2014 Project Abstract
For the Period Ending June 30, 2017

PROJECT TITLE: Watershed Water Budgets for Managing Minnesota's Groundwater
PROJECT MANAGER: Erik A. Smith
AFFILIATION: U.S. Geological Survey
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FUNDING SOURCE: Environment and Natural Resources Trust Fund)
LEGAL CITATION: M.L. 2014, Chp. 226, Sec. 2, Subd. 03i

APPROPRIATION AMOUNT: $ 129,000.00
AMOUNT SPENT: $ 129,000.00
AMOUNT REMAINING: $ 0.00

Overall Project Outcomes and Results

A new visual mapping technique that illustrates the relative and cumulative streamflow contributions from across a large watershed was developed for two pilot areas in Minnesota: Cannon River and St. Louis River. Both areas were selected because of mining-related activities. For the Cannon River, for the surficial sand mining, and for the St. Louis River, for the ongoing iron ore mining of the Mesabi Iron Range. Each large watershed (Cannon, St. Louis) was sub-divided into a series of much smaller sub-watersheds (Cannon: 153; St. Louis: 353). For each sub-watershed, the estimated groundwater (as baseflow) and surface runoff fluxes flowing into all surface-water features was summed under different typical conditions, such as drought or flood conditions. Downstream sub-watersheds aggregate upstream surface-water flows in addition to baseflow and surface runoff directly from the sub-watershed. These maps, termed as streamflow distribution maps, can help illustrate sub-watersheds that are vulnerable due to either groundwater or surface-water appropriations, particularly under drought conditions.

For each pilot watershed, a series of the streamflow distribution maps were developed at selected flow regimes: extreme drought conditions, drought conditions, an average condition, and a flood condition. Each pilot watershed is displayed as a single map sheet with the four flow regimes as separate panels for ease of comparison. The selected streamflow distribution maps illustrate streamflow contributions from different parts of the watershed for typical conditions, not necessarily the contribution for any particular time. These maps will provide a tool for State cooperators, such as the Minnesota Department of Natural Resources and the Minnesota Pollution Control Agency, for proactive water management and water-use sustainability. Furthermore, by highlighting the sub-watersheds in terms of surface-water flows, the streamflows can be evaluated in the context of meeting specific ecological flows under different flow regimes and potentially assist with decisions regarding groundwater and surface-water appropriations.

Project Results Use and Dissemination

The new visual mapping technique will be summarized in a U.S. Geological Survey Scientific Investigations Map (SIM). The SIM series includes map sheets and an accompanying report to discuss the methodology for creating the map products. In the case of this study, the SIM will include the following: (1) separate map sheets for each watershed (Cannon River, St. Louis River) that includes four panels of selected flow regimes: extreme drought, drought, mean flow, and flood; (2) the accompanying report with included tables and figures that support the map construction; (3) three separate model archives related to the mapping work. The web locations for the Scientific

Investigations Map and model archives will be included with the final report, expected to be completed by November 2017. With this final workplan update/progress report, a complete draft of the SIM and the accompanying map sheets has been included. By the requirement of U.S. Geological Survey guidelines, all materials used in the construction of these maps will be made available through public webpage (https://www.usgs.gov/) upon release of the final SIM report.

The U.S. Geological Survey also organized two phone calls during the project timeline to interface with key partners from the Minnesota Department of Natural Resources (MNDNR) and the Minnesota Pollution Control Agency (MPCA). These meetings were meant to ensure that the mapping products produced from the project would meet their needs, and the USGS project team did adapt some of the final products to make the maps more useful. Keen interest was shown in the final products, and upon release of the final Scientific Investigations Map, the lead project managers (Erik Smith and Chris Sanocki) will be meeting again with key MNDNR and MPCA to develop next steps for other watersheds in the State.

Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2014 Work Plan

Date of Report: August 11, 2017

Date of Next Status Update Report: N/A

Date of Work Plan Approval: June 4, 2014

Project Completion Date: June 30, 2017

Does this submission include an amendment request? No

PROJECT TITLE: Watershed Water Budgets for Managing Minnesota's Groundwater

Project Manager: Erik Smith

Organization: U.S. Geological Survey

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City/State/Zip Code: Mounds View, MN 55112

Telephone Number: (612) 419-4777

Email Address: easmith@usgs.gov

Web Address: http://mn.water.usgs.gov/index.html

Location: St. Louis and Goodhue, Rice, and Steele with some additional small areas in neighboring counties.

Total ENRTF Project Budget:		
	ENRTF Appropriation:	**$129,000.00**
	Amount Spent:	**$129,000.00**
	Balance:	**$ 0.00**

Legal Citation: M.L. 2014, Chp. 226, Sec. 2, Subd. 03i

Appropriation Language:
$129,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with the United States Geological Survey to create a pilot study to calculate complete watershed water budgets for two counties in Minnesota for enhanced groundwater management. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

I. PROJECT TITLE: Watershed Water Budgets for Managing Minnesota's Water

II. PROJECT STATEMENT:
Responsible groundwater management requires knowledge the water budget. The water budget is the quantity of water that is flowing through the hydrologic system as well as the amount of groundwater in aquifers (storage). We often have a good idea of groundwater storage (from a county atlas, for example); we have good knowledge of surface-water flow (from USGS and DNR streamflow gages); but we seldom know groundwater flow. This project will tie together those pieces of information.

