

M.L. 2014 Project Abstract

For the Period Ending June 30, 2018

PROJECT TITLE: Nutrient Capture through Water Management and Biomass Harvesting

PROJECT MANAGER: Leah Thvedt

AFFILIATION: Red River Basin Commission

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FUNDING SOURCE: Environment and Natural Resources Trust Fund

LEGAL CITATION: M.L. 2014, Chp. 226, Sec. 2, Subd. 06h as extended M.L. 2017, Chapter 96, Section 2, Subdivision 18

APPROPRIATION AMOUNT: \$300,000

AMOUNT SPENT: \$279,577

AMOUNT REMAINING: \$20,423

Overall Project Outcome and Results

This project evaluated the potential for capturing nutrient runoff from nonpoint sources by utilizing cattails or other vegetation within existing shallow flood storage reservoirs. Utilizing the North Ottawa (NO) Project in the Bois de Sioux Watershed District(BDS). Over 80% of the phosphorus and nitrogen (nutrient) loads that are being discharged downstream are coming from nonpoint runoff mostly from agricultural fields. This project developed and evaluated a new methodology for capturing and reducing the nutrient loads coming off agricultural dominated watersheds. This technique provides a new and effective "tool" for addressing nutrient reductions.

The project provides water quality improvements downstream of the impoundment which is then passed on to the rivers and streams of this project including the Red River. As the desire for reductions in phosphorus and nitrogen have led to increased regulation in the state of Minnesota these types of projects will only assist in meeting these regulations and offering another layer of reduction. The data that has been collected is submitted to EQUIS.

The desired outcome is to capture and remove 50- 100 percent of the phosphorus and nitrogen nutrients found in surface drainage water from the 75 square mile agricultural watershed above the North Ottawa flood impoundment. The interior dikes were constructed for the management of water within the 1920 acre impoundment in 160 acre treatment cells. The four-160 acre Pool B cells will give us the ability to hold water for differing time periods and to manage vegetation differently within these cells to maximize nutrient capture.

In 2016, the RRBC harvested cattail biomass from the NO Impoundment and utilized the harvested material as a green manure on agricultural land within the upstream drainage area. Using conventional forage chopping equipment resulted in a 4.76 tons per acre biomass yield. Nutrient analysis of the harvested biomass equated to 48 lbs. nitrogen and 6.6 lbs. phosphorus captured per acre harvested (10 acres) resulting in 480 lbs of Nitrogen and 66 lbs of Phosphorus removed from the system . By scaling up the harvesting, capture and removal of 50 - 100 percent of the phosphorus and nitrogen nutrients is feasible.

Ongoing monitoring is critical to and allows an accurate determination of when nutrients are entering the impoundment and how to manage water levels to optimize water quality benefits. Management strategies included drawdown timing and velocity, water retention time for settling nutrients, and optimizing vegetation for nutrient reduction.

Project Results Use and Dissemination

The goals and outcomes of this project continue to be presented and shared at most events in the Red River Basin. The RRBC is presently working closely with the Bois de Sioux Watershed District Managers and Administrative staff to provide all the information and outcomes from the work being done at their North Ottawa Impoundment. The BDS has established a project team specific to this effort to look at future tasks and work that could be evaluated at the impoundment site.

The marketing materials, handouts and videos produced will be distributed as a part of our larger basin outreach strategy. These materials will also be showcased at our upcoming Ex Officio board meeting and annual conferences. The final documents will also be posted on our website. Manitoba is also doing research with cattail bio mass and nutrient reduction but on a much smaller scale than North Ottawa. They are extremely interested in the results and continued data that will come out of this project. The RRBC and our partners have done more than 5 tours of North Ottawa since the beginning of this project in 2014.

RRBC Staff have presented too many entities as part of the RRBC's larger outreach strategy around the basin about this effort and conclusions and recommendations for the future. We are diligently working to communicate the excellent data that has come out of this effort to other entities to garner future financial support to continue monitoring for the foreseeable future. This would allow an opportunity to understand the system and the uncontrollable variables that impact the functioning of this impoundment and how that translates into water quality benefits. It will also speak to the longevity of these types of projects and the life of nutrient capture in impoundments. We will be able to use this information and apply to projects of this nature and hopefully one day be provide quantitative data in proposed retention/detention project cost benefit ratios.



