Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2016 Work Plan

Date of Report: May 29, 2016

Date of Next Status Update Report: January 30, 2016

Date of Work Plan Approval: June 7, 2016

Project Completion Date: June 30, 2019

Does this submission include an amendment request?

PROJECT TITLE: Assessing Effectiveness of Wetland Restorations for Improved Water Quality

Project Manager: Jacques Finlay

Organization: University of Minnesota

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Location: Becker County, Big Stone County, Douglas County, Grant County, Lac Qui Parle County, Lyon County, Mahnomen County, Otter Tail County, Pope County, Swift County, Todd County.

Total ENRTF Project Budget:		
	ENRTF Appropriation:	**$420,000**
	Amount Spent:	**$0**
	Balance:	**$420,000**

Legal Citation: M.L. 2016, Chp. 186, Sec. 2, Subd. 04u

Appropriation Language:
$420,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to quantify the environmental benefits of sediment removal and native plant communities in wetland restorations by measuring resulting reductions in nitrogen and phosphorus delivery to groundwater and surface water. This appropriation is available until June 30, 2019, by which time the project must be completed and final products delivered.

I. PROJECT TITLE: Assessing wetland restorations for improved water quality

II. PROJECT STATEMENT:

Wetland restoration is a priority for improving environmental services in Minnesota, but the methods to achieve the widest benefit for the least cost are unclear. A key unanswered question is whether wetland restoration practices designed to improve waterfowl habitat by restoring native plant communities also provide benefits to water quality. This question is of considerable concern, since restoration and management practices are costly and may limit the ability of managers to accept additional wetland restoration projects. We will assess the benefits of two specific restoration and management activities - sediment removal and native plant management - by quantifying and comparing the amount of nitrogen (N) and phosphorus (P) that are stored in wetland basins and removed from surface waters as they percolate through wetlands into the ground water supply.

Between 1850 and 1980, about 80% of Minnesota's prairie pothole wetlands were drained for agriculture. Temporary and seasonal (hereafter seasonal) wetlands were particularly vulnerable because they are local depressions that do not remain wet throughout the entire growing season, but fill and slowly drain into the groundwater supply following rainfall events. These seasonal wetlands are thought to be particularly valuable habitat for breeding and rearing waterfowl, flood water retention, and excess nutrient storage and removal. Over time, these wetland basins fill with topsoil eroded from the surrounding landscape, burying native plant seeds in the relic wetland soils. Eroded topsoil accumulation decreases the volume of water held in wetland basins and the duration of time that the water can be held on the landscape. Furthermore, the accumulated sediment may alter the availability of nitrogen (N) and phosphorus (P) in the soil which can influence the rates of microbial activity and subsequent nutrient burial or removal.

One strategy used to restore agricultural wetlands is to excavate the accumulated sediment – exposing buried, relic wetland soils – prior to restoring the water supply. After sediment excavation native wetland plants quickly re-establish, but invasive hybrid cattail (*Typha x glauca*) and reed canary grass (*Phalaris arundinacea*) regularly invade the restored basins and outcompete native vegetation. These invasive plants form dense monocultures that provide very little food and cover for waterfowl. In addition, the root systems of native and invasive plants can be drastically different from one another. Native plants tend to have robust root systems with many fine roots, while cattail and reed canary grass have shallow root systems with fewer, larger roots. The robust root systems of native plant species may provide increased surface area and habitat for microbially mediated nitrogen removal. Our goal is to understand how water quality is influenced by wetland restoration practices and the resulting plant communities.

Through the Partners for Fish and Wildlife Program, the United States Fish and Wildlife Service (USFWS) is engaged in an adaptive management project characterized by a series of wetland restorations with and without accumulated sediment removal. The goal of sediment excavation is to restore the original hydrologic regime of the basin, increase water storage potential, and expose wetland soils and the associated native plant community, thereby increasing the probability of restoring high quality waterfowl habitat and increasing nutrient removal from surface and groundwater. We will survey approximately 50 wetlands between 0.1 and 3 acres in size that were restored by the USFWS in the last 5 years in western Minnesota. Accumulated sediment was excavated and removed in half of the wetlands. We will measure how much N and P is stored in the wetland basin and removed from surface water as it percolates into the groundwater supply. We will calculate differences in nutrient removal in wetlands with and without sediment excavation. In addition, we will examine whether native wetland plants increase the rate of nitrogen removal compared to invasive plants. This project will provide valuable quantitative information that will directly influence wetland restoration and management decisions in Minnesota.

