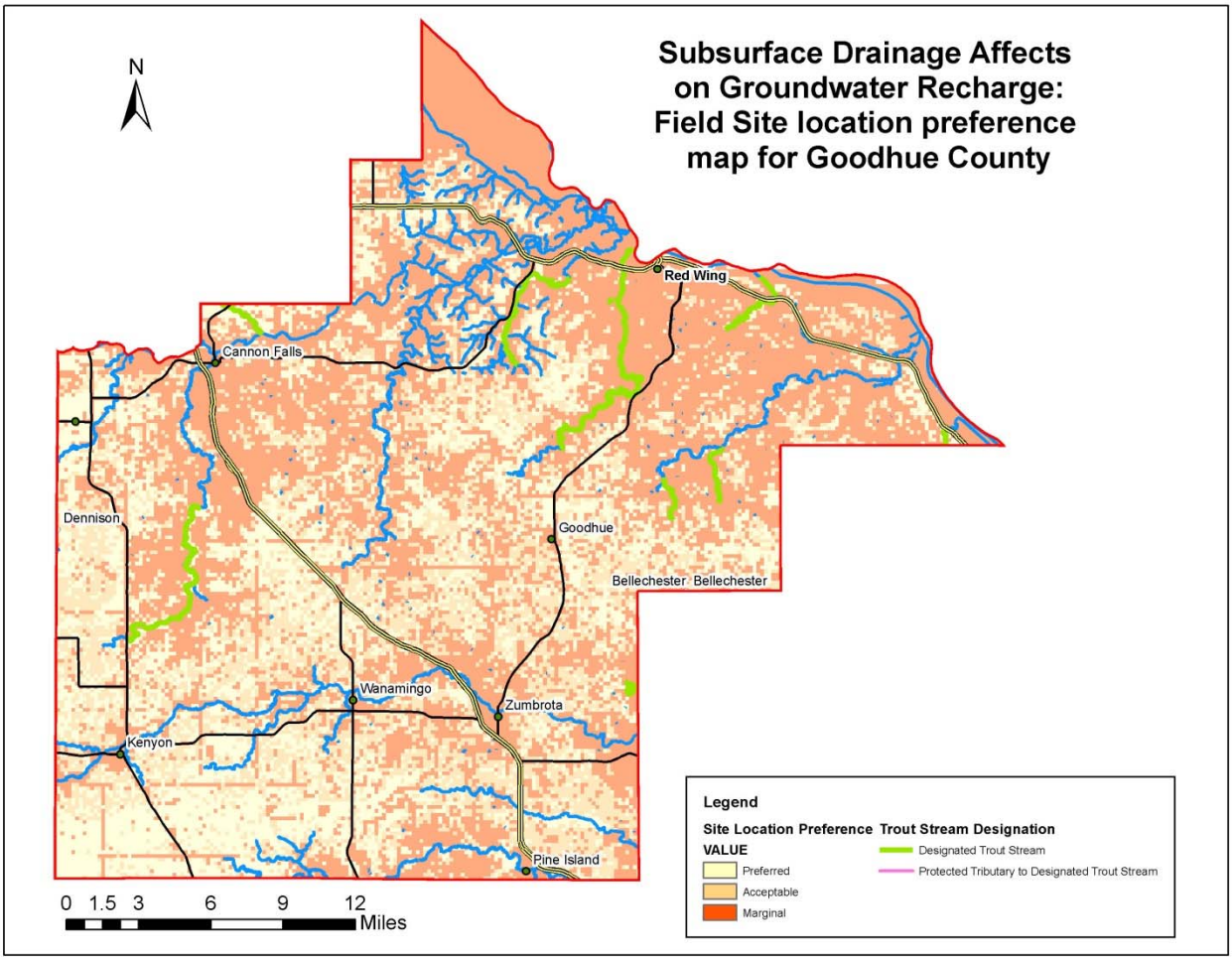

Figure 1. Site location preferences for Goodhue County, shown as preferred, acceptable, and marginal. Site location preference values based on an algorithm which considers the land slope, land cover type based on the National Land Cover Dataset classifications, depth to bedrock, and distance to a Department of Natural Resources (DNR) designated trout stream or protected tributary to designated trout stream.

