M.L. 2015, Chp. 76, Sec. 2, Subd. 04g Project Abstract
For the Period Ending September 30, 2018

PROJECT TITLE: Using Hydroacoustics to Monitor Sediment in Minnesota Rivers
PROJECT MANAGER: Jeffrey R. Ziegeweid
AFFILIATION: U.S. Geological Survey
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FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2015, Chp. 76, Sec. 2, Subd. 04g

APPROPRIATION AMOUNT: $455,000
AMOUNT SPENT: $455,000
AMOUNT REMAINING: $0

Overall Project Outcome and Results

Excessive sediment in rivers degrades water quality, reduces aquatic habitat, increases need for navigation channel dredging, reduces recreational opportunities, and transports harmful contaminants. Lake Pepin, a naturally-formed lake on the Mississippi River, is filling in with sediment at a rapid rate compared to conditions prior to European settlement, and 85-90 percent of the sediment depositing in Lake Pepin comes from the heavily-cultivated Minnesota River Basin. However, we lack detailed spatial information within the watershed to focus sediment-reduction efforts. Therefore, the U.S. Geological Survey (USGS) began a project funded by the Environment and Natural Resources Trust Fund to better understand sources and sinks of sediment in the watershed upstream of Lake Pepin, which includes the Minnesota, St. Croix, and upper Mississippi Rivers. We sampled nine stream locations and developed surrogate relations between newly installed, continuous hydroacoustic sensors and collected suspended sediment samples. Data from this study allows determination of sediment loads for streams in the study area that are more accurate and at a higher spatial resolution of sampling sites than prior monitoring efforts. Higher gradient river reaches in upstream portions of the study area were consistent sources of sediment. Low gradient areas near river confluences were consistent sinks of sediment, storing more sediment in floodplain or lake environments than was input from upstream. In contrast, mid gradient areas were dynamic, generating sediment load in some conditions but storing sediment in other conditions. Channelized river reaches, latitudinal precipitation patterns, and inputs from sediment-laden tributaries in the southern part of the watershed likely contributed to fluctuating sediment dynamics in mid-gradient areas. The spatial density of continuous sediment monitors was critical to understanding the source/sink dynamics of sediment in the study area. Results of this study may help resource-management agencies target sediment-reduction efforts at areas within the watershed that act as sediment sources.

Project Results Use and Dissemination

Results of this project will be disseminated in a number of ways. First, suspended sediment data collected at hydroacoustic streamgages in the study area are publicly available on the U.S. Geological Survey (USGS) National Water Information System (NWIS) data portal (https://waterdata.usgs.gov/mn/nwis/sw). Second, real-time suspended sediment data has been made available through the USGS National Real-Time Water Quality website (https://nrtwq.usgs.gov/) for the Minnesota River at Fort Snelling State Park, Minn. (USGS streamgage 05330920), and real-time suspended sediment data will be added for a subset of project streamgages in the near future. Finally, project results will be summarized in a USGS Scientific Investigations Report (Groten and others, in review – draft files attached) that will be publicly-available for dissemination after official publication.

Results of this project have been presented to other agencies, including the U.S. Army Corps of Engineers, the National Weather Service, and the Lower Minnesota River Watershed District; funding through the Environment and Natural Resources Trust Fund has been acknowledged during every presentation given. Furthermore, USGS scientists involved in this project have discussed ways to integrate results of the project into existing cooperative efforts between the USGS and the Minnesota Department of Natural Resources, and the Minnesota Pollution Control Agency (MPCA). Finally, the project chief has been actively involved in discussions with the Upper Mississippi River Basin Association, the Mississippi River Cities and Towns Initiative, and the USGS Midwest Regional Office about ways to integrate project hydroacoustic streamgages into larger regional efforts to improve the health of the Mississippi River.

The results of this study may help the MPCA evaluate progress towards sediment reduction goals for Lake Pepin. For locations that were consistent sources of sediment throughout the study, implementation of best management practices (BMPs) on the landscape may reduce amounts of sediment entering the Minnesota River. However, locations that can change between sources and sinks for sediment likely indicate temporary storage in the Minnesota River and delayed transport to the Mississippi River. The timing and magnitude of in-channel sediment transport in these locations varies substantially with changes in weather and streamflow. Without continuous monitoring of sediment in these dynamic locations, the effects of in-channel sediment transport would be difficult to quantify, complicating efforts to evaluate long-term progress towards sediment reduction goals.

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

Date of Report: October 29, 2018

Final Report

Date of Work Plan Approval: June 11, 2015

Project Completion Date: December 31, 2018

PROJECT TITLE: Using Hydroacoustics to Monitor Sediment in Minnesota Rivers

Project Manager: Jeffrey R. Ziegeweid

Organization: U.S. Geological Survey

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Location: Blue Earth, Brown, Carver, Dakota, Goodhue, Hennepin, Le Sueur, Nicollet, Ramsey, Scott, Sibley, Wabasha, Washington counties

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Total ENRTF Project Budget:		
	ENRTF Appropriation:	**$455,000.00**
	Amount Spent:	**$455,000.00**
	Balance:	**$0**

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

Appropriation Language:
$455,000 the first year is from the trust fund to the commissioner of natural resources for an agreement with the United States Geological Survey to install hydroacoustic equipment on the lower Minnesota and Mississippi Rivers to improve measurement and monitoring accuracy for suspended sediment and enhance ongoing sediment reduction efforts by state, federal, and local agencies. 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: Using Hydroacoustics to Monitor Sediment in Minnesota Rivers

II. PROJECT STATEMENT:

Executive Summary: Sediment-laden rivers and streams cost the State of Minnesota millions of dollars each year. Excessive sediment in rivers degrades water quality and aquatic habitat, requires removal of dredge material, reduces recreational opportunities, and transports harmful contaminants. In Minnesota, sediment is listed as the top water quality impairment, affecting over 5,800 miles of streams. Representative, consistent, and accurate measurements of sediment are needed because significant resources are being dedicated to understanding the causes, effects, and sources of sediment in rivers. Due to the difficulty, expense, training and the limited opportunities to collect physical sediment samples, there are relatively few suspended-sediment concentration (SSC) samples available along the lower Minnesota and Mississippi Rivers in Minnesota. Given this, sediment prediction models are increasingly relied upon to obtain estimates of sediment concentrations and loads; however, model results often vary from measured loads by large amounts, causing a high level of uncertainty about their ability to accurately predict loads. Thus, physically collected samples of suspended sediment still remains the most accurate and reliable means for determining sediment loads and quantifying the amount of erosion from a watershed. The challenge is to meet the current and future needs of measuring sediment to improve accuracy while reducing costs. One method uses acoustic Doppler velocity meters (ADVMs) mounted permanently on bridge piers below the water surface to measure suspended sediments. Sound waves emitted from the ADVMs are generated from sediments in suspension and can be correlated to SSC from samples collected using specially designed isokinetic samplers. Project findings will provide important information for current and future water resource policy decisions.

Project outcomes:

- Accurate, high resolution, continuous measurements of sediment concentrations for the lower reach of the Minnesota River and the South-Metro Area of the Mississippi River
- Accurate sediment budgets and sediment load contributions from the Minnesota River
- Current calculations of fill rates and trapping efficiency for Lake Pepin
- Instrument for measuring the effectiveness of best management practices
- Tool for monitoring the progress of the State's sediment reduction strategy for the Minnesota and Mississippi Rivers

Elevated sediment loads have been attributed to human activities such as urbanization and agricultural activities that increase impervious surfaces and reduce soil permeability. Water that would normally infiltrate into the soil becomes overland flow that is available to erode and transport sediment to the stream channel. Increases in sediment also can be attributed to human-induced changes to the river like creating levees, and straightening, dredging and widening the channel for navigation. Levees prevent the river from connecting to the natural floodplain, and straightening and dredging the channel increases the river's gradient; all increase stream velocity and energy. In Minnesota, sediment is listed as the top water quality impairment, affecting over 5,800 miles of streams.

Suspended-sediment sampling in Minnesota began as early as 1879 by the U.S. Engineer Department as part of a larger sampling project along the Mississippi and Missouri Rivers. From 1930 through 1933, daily samples on the upper Mississippi River and its tributaries were collected by the St. Paul U.S. Engineer District, and in 1937 and 1938, suspended-sediment samples were collected on the Minnesota, Zumbro, and Root Rivers by the U.S. Army Corps of Engineers. The U.S. Geological Survey (USGS) began collecting suspended-sediment concentration (SSC) samples in Minnesota in the early 1960s using isokinetic samplers. Following an active sampling period in the 1970s and 1980s, suspended-sediment sampling declined in Minnesota for more than two decades until 2007 when the USGS, in cooperation with the Minnesota Pollution Control Agency (MPCA), established a sediment monitoring network of sites and began systematic sampling across the State.