Problem: The surficial aquifer system is intimately tied to surface-water flow and to flow to and from deeper, buried aquifers. The connection among those systems is poorly understood across much of Minnesota. The lack of understanding of those connections hinders the state's efforts to define the sustainability of water use from surficial aquifers as well as streams and rivers through the state.

Benefits: The water budget information obtained from this study will assist the state in planning for long-term water-use sustainability. The proposed study will provide the Minnesota Department of Natural Resources with information necessary to protect wetlands and ensure streamflows for ecological needs. It should also provide information to the Minnesota Pollution Control Agency information necessary to better understand the interaction between surface- and groundwater.

Scope and Objective: The objective of the proposed pilot study is to calculate the water budgets, including the groundwater flow component, for selected watersheds in St. Louis and Goodhue counties. The goal of the proposed project is to provide information for proactive water management in two areas undergoing mining exploration.

Water budgets would be computed primarily using soil-water-balance (SWB). A current USGS project that uses SWB calculates only recharge for the state; the proposed project would extend those computations to include calibrated evapotranspiration and runoff, giving the water balance. Other data inputs into the watershed water budgets would include data from the USGS synthetic hydrograph project to help understand and map general flowpaths from surficial aquifers to streams.

III. PROJECT STATUS UPDATES:

Project Status as of 12/31/2014:
A detailed project work plan and budget were prepared and approved by the LCCMR. A corresponding technical project proposal was prepared, reviewed and approved by the USGS. A Joint Funding Agreement was prepared for review by the USGS headquarters and by the Minnesota Department of Natural Resources. That agreement was not signed until November 4, 2014. Off-budget time was spent planning this project.
For Activity 2, the GIS and climatological data from the statewide SWB study were extracted and down-scaled for the St. Louis and Cannon River basins.
For Activity 3, water-use data from 2000-2012 were compiled for the St. Louis and Cannon River basins.

Project Status as of 06/30/2015:
For Activity 1, progress does include identifying the characteristics that explain spatial distribution have been identified, but not yet applied specifically to the entire basins. The spatial distribution for groundwater discharge has been computed as a pilot for one tributary in the Cannon River basin.
For Activity 2, all of the remaining input files (in particular the flow direction grid) were compiled for the greater Cannon River SWB model. The SWB calibration began for the Cannon River watershed. As part of the greater Cannon River SWB model, the following calibration targets have been included: USGS 05355200 (Cannon River at Welch, MN) and USGS 05353800 (Straight River near Faribault, MN). Hydrograph separation will be used

on all of these records, and the SWB calibration targets will include the baseflow-separated component as well as total flow.

No progress on Activity 3 was made during this reporting period. None was scheduled.

Project Status as of 12/31/2015:

For Activity 1, progress included identifying the characteristics that explain spatial distribution of the flow-duration curves, for both the St. Louis and Cannon River basins. Furthermore, the flow-duration curves were calculated for both basins for each of the DNR sub-watersheds.

For Activity 2, minor progress was made for further calibration of the Cannon River watershed SWB model, but this work is still not completed.

For Activity 3, water-use data from 2000-2012 were compiled for the St. Louis and Cannon River basins.

Amendment Request (12/14/2015)

This amendment request is to change the project manager from Dave Lorenz to Erik Smith, due to Dave Lorenz's retirement from the U.S. Geological Survey in January 2016. Also, on the Work Plan Budget, the name was changed over to Erik Smith and the specific names were crossed out. The roles remain the same, but due to retirements and staff leaving, some of the specific people have changed.

Project Status as of 06/30/2016**:**

For Activity 1, additional low flow frequency statistics were calculated using the regional regression models developed by USGS. All the flow statistics have now been calculated for all watersheds and sub-watersheds.
For Activity 2, preliminary SWB model results were analyzed to identify portions of the watersheds where the initial "flow correction" of the digital elevation models (DEMs) was inadequate. Additional adjustments, corrections, to the DEMs have been made and model calibrations are in progress. Further adjustment of these input datasets may be necessary pending subsequent calibration results.
No progress was made on Activity 3 this period, once calibration of the SWB models is deemed as acceptable this task will begin.

Amendment Request (06/29/2016)

This amendment request is to change the project manager from Erik Smith to Jason Roth, due to Erik Smith's promotion to a supervisory role at MNWSC. Also, on the Work Plan Budget, the name was changed over to Jason Roth and the specific names were crossed out.

Project Status as of 12/31/2016:

For Activity 1, the low-flow statistics calculated for both watersheds have been integrated into ArcGIS maps in order to begin the merger of these results with the SWB results from Activity 2.
For Activity 2, soil-water-balance (SWB) model has been run and the refined recharge grid resolution for the Cannon River watershed has been finalized. At this time, the refined St. Louis River SWB recharge grid is in progress, with the refined grid resolution finalized in early January 2017.
No progress was made on Activity 3 this period. With the newly refined recharge grids available for both watersheds by early January 2017, this task will continue for the final months of the project including the final deliverables.