III. OVERALL PROJECT STATUS UPDATES:

Project Status as of December 2016:

Project Status as of June 2017:

Project Status as of December 2017:

Project Status as of June 2018:

Project Status as of December 2018:

Overall Project Outcomes and Results:

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Quantifying rates of nitrogen removal from groundwater in restored wetlands

Description: Comparing nitrogen storage and removal in restored wetlands with and without accumulated sediment requires an understanding of the movement of nutrient between different pools. In order to evaluate nitrogen dynamics, we will consider 4 major processes and the associated factors that influence nitrogen retention in wetlands:

A. Nitrogen storage in wetland soils and sediments,
B. Permanent nitrogen removal via denitrification,
C. Nitrogen uptake by emergent macrophytes, and
D. Nitrogen transport from ponded surface water to the shallow aquifer.

To measure nitrogen storage in soils and sediments, we will use elemental analysis to quantify nitrogen and carbon content of accumulated sediment and wetland soils. These values will be scaled to nutrient per volume of soil using measurements of soil bulk density. The nutrient content of soil can be used to calculate the quantity of nutrient contained in accumulated sediments removed during wetland restoration and the potential for nutrient storage in wetland basins.

Permanent nitrogen removal will be measured using assays designed to quantify denitrification rates and the factors that regulate nitrogen removal. We will compare measurements of denitrification potential and soil characteristics that are known to influence denitrification rates at sites with and without accumulated sediment. We will pair denitrification rates with measurements of the duration of saturation made using shallow groundwater wells to quantify the role of sediment removal on permanent nitrogen removal in restored wetlands throughout the growing season.

To examine temporary nutrient storage in emergent macrophytes, we will measure nitrogen assimilation and fate in plant tissues. We will quantify temporary nitrogen storage in aboveground and belowground biomass using elemental analysis of nitrogen and carbon. We will pair these measurements with traditional plant surveys and productivity measurements to calculate the nutrient storage by plants per unit area. In particular, we will compare the nutrient storage capacity of invasive plant species, including cattail (*Typha species*) and reed canary grass (*Phalaris arundinacea*) with native plant species including sedges, rushes, and forbs.

Nitrogen transport to shallow groundwater will be quantified by comparing measurements of nutrient concentration in surface and groundwater at periods of groundwater recharge. Ammonium and nitrate concentrations in water samples will be measured using the phenol hypochlorite and cadmium reduction methods, respectively. Dissolved nutrient concentrations will be paired with sediment temperature profiles to estimate the quantity of nutrient flowing from surface to shallow groundwater supplies in wetland basins. We will compare nutrient export from wetlands in basins with and without accumulated sediment and basins with and without native wetland plant communities.

Summary Budget Information for Activity 1:	**ENRTF Budget:**	**$ 303,000**
	Amount Spent:	**$ 0**
	Balance:	**$ 303,000**

Outcome	Completion Date
1. Measure nutrient concentrations in the accumulated sediment and soils from wetland basins with sediment removed, and evaluate nitrogen retention.	June 2018
2. Measure denitrification in wetlands with and without accumulated sediments.	June 2019
3. Collect emergent macrophyte samples for nutrient analysis, and analyze nutrient content in aboveground and belowground biomass.	June 2019
4. Install instrumentation to measure nutrient transfer from surface to shallow groundwater.	December 2017
5. Compare surface water and groundwater nitrogen concentrations at wetlands with and without accumulated sediments and native plant communities.	June 2019

Activity Status as of December 2016:

Activity Status as of June 2017:

Activity Status as of December 2017:

Activity Status as of June 2018:

Activity Status as of December 2018:

Final Report Summary:

ACTIVITY 2: Quantify phosphorus capture and burial in wetland basins

Description: Comparing phosphorus storage and removal in restored wetlands with and without accumulated sediment requires an understanding of the movement of nutrient between different pools. In order to evaluate phosphorus dynamics, we will consider 3 major processes and the associated factors that influence phosphorus retention in wetlands:

A. Phosphorus storage in wetland soils and sediments,
B. Phosphorus uptake by emergent macrophytes, and
C. Phosphorus transport from ponded surface water to the shallow aquifer.

We will use total and particulate phosphorus analyses to quantify phosphorus content in accumulated sediment and wetland soils. These values will be scaled to nutrient per volume of soil using measurements of soil bulk density. The nutrient content of soil can be used to calculate the quantity of nutrient contained in accumulated sediments removed during wetland restoration and the potential for nutrient storage in wetland basins.