Representative, consistent, and accurate measurements of sediment are needed because significant resources are being dedicated to understanding the causes, effects, and sources of sediment in rivers. For many decades, there have been few changes in the methods used to collect physical sediment samples. The MPCA had incorporated grab sampling and total suspended solids (TSS) laboratory analysis as its measure of fluvial sediment in the early 1970s. The TSS method was originally designed for analyses of point samples from wastewater treatment facilities. Total suspended solids were adopted by the MPCA for various reasons, some of which included the assumption that the TSS method would provide an adequate representation of suspended sediment and that isokinetic sampling and laboratory analysis of whole sample suspended-sediment concentration (SSC) was too costly. Total suspended solids samples are collected at the center of the stream cross-section less than 1 meter (3.3 feet) below the water surface, whereas SSC samples are collected using isokinetic samplers at 10 equally spaced locations across the stream cross-section and through the entire stream depth. Isokinetic samplers are designed to obtain a representative sample of the water-sediment mixture by allowing water in the stream to enter the sampler at the same speed and direction as the streamflow. The primary difference in laboratory procedures is that the TSS analytical method uses a pipette to extract a subsample from the original water sample to determine the amount of suspended material, whereas the SSC analytical method measures all of the sediment and the mass of the entire water-sediment mixture. According to a USGS report published by Gray and others (2000), the use of a pipette to obtain subsamples subjects the analyses to substantial biases as compared to the SSC method.

In 2007, the MPCA, in cooperation with the USGS, decided to determine if significant differences existed between the grab sampling method of collecting TSS and the USGS method of collecting suspended-sediment concentrations (SSC). Over 120 paired TSS/SSC samples were collected at 7 sites across the state. The data and subsequent analysis indicated that the TSS method was under-representing the amount of sediment in Minnesota's Rivers by approximately 50%. The concern is that the under-representation of sediment transmits directly into inaccuracies in sediment load computations and subsequent interpretations. It is possible that decisions based on inadequate data can cause the loss of millions of dollars if water-quality improvement programs and stream restoration and fish enhancement projects fail. The USGS study was released to the public in January 2014 and can be found at (http://pubs.usgs.gov/sir/2013/5205/pdf/sir2013-5205.pdf).

Due to the difficulty, expense, training and the limited opportunities to collect physical sediment samples, there are relatively few samples of SSC available along the lower Minnesota and Mississippi Rivers in Minnesota. Thus, alternate methods using models are often relied upon to obtain estimates of sediment concentrations and loads. Sediment transport models offer the advantage of examining various simulation scenarios; however, their ability to accurately predict sediment concentrations and loads are dependent upon reliable, consistent inputs and correct interpretations. Research has shown that sediment prediction models often vary from measured loads by large amounts, causing a high level of uncertainty about their ability to accurately predict loads. One of the problems associated with models is their ability to adequately determine sediment supply, which is dependent on many factors like sediment availability, season, watershed size, and source location in the watershed. Consequently, physically collected samples of suspended sediment still remains the most accurate and reliable means for determining sediment loads and quantifying the amount of erosion from a watershed. The challenge is to meet the current and future needs of measuring sediment to improve accuracy while reducing costs.

The objectives of this project are: 1) improve measurements of sediment concentrations for the lower reach of the Minnesota River; 2) to accurately quantify sediment load contributions to the Mississippi River from the Minnesota River; and 3) to calculate accurate fill rates for Lake Pepin. A total of nine sites will be used in the study. Five of the nine sites have a pre-existing hydroacoustic device installed as part of the USGS streamgaging network. Four additional hydroacoustic devices will be installed to meet the study design requirements. Recent technological advances along with the continued need to measure fluvial sediment has led to the use of surrogates for measuring suspended sediment, particularly in locations where streamflow alone is not a good estimator of SSC. One of these surrogate methods, proposed in this study, uses acoustic Doppler velocity meters (ADVMs) mounted permanently on bridge piers below the water surface (fig 1.). Sound waves emitted from the ADVMs are correlated to suspended-sediment concentrations (SSC) from samples collected using isokinetic samplers and rigorous sampling procedures. The benefit of using hydroacoustics as a surrogate is that the

acoustic signal response is directly generated from sediment in suspension. Historically, streamflow has been used to predict sediment between sample collection intervals but results using streamflow are inconsistent. Gaps in the data will be eliminated because SSC will be measured continuously in real time. Using continuous measurements, load accuracies will be significantly improved. This will be accomplished by installing hydroacoustic equipment at permanent in-stream monitoring stations to collect continuous measurements at existing USGS and/or DNR streamgaging sites.

III. OVERALL PROJECT STATUS UPDATES:

Project Status as of January 1, 2016:

Site reconnaissance was completed for each of the 4 sites selected for installation of the acoustic equipment. Velocity profiles of the proposed monitoring sites were collected using an acoustic Doppler current profiler to determine the optimum location, depth, and orientation of the sediment-acoustic equipment. Installation permits were submitted to and approved by the required agencies, which included Scott County, the Minnesota Department of Transportation, the Minnesota Department of Natural Resources, the U.S. Coast Guard, and the U.S. Army Corps of Engineers. All equipment installations were completed by November 30 at the four sites. Equipment installed below the water surface included 3 Acoustic Doppler Velocity Meters (ADVMs) at Minnesota River sites near Judson, at St Peter, and near Jordan, and one site near Lake City below Lake Pepin. Each ADVM was coated with anti-biofouling paint to minimize algae growth on equipment surfaces. For the Lake City site, a rail deployment system was installed on a piling in the river. Enclosures were installed at 3 out of the 4 sites, with the exception of the Minnesota River near Jordan. For the Minnesota River near Jordan, an existing Metropolitan Council shelter is being used to secure the data logging and power equipment. Enclosures were outfitted with a solar panel, battery, and a voltage conditioner. For each of the sites, the data and power cables were extended from the enclosure to the USGS or DNR streamgage containing the datalogging equipment. The ADVMs were programmed to collect acoustic backscatter data using 5 cells. The ADVMs store the data internally and will require periodic downloading from field technicians. Beam checks were accomplished at each site and indicated good return signals with optimum orientation for collecting data to correlate with physically collected sediment samples. The ADVM at Judson was removed for the winter months due to the shallow depths during base flow conditions and will be reinstalled immediately upon ice-out. All other ADVMs will be left in the water during the winter months. Physical sediment sampling will begin upon ice-out in the spring of 2016.

Amendment Request (03/14/2016:

This request consists of two changes that involve shifting budget item amounts among activities. The first change involves shifting funds ($30K) from activity two/budget item (Develop relations among streamflow, acoustic signals, and physical sediment samples and document the results in a Scientific Investigations Report) to activity one/budget item (Install Acoustic Doppler Velocity Meters (ADVMs); log and transmit data to office; collect sediment samples using USGS sampling protocols). This is necessary because additional time was needed to ensure correct installation, alignment, and programming of the ADVMs. The adjustments and modifications to the ADVMs increased the time, and thus budget, needed to support this activity. The associated reduction of $30K in activity two (Develop relations among streamflow, acoustic signals, and physical sediment samples and document the results in a Scientific Investigations Report) is not anticipated to adversely impact activity two. The second change involves shifting funds ($4K) from activity one/budget item (Travel expenses in Minnesota) to activity one/budget item (Equipment/Tools/Supplies). This change is necessary to account for additional equipment and supplies needed to make modifications to the ADVMs to ensure their correct installation, programming, and alignment. The associated reduction of $4K to activity one (Travel expenses in Minnesota) is not anticipated to adversely impact travel expenses for this activity.

Amendment Request Approved on 03/28/2016

Amendment Request (05/10/2016):

This request involves changing the Project Manager from Christopher A. Ellison to Jeffrey R. Ziegeweid. Chris took another job with the USGS Water Science Center in Helena, MT. Jeff Ziegeweid will be taking over management of the project as well as supervision of the field staff that were previously supervised by Chris Ellison. Jeff has previous experience installing, operating, and publishing data from acoustic Doppler velocity meters in the St. Croix River. Jeff will provide additional information about his background and credentials if requested, and he will be happy to meet with LCCMR staff for additional discussion and orientation. Jeff has experience in project and team management and has worked on several USGS projects funded by LCCMR.

Amendment Request Approved on 05/13/2016

Project Status as of July 1, 2016:

The project has progressed as planned in the project proposal and the work plan. Final installations and calibrations of hydroacoustic equipment were completed shortly after ice-out in spring 2016. Physical collection of suspended-sediment samples began on March 22, 2016. As of June 29, 2016, 67 of the 90 sediment samples planned to be collected in 2016 have been collected by the three field teams. The remaining 23 planned sediment samples will be collected in July and August of 2016. Collected sediment samples at each site span a range of streamflows and water levels on both the rising and falling hydrograph limbs of precipitation events that affect how suspended sediments are transported in rivers. During collection of sediments samples, streamgages were inspected to ensure that high-quality real-time data were being collected and transmitted via the USGS National Water Information System (NWIS; http://waterdata.usgs.gov/mn/nwis/). In addition, data were downloaded from ADVMs during site visits and archived on the network at the USGS Minnesota Water Science Center. All collected samples have been transported to the USGS Sediment Laboratory in Iowa City, Iowa, for analysis.