Amendment Request (12/30/2016)

This amendment request is to change the project manager from Jason Roth back to Erik Smith, due to Jason Roth's acceptance of a position outside of the U.S. Geological Survey. Also, as the new project manager, Erik Smith would like to request a no-cost extension of the project deadline to June 30, 2018. **LCCMR approval of the project manager change – 1-18-17. Request for extension withdrawn.**

Overall Project Status as of 08/11/2017**:**

A new visual mapping technique that illustrates the relative and cumulative streamflow contributions from across a large watershed was developed for two pilot areas in Minnesota: Cannon River and St. Louis River. Both areas were selected because of mining-related activities. For the Cannon River, for the surficial sand mining, and for the St. Louis River, for the ongoing iron ore mining of the Mesabi Iron Range. Each large watershed (Cannon, St. Louis) was sub-divided into a series of much smaller sub-watersheds (Cannon: 153; St. Louis: 353). For each sub-watershed, the estimated groundwater (as baseflow) and surface runoff fluxes flowing into all surface-water features was summed under different typical conditions, such as drought or flood conditions. Downstream sub-watersheds aggregate upstream surface-water flows in addition to baseflow and surface runoff directly from the sub-watershed. These maps, termed as streamflow distribution maps, can help illustrate sub-watersheds that are vulnerable due to either groundwater or surface-water appropriations, particularly under drought conditions.

For each pilot watershed, a series of the streamflow distribution maps were developed at selected flow regimes: extreme drought conditions, drought conditions, an average condition, and a flood condition. Each pilot watershed is displayed as a single map sheet with the four flow regimes as separate panels for ease of comparison. The selected streamflow distribution maps illustrate streamflow contributions from different parts of the watershed for typical conditions, not necessarily the contribution for any particular time. These maps will provide a tool for State cooperators, such as the Minnesota Department of Natural Resources and the Minnesota Pollution Control Agency, for proactive water management and water-use sustainability. Furthermore, by highlighting the sub-watersheds in terms of surface-water flows, the streamflows can be evaluated in the context of meeting specific ecological flows under different flow regimes and potentially assist with decisions regarding groundwater and surface-water appropriations.

Overall Project Outcomes and Results:

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Estimate groundwater contribution to streamflow

Description:

The groundwater contribution to streamflow throughout each area will be estimated from the relations among low streamflows, landscape characteristics, and climate identified in the synthetic hydrograph project. Multiple linear regressions will be used to fit selected points of the flow-duration curve to physical characteristics that can be mapped as part of the synthetic hydrograph project. The overall contribution will be computed from those regression analyses to construct a series that cover a range of base-flow conditions, corresponding to the points on the flow-duration curve.

The product will be a series of maps, and corresponding GIS data, that cover a range of base-flow conditions. The maps will represent the relative contribution from the surficial aquifer system to streamflow under various flow conditions. They will be similar to the specific yield map in Lorenz and Delin (2007) shown in figure 1 (section IX), but will cover only the area of the watershed and be relative contribution rather than the actual value of the variable.

Summary Budget Information for Activity 1:

ENRTF Budget: $ 33,500.00
Amount Spent: $ 33,500.00
Balance: $ 0.00

Activity Completion Date: 06/30/2015

Outcome	Completion Date	Budget
1. Spatial distribution of the average amount of groundwater discharge to rivers.	06/30/2015	$28,500

2. Identify landscape characteristics that explain the spatial distribution of groundwater discharge to streams.	06/30/2015	$5,000

Activity Status as of 12/31/2014:
No activity during this period.

Activity Status as of 06/30/2015:
Neither outcome that was scheduled for completion by 06/30/2015 was completed due to a delay in the completion of the project on which these outcomes rely (the USGS synthetic hydrograph project). Actual progress does include identifying the characteristics that explain spatial distribution have been identified, but not yet applied specifically to the entire basins. The spatial distribution for groundwater discharge has been computed as a pilot for one tributary in the Cannon River basin.

Activity Status as of 12/31/2015:
Progress included identifying the characteristics that explain spatial distribution of the flow-duration curves, for both the St. Louis and Cannon River basins. Furthermore, the flow-duration curves were calculated for both basins for each of the DNR sub-watersheds.

Activity Status as of 06/30/2016**:**
Low flow frequency statistics (LFFS) were calculated for all DNR level 9 sub-watersheds in the St. Louis and Cannon River watersheds. These calculations indicate the relative contributions of the sub-watersheds to overall flow within the larger watershed at low flows and provide further insight, with respect to the previously calculated flow duration curves (FDR), as to the spatial contributions of different portions of the larger water sheds at low flows. Ultimately, select results from the LFFS and/or FDR will be merged with the products from task 2 to form the final deliverable during task 3.

Activity Status as of 12/31/2016:
Low flow frequency statistics calculated for all DNR level 9 sub-watersheds in the St. Louis and Cannon River watersheds have been integrated into ArcGIS maps in order to begin the merger of these results with the SWB results from Activity 2.