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

Date of Report: August 15, 2018
Date of Next Status Update Report: Final Report
Date of Work Plan Approval: July 1, 2014
Project Completion Date: June 30, 2018
Does this submission include an amendment request? Yes

PROJECT TITLE: Nutrient Capture through Water Management and Biomass Harvesting

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Location: May work on up to 3 sites within the Red River Basin if additional funding can be secured. This funding will be utilized at the North Ottawa Impoundment in Traverse and Grant Counties. See attached maps.

Total ENRTF Project Budget:

ENRTF Appropriation:	\$300,000
Amount Spent:	\$27982,577
Balance:	\$ <u>2017,423</u>

Legal Citation: M.L. 2014, Chp. 226, Sec. 2, Subd. 06h
M.L. 2017, Chapter 96, Section 2, Subdivision 18

Appropriation Language:

\$300,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with the Red River Basin Commission to evaluate the potential capture of excess nutrients using cattails grown and harvested within shallow flood reservoirs for bioenergy use. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.
Carryforward (a) The availability of the appropriations for the following projects are extended to June 30, 2018:
(4) Laws 2014, chapter 226, section 2, subdivision 6, paragraph (h), Nutrient Capture through Water Management and Biomass Harvesting.

I. PROJECT TITLE: Nutrient Capture through Water Management and Biomass Harvesting

II. PROJECT STATEMENT:

This project will evaluate the potential for capturing nutrient runoff from mostly nonpoint sources by utilizing cattails or other vegetation within existing shallow flood storage reservoirs. We plan to look at 3 pilot sites within the Red River Basin including the North Ottawa Project in the Bois de Sioux Watershed District. Over 80% of the phosphorus and nitrogen (nutrient) loads that are being discharged downstream are coming from nonpoint runoff mostly from agricultural fields. This project will develop and evaluate a new methodology for capturing and reducing the nutrient loads coming off agricultural dominated watersheds. This technique will provide a new and effective “tool” for addressing nutrient reductions.

Within the Red River Basin, a goal of reducing the flood water discharged by 20% has led to the planning and construction of distributed water storage sites throughout the basin. The North Ottawa Impoundment exterior diking was completed in 2011. These storage sites are often shallow, off-channel impoundments where high flows are stored and slowly released. Please see the attached photo and information brochure for further detail. We are planning on utilizing these storage areas by constructing treatment cells within the flood reservoir to grow vegetation for nutrient removal, harvest the vegetation and evaluate the potential utilization of cattails for various beneficial purposes including bioenergy. Attached is a detailed plan sheet of the North Ottawa Impoundment that shows the exterior and planned interior dike system. The RRBC is working with the Bois de Sioux Watershed District to complete the interior dike to construct between two to four 160-acre interior pools where we can manipulate water levels to grow and harvest cattails to capture and remove nutrients (phosphorous and nitrogen) from the system. The system we are constructing will operate similar to a two-stage wastewater treatment pond where we will utilize the existing 640-acre Pool C area as a primary treatment pond. Water will be directed from Pool C to the constructed treatment cells that will as shown on the attachments as the Pool B area on the information brochure that is attached. The system will allow for water holding times to maximize the uptake of nutrients by the cattails in the Pool B area. Water levels within the Pool B areas will be drawn down to facilitate the cattail harvesting within the Pool B areas.

Detailed nutrient monitoring of the waters being discharged from the watershed above the North Ottawa flood reservoir, soils within the pool area, vegetation that will be harvested and removed, and the waters being discharged from the flood reservoir will be completed. This detailed monitoring managed through an automated system installed at the inlet and outlet as recommended by Dr. Joe Magner, will allow us to document the nutrient loads of phosphorous and nitrogen coming into the pool area and the effectiveness of the cattail treatment cells in capturing and reducing nutrients being discharged downstream. Monitoring work is proposed to be designed and coordinated by Dr. Joe Magner U of MN-St. Paul as a research project with one or more graduate students.

This project will also evaluate potential utilization of the cattails harvested for several different purposes. We will evaluate the value of cattails harvested being applied back to cropland as a type of “green manure”. We will evaluate the nutrient content of the cattails as well as look at the benefits of adding additional organic material to enhance soil health. We will also work with Dr. Dan Svedarsky U of MN-Crookston to look at potential utilization of cattail biomass for energy and other purposes. An economic evaluation of potential uses will be completed with Dr. David Ripplinger NDSU Fargo.