Amendment Request (08/22/2016):

This request involves moving Activity 1 funds within different budget items, specifically moving budgeted funds from Travel, Overtime, and Professional/Technical/Service Contracts to the Equipment/Tools/Supplies budget item. I am requesting a total of $21,630.59 be moved into the "Equipment/Tools/Supplies" budget item. **The requested amendment will be applied retroactively to cover equipment/tools/supplies that have already been purchased.** There are several reasons why the original budget for equipment/tools/supplies was not sufficient and why additional equipment was purchased prior to amending the project budget. First, the cost of some budget items, such as the cost of ADVM cables and batteries, were higher than quoted by the original project manager in the approved work plan. The original project manager also greatly underbudgeted the costs of the miscellaneous supplies needed to install the ADVM gages. Next, the number of cables, batteries, and solar panels were insufficient for powering the ADVM gages, particularly at sites above and below Lake Pepin, which received substantial shading because of the surrounding bluffs. Because the project relies on collecting data during and following storm events, it was critical to get the gages fully operational so that field crews could track the effects of storms on the study sites and be deployed on short notice. Therefore, the additional equipment was purchased before an amendment could be submitted and approved. Finally, the additional equipment/tools/supplies were purchased under the supervision of Chris Ellison, the original project manager who left the USGS Minnesota Water Science in April 2016 to take a position in Montana. However, the costs associated with travel, overtime, and professional/technical service contracts are less than originally anticipated because of developed sampling efficiencies and improved coordination of travel with other projects being conducted in the USGS Minnesota Water Science Center. Therefore, the budget amendment should not affect the budgeted total for Activity 1, and the budget amendment should not affect our ability to complete the project within the specified dollar amount and timeline.

Amendment approved by LCCMR 8/30/2016

Project Status as of January 1, 2017:

The project has progressed as planned in the project proposal and the work plan. Sediment samples collected in 2016 spanned a wide range of flow and sediment-transport conditions, including the severe flooding that took place in south-central Minnesota at the end of September. During collection of sediments samples, streamgages were inspected to ensure that high-quality real-time data were being collected and transmitted via the USGS National Water Information System (NWIS; http://waterdata.usgs.gov/mn/nwis/). In addition, data were downloaded from ADVMs during site visits and archived on the network at the USGS Minnesota Water Science Center. All collected samples have been transported to the USGS Sediment Laboratory in Iowa City, Iowa, for analysis.

Project Status as of July 1, 2017:

The project has progressed as planned in the project proposal and the work plan. As of July 1st, we are 50% of the way through our planned sample collection activities for this calendar year. Collected sediment samples spanned a wide range of flow and sediment-transport conditions and filled gaps in defining relations between acoustic backscatter and suspended sediment concentration. During collection of sediments samples, streamgages were inspected to ensure that high-quality real-time data were being collected and transmitted via the USGS National Water Information System (NWIS; http://waterdata.usgs.gov/mn/nwis/). In addition, data were downloaded from ADVMs during site visits and archived on the network at the USGS Minnesota Water Science Center. Most of the sediment samples collected so far this year have been transported to the USGS Sediment Laboratory in Iowa City, Iowa for analysis.

Amendment Request (08/31/2017):

This request involves moving Activity 1 funds within different budget items, as well as moving some extra funds from Activity 1 Overtime into Activity 2 Personnel costs. I am requesting an increase of "Sediment samples laboratory analyses" funds from $12,060.00 to $12,673.21 to account for increased cost of laboratory analyses. I am also requesting an increase in the "Equipment/Tools/Supplies" funds from $56,460.59 to $59,754.78 because we underestimated the cost of miscellaneous supplies needed to maintain installed gages and sampling equipment. Also, I am requesting an increase in the "Travel" funds from $8,739.00 to $9,142.32 to account for additional travel associated with capturing sporadic, event-based sediment samples. Unfortunately, **requested increases in "Equipment/Tools/Supplies" and "Travel" funds will have to be applied retroactively to cover purchases that have already been made.** I did my best to monitor the charges as they came in, but not all charges showed up right away. Furthermore, with multiple field crews out simultaneously and the sporadic, event-based nature of sediment sampling, field crews often did not have time to check in before making purchases needed to maintain equipment and collect samples in order to successfully complete outlined work plan activities. However, I monitored the overall project budget closely, and the requested increases in category funds will be offset by requested decreases in other category funds. I am requesting a decrease in the "Boat" funds from $6,742.50 to $3,839.60 to account for reduced boat costs in 2017 resulting from low-flow conditions that forced us to collect many samples using a bridge crane rather than a boat. In addition, I am requesting a decrease in "Overtime" funds from $14,226.91 to $11,035.79 because the distribution of field sites and activities allowed field crews to collect most samples without charging overtime. Also, I am requesting a decrease in "Shipping" funds from $1,000.00 to $636.50 because we were able to get equipment in fewer shipments than we originally anticipated. We were able to complete tasks associated with Activity 1 in August of 2017. After the amendments requested earlier in this paragraph and the billing that will be done in mid-September of 2017, we will have an additional $2,146.80 in "Overtime" funds. I am requesting that these additional funds be added to Activity 2 "Personnel" funds to provide additional support for completing data analyses and report writing required to successfully complete Activity 2 of the Work Plan. In addition, moving the extra "Overtime" funds to

Activity 2 will help restore a portion of the funds that I transferred out of Activity 2 in a 2016 amendment to cover the unexpected costs associated with the gage installations for Activity 1. The requested amendments will not affect our ability to complete the project within the established overall project budget, nor will the amendments affect our ability to complete the project and report on time.

Amendment Approved by LCCMR 9/7/2017

Project Status as of January 1, 2018:

The project has progressed as planned in the project proposal and the work plan. We completed our planned sample collection activities for activity 1 in October 2017. Collected sediment samples spanned a wide range of flow and sediment-transport conditions and filled gaps in defining relations between acoustic backscatter and suspended sediment concentration. During collection of sediments samples, streamgages were inspected to ensure that high-quality real-time data were being collected and transmitted via the USGS National Water Information System (NWIS; http://waterdata.usgs.gov/mn/nwis/). In addition, data were downloaded from ADVMs during site visits and archived on the network at the USGS Minnesota Water Science Center. Collected sediment samples were transported to the USGS Sediment Laboratory in Iowa City, Iowa for analysis. Most of the data from samples collected in 2017 have been received from the USGS Sediment Laboratory in Iowa City, Iowa. We have begun compiling and reviewing data for construction of surrogate relations as part of activity 2.

Project Status as of July 1, 2018:

The project has progressed as planned in the project proposal and the work plan. We have completed data quality assurance checks and the statistical analyses used to develop surrogate relations for estimation of continuous sediment loads. We have begun writing the final report, and we expect to stay on track for the project completion date of December 31, 2018.

Amendment Request (08/31/2017):

This request involves moving the entire remaining project balance ($27,128.88) into the “Activity 2 Personnel” category. This includes the existing balance of $12,885.92 currently remaining in the “Activity 2 Personnel” category. In addition, I am requesting that the $10,000 for “Contract Fees for USGS report” be moved to the “Activity 2 Personnel” category. Our center recently changed the structure of how reports are billed, and we are able to cover report costs through other internal fund sources. Finally, I am requesting that $4,242.96 be moved from the “Equipment/Tools/Supplies” category; of these funds, $3,442.96 will come from the remaining balance in Activity 1, and $800.00 will come from the remaining balance in Activity 2. We were able to complete the necessary data collection activities without having to spend as much to replace and maintain equipment as expected. Moving the specified funds to the “Activity 2 Personnel” category will help restore a portion of the funds that I transferred out of Activity 2 in a 2016 amendment to cover the unexpected costs associated with the gage installations for Activity 1. The requested amendments will not affect our ability to complete the project within the established overall project budget, nor will the amendments affect our ability to complete the project and report on time.

Amendment Approved by LCCMR 8/31/2018

Overall Project Outcomes and Results:

Excessive sediment in rivers degrades water quality, reduces aquatic habitat, increases need for navigation channel dredging, reduces recreational opportunities, and transports harmful contaminants. Lake Pepin, a naturally-formed lake on the Mississippi River, is filling in with sediment at a rapid rate compared to conditions prior to European settlement, and 85-90 percent of the sediment depositing in Lake Pepin comes from the

heavily-cultivated Minnesota River Basin. However, we lack detailed spatial information within the watershed to focus sediment-reduction efforts. Therefore, the U.S. Geological Survey (USGS) began a project funded by the Environment and Natural Resources Trust Fund to better understand sources and sinks of sediment in the watershed upstream of Lake Pepin, which includes the Minnesota, St. Croix, and upper Mississippi Rivers. We sampled nine stream locations and developed surrogate relations between newly installed, continuous hydroacoustic sensors and collected suspended sediment samples. Data from this study allows determination of sediment loads for streams in the study area that are more accurate and at a higher spatial resolution of sampling sites than prior monitoring efforts. Higher gradient river reaches in upstream portions of the study area were consistent sources of sediment. Low gradient areas near river confluences were consistent sinks of sediment, storing more sediment in floodplain or lake environments than was input from upstream. In contrast, mid gradient areas were dynamic, generating sediment load in some conditions but storing sediment in other conditions. Channelized river reaches, latitudinal precipitation patterns, and inputs from sediment-laden tributaries in the southern part of the watershed likely contributed to fluctuating sediment dynamics in mid-gradient areas. The spatial density of continuous sediment monitors was critical to understanding the source/sink dynamics of sediment in the study area. Results of this study may help resource-management agencies target sediment-reduction efforts at areas within the watershed that act as sediment sources.