Final Report Summary:
All the flow-duration curve (FDC) statistics, which ultimately became the mapping product rather than the LFFS, were imported into ArcGIS 10.4. A total of 505 sub-watersheds (Cannon: 152; St. Louis, 353) had separate FDC statistics for all 13 of the exceedance-probability quantiles that define the FDC. All the FDC statistics were re-adjusted, based on a comparison between the mean FDC streamflow and the mean Soil-Water-Balance (SWB) flow.

ACTIVITY 2: Estimate groundwater recharge for each area
Description:
Recharge will be calculated across two selected watersheds in St. Louis and Goodhue counties utilizing the SWB – Soil-Water-Balance Code (Westenbroek and others, 2010). The SWB application will incorporate spatial and temporal variability by using commonly available geographic information system (GIS) data layers and daily, gridded climatological data. As components of the soil-water-balance approach are calculated at daily time steps, recharge estimates can be output as daily, monthly, and/or annual estimates.
Within the SWB approach, recharge is calculated within each grid cell of the model domain based on the difference between soil moisture and the sources (precipitation, snowmelt, inflow) and sinks (interception, outflow, evapotranspiration (ET)) (eq. 1):

$$\text{Recharge} = (\text{precip} + \text{snowmelt} + \text{inflow}) - (\text{interception} + \text{outflow} + \text{ET}) - \Delta\text{soil moisture} \quad (1)$$

Input for the sources and sinks is provided by climate data and landscape characteristics. Output is only limited by the resolution of the climatological data and available land use, land cover, and soil cover data layers. The first step in the approach is to assemble all the required gridded data sets for the state, including the following:

1. Land use / land cover
2. Surface water flow direction
3. Hydrologic soil group
4. Available soil-water capacity

Several data sources will be key for building these statewide grids. The National Land Cover Data (NLCD) will be used as the source for land use/land cover data. A 30-meter Digital Elevation Model (DEM) will be used to determine cell-by-cell flow direction. The Soil Survey Geographic (SSURGO) database will be used to determine the hydrologic soil group and available soil-water capacity.

The daily, gridded climate datasets available from DAYMET (Oak Ridge National Laboratory, 2014) will be the primary sources of information for populating the climate data tables for the model. The minimum data requirements for SWB include daily precipitation, daily minimum air temperature, and daily maximum air temperature. The final required data set, the matrix of soil-water retention for given accumulated potential water loss, is an included part of the SWB code and is derived from Thornthwaite and Mather (1957).

After all the required data sources have been collected, the next step is to build and format the input files (i.e., control files) for running the SWB code. Also, all the initial conditions need to be set in addition to setting options, such as the surface water routing method and the evapotranspiration method. Upon completion of these steps, the SWB will be run for a period of at least 10 years to incorporate climatic variability. Results from the SWB method will be used to create daily, monthly, and/or annual recharge estimates for the two selected watersheds.

Output for the selected watersheds will be similar to Figure 2, except a summary of recharge across the two selected watersheds in St. Louis and Goodhue counties.

Summary Budget Information for Activity 2:

ENRTF Budget:	**$ 28,500.00**
Amount Spent:	**$ 28,500.00**
Balance:	**$ 0.00**

Activity Completion Date: 12/31/2015

Outcome	Completion Date	Budget
1. Compile and produce GIS and climatological datasets.	12/31/2014	$5,000
2. Calculate groundwater recharge and produce preliminary distribution maps.	12/31/2015	$23,500

Activity Status as of 12/31/2014:

The GIS and climatological data from the statewide SWB study were extracted and down-scaled for the St. Louis and Cannon River basins. The GIS data include land use/land cover, surface water flow direction, hydrologic soil group, and available soil-water capacity. The climatological data include daily precipitation, daily minimum air temperature, and daily maximum air temperature. The data were resampled or down-scaled to 30-meter resolution, which is appropriate for the scale of the basins.

Activity Status as of 06/30/2015:

For Activity 2, all of the remaining input files (in particular the flow direction grid) were compiled for the greater Cannon River SWB model. The SWB calibration began for the Cannon River watershed. As part of the greater Cannon River SWB model, the following calibration targets have been included: USGS 05355200 (Cannon

River at Welch, MN) and USGS 05353800 (Straight River near Faribault, MN). Hydrograph separation will be used on all of these records, and the SWB calibration targets will include the baseflow-separated component as well as total flow.

Activity Status as of 12/31/2015:
Minor progress was made for further calibration of the Cannon River watershed SWB model, but this work is still not completed.

Activity Status as of 06/30/2016**:**
Previous SWB calibration efforts were analyzed for areas within the watersheds having inappropriate hydrologic routing within the Digital Elevation Models (DEM) i.e. flow direction grids. The DEM's were then "flow corrected" in areas deemed to have inappropriate routing ensuring the runoff computed in the SWB simulations is appropriately routed throughout the basins to ensure best possible calibration and water budgets are obtained from the simulations. This is a trial and error process and calibration of the SWB models is still in progress.