The overall project outcome is to capture and remove 50- 100 percent of the phosphorus and nitrogen nutrients found in surface drainage water from the 75 square mile agricultural watershed above the North Ottawa flood impoundment. Based on work completed in Manitoba we can expect to remove between 10 – 20 pounds of phosphorus for each acre of cattails harvested. We plan to construct a minimum of two and up to four 160-acre treatment cells which will divert all runoff from the watershed through these treatment cells. We will grow aquatic vegetative plants in these cells that will be harvested and removed as the main method of nutrient capture with phosphorous as the targeted nutrient. These treatment cells have the potential to capture up to

100% of the average phosphorus load from the 75 square mile watershed above the North Ottawa Impoundment. The cattail biomass harvested will be used for various purposes. Some of the cattails will be reapplied to cropland thus recycling the phosphorus back within the watershed. The amount of phosphorus removed as well as the amount of nitrogen captured will be documented and a detailed nutrient budget will be prepared.

III. PROJECT STATUS UPDATES:

Project Status as of *January 1, 2015*:

The design and construction of the interior control structures and diking system is almost complete which will allow for the operation of individual treatment cells within the impoundment. The bid that the Bois de Sioux Watershed District awarded for this portion of the project was well under their estimated costs, potentially allowing for a future amendment request. RRBC continues to work with various partners including Dan Svedarsky, to coordinate cattail work which is currently being completed. We held a “cattail summit” hosted by Dr. Svedarsky at the University of Minnesota-Crookston. This summit will be held quarterly.

RRBC was awarded a small EPA 319 grant that was used to do some of the early soil, vegetation and water sampling work. Water sampling at the inlet, within the impoundment and at the outfalls was started on a limited basis the past season. First year sample results were very encouraging for nutrient (see attachment for water quality parameters considered in this project) capture currently occurring at the impoundment. Design for our longer-term monitoring system was completed with Dr. Joe Magner. The water sampling equipment will be ordered and installed prior to spring runoff. All solicitation for equipment requisitions will be coordinated by the Red River Basin commission following organizational procedures through allowable state policies and vendor contracts supported by the state of Minnesota through the Minnesota Pollution Control Agency as approved within EPA 319 and ENRTF project requirements. RRBC was awarded a Bush Foundation Community Innovation Grant that will assist with the outreach work tasks under Activity 5.

The Bois de Sioux Watershed District did go through a selection process for its engineering services. This process resulted in the assignment of a new Engineering firm replacing the District’s past firm (WSN). We will discuss this in greater detail in a future amendment request. The engineering firm of (Widseth, Smith and Nolting (WSN) is working through 2015 to help finalize site work and will remain as the current site based technical services provider as described in our original WP and budget for any spring through fall engineering needs onsite including installation of inlet and outlet equipment.

Amendment Request *January 1, 2015*:

We are requesting to shift \$50,000 from activity 1, “design, redesign & operate North Ottawa Impoundment to Activity 3, Harvesting Cattails (\$10,000) five thousand to expand nutrient analysis work (primarily phosphorous, nitrogen) in the lab to determine if phosphorous and/or nitrogen can be extracted as a liquid or in other forms and used directly as a fertilizer product for agricultural or horticultural purposes and five thousand to support cattail harvesting expenses to include additional staff time and harvest costs which are estimated at \$105. Per acre based on 2014 University of MN custom harvest rates for forage-based harvest, chopping and land application. Activity 4, monitoring (\$40,000) to support our planned deliverable that will “develop detailed monitoring system to track nutrient inputs, outputs and nutrient storage within the impoundment”. The request will support installation of an automated water monitoring system at the impoundment inlet and outlet. The request will support monitoring equipment and supplies to retrofit the current outlet structure and setup the inlet infrastructure and equipment to monitoring flow, dissolved oxygen, temperature, turbidity, barometric pressure and nutrients (phosphorus and nitrogen) from drainage water entering and leaving the impoundment. The dynamics of phosphorous cycling as the basin matures and changes over time requires adjustments to accurately measure phosphorous loading in relation to climate, rainfall and changing agricultural drainage practices. The automated systems at the inlet and outlet enables daily monitoring to collect data necessary for