IV. PROJECT ACTIVITIES AND OUTCOMES:

This project will establish a network of five sediment monitoring sites on the Minnesota River and four sediment monitoring sites on the Mississippi River (fig 2). Each hydroacoustic site will be co-located at a USGS or MPCA/DNR continuous recording streamgage with one exception. The exception is the site on the Mississippi River below Lake Pepin near Lake City. This site is located along the river between Lake Pepin and the confluence of the Mississippi River and the Chippewa River (fig 2). Establishing a site at this location will provide a measure of the sediment trapping efficiency of Lake Pepin prior to contributions from the Chippewa River. For the Minnesota River, sites will be established at Judson, Mankato, St. Peter, Jordan, and at Ft Snelling Park. These sites have continuous-recording streamgages and were selected to measure sediment loads in key reaches along the lower Minnesota River. The furthest upstream site at Judson is approximately 10.8 river miles above the erosive Blue Earth Watershed, which is estimated to contribute greater than 30% of the total suspended solids entering the Minnesota River. Measuring sediment concentrations and loads on the main stem of the Minnesota River above the confluence with the Blue Earth River is important to quantify the loads prior to contributions from the Blue Earth Watershed. Approximately 1 mile downstream from the Blue Earth River, sediment concentrations will be measured at the USGS streamgage at Mankato. Measuring loads at Mankato will help provide accurate load contributions from the Blue Earth River Watershed. In addition to the sites at Judson and Mankato, there are 3 other primary river reaches that will provide important information to understanding sediment transport along the lower Minnesota River. These include the river reaches between Mankato and St. Peter, St. Peter and Jordan, and Jordan to Ft Snelling Park (fig 2). Ft Snelling Park is within three river miles of the confluence with the Mississippi River. Placing hydroacoustic equipment at these sites will provide a data set that can be used to calculate the production, transport, discharge, and storage of sediment within each reach. This is important to correlating natural and anthropogenic conditions that affect variations in transport and storage rates within each of the reaches. These data can be used to measure the effectiveness of best management practices and to monitor the progress of the State's sediment reduction strategy. Additionally, this will provide decision-makers important information to focus efforts that will maximize sediment reductions. Datalogging and satellite telemetry equipment available at existing streamgages will be used to record and transmit the data to the USGS office in Mounds View.

ACTIVITY 1: Install ADVMs at four streamgaging sites on the Minnesota and Mississippi Rivers and collect water-samples for suspended-sediment concentration (SSC) following USGS sampling procedures
Description: Initially, site reconnaissance will be accomplished to determine optimum placement of the ADVM in the stream channel. To do this, an acoustic Doppler current profiler will be deployed to determine variability of the acoustic backscatter in the stream cross-section. The backscatter data will be evaluated to determine

where the highest and most uniform backscatter values occur. Permits will be submitted to the appropriate county or state authority to obtain permission to use the bridge as a structure to support the ADVM and associated equipment. Once the permits are approved, the Minnesota Department of Transportation will be contacted to contract the "snooper" for use in installing the ADVMs. The snooper is a crane and bucket system that can transport personnel safely over the side of the bridge to allow the ADVM and cables to be attached to the bridge pier. At the top downstream side of the bridge, an enclosure containing a data transmitter (i.e. radio link or Satlink2), voltage conditioner and battery will be installed to the side of the bridge deck. The ADVM will be programmed to collect acoustic backscatter data in 5 cells and transmitted to the USGS office in Mounds View. This is expected to be completed by November 30, 2015. The following spring (2016), 3 teams of 2 personnel each will be deployed during spring snowmelt runoff to collect the initial set of physical sediment samples that will be correlated to the acoustic backscatter data. Samples will be collected using isokinetic samplers and will be width/depth integrated following USGS sampling procedures. Two sets of samples will be collected at each site during each visit. This will continue at each of the nine sites over a wide range of streamflow to encompass the rising and falling limbs of the streamflow hydrograph during the spring runoff period. A total of up to 90 sediment samples will be collected during the spring runoff period which typically ends in May – June. Following this sampling period, samples will be collected during lower flows to determine sediment concentrations at lower flows. Along with low flow sampling, storm events also will be sampled to determine the variability in sediment concentrations under these conditions. Up to 90 additional samples will be collected during this time period, which will continue until November until a total of up to 180 samples are collected. Samples will be kept in the USGS warehouse; in July and December, all samples will be transported to the USGS Iowa sediment lab for analysis. Laboratory analysis will consist of sediment concentration and an analysis of the percentage of particle sizes that are less than 0.062mm (fines size). Sizes larger than 0.062mm in suspension will be assumed to be sand-sized particles. It typically takes 4 – 6 weeks to receive the results from the lab. Once the results are received, the data will be formatted and inspected to determine if there are any anomalies that require further investigation. For example, if it is noticed that a sample has a large sediment concentration along with a relatively large percentage of sand when compared to other samples at similar flows, it may be that the field technician inadvertently disturbed the channel bottom with the sampler and contaminated the sample. Because the sample likely contains disturbed sediments from the channel bed, it is not representative of the suspended-sediment concentrations in the river and it may not be used in the data set.

Summary Budget Information for Activity 1:

ENRTF Budget: $384,068.24
Amount Spent: $384,068.24
Balance: $0.00

Outcome	Completion Date
1. *ADVMs installed on Minnesota River at Judson, St. Peter, Jordan and on the Mississippi River below Lake Pepin near Lake City, initiate data logging and transmissions to USGS office in Mounds View*	November 30, 2015
2. *Collect up to 90 sediment samples (10 each site) during spring snowmelt runoff on Minnesota River at Judson, Mankato, St. Peter, Jordan, Ft. Snelling Park, on the St Croix River at Prescott, and on the Mississippi River at St. Paul, Red Wing, and below Lake Pepin near Lake City*	June 15, 2016
3. *Transport sediment samples to USGS Iowa sediment lab for analysis*	July 1, 2016
4. *Collect up to 90 sediment samples (10 each site) during storm events, if available, and during lower stream flows on the Minnesota River at Judson, Mankato, St. Peter, Jordan, Ft. Snelling Park, on the St Croix River at Prescott, and on the Mississippi River at St. Paul, Red Wing, and below Lake Pepin near Lake City*	November 15, 2016
5. *Transport sediment samples to USGS Iowa sediment lab for analysis*	December 1, 2016
6. *Receive data from Iowa Sediment lab. Format data and perform quality assurance/quality control, enter into National Water Information System database*	March 1, 2017

7. *Collect up to 90 sediment samples (10 each site) during spring snowmelt runoff on Minnesota River at Judson, Mankato, St. Peter, Jordan, Ft. Snelling Park, on the St Croix River at Prescott, and on the Mississippi River at St. Paul, Red Wing, and below Lake Pepin near Lake City*	June 15, 2017
8. *Transport sediment samples to USGS Iowa sediment lab for analysis*	July 1, 2017
9. *Collect up to 90 sediment samples (10 each site) during storm events, if available, and during lower stream flows on the Minnesota River at Judson, Mankato, St. Peter, Jordan, Ft. Snelling Park, on the St Croix River at Prescott, and on the Mississippi River at St. Paul, Red Wing, and below Lake Pepin near Lake City*	November 15, 2017
10. *Transport sediment samples to USGS Iowa sediment lab for analysis*	December 1, 2017
11. *Receive data from Iowa sediment lab. Format data and perform quality assurance/quality control, enter into National Water Information System database*	March 1, 2018

Activity Status as of January 1, 2016:

All equipment installations were completed by November 30 at the four sites. Equipment installed on bridge piers using aluminum H-beams below the water surface included 3 Acoustic Doppler Velocity Meters (ADVMs) at Minnesota River sites near Judson, at St Peter, and near Jordan, and one site near Lake City below Lake Pepin. Each ADVM was coated with anti-biofouling paint to minimize algae growth on equipment surfaces. For the Lake City site, a rail deployment system was installed on a piling in the river. Enclosures were installed at 3 out of the 4 sites, with the exception of the Minnesota River near Jordan. For the Minnesota River near Jordan, an existing Metropolitan Council shelter is being used to secure the data logging and power equipment. Enclosures were outfitted with a solar panel, battery, and a voltage conditioner. For each of the sites, the data and power cables were extended from the enclosure to the USGS or DNR streamgage containing the datalogging equipment. The ADVMs were programmed to collect acoustic backscatter data using 5 cells. The ADVMs store the data internally and will require periodic downloading from field technicians. Beam checks were accomplished at each site and indicated good return signals with optimum orientation for collecting data to correlate with physically collected sediment samples. The ADVM at Judson was removed for the winter months due to the shallow depths during base flow conditions and will be reinstalled immediately upon ice-out. All other ADVMs will be left in the water during the winter months. Physical sediment sampling will begin upon ice-out in the spring of 2016.

Activity Status as of July 1, 2016:

Remaining installations and calibrations of hydroacoustic equipment were completed shortly after spring ice-out. Physical collection of suspended-sediment samples began on March 22, 2016. As of June 29, 2016, 67 of the 90 sediment samples planned to be collected in 2016 have been collected by the three field teams. The remaining 23 planned sediment samples will be collected in July and August of 2016. Collected sediment samples at each site span a range of streamflows and water levels on both the rising and falling hydrograph limbs of precipitation events that affect how suspended sediments are transported in rivers. During collection of sediments samples, streamgages were inspected to ensure that high-quality real-time data were being collected and transmitted via the USGS National Water Information System (NWIS; http://waterdata.usgs.gov/mn/nwis/). In addition, data were downloaded from ADVMs during site visits and archived on the network at the USGS Minnesota Water Science Center. All collected samples have been transported to the USGS Sediment Laboratory in Iowa City, Iowa, for analysis.