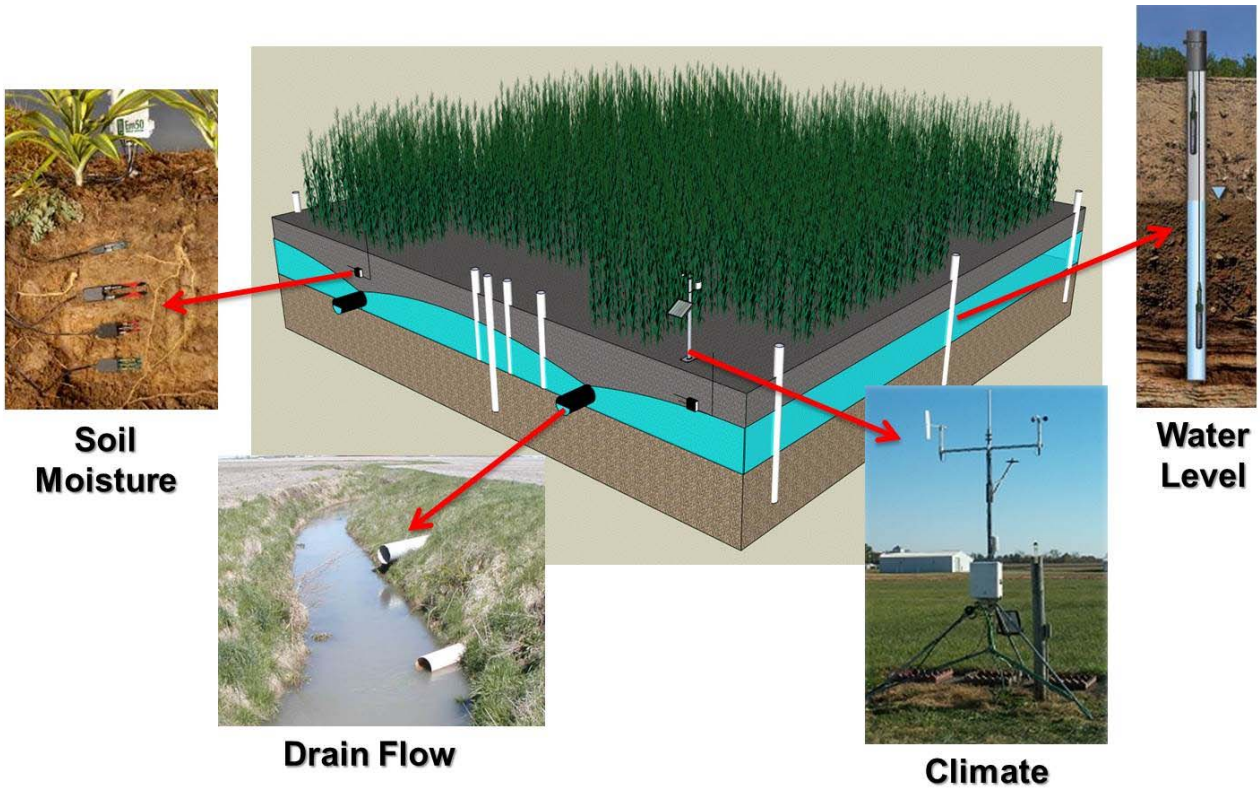

Figure 2. A hypothetical configuration of one of the two drained field sites, including a weather station for measuring climate data, a piezometer network for continuous water level measurements, soil moisture probes, and subsurface drainage flow. The third undrained field site will have a similar configuration, with the absence of subsurface drainage flow.