To examine temporary nutrient storage in emergent macrophytes, we will measure phosphorus assimilation and fate in plant tissues. We will quantify temporary phosphorus storage in aboveground and belowground biomass using total and particulate phosphorus analyses. We will pair these measurements with traditional plant surveys and productivity measurements to calculate the nutrient storage by plants per unit area. In particular, we will compare the nutrient storage capacity of invasive with native plant species.

Phosphorus transport to shallow groundwater will be quantified by comparing measurements of nutrient concentration in surface and groundwater at periods of groundwater recharge. Soluble reactive phosphorus concentrations in water samples will be measured using the ascorbic acid method. Dissolved nutrient concentrations will be paired with sediment temperature profiles to estimate the quantity of nutrient flowing from surface to shallow groundwater supplies in wetland basins. We will compare nutrient export from wetlands in basins with and without accumulated sediment and basins with and without native wetland plant communities.

Summary Budget Information for Activity 2: **ENRTF Budget: $ 115,000**

Amount Spent: $ 0
Balance: $ 115,000

Outcome	Completion Date
1. Measure nutrient concentrations in the accumulated sediment and soils from wetland basins with sediment removed, and evaluate phosphorus retention.	June 2017
2. Collect emergent macrophyte samples for nutrient analysis, and analyze nutrient content in aboveground and belowground biomass.	June 2019
3. Compare surface water and groundwater phosphorus concentration at wetlands with and without accumulated sediments and native plant communities.	June 2019

Activity Status as of December 2016:

Activity Status as of June 2017:

Activity Status as of December 2017:

Activity Status as of June 2018:

Activity Status as of December 2018:

Final Report Summary:

ACTIVITY 3: Dissemination of results

Description: We will report our results to the public through several avenues. We will participate in outreach events at the West Central Research and Outreach Center in Morris, MN. In addition we will create a fact sheet for distribution through the University of Minnesota Extension service. In addition, we will submit manuscripts reporting our results to high impact peer reviewed journals. Finally, we will provide a comprehensive report of our results and analyses to the LCCMR.

Summary Budget Information for Activity 3:
ENRTF Budget: $ 2,000
Amount Spent: $ 0
Balance: $ 2,000

Outcome	Completion Date
1. West Central Research and Outreach Center presentation.	June 2019
2. Manuscript preparation for publication in notable peer reviewed journals, at least 1 informational flyer, and a final report of results.	June 2019
3. Poster presentations by undergraduate students.	May 2019

Activity Status as of December 2016:

Activity Status as of June 2017:

Activity Status as of December 2017:

Activity Status as of June 2018:

Activity Status as of December 2018:

Final Report Summary:

V. DISSEMINATION:

Description: We will submit our results for publication in peer-reviewed journals, and we will present our work at state meetings (e.g., Minnesota Chapter of the Wildlife Society, Minnesota Water Resources Conference) frequented by natural resource management officials. Through our close collaboration with the United States Fish and Wildlife Service, we will inform current management practices in Minnesota. In addition, we will foster relationships with the Minnesota Department of Natural Resources and the Minnesota Pollution Control Agency. We will work with the West Central Research and Outreach Center, affiliated with the University of Minnesota, to present our results to the public and provide informational flyers about wetlands in water quality. Finally, we will provide a comprehensive report of results and analyses from this project to the LCCMR by June 2019.

Status as of December 2016:

Status as of June 2017:

Status as of December 2017:

Status as of June 2018:

Status as of December 2018:

Final Report Summary:

VI. PROJECT BUDGET SUMMARY:

A. ENRTF Budget Overview:

Budget Category	$ Amount	Overview Explanation
Personnel:	$ 313,000	• Project Coordinator, 4% time for 3 years, 75% salary, 25% benefits [$21,000]. • Project Collaborator, 4% time for 3 years, 75% salary, 25% benefits [$23,000]. • Graduate Research Assistant, 50% time for 3 years, 51% salary, 49% benefits during academic year; 85% salary, 15% benefits during summer [$142,000]. • 3 Undergraduate Students, 44% time for 3 years, 100% salary, 0% benefits [$73,000]. • Lab Technician for 3 years, 23% time, 78% salary, 22% benefits [$21,000]. • Junior Scientist, 25% time for 3 years, 78% salary, 22% benefits [$33,000].
Equipment/Tools/Supplies:	$47,000	• Sample collection and preservation supplies including polycarbonate tubes and caps, survey stakes, polycarbonate bottles, capsule and glass fiber filters, geopump, sieves, waders, etcetera [$8,500]. • Sample preparation supplies including laboratory tape, 60 mL syringes, aluminum weighing dishes, centrifuge tubes, grinders for soils, and chemicals for nutrient extractions and analyses [$8,000]. • Supplies to construct and deploy piezometers, temperature sensors, and water level meters including buckets, garden