Activity Status as of January 1, 2017:

Collected sediment samples at each site span a range of streamflows and water levels on both the rising and falling hydrograph limbs of precipitation events that affect how suspended sediments are transported in rivers. During collection of sediments samples, streamgages were inspected to ensure that high-quality real-time data were being collected and transmitted via the USGS National Water Information System (NWIS; http://waterdata.usgs.gov/mn/nwis/). In addition, data were downloaded from ADVMs during site visits and

archived on the network at the USGS Minnesota Water Science Center. All collected samples have been transported to the USGS Sediment Laboratory in Iowa City, Iowa, for analysis, and some sediment data from the first half of the summer have been received from the laboratory and entered into the USGS database. This winter, we will continue to examine 2016 data as it is received from the laboratory, and we will prepare to collect additional sediment samples during the open-water period of 2017.

Activity Status as of July 1, 2017:
This winter, all samples collected in 2016 were analyzed by the USGS Sediment Laboratory in Iowa City, Iowa, and data were received and entered into the USGS database. This winter, we prepared to start collecting additional samples after ice-out. New field sampling began on April 17, 2017. Collected sediment samples at each site span a range of streamflows and water levels on both the rising and falling hydrograph limbs of precipitation events that affect how suspended sediments are transported in rivers. During collection of sediments samples, streamgages were inspected to ensure that high-quality real-time data were being collected and transmitted via the USGS National Water Information System (NWIS; http://waterdata.usgs.gov/mn/nwis/). In addition, data were downloaded from ADVMs during site visits and archived on the network at the USGS Minnesota Water Science Center. Most collected samples have been transported to the USGS Sediment Laboratory in Iowa City, Iowa, for analysis.

Activity Status as of January 1, 2018:

Collection of sediment samples needed to develop surrogate relations with acoustic backscatter were completed in October 2017. Collected sediment samples at each site spanned a range of streamflows and water levels on both the rising and falling hydrograph limbs of precipitation events that affect how suspended sediments are transported in rivers. During collection of sediments samples, streamgages were inspected to ensure that high-quality real-time data were being collected and transmitted via the USGS National Water Information System (NWIS; http://waterdata.usgs.gov/mn/nwis/). In addition, data were downloaded from ADVMs during site visits and archived on the network at the USGS Minnesota Water Science Center. All collected samples have been transported to the USGS Sediment Laboratory in Iowa City, Iowa, for analysis, and most of the data have been received from the laboratory and entered into the USGS database.

Activity Status as of July 1, 2018:

Activity 1 has been completed according to the timeline listed above. All samples have been analyzed by the laboratory, and the data passed quality assurance checks before being entered into the database. The administrative staff have not completed the final billing associated with remaining Activity 1 funds, but this will be completed between now and the project completion date of December 31, 2018.

Final Report Summary:

Activity 1 has been completed according to the timeline listed above. All samples have been analyzed by the laboratory, and the data passed quality assurance checks before being entered into the database. The administrative staff have completed the final billing associated with remaining Activity 1 funds, and the final execution of this billing is contingent upon completion of this Work Plan Final Report. Through activity 1, a lot of information was gained about the challenges related to the installation and maintenance of hydroacoustic equipment. If we were going to do the work over again, we would budget more funds for the initial site reconnaissance and equipment installation. We also had to troubleshoot several issues with next generation Sontek hydroacoustic meters because the company had not worked out all the software bugs for their new meters. However, we were ultimately able to collect high-quality data that informed Activity 2, which helps link the collected data to the management objectives of several state and federal agencies. The spatial resolution of the continuous monitors and sampling locations was critical to identifying mid-gradient areas where sediment

source/sink dynamics were highly variable. Continued monitoring in the dynamic locations likely would improve targeted State management efforts and evaluation of progress towards sediment reduction goals.

ACTIVITY 2: Develop relations among streamflow, acoustic signals, and physical sediment samples and document the results in a Scientific Investigations Report.

Description:

This will entail formatting the data for input into "R" language statistical software. Data will be quality controlled/checked prior to analysis. Standard statistical methods of simple and/or multiple linear regression analysis will be used to evaluate the relations among the parameters. Results from the analyses will be documented in table format. Graphs will be constructed to display the relations among parameters. Once the tables and graphs are completed, an analysis and interpretation of the data will be completed and documented, along with the raw data, which will be presented in an appendix, in a Scientific Investigations Report (SIR). The draft SIR will be thoroughly reviewed by a minimum of 5 reviewers, including a final review by the USGS Bureau Approval Authority. Once the SIR and statistical models have been peer reviewed, an online web-based portal will be constructed for viewing real-time suspended-sediment concentrations at each of nine monitoring sites.

Summary Budget Information for Activity 2:

ENRTF Budget: $70,931.76
Amount Spent: $70,931.76
Balance: $0

Outcome	Completion Date
1. *Prepare ADVM, streamflow, and sediment data for analysis; match acoustic signals with streamflow and sediment concentrations*	April 1, 2018
2. *Develop relations among acoustic signals, streamflow, and sediment concentrations using standard statistical methods; identify outliers and construct regression equations*	May 15, 2018
3. *Complete draft SIR; write text, construct figures and graphs, and submit for initial in-office USGS peer review*	August 30, 2018
4. *Make corrections and complete additional analysis as recommended by reviewers, submit SIR for USGS colleague peer reviews (2 colleague reviews)*	September 30, 2018
5. *Make corrections and complete additional analysis as recommended by reviewers, submit SIR to USGS Bureau Approval Authority for final review*	October 30, 2018
6. *Submit SIR for final publication; release to public*	December 31, 2018

Activity Status as of January 1, 2016:

No activity to report for Activity 2 during this reporting period.

Activity Status as of July 1, 2016:

No activity to report for Activity 2 during this reporting period.

Activity Status as of January 1, 2017:

No activity to report for Activity 2 during this reporting period.

Activity Status as of July 1, 2017:

No activity to report for Activity 2 during this reporting period.

Activity Status as of January 1, 2018:

Available sediment data have been quality-control checked and entered into the USGS database. We have begun compiling the data for each site and have started using statistical software tools to examine relations between acoustic backscatter and measured suspended sediment concentration. We are on track to complete development of surrogate relations and write the final report within the allotted timeframe and budget.

Activity Status as of July 1, 2018:

We are on track to complete Activity 2 according to the timeline listed above. We have completed Outcomes 1 and 2, and we are currently in the process of completing Outcome 3.

Final Report Summary:

Activity 2 has been mostly completed. We have developed relations among streamflow, acoustic signals, and physical sediment samples and documented the results in a Scientific Investigations Report (SIR). The report has been through USGS peer review and is currently being reviewed by the USGS Science Publishing Network. A draft of the SIR is included with this Work Plan Final Report, and the SIR will be officially published and available for public dissemination by December 31, 2018 as outlined in the original work plan. The analyses presented in the report demonstrate that hydroacoustic surrogates are effective for estimating suspended sediment loads in large rivers for area not heavily affected by locks, dams, and lakes. Collected sediment data were used to identify consistent sources and sinks of sediment in the study area and dynamic locations where sediment transport and deposition depend on latitudinal patterns in precipitation and streamflow. The spatial resolution of streamgages was critical to understanding these dynamic sediment processes. Results of this project can be used by several agencies to more efficiently manage environmental, recreational, and commercial interests in the Upper Mississippi River Basin, thus making better use of taxpayer dollars and agency staff time.

V. DISSEMINATION:

Description:

The results of USGS sampling and analyses will be stored in the USGS National Water Information System (NWIS) data base and made available to the public via the USGS Minnesota Water Science Center web site at http://mn.water.usgs.gov/index.html. Once the hydroacoustic signals have been calibrated to the physical sediment samples, we will seek cooperator support to add additional equipment (CR1000 dataloggers - Campbell Scientific Inc.) that will enable online graphical illustrations for the public to view real-time continuous sediment concentrations at all nine sites at the above mentioned website. Additionally, a Scientific Investigations Report (SIR) will document the results of the study and will be available at the end of the study. All of the ADVM, streamflow, and sediment data will be provided in an attached appendix to the SIR. Also, these data will be presented at various forums such as the Minnesota Water Resources Conference and the Minnesota Annual Watershed District Meeting. These data will synthesize results for incorporation with past, present, and future sediment studies on the Minnesota and Mississippi Rivers.

Activity Status as of January 1, 2016:

The USGS office in Middleton, WI was contacted to discuss important technical and programming assistance for future deployment of Campbell Scientific CR1000 dataloggers and modem design. The Lake City site is being configured to evaluate the benefits and applicability of a modem-based data transfer of all ADVM collected data. Currently, dataloggers at each of the sites do not provide the capability to transfer all of the ADVM data to the USGS office in Mounds View.

Activity Status as of July 1, 2016:

With the help of the USGS office in Middleton, WI, a modem and datalogger at Lake City were configured to allow two-way communication with the streamgage in order to download data and troubleshoot issues remotely.