Activity Status as of 12/31/2016:
The refined resolution Cannon River watershed SWB results were finalized, with some initial progress for the St. Louis River watershed's SWB model. The St. Louis River watershed's SWB results should be completed by early January 2017.

Final Report Summary:
Both the Cannon River and St. Louis River SWB models were completed, refining the earlier published statewide Minnesota SWB model (Smith and Westenbroek, 2015), for better fits specific to these watersheds. Additionally, the new SWB models have refined resolution at 100-meters rather than 1-kilometer. Final model archival has been completed, with all model materials freely available for download by the public.

ACTIVITY 3: Analysis and map production
Description:
Integrate the results from activities 1 and 2 to reconcile differences and calculate all components of the surface- and groundwater budgets in the watersheds. The integration process takes the recharge data and applies it to the relative contribution information from activity 1 to produce the actual contribution to streamflow at selected flow regimes. The integration also incorporates surface runoff, estimated by the recharge estimates in activity 2, to estimate the contribution to flow at higher flow regimes, floods for example. The resulting products represent the contribution for typical conditions, not necessarily the contribution for any particular time.

Figure 3 shows the current watershed budget for the Cannon River watershed, which covers part of Goodhue County. It is a very crude representation of the watershed budget, showing only average flow. The updated product will show the streamflow for selected flow regimes, like average, drought, and severe drought; and the aquifers that contribute to the streamflow at those flow regimes. The data can be extracted from the GIS products, which will be useful to watershed planners and mangers.

Summary Budget Information for Activity 3:

ENRTF Budget:	**$ 67,000.00**
Amount Spent:	**$ 67,000.00**
Balance:	**$ 0.00**

Activity Completion Date: 06/30/2017

Outcome	Completion Date	Budget
1. Compile water-use data.	12/31/2014	$5,000
2. Produce final distribution maps.	12/31/2016	$31,000
2. Produce map reports.	06/30/2017	$31,000

Activity Status as of 12/31/2014:
Water-use data from 2000-2012 were compiled for the St. Louis and Cannon River basins. The water use data for this project included consumptive uses, including public supply, domestic supply, agricultural, industrial, and mining uses from both surface- and groundwater sources. The water-use data will be integrated into the final over-all water budget for each basin.

Activity Status as of 06/30/2015:
No activity during this period.

Activity Status as of 12/31/2015:
No activity during this period.

Activity Status as of 06/30/2016**:**
No activity during this period.

Activity Status as of 12/31/2016:
No activity during this period.

Final Report Summary:
The final streamflow distribution maps integrate the recharge data from activity 2 and applies it to the relative contribution information from activity 1 to produce the actual contribution to streamflow at selected flow regimes. All mapping products have been completed and will be a part of the pending USGS Scientific Investigations Map (SIM), set to be release by November 2017. A series of four panels for each watershed illustrate the streamflow distribution at selected flow regimes: extreme drought, drought, a mean flow condition, and a flood condition. [The integration also incorporates surface runoff, estimated by the recharge estimates in activity 2, to estimate the contribution to flow at higher flow regimes, floods for example.]

V. DISSEMINATION:

Description: A USGS Scientific Investigations Map and the corresponding GIS data will be published by June 30, 2017. The report and supporting data will be hosted on the USGS publications website: http://pubs.er.usgs.gov/. In addition to the report, a group composed of staff of the USGS and the MDNR will monitor the progress and help direct the final product to improve its usefulness. That group will also be instrumental in keeping other interested parties informed of the progress and the final product.

Status as of 12/31/2014:
No activity during this period.

Status as of 06/30/2015:
No activity during this period.

Status as of 12/31/2015:
No activity during this period.

Status as of 06/30/2016**:**
No activity during this period.

Status as of 12/31/2016:
No activity during the period.

Status as of 06/30/2017**:**
A draft USGS Scientific Investigations Map (SIM) and the corresponding GIS data has been completed.

Final Report Summary:
A draft USGS Scientific Investigations Map (SIM) and the corresponding GIS data has been completed. Along with the final work plan update, a draft copy of the USGS SIM has been included as a separate attachment along with the accompanying map sheets for Cannon and St. Louis River watersheds.

VI. PROJECT BUDGET SUMMARY:

A. ENRTF Budget Overview:

Budget Category	$ Amount	Explanation
Personnel:	$129,000	
TOTAL ENRTF BUDGET:	**$129,000**	

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: 1.0

Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation: N/A

B. Other Funds:

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
Non-state			
USGS	$63,700	$63,700	All activities—USGS administrative and indirect costs
TOTAL OTHER FUNDS:	**$63,700**	**$63,700**	

VII. PROJECT STRATEGY:

A. Project Partners:

Minnesota Department of Natural Resources and Minnesota Pollution Control Agency. Both are interested in the project and a project guiding task force will be formed by representatives from both agencies and the U.S. Geological Survey so that the final product will be most useful to the state agencies.

B. Project Impact and Long-term Strategy:

The water budget information obtained from this study will assist the state in planning for long-term water-use sustainability. The proposed study will provide the Minnesota Department of Natural Resources with information necessary to protect wetlands and ensure streamflows for ecological needs. It should also provide information to the Minnesota Pollution Control Agency information necessary to better understand the interaction between surface- and groundwater.