the impoundment and contributing drainage area. The preliminary costs to retrofit the existing outlet are \$16,425 and estimates to set up the inlet monitoring station are \$23,575. The Bois de Sioux Watershed district utilizes the Storm Central data collection service to manage the existing outlet structures real time data reporting and distribution. The additional equipment will be used to expand the data reported by the watershed district on Storm Central with plans to maintain and use all equipment beyond the grant for its useful life expectancy. The Red River Basin Commission and the University of Minnesota, as a part of long range planning, would like to extend this study (up to 10 years) project to help develop more accurate phosphorous load budgets that reflective of changes over time and will remain as a partner with the watershed district to support equipment maintenance and use. The request comes as a result of the recommendations of Dr. Joe Magner, University of Minnesota who is contracted to develop the monitoring protocols relevant to the success of this project.

Amendment Approved by LCCMR 2/20/2015

Project Status as of July 1, 2015:

The project is on track with intended monitoring outcomes to date. The inlet and outlet automated sampling systems are in place and operating. Two major rain events in May supported testing and collection from the automated (ISCO) sampling systems and the additional funding provided through the MPCA 319 grant supported monitoring from ten additional sites from the upstream drainage area that provides the surface water runoff to the North Ottawa Impoundment. This data is critical in determining the detailed nutrient monitoring of phosphorous and nitrogen sources entering the impoundment. The fill for the interior dike has been hauled in and the cells are constructed but the cells will not be able to be used for water retention and cattail growth until all interior dikes are seeded and ground cover is established. This creates a challenge with using the cells for treatment in 2015 so all evaluation work this growing season will be completed from the larger Pool C retention area. The lack of any spring run-off presented additional challenges as there was no water entering the impoundment that would have been available to divert into treatment cells.

Project Status as of January 1, 2016:

The interior dike work is substantially completed as of January 1, 2016. The seeding and vegetation establishment was completed late in the season but will require additional work in the Spring of 2016. The completion of the interior dike work will allow for the interior pool network to be operated for the first time this season for nutrient capture and natural resource enhancement purposes. This work is approximately one year later than what was anticipated when we began this project. An operating plan has been developed that will allow Red River Basin Commission to utilize two cells of the interior diking network for nutrient capture, one for primary settlement/storage and the other for dissolved nutrient uptake by cattail vegetation. This operating plan differs slightly from the original proposed operation. The original operating plan was going to combine the MDNR moist soils management with the RRBC nutrient capture into the same management cells. The new management plan separates the MDNR management from the RRBC management until the system gets calibrated and we learn more about overall management of this impoundment. The management plan will be dependent on climate and the amount of water we have to work with throughout the growing season. If flooding or drought conditions occur the management plan will be adjusted to best achieve project goals.

Summer 2015 nutrient loading to the impoundment is currently being calculated. The Summer 2015 construction work on the interior dikes resulted in changes to the normal operating plans. We are working on verifying water flow calculations within the impoundment system. Nitrate, Total Nitrogen, Orthophosphate, Total Phosphorus, and Total Suspended Sediment data from 2015 suggest that storage of water in the North Ottawa Impoundment results in lowering the concentration of these nutrients between inflow and outflow water. A detailed nutrient budget will be developed for 2016. Soil samples were also collected from the cells of the impoundment and analyzed for phosphorus content. This was the second round of soil sampling and will help us understand the movement of nutrients within the impoundment area.

The fall 2015 planned harvest of cattails was not completed from the larger Pool C portion of the impoundment as anticipated. The RRBC is planning for the 2016 harvest activities to take place within the approximate 100-acre secondary treatment cell (B4) portion of the impoundment. The harvested cattail will be utilized as green manure on agricultural land within the upstream drainage area.

Amendment Request June 8, 2016:

Based on a review of the project it is anticipated that insufficient funds were allocated to specific salary activities and the line item that included professional/technical/services. As part of this amendment the RRBC is requesting to shift funds within the budget for the project to allow for continued support of project activities. Proposed budget shifts:

1. Shift personnel funds between activities from Monitoring (\$8,000) into Evaluate Potential Use (\$2,000), Harvest Cattails (\$4,000), and Outreach (\$2,000) activities.
2. Shift funds from Equipment/Tools/Supplies (\$4,000) into Professional/Technical/Service Contracts to cover additional anticipated costs for technical assistance from consulting professionals for updating and maintaining sampling equipment.