Activity Status as of January 1, 2017:

Data collected by installed ADVMs are being transmitted via NWISweb from all USGS streamgages. For USGS equipment collocated with MN DNR streamgages, data must be downloaded regularly during site visits. All collected data are reviewed according to published USGS methods.

Activity Status as of July 1, 2017:

Data collected by installed ADVMs are being transmitted via NWISweb from all USGS streamgages. For USGS equipment collocated with MN DNR streamgages, data must be downloaded regularly during site visits. All collected data are reviewed according to published USGS methods. Data gaps identified from samples collected in 2016 continue to be filled with samples collected in 2017. Filling of these data gaps will strengthen relations among streamflow, acoustic signals, and physical sediment samples.

Activity Status as of January 1, 2018:

Data collected by installed ADVMs are transmitted via NWISweb from all USGS streamgages. For USGS equipment collocated with MN DNR streamgages, data were downloaded regularly during site visits. All collected data were reviewed according to published USGS methods. Data gaps identified from samples collected in 2016 were filled with samples collected in 2017. Filling of these data gaps will strengthen relations among streamflow, acoustic signals, and physical sediment samples.

Activity Status as of July 1, 2018:

Data collected by installed ADVMs are transmitted via NWISweb from all USGS streamgages. For USGS equipment collocated with MN DNR streamgages, data were downloaded regularly during site visits. All collected data were reviewed according to published USGS methods. Suspended sediment concentrations and bedloads from physically collected samples have been uploaded to NWISweb and are publicly available.

Final Report Summary:

Results of this project will be disseminated in a number of ways. First, suspended sediment data collected at hydroacoustic streamgages in the study area are already publicly available on the U.S. Geological Survey (USGS) National Water Information System (NWIS) data portal (https://waterdata.usgs.gov/mn/nwis/sw). Second, real-time suspended sediment data has been made available through the USGS National Real-Time Water Quality website (https://nrtwq.usgs.gov/) for the Minnesota River at Fort Snelling State Park, MN (USGS streamgage 05330920), and real-time suspended sediment data will be added for a subset of project streamgages in the near future. Finally, project results will be summarized in a USGS Scientific Investigations Report (Groten and others, in review – draft files attached) that will be publicly-available for dissemination after official publication before December 31, 2018.

Results of this project have been presented to other agencies, including the U.S. Army Corps of Engineers, the National Weather Service, and the Lower Minnesota River Watershed District; funding through the Environment and Natural Resources Trust Fund has been acknowledged during every presentation given. Furthermore, USGS scientists involved in this project have discussed ways to integrate results of the project into existing cooperative efforts between the USGS and the Minnesota Department of Natural Resources, and the Minnesota Pollution Control Agency. Finally, the project chief has been actively involved in discussions with the Upper Mississippi

River Basin Association, the Mississippi River Cities and Towns Initiative, and the USGS Midwest Regional Office about ways to integrate project hydroacoustic streamgages into larger regional efforts to improve the health of the Mississippi River.

The results of this study may help the MPCA evaluate progress towards sediment reduction goals for Lake Pepin. For locations that were consistent sources of sediment throughout the study, implementation of best management practices (BMPs) on the landscape may reduce amounts of sediment entering the Minnesota River. However, locations that can change between sources and sinks for sediment likely indicate temporary storage in the Minnesota River and delayed transport to the Mississippi River. The timing and magnitude of in-channel sediment transport in these locations varies substantially with changes in weather and streamflow. Without continuous monitoring of sediment in these dynamic locations, the effects of in-channel sediment transport would be difficult to quantify, complicating efforts to evaluate long-term progress towards sediment reduction goals.

VI. PROJECT BUDGET SUMMARY:

A. ENRTF Budget Overview:

Budget Category	$ Amount	Overview Explanation
Personnel:	$ 313,866.76	1 USGS Studies Chief at 4% FTE each year for 3 years; 1 USGS Project Chief at 20% FTE each year for 3 years; 1 USGS Hydrologist at 21% FTE each year for 3 years; 2 USGS Hydrologic Technicians at 21% FTE (each) each year for 3 years; 1 USGS junior Hydrologic Technician at 18% FTE each year for 3 years; 2 USGS Surface Water/Water Quality Specialists at 4% FTE (each) each year for 3 years; 2 Database/IT Support Specialists at 4% FTE (each) each year for 3 years; 2 Admin Support at 7.6% FTE (each) each year for 3 years.
Professional/Technical/Service Contracts:	$ 16,512.81	USGS Iowa sediment sample laboratory analysis; MNDOT contract (snooper) to install equipment on bridges; boat contract to collect samples and perform maintenance on ADVM equipment; Scientific Publishing Network contract to edit, assemble, and publish final report
Equipment/Tools/Supplies:	$ 56,311.82	Cables, weatherproof enclosures, radiolinks, solar panels, batteries, Satlink data transmitter, antenna
Capital Expenditures over $5,000:	$ 47,494	Acoustic Doppler Velocity Meters, D-96 sediment sampler for sampling large, deep rivers
Travel Expenses in MN:	$ 9,142.32	Mileage (.55/mile), lodging, meals
Other:	$ 11,672.29	Overtime compensation for extended field sampling days; shipping of equipment from vendors.
TOTAL ENRTF BUDGET:	**$455,000**	

Explanation of Use of Classified Staff: N/A

Explanation of Capital Expenditures Greater Than $5,000:
Capital expenditures greater than $5,000 include four acoustic Doppler velocity meters (ADVMs) ($10,343 each - $41,373 total) and one D-96 sediment sampler ($6,122). The ADVMs are expected to remain at the installation sites for the duration of their lifespan. Because they don't have moving parts, they should continue to work for 10 or more years. The ADVMs are installed on the downstream side of bridge piers and are protected from floating debris and strong stream velocities. It is anticipated that once the sites are established and the ADVMs are calibrated to the physical sediment samples, they will be maintained through cooperative agreements between the USGS, MPCA, U.S. Army Corps of Engineers, Lower Minnesota River Watershed District, and possibly other state, university, and local government agencies. The D-96 sediment sampler is designed to sample in large rivers with deep water columns (>15 feet) and during stream velocities up to 12 feet per second. The D-96 sampler is needed to collect representative samples in the Minnesota and Mississippi Rivers because it allows the water-sediment mixture to enter the sampler at the same speed and direction as the flowing water. The USGS in Minnesota currently only has 1 of these samplers and needs the second sampler to ensure that all of the sites will be sampled during the limited time period available for spring snowmelt runoff and storm events. Having two samplers will enable two sampling teams to collect samples at sites simultaneously and ensure the desired numbers of samples are collected.

Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation: 4.05 FTEs

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			
U.S. Geological Survey	$189,216	$189,216	Personnel, travel, supplies
State			
N/A	$0	$0	
TOTAL OTHER FUNDS:	**$189,216**	**$189,216**	

VII. PROJECT STRATEGY:
A. Project Partners: There are no current agreements with partners to collaborate with this project. Historically, there were three partners that provided funding to support the collection and analysis of sediment data at three of the sites (Minnesota River at Mankato, Jordan, Ft Snelling Park) listed as monitoring sites for this project.

B. Project Impact and Long-term Strategy:
It is anticipated that this project will provide important data to accurately quantify sediment loads discharging into the Mississippi River from the Minnesota River. These data will be useful for calculating the current sediment fill rate into Lake Pepin. Data gaps resulting from point samples (historically, periodic samples were collected using point samples) will be eliminated because SSC will be measured continuously in real time. Using continuous measurements, load accuracies will be significantly improved. Other expected benefits include the ability to distinguish among and/or attribute sediment loads to streambanks, ravines, and bluffs, which have been identified as major contributors (60-80%) of sediment. Monitoring the South-Metro Mississippi River will provide accurate sediment loads into Lake Pepin. Also, this data will provide direct monitoring support for the MPCA's Sediment Reduction Strategy to reduce sediment loads in the Minnesota River by 80-90 percent and in the South-Metro Mississippi River by 50-60 percent. These data will provide accurate sediment loads for maintaining the navigation channel on the Minnesota and Mississippi Rivers by the U.S. Army Corps of Engineers. The long term strategy is to maintain the sites for 10 or more years to monitor loads, expand their

use to monitoring additional contaminants like nutrients, heavy metals and pesticides, and attribute changes in loads to natural causes, sediment reduction strategies, or land-use changes.

C. Funding History:

Funding Source and Use of Funds	Funding Timeframe	$ Amount
Minnesota Pollution Control Agency: Appropriation of funds used to collect and analyze sediment concentrations at the Minnesota River at Mankato	July 1, 2010 – September 30, 2014	$200,000
U.S. Army Corps of Engineers: Appropriation of funds used to collect and analyze sediment concentrations at the Minnesota River near Jordan and at Ft. Snelling Park	October 1, 2011 – September 30, 2014	$128,000
Lower Minnesota River Watershed District: Appropriation of funds used to collect and analyze bedload sediments at the Minnesota River near Jordan and at Ft. Snelling Park	January 1, 2012 – December 31, 2014	$15,000

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: N/A

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.