This project is a proof-of-concept study in two watersheds in Minnesota. It is intended to research and find the most practical methods to produce the GIS products. The long-term goal would be to extend the results to all watersheds in Minnesota.

C. Spending History:

Funding Source	M.L. 2008 or FY09	M.L. 2009 or FY10	M.L. 2010 or FY11	M.L. 2011 or FY12-13	M.L. 2013 or FY14
LCCMR-ENRTF	NA	NA	NA	NA	NA
USGS Cooperative Water Program	NA	NA	NA	NA	NA

VIII. ACQUISITION/RESTORATION LIST: N/A

IX. VISUAL ELEMENT or MAP(S):

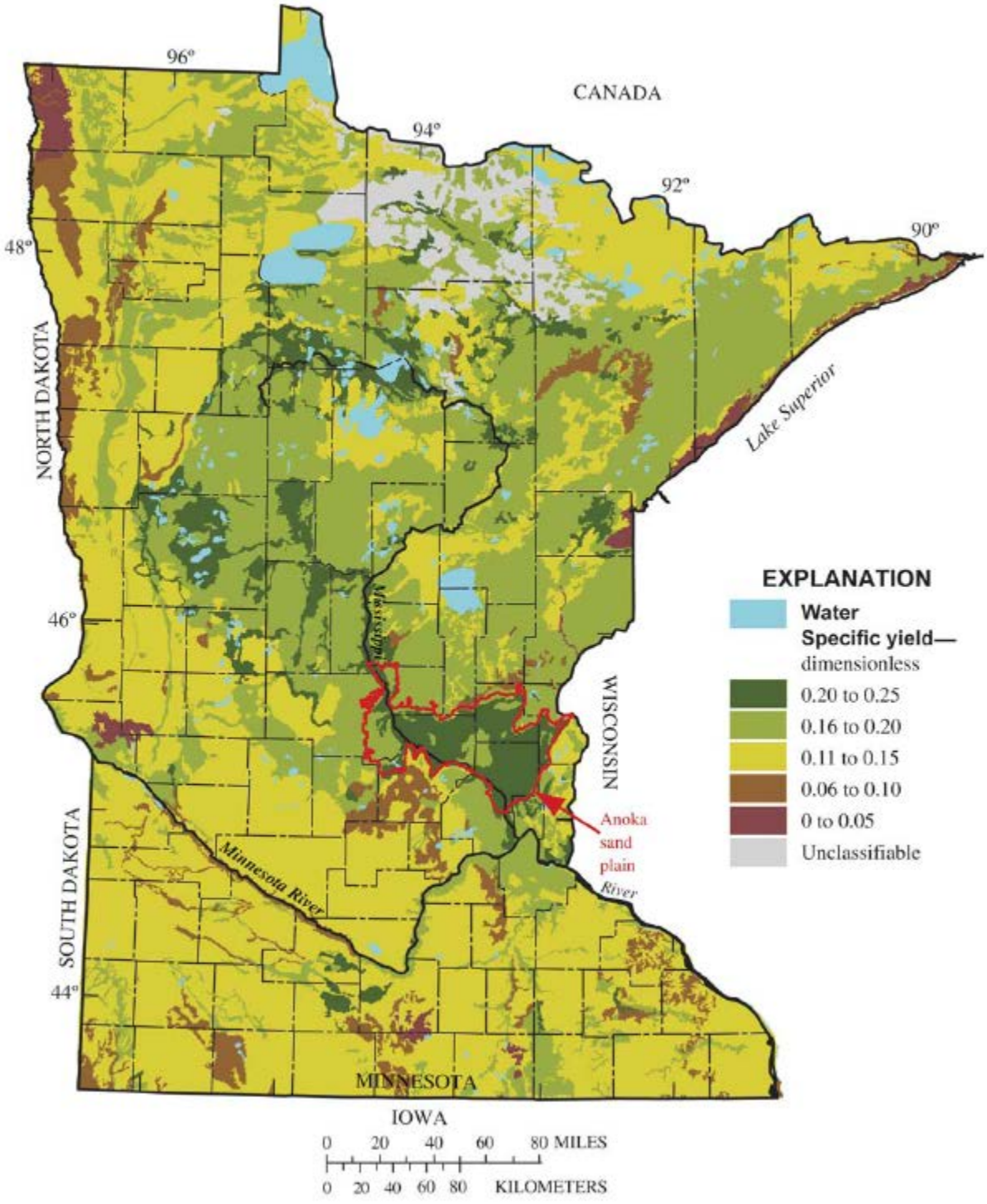

Figure 1. Specific yield of surficial materials in Minnesota.