Environment and Natural Resources Trust Fund
M.L. 2015 Project Budget

Project Title: Southeast Minnesota Subsurface Drainage Impacts on Groundwater Recharge
Legal Citation: M.L. 2015, Chp. Xx, Sec. xx, Subd. Xx
Project Manager: Erik Smith
Organization: United States Geological Survey
M.L. 2015 ENRTF Appropriation: $488,000
Project Length and Completion Date: 3.5 Years, December 31, 2018
Date of Report: 10/15/2014

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Amount Spent	Activity 1 Balance	Activity 2 Budget	Amount Spent	Activity 2 Balance	Activity 3 Budget	Amount Spent	Activity 3 Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM	Site Selection, Installation of Field Instrumentation, Data Collection, and Field Characterization Activities			Data Compilation, Analysis and Field-Scale Water Budgets			Data analysis and upscaling calculated recharge rates.				
Personnel (Wages and Benefits)	$131,200	$0	$131,200	$105,700	$0	$105,700	$105,700	$0	$105,700	$342,600	$342,600
1 USGS Studies Chief, (GS-13): $16,200 (73% salary, 27% benefits); Position at 4% FTE each year for 3 years											
1 USGS Project Chief, (GS-12): $112,100 (76% salary, 24% benefits); Position at 33% FTE each year for 3 years											
1 USGS Hydrologist, (GS-11): $91,400 (75% salary, 25% benefits); Position at 33% FTE each year for 3 years											
1 USGS Geographer, (GS-12): $29,100 (73% salary, 27% benefits); Position at 7% FTE each year for 3 years											
1 USGS Hydrologic Technician, (GS-7): $12,700 (83% salary, 17% benefits); Position at 11.5% FTE each year for first 2 years											
1 Admin Support, (GS-9): $12,600 (69% salary, 31% benefits); Position at 4.5% FTE each year for 3 years											
2 USGS Groundwater/Surface Water Specialists (GS-13): $37,100 (75% salary, 25% benefits); Position at 4% FTE each year for 3 years											
2 Database/IT Support Specialists (GS-12): $31,300 (73% salary, 27% benefits); Position at 4% FTE each year for 3 years											
Professional/Technical/Service Contracts											
TBD (based on location): Agricultural producer in either Goodhue, Olmsted, or Fillmore Counties (depending on final site locations); reimbursement for agricultural field out of production for 2 years, at 3 field sites, for activity 1	$6,000	$0	$6,000							$6,000	$6,000
TBD (based on location): Soil and Water Conservation District in either Goodhue, Olmsted, or Fillmore Counties (depending on final site locations); assistance with field site locations and relationship with agricultural producers for activity 1	$5,000	$0	$5,000							$5,000	$5,000
USGS: Groundwater network contract, 12 individual reference piezometers total over 3 field sites for activity 1	$34,400	$0	$34,400							$34,400	$34,400
USGS: Geoprobe drilling, 6 weeks total at $750/week, operations and maintenance for activity 1	$4,500	$0	$4,500							$4,500	$4,500
USGS: Contract fees for USGS report (Science Publishing Network) that includes editing, reviewing, and preparation for electronic publishing and distribution							$10,000	$0	$10,000	$10,000	$10,000
Equipment/Tools/Supplies	$66,300	$0	$66,300							$66,300	$66,300
21 submersible pressure transducers ($1100/each)											
14 soil moisture probes ($225/each)											
3 Data Loggers, Storage Modules, Power Supply, and Housing ($3,400 each)											
3 Sets of Weather Station Sensors ($3,300 each)											
2 Drain flow and water chemistry instrumentation ($4,500 each)											
Supplies to install shallow piezometers and coring supplies											
Travel expenses in Minnesota											
Travel to and between data gathering, including annual summer field weeks, site exploration and coring, and periodic trips for data collection activities. Mileage: $5,200; lodging: $8,600; meals: $5,400	$19,200	$0	$19,200							$19,200	$19,200
COLUMN TOTAL	**$266,600**	**$0**	**$266,600**	**$105,700**	**$0**	**$105,700**	**$115,700**	**$0**	**$115,700**	**$488,000**	**$488,000**