In November 2015 the RRBC terminated employment with the project manager. Since this project staff change the RRBC executive director has managed the project without seeking compensation. The RRBC is requesting to update personnel information related to project staff to place Aaron Ostlund as project manager for the RRBC. This personnel change includes changes in billable rates but will not result in exceeding any budgeted salary totals.

Amendment Approved by LCCMR 6/10/2015

Project Status as of July 1, 2016:

In the spring of 2016 there was limited to no snow melt within the North Ottawa watershed. This resulted in no measurable spring runoff for the North Ottawa Impoundment to capture. Typically, the spring runoff in this region is significant and requires the impoundment to be drawn down every fall to allow for maximum holding capacity to mitigate spring flooding. The lack of spring runoff resulted in very limited water entering the impoundment until spring rain events in mid-April and early May. These rain events were minor in magnitude and did not result in significant runoff from the watershed. Precipitation for the North Ottawa watershed is approximately 50% below normal rainfall for the region. The onsite rain gauge has measured less than six inches of rain since March 2016. A June 28, 2016 USDA/NOAA Drought Monitoring report lists the entire North Ottawa watershed in a moderate drought.

As a result of limited spring runoff and rain events the RRBC and the MDNR collaborated to discuss options for increasing water flow into the impoundment to allow for minimum management according to the operation plan. It was determined that the MDNR would remove beaver dams from the Mud Lake area of the watershed. This resulted in an elevated base flow into the impoundment as Mud Lake was dropped by around a foot following dam removal. This elevated base flow has allowed both RRBC and MDNR to implement planned management of the interior pools for water quality and biomass harvesting and habitat enhancement as outlined in the operations plan. As of June 2016, the RRBC has been able to hold water in cell A4 for pretreatment and sedimentation and maintain mudflats in cell B4. The B4 cell was intermittently flooded to maintain saturated soils which has allowed for cattail establishment from the natural seed bank present in this region. Cattail establishment within B4 has been the main goal given the limited flow to the impoundment to ensure that future water management at the impoundment will allow for biological uptake of nutrients in this cell. The management plan will continue to be dependent on climate and the amount of water we have to work with throughout the growing season and in future years. If flooding or drought conditions occur the management plan will be adjusted to best achieve project goals.

Monitoring of water entering the impoundment and upstream within the watershed has been ongoing this spring. Sampling gaps identified from 2015 monitoring have been addressed to help develop detailed nutrient loading of the watershed and impoundment. With funds from the MPCA 319 grant we have gathered three rounds of watershed samples following rain events which will continue to help delineate where and how nutrients are flowing from the watershed to the impoundment. The sampling system setup at the inlet to the impoundment is setup to capture rain events resulting in flow to the impoundment as well as collecting base flow samples. This monitoring strategy will allow us to better determine when nutrients are entering the impoundment and how to manage water levels to optimize water quality benefits.

Summer 2015 nutrient loading to the impoundment has been determined using empirical and synthetic methods. The calculation of inflow to the impoundment and outflow from the impoundment required some modeling to complete the load analysis. With the limited data available, loads for 2015 have been calculated using models that average flow and concentration between sampling intervals which may introduce a degree of uncertainty. The calculations indicate a total phosphorus load reduction of 11%; a dissolved orthophosphate reduction of 86% and a Total suspended solids load reduction of 24%. The load calculations for total nitrogen showed an overall export of nitrogen in 2015 of 70%. This may likely be due to the limited sampling conducted during periods of flow into the impoundment which did not capture concentrations of nitrogen frequent enough and during various flow conditions. A Nitrate-Nitrite load reduction of 97% was calculated. These load reduction calculations have allowed us to better design and implement our monitoring initiative to develop the detailed nutrient budgets the project desires.

The RRBC is planning for the 2016 cattail biomass harvest activities to take place within the B4 and C cells of the impoundment. Harvesting activities will target two intervals for biomass collection to determine optimal harvest windows for both nutrient capture and utilization opportunities. The first round of harvested cattail will be utilized as green manure on agricultural land within the upstream drainage area. This will allow for nutrient cycling within the watershed and for potential reductions in fertilizer needs in areas of biomass application. The second round of harvested material will be on a smaller scale to collect cattail biomass at a lower moisture content for identifying utilization opportunities as fiber and bioenergy.