		hose fittings, PVC tubing and fittings, sign posts, bentonite clay, fiberglass cloth, hole digger and auger, etcetera [$6,000]. • Field denitrification assay supplies including incubation bottles and caps, pipettes, portable scale, and shaker table [$7,000]. • Bead bath for hot water extractions [$1,500]. • Sample dryer for soils and vegetation [$4,000]. • 20 water level loggers ($300 each) [$6,000]. • 100 temperature loggers ($60 each) [$6,000].
Printing:	$2,000	• Printing posters and educational brochures for outreach activities [$2,000].
Travel Expenses in MN:	$23,000	• University of Minnesota vehicle rental (3 months, $775 per month for 3 years) and fuel reimbursement for travel to and from Fergus Falls wetland management district and select sites (approx. 500 miles per week, 12 weeks per year, 3 years, $0.23 per mile) [approx. $11,120]. • Travel reimbursement for fuel used while traveling to and from the Fergus Falls, Morris, and Detroit Lakes wetland management offices (approx. 360 miles per week, 18 weeks per year, 3 years, $0.575 per mile) [approx. $11,180]. • Camping fees while working out of the Morris wetland management office ($15 per night, 2 sites per night, 8 nights per year, 3 years) [approx. $720].
Other:	$35,000	• Sample analysis processing fees; plant tissue and soil elemental analysis ($6/sample, 300-400 samples total), dissolved organic carbon analysis ($2.59/sample, 1000-1300 samples total), dissolved phosphorus analysis ($11.40/sample, 1300-1400 samples total), particulate phosphorus analysis ($11.40/sample, 200-300 samples total), and dissolved inorganic nitrogen analysis ($12.24/sample, 1000-1100 samples total) [$35,000].
TOTAL ENRTF BUDGET:	**$420,000**	

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: 8.5 FTE

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			
University of Minnesota (In-kind services)	$187,000	$0	Indirect costs, lab space, electricity, et cetera.
TOTAL OTHER FUNDS:	**$187,000**	**$0**	

VII. PROJECT STRATEGY:

A. Project Partners:

Project Partners Receiving Funds:

- Dr. Jacques Finlay (Project Manager; University of Minnesota): $397,000 for to oversee data acquisition, sample processing, and overall project management.
- Dr. James Cotner (Collaborator; University of Minnesota): $23,000 for sample processing.

Project Partners Not Receiving Funds:

- Sheldon Myerchin (Collaborator; USFWS): coordinating in-kind support from USFWS.
- Shawn Papon (Collaborator; USFWS)
- Dr. Chip Small (Collaborator; University of St. Thomas): providing logistical and technical support for denitrification assays and access to membrane inlet mass spectrometer.

B. Project Impact and Long-term Strategy: This research will inform land management decisions by providing valuable data about how wetland restoration practices and invasive plant species influence water quality in the state of Minnesota. Specifically, the USFWS will use the data to inform on-the-ground restoration and management decisions. In addition, we will take the initiative to share our results with Minnesota state agencies whenever possible, and public presentations of our results will be designed to reach as many of Minnesota's natural resource management professionals as possible.

C. Funding History:

Funding Source and Use of Funds	Funding Timeframe	$ Amount
University of Minnesota	June 1, 2015 – October 31, 2015	$8,100
United States Fish and Wildlife Service (In-kind support)	June 1, 2015 – August 31, 2015	$3,445
United States Fish and Wildlife Services (wetland restorations: values are based on historical average restoration cost per acre, and assuming each restoration is approximately an acre in size).	June 1, 2011 – August 31, 2015	$37,500

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 figure.

X. RESEARCH ADDENDUM: See attached research addendum.

XI. REPORTING REQUIREMENTS:

Periodic work plan status update reports will be submitted no later than December 30, 2016; June 30, 2017; December 30, 2017; June 30, 2018; and December 30, 2018. A final report and associated products will be submitted between June 30 and August 15, 2019.