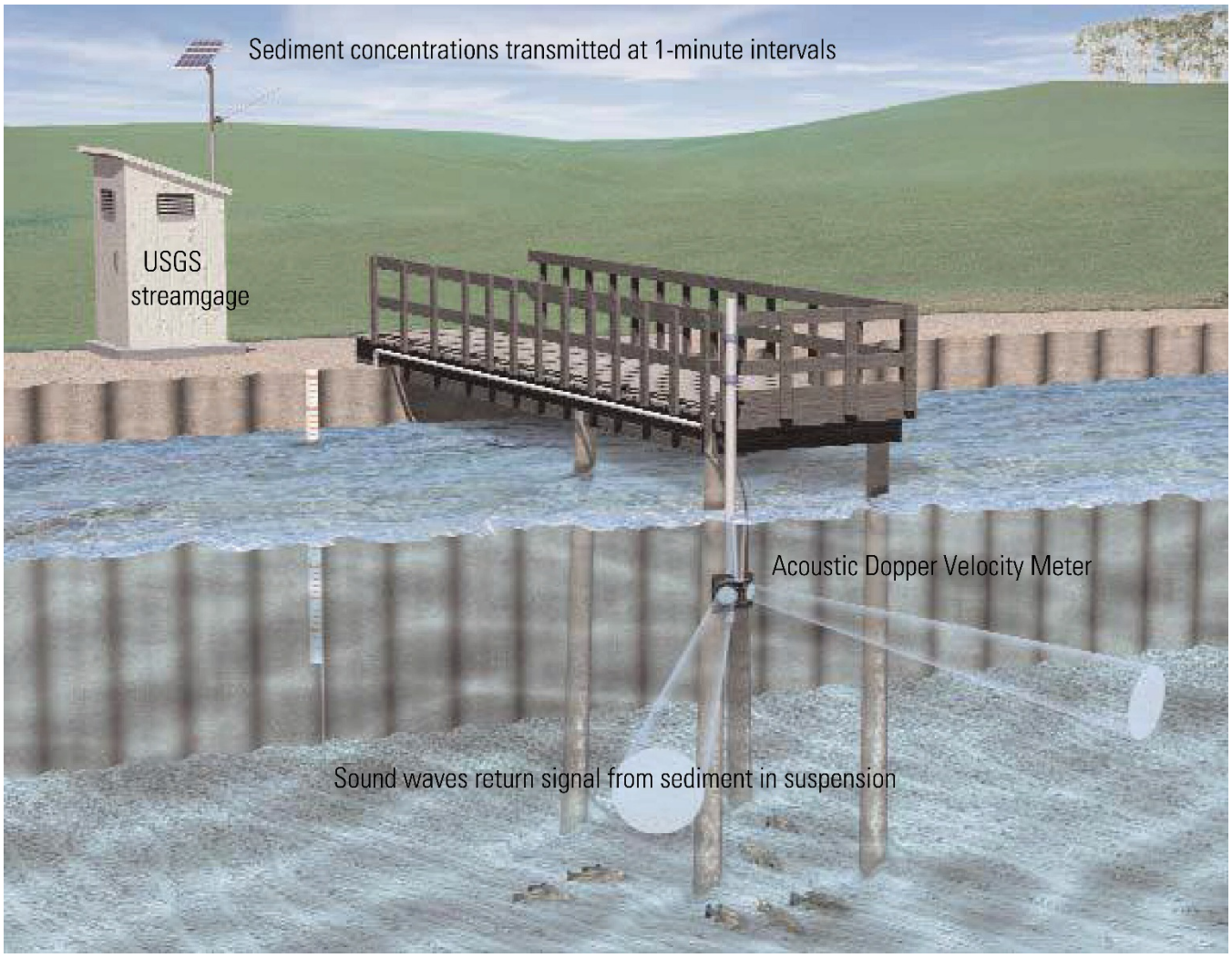


Figure 1. Illustration of acoustic Doppler velocity meter installation.

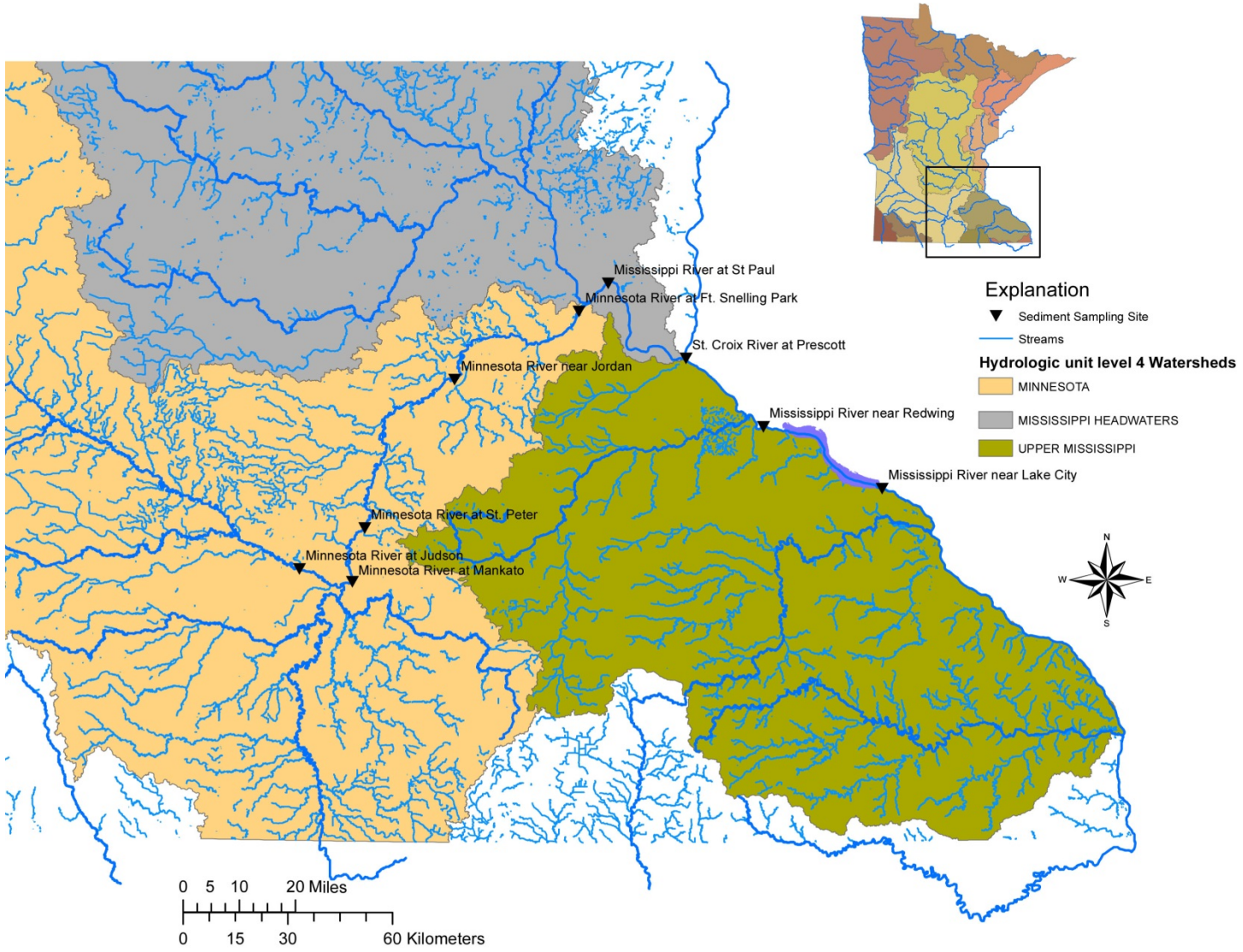
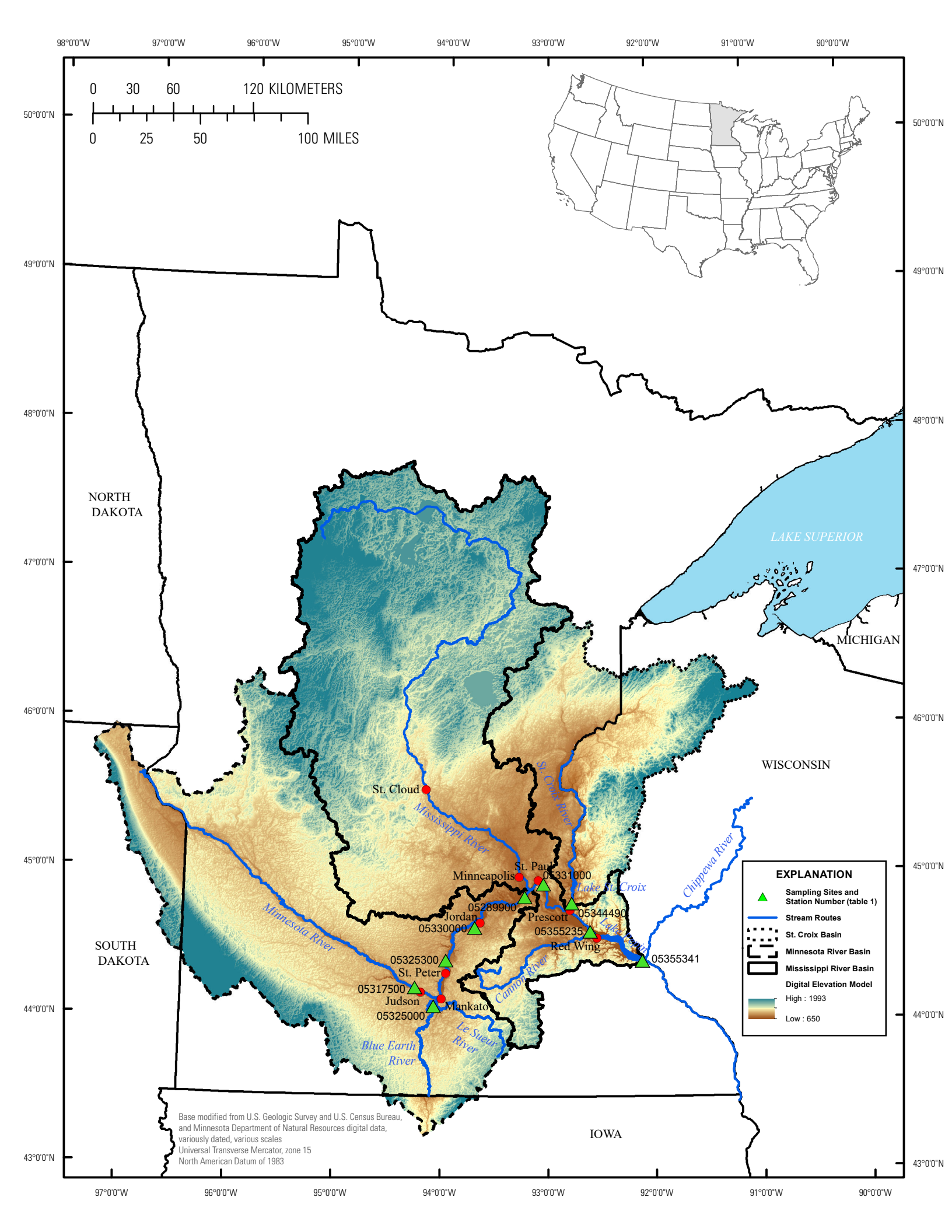