Amendment Request November 10, 2016:

Activity 2 of this project is focused on cattail biomass utilization. We are collaborating with Dr. Svedarsky to evaluate energy potential of cattail biomass. We are also collaborating with Dr. Ripplinger to develop a market analysis of cattail utilization. This collaborative work has resulted in interest to explore promising utilization opportunities beyond bioenergy to further evaluate the potential additional markets that could be developed utilizing this material. To this effort we are proposing to divert half of the original \$20,000 budget for bioenergy investigation to these other opportunities. This amendment request is to add additional contract lines to the grant to allow for contracts to be developed and executed in exploring these additional utilization opportunities. Specifically, the addition of contract lines for biocomposites, fiber, and agricultural amendment utilization investigations for the amounts of \$4,000, \$3,500, and \$2,500 respectively. Contracts will be bid and rewarded in compliance with State of Minnesota Policy.

Amendment Approved by LCCMR 11/21/2016

Project Status as of December 22, 2016 submitted as *January 1, 2017 update*:

During the 2016 season the interior dike network of the North Ottawa Impoundment was utilized for water level management for the first time. The Natural Resource Enhancement Management Plan was implemented that designates the C cell to be the primary storage pool, the A and B cells to be utilized for natural resource management through a moist soils management rotation, and two cells, A4 and B4 for water quality management and biomass harvesting. The RRBC successfully harvested cattail biomass from the North Ottawa Impoundment in the end of August and utilized the harvested material as a green manure on agricultural land

within the upstream drainage area. Harvesting was accomplished using conventional forage chopping equipment and resulted in a 4.76 tons per acre biomass yield. Nutrient analysis of the harvested biomass equated to 48 lbs. nitrogen and 6.6 lbs. phosphorus captured per acre harvested. During this pilot harvest a total of 10 acres were harvested resulting in 480 lbs of Nitrogen and 66 lbs of Phosphorus removed from the system. Given the pilot scale harvest effectiveness at removing nutrients we can estimate that by scaling up the harvesting we could accomplish the overall project outcome to capture and remove 50 - 100 percent of the phosphorus and nitrogen nutrients found in surface drainage water from the 75 square mile agricultural watershed above the North Ottawa flood impoundment. Based on 2015 water quality monitoring we could remove 100% of the nitrogen load into the impoundment by harvesting 375 acres of cattails and 100% of the phosphorus load into the impoundment by harvesting 480 acres of cattails. This scaled up harvesting is well within the possible management of the North Ottawa Impoundment which has a 2,000-acre footprint.

Detailed nutrient monitoring of the inflowing surface waters from the watershed above the North Ottawa Impoundment and water discharged from the impoundment was conducted during the 2016 season. Nutrient loading to the impoundment was minimal during the very dry spring and early summer months. The base flows that were sustained from management of Mud Lake early in the year were relatively low in nutrients. Summer rain events resulted in observed increase nutrient loading to the impoundment. Limited water was exported from the system until the first drawdown in August that was conducted to facilitate harvesting of cattail biomass in the C cell. The remaining water in C cell was then slowly drawn down during October to provide maximum holding capacity for next spring. Nutrient load reductions were calculated for the C cell from quantifying nutrients loads into and out of the C cell. The C cell management produced nutrient load reductions of 27% for total phosphorus, 56% for total nitrogen, and 57% for Total Suspended Solids. Overall load reduction calculations for the impoundment are currently being analyzed. Additional analysis of the 2016 data is being conducted to better understand the trends in loading and how they can affect the capture efficiency of the system. This additional analysis will be included in future updates and in a final report.

Amendment Request December 22, 2016:

The RRBC is requesting an extension of one year for the project to allow for additional biomass harvesting to be conducted again in 2017 as part of the project. Due to missing harvesting opportunities in 2014 and 2015 there is a budgeted balance remaining for these activities. The missed harvests were due primarily to excessive water holding at the North Ottawa Impoundment during 2014, limiting management opportunities, and delayed construction completion dates for interior diking that extended through 2015, limiting harvesting opportunities. We were able to conduct a successful biomass harvest in fall 2016 and learn a lot about effectiveness and efficiency of biomass harvesting. We feel it would benefit the overall understanding of this potential best management practice to apply what we have learned in another round of harvesting in 2017.