Environment and Natural Resources Trust Fund
M.L. 2016 Project Budget
Project Title: Assessing Effectiveness of Wetland Restorations for Improved Water Quality
Legal Citation: M.L. 2016, Chp. 186, Sec. 2, Subd. 04u
Project Manager: Jacques Finlay
Organization: University of Minnesota
M.L. 2016 ENRTF Appropriation: **$**420,000
Project Length and Completion Date: 3 Years, June 30, 2019
Date of Report: May 29, 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 BALANCE
BUDGET ITEM	Quantifying rates of nitrogen removal from groundwater in restored wetlands			Quantify phosphorus capture and burial in wetland basins			Dissemination of results			
Personnel (Wages and Benefits)	$230,000			$83,000			$0			$313,000
Jacques Finlay, Project Manager: $21,000 (75% salary, 25% benefits): 4% FTE each year for 3 years.										
James Cotner, Project Collaborator: $23,000 (75% salary, 25% benefits): 4% FTE each year for 3 years.										
1 Graduate Research Assistant: $142,000 (51% salary, 49% benefits during academic year; 85% salary, 15% benefits during summer): 50% FTE each year for 3 years.										
3 Undergraduate Research Assistant: $73,000 (100% salary, 0% benefits): 44% FTE each year for 3 years.										
1 Laboratory Technician: $21,000 (78% salary, 22% benefits): 23% FTE each year for 3 years.										
1 Junior Scientist: $33,000 (78% salary, 22% benefits): 25% FTE each year for 3 years.										
Equipment/Tools/Supplies	$42,000			$5,000			$0			$47,000
Sample Collection and Preservation Supplies. Samples include soils (e.g., 100 polycarbonate plastic core tubes and caps, 2 sieves, plastic bags), vegetation (e.g., 1 - 200 meter field measuring tape, 15 survey stakes, 2 hedge shears, 1 shovel, plastic bags), surface and ground water (e.g., 1400 - 60 mL polycarbonate bottles, 300 capsule filters, 1000 glass fiber filters, 5 packs water resistant labels, 1 geopump for collecting water from piezometers, dry ice for storage and transport), and personal protective gear for field assistants (e.g., 3 pair of waders) [$8500 total].										
Sample Preparation Supplies including laboratory tape (15 rolls), 60 mL syringes (200 syringes), aluminum weighing dishes (5000 dishes), coffee grinder for soil and vegetation (3 grinders), 50 mL centrifuge tubes (500 tubes), chemicals for ammonium, nitrate, and phosphorus analyses and extractions, et cetera [$8000 total].										

Hydrology Monitoring Meter Construction, Housings, and Deployment Supplies including 5 gallon buckets (30 buckets), garden hose fittings (30 fittings), 1 plastic graduated cylinder, PVC tubing and fittings (for 20 water level loggers), sign posts (70 posts), bentonite clay (approx. 50 lbs.), sand (approx. 100 lbs.), fiberglass cloth), 1 hole digger, 1 hole digger auger, et cetera. [$6000 total].										
Field Denitrification Assay Supplies including incubation bottles (192 @ $476/48 bottles) and caps (200 @ $144/100 caps), pipettes (6 @ $280/pipette), portable scale ($325), and shaker table ($2600) [$7000 total].										
20 Water Level Loggers ($300 each; $6000 total)										
100 Temperature Loggers ($60 each; $6000 total)										
Sample Dryer for soils and vegetation [1 unit; $4000].										
Bead Bath for sample extractions [1 unit; $1500].										
Printing	$0			$0			$2,000			$2,000
Posters for presentations of research results ($80 per poster, 3 undergraduate and 1 graduate poster per year, 3 years) [$960 total].										
Educational brochure for outreach activities (500 brochures at $140 per 100) [$700 total].										
Travel expenses in Minnesota	$15,000			$8,000			$0			$23,000
University vehicle rental (3 months, $775 per month for 3 years) and fuel reimbursement for travel to wetland management office and select sites (approx. 500 miles per week, 12 weeks per year, 3 years, $0.23 per mile) [$11,120 total].										
Travel reimbursement for personal vehicle use by graduate student (approx. 360 miles per week, 18 weeks per year, 3 years, $0.575 per mile) [$11,180 total].										
Camping Fees for Sites in the Morris Wetland Management District ($15 per night, 2 sites per night, 8 nights per year, 3 years) [$720 total].										
Other	$16,000			$19,000			$0			$35,000
Sample processing and analyses including plant tissue and soil elemental analysis ($6/sample, 300-400 samples total), dissolved organic carbon ($2.59/sample, 1000-1300 samples total), dissolved phosphorus ($11.40/sample, 1300-1400 samples total), particulate phosphorus ($11.40/sample, 200-300 samples total), and dissolved inorganic nitrogen analysis ($12.24/sample, 1000-1100 samples total) [$35,000 total].										
COLUMN TOTAL	**$303,000**			**$115,000**			**$2,000**			**$420,000**