Figure 2. Locations of acoustic Doppler velocity meters on the Minnesota and Mississippi Rivers.

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

Project Title: *Using Hydroacoustics to monitor sediment in Minnesota's Rivers*
Legal Citation: *M.L. 2015, Chp. 76, Sec. 2, Subd. 04g*
Project Manager: *Jeffrey R. Ziegeweid*
Organization: *U.S. Geological Survey*
M.L. 2015 ENRTF Appropriation: **$** *455,000*
Project Length and Completion Date: 4 *Years, December 31, 2018*
Date of Report: *10/03/2018*

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Revised Activity 1 Budget 8/16/2018	Amount Spent	Activity 1 Balance	Revised Activity 2 Budget 8/16/2018	Amount Spent	Activity 2 Balance	Revised TOTAL BUDGET 8/16/2018	TOTAL BALANCE
BUDGET ITEM								
Personnel (Wages and Benefits)	**$242,935.00**	$242,935.00	**$0.00**	**$70,931.76**	$70,931.76	$0.00	**$313,866.76**	**$0.00**
1 USGS Studies Chief, (GS-13): $16,930 (73% salary, 27% benefits); Position at 4% FTE each year for 3 years								
1 USGS Project Chief, (GS-12): $77,938 (80% salary, 20% benefits); Position at 22% FTE each year for 3 years								
1 USGS Hydrologist, (GS-11): $53,076 (73% salary, 27% benefits); Position at 25% FTE each year for 3 years								
2 USGS Hydrologic Technicians, (GS-8): $50,945 (78% salary, 22% benefits); Position at 21% FTE each year for 3 years								
1 USGS Hydrologic Technician, (GS-5): $22,079 (83% salary, 17% benefits); Position at 18% FTE each year for 3 years								
2 USGS Surface Water/Water Quality Specialists (GS-13): $38,092 (77% salary, 23% benefits); Position at 4% FTE each year for 3 years								
2 Database/IT Support Specialists (GS-12): $31,808 (73% salary, 27% benefits); Position at 4% FTE each year for 3 years								
2 Admin Support, (GS-9): $22,999 (70% salary, 30% benefits); Position at 8% FTE each year for 3 years								
Professional/Technical/Service Contracts								
Sediment samples laboratory analyses: USGS Iowa sediment laboratory, 180 total samples at $52.52 each and 180 samples at $17.86 each = $12,673.21	$12,673.21	$12,673.21	**$0.00**	$0.00	$0.00	$0.00	**$12,673.21**	**$0.00**
Boat: $100/day - installation and maintenance of ADVMs; field sampling at Ft. Snelling and site below Lake Pepin; ADVM installations sediment sampling at Ft. Snelling Park and Lake Pepin site; maintenance of ADVMs 2 times per year at 4 sites.	$3,839.60	$3,839.60	**$0.00**	$0.00	$0.00	$0.00	**$3,839.60**	**$0.00**
Equipment/Tools/Supplies	**$56,311.82**	$56,311.82	**$0.00**	$0.00	$0.00	$0.00	**$56,311.82**	**$0.00**
ADVM cable, powers ADVM and transmits ADVM data, 5 cables at $1,720 each.								
Weatherproof enclosures, 4 each, protect and secure electronic dataloggers, data transmission equipment, $700 each.								
Electronic voltage conditioner, protects ADVM against voltage spikes, 6 at $245.50.								
RadioLink - DAA H-424-MS-SDI-12, 6 each, used to transmit ADVM data, $1495 each.								
Solar Panel, 4 100-watt panels ($164 each) and 4 cables ($41).								
Alkaline battery pack, SonTek; used to power ADVM, 10 batteries at $225 each.								
Sutron SAT2-V2 w/GOES HDR, Enclosure, USB, Datalogger and data transmitter for ADVM at site below Lake Pepin, 1 each, $3,500 each.								
Antenna, Yagi for GOES transmitter, $292 each.								
Canal Mounting system, used to deploy ADVM at site below Lake Pepin on side of river bank, 35 feet, $4,350.								
Miscellaneous supplies, H-beams, bolts, flanges, concrete, forms, liquitite conduit, wood posts, earth anchors, metal plates, pipes, etc.Total = $23,236.82.								
Capital Expenditures Over $5,000								
Acoustic Doppler Velocity Meter (ADVM) , SonTek SL1500, 4 each, used to collect acoustic backscatter to relate to sediment samples; $10,343 each.	$41,372.00	$41,372.00	**$0.00**	$0.00	$0.00	$0.00	**$41,372.00**	**$0.00**
1 D-96 Sediment Sampler, used for sampling large rivers with velocities >10ft/sec and depths > 15ft, $6,122.	$6,122.00	$6,122.00	**$0.00**	$0.00	$0.00	$0.00	**$6,122.00**	**$0.00**
Travel expenses in Minnesota			**$0.00**			$0.00		
Travel to complete installations of ADVM equipment; travel to collect sediment samples and perform periodic maintenance on ADVMs. Mileage: $3,019; lodging: $2,520; meals: $3200.	**$9,142.32**	$9,142.32	**$0.00**	$0.00	$0.00	$0.00	**$9,142.32**	**$0.00**
Other			**$0.00**			$0.00	**$0.00**	
Overtime: Compensation for field technicians during extended time needed to collect data during high flow events; determined to be more cost-effective as compared to terminating field sampling after an 8-hour day during high flows, $14,226.91.	$11,035.79	$11,035.79	**$0.00**	$0.00	$0.00	$0.00	**$11,035.79**	**$0.00**
Shipping: $1,000 for shipping equipment from vendors	$636.50	$636.50	**$0.00**	$0.00	$0.00	$0.00	**$636.50**	**$0.00**
COLUMN TOTAL	**$384,068.24**	**$384,068.24**	**$0.00**	**$70,931.76**	**$70,931.76**	**$0.00**	**$455,000.00**	**$0.00**


0 30 60 120 KILOMETERS
0 25 50 100 MILES
98°0'0"W
97°0'0"W
96°0'0"W
95°0'0"W
94°0'0"W
93°0'0"W
92°0'0"W
91°0'0"W
90°0'0"W
50°0'0"N
49°0'0"N
48°0'0"N
47°0'0"N
46°0'0"N
45°0'0"N
44°0'0"N
43°0'0"N
NORTH DAKOTA
SOUTH DAKOTA
MICHIGAN
WISCONSIN
IOWA
LAKE SUPERIOR
St. Cloud
Minneapolis
St. Paul
05331000
05289900
Jordan
05330000
Prescott
05344490
05355235
Red Wing
05355341
05325300
St. Peter
05317500
Judson
Mankato
05325000
Mississippi River
St. Croix River
Lake St. Croix
Chippewa River
Minnesota River
Cannon River
Le Sueur River
Blue Earth River
EXPLANATION
Sampling Sites and Station Number (table 1)
Stream Routes
St. Croix Basin
Minnesota River Basin
Mississippi River Basin
Digital Elevation Model
High : 1993
Low : 650
Base modified from U.S. Geologic Survey and U.S. Census Bureau, and Minnesota Department of Natural Resources digital data, variously dated, various scales
Universal Transverse Mercator, zone 15
North American Datum of 1983