To support project time and expenses associated with extending the completion date two additional budget shifts are requested. Shifting \$8,500 from activity 3 under service contract to harvest into activity 3 personnel and an additional \$1,500 from activity 3 under service contract competitive bid to harvest into activity 3 travel expenses. This will allow the RRBC to conduct the additional field work associated with harvesting in 2017 while leaving an adequate balance under the service contract to conduct harvesting.

In addition to this reallocation to support additional harvesting the RRBC will utilize funding from two other grants to supplement costs associated with the project. These additional funds will support ongoing water quality monitoring, biomass analysis and outreach activities for the project.

Amendment Approved by LCCMR 12/28/2016

Extension Amendment Approved: May 30, 2017

Project Status as of July 1, 2017:

The RRBC in collaboration with the project partners has been able to manipulate inlet and interior structures for water management within the impoundment for 2017 according to the adopted operating plan. The inflow to the impoundment in the spring of 2017 has allowed both RRBC and MNDNR to implement planned management of the interior pools for water quality and habitat enhancement as outlined in the operation plan. Monitoring of water entering the impoundment and upstream within the watershed has been ongoing this spring. The sampling system setup at the inlet to the impoundment is programmed to capture runoff events resulting in flow to the impoundment as well as collecting base flow samples. A summary of the monitoring activities conducted to date have been outlined in the attached report *North Ottawa Impoundment Water Quality Summary*. The monitoring and nutrient budget data will be used to advise management of the impoundment to maximize water quality benefits.

The RRBC is continuing to collaborate with Dr. Svedarsky to evaluate energy potential of cattail biomass and with Dr. Ripplinger exploring promising utilization opportunities for biocomposites, fiber and agricultural applications. An exploration of biocomposites with C2Renew allowed for production and analysis of cattail filled injection molding grade polylactic acid biocomposites for use in a wide range of injection molded products (i.e. agricultural and outdoor recreational bio-based components). The project report is included as an attachment to this update. Additional work with Masonite to explore the opportunity to utilize cattail biomass as a supplemental fiber in their manufacturing process has begun. The RRBC is also continuing to investigate feed value, agriculture amendments and other cattail utilization opportunities.

As a result of limited success harvesting biomass in 2014 and 2015 an extension of the project was requested and approved to allow for additional biomass harvesting to be conducted again in 2017. The RRBC is planning for the 2017 cattail biomass harvest activities to take place within the A4 and B4 cells of the impoundment. Harvesting activities will target two intervals for biomass collection to further determine optimal harvest windows for both nutrient capture and utilization opportunities.

The goals and outcomes of this project continue to be presented and shared at events in the Red River Basin. The RRBC presented on the project during the Red River Watershed Management Board March meeting, the Izaak Walton League spring meeting, the 3rd International Sustainable Wetland Plant Management Conference and the Red River Basin Commission Conference in January. The RRBC continues to work with multiple groups in the basin on water quality and flood damage reduction activities where the information from this project is shared.

Project Status as of January 1, 2018:

Significant rainfall totals in the drainage area of the North Ottawa impoundment in the months of August and September (11+ inches of rainfall) eliminated any opportunity for a cattail harvest in the designated cells within the impoundment. This also had a significant impact on how the impoundment was managed in terms of fall draw down between the DNR and the BdSWD. We continued to communicate and visit the site frequently with one failed attempt at getting the harvesting equipment into the cell for harvest which resulted in getting the equipment stuck. These challenging conditions continue to reinforce the need for continued and sustained water quality data monitoring for the foreseeable future to better understand the role climate conditions play on water quality, multi-purpose benefits and overall effectiveness and longevity of the North Ottawa impoundment. A large piece of this puzzle is how the impoundment is managed as this is still considered a new project. The DNR and BdSWD, in partnership with the RRBC, continue to learn best management practices each year despite no one year being the same and the large number of variables that factor into how this project is managed. This again reinforces the need for future monitoring to understand how all these variables are impacting water quality.

Currently the BdSWD and MN DNR are working together to determine an acceptable path forward for both entities in regards to how many and which cells are being farmed and which cells should be designated for wildlife habitat and shore birds. Future conversations with all parties will be imperative.

Amendment Request September 1, 2017:

Amendment Request Submitted by RRBC to update budget allocations and project manager contact information for the duration of the project ending June 30, 2018.