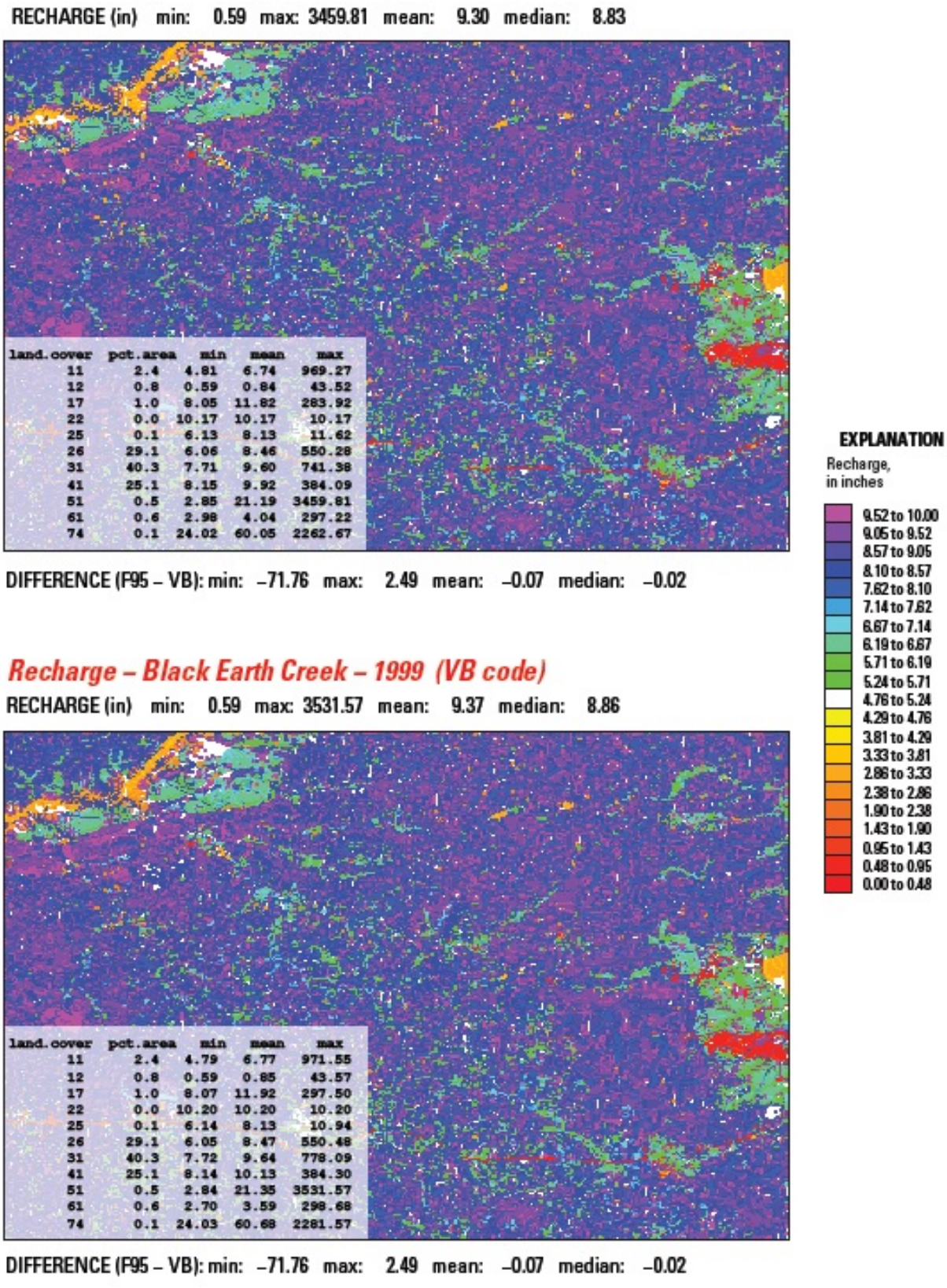

Figure 2. Recharge across an example watershed, Black Earth Creek, WI (copied from Westenbroek and others, 2010).

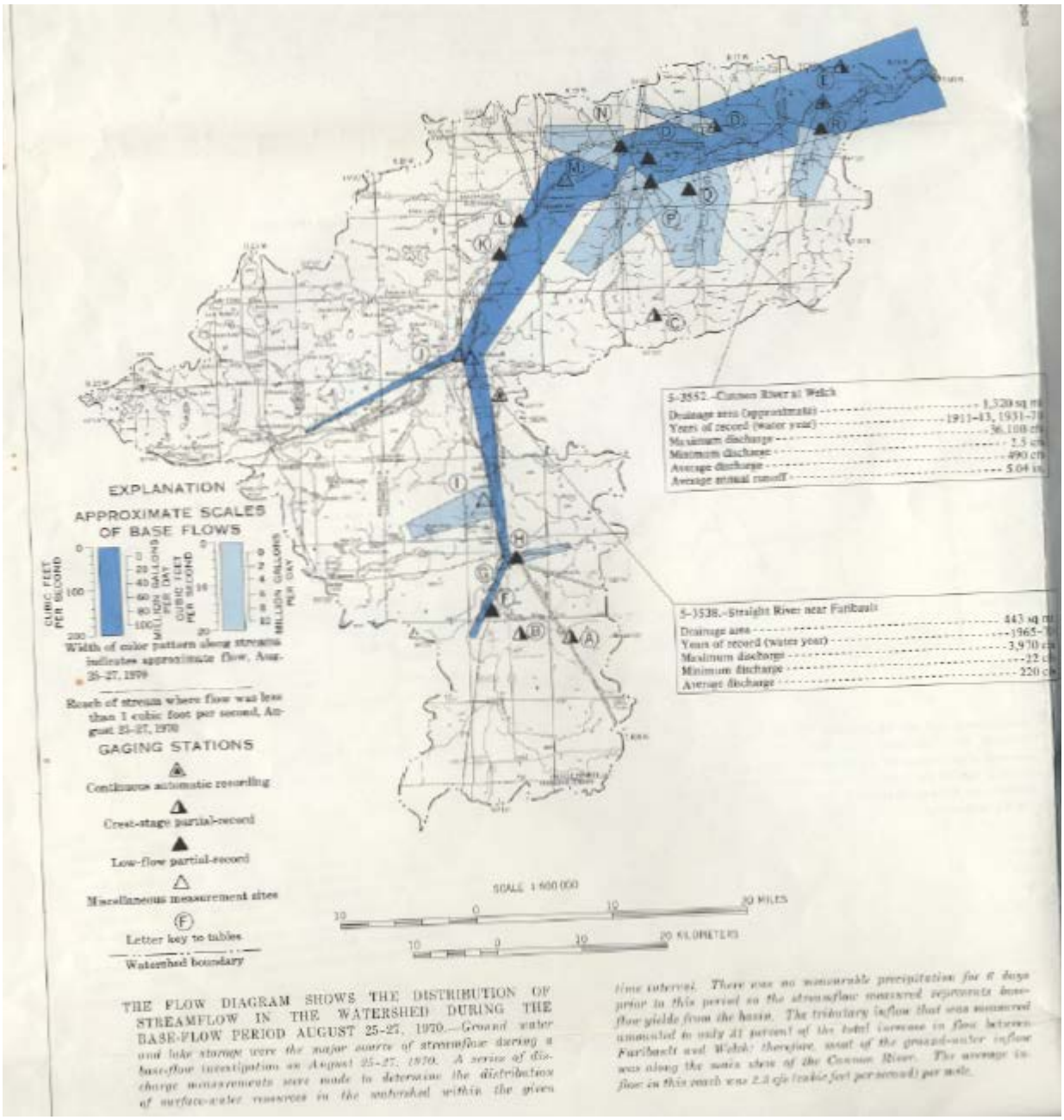

Figure 3. Water budget from Anderson and others, 1974.

X. ACQUISITION/RESTORATION REQUIREMENTS WORKSHEET: N/A

XI. 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 April 30, 2014.

XII. REPORTING REQUIREMENTS:

Periodic work plan status update reports will be submitted no later than June 30, 2015; June 30, 2016; and June 30, 2017. A final report and associated products will be submitted by June 30, 2017.

XIII REFERENCES:

Anderson, H.W., Jr., Farrell, D.F., Broussard, W.L., and Felsheim, P.E., 1974, Water resources of the Cannon River watershed, southeastern Minnesota: U.S. Geological Survey Hydrologic Atlas HA-522, 3 sheets, scales 1:250,000 and 1:500,000.

Lorenz, D.L., and Delin, G.N., 2007, A regression model to estimate regional ground-water recharge in Minnesota: Ground Water, v. 45, no. 2, 10.1111/j.1745-6584.2006.00273.x.

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Environment and Natural Resources Trust Fund

M.L. 2014 Project Budget

Project Title: Watershed Water Budgets for Managing Minnesota's Groundwater
Legal Citation: M.L. 2014, Chp. 226, Sec. 2, Subd. 03i
Project Manager: Erik Smith
Organization: U.S. Geolgical Survey
M.L. 2014 ENRTF Appropriation: $ 129,000
Project Length and Completion Date: 3 Years, June 30, 2017
Date of Report: December 30, 2016

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	**Estimate groundwater contribution to streamflow**			**Estimate groundwater recharge for each area**			**Analysis and map production**				
Personnel (Wages and Benefits)	$33,500.00	$33,500.00	$0.00	$28,500.00	$28,500.00	$0.00	$67,000.00	$67,000.00	$0.00	$129,000.00	$0.00
USGS Project Chief 267 hours, 78%salary, 22%benefits ($17,800)											
USGS Hydrologist 425 hours, 73% salary, 27% benefits ($26,000)											
USGS Hydrologist 828 hours, 73% salary, 27% benefits ($53,500)											
USGS Water-Use Specialists 160 hours, 73% salary, 27% benefits ($10,000)											
USGS Technical Administration (2 staff) 180 total hours, 69% salary, 31% benefits ($7,000)											
USGS Project Administration and Oversight (2 staff) 50 total hours, 69% salary, 31% benefits ($4,200)											
USGS Technical Specialists (2staff) 150 hours total, 73% salary, 27% benefits ($10,500)											
COLUMN TOTAL	$33,500.00	$33,500.00	$0.00	$28,500.00	$28,500.00	$0.00	$67,000.00	$67,000.00	$0.00	$129,000.00	$0.00