Amendment withdrawn on February 15, 2018

Amendment Request June 1, 2018:

This amendment is a result of allocating remaining funds in each activity area in which an activity has been completed but work in other activities remains in order to complete the project.

Activity Summary:

1. Activity 1 and 3 have been brought to zero balance. Activity 1 completed the objectives within the project proposal. Activity 3 has been completed based on the timeframe remaining to get in an additional harvest. Only 1 harvest was completed for the project.
2. Activity 2: The fiber potential and agricultural amendment objectives were not completed due to the the lack of additional harvests. These activities will be shifted to input additional focus on the outcomes and results of the market analysis of cattail biomass utilization and effectively articulating this information to all end users that would benefit. We also did not complete the energy potential of cattail biomass and in consultation with the Watershed District it was requested to look at the agricultural benefits of crops within the impoundment. Additional information on this is below.
3. Activity 4 and 5 have received the bulk of the remaining budget for this project due to what is remaining. This is summarized below. Outreach and education is the cornerstone of the RRBC and this project in terms of continuing to pursue future funding for ongoing water quality sampling and monitoring at this site. The Bois de Sioux Watershed District and the other partners are all in agreement that 3 years is not nearly enough data to completely understand the capabilities of retention and detention sites as it relates to nutrient reduction.

As part of this amendment the RRBC is requesting to shift funds within the budget for the project to allow for continued support of project activities. Proposed budget shifts:

1. Aaron Ostlund left the RRBC in September, 2017. Leah Thvedt will be added as the project manager of the project. Updated contact information is reflected in the report. (same salary/benefit allocation and FTE)
2. The budget shifts related to the salary and travel for Julie Goehring and Leah Thvedt are the only items that will require a retroactive approval to January 1. We understand this is typically not the practice for LCCMR however due to the circumstances of our previous Executive Director and previous Project Managers and ongoing turnover in these areas, it has required a bit more attention and time to catch up from two current staff whom together have over 40 years with the RRBC organization.

Activity 1

3. Shift Activity 1 wages for Julie Goehring to Activity 5 in the amount of \$1,470.99.
4. Shift Activity 1 balance for WSN to Activity 4 & 5 for travel expenses in the amount of \$1,530.07
5. Shift Activity 1 balance for Service Contract (Harvest Cattails) to Activity 4 and 5 to Leah Thvedt Salary in the amount of \$5,000 (\$1,443.90 – Activity 4 & 3556.10 – Activity 5). Due to the amount of turnover we have experienced there were a number of things that were said to be done and were not including the amendment when Aaron Ostlund was leaving the RRBC. We have had a significant learning curve to

take on a very specific technical project that was part of our previous Executive Director's expertise and Mr. Ostlunds. Together Mrs. Goehring and Leah Thvedt have over 40 years with the RRBC. We have worked diligently to understand and get caught up in a very short period of time while maintaining our own job expectations. The two salary adjustments are the only work that would need the budget to be retroactive to January 1. We understand that this might not be an option and sincerely appreciate any consideration you can extend for this unusual situation.

The shift in funds for this activity should result in a zero balance as this activity has been satisfied.

Activity 2

1. Shift Activity 2 balance for Dr. Dan Svedarsky to Activity 4 for Dr. Joe Magner in the amount of \$10,000. Dr. Dan Svedarsky retired and notified RRBC that he would not be able to contract with us for this work. Dr. Joe Magner has already done a lot with this work and will continue to do so via the monitoring and harvesting data captured from the impoundment. The additional funds will be allocated to work being done from June 1 to June 30.
2. Shift Activity 2 balance for three Professional Services Contracts... - TBD to Activity 2 to Dr. David Ripplinger in the amounts of \$1,920/\$3,500/\$2,500. Dr. Ripplinger has proposed to develop a number of marketing materials and educational videos based on potential uses for cattail biomass for this project in addition the his current work. Due to the conditions not allowing for more than one cattail harvest the activities for the referenced amounts above were unable to be explored within the time remaining further leaving these funds unused.

Activity 3

1. Shift Activity 3 balance for Service Contract to harvest cattails in the amount of \$15,003.60. Due to a number of uncontrollable climatic conditions, we were able to complete one cattail harvest in 2016. As the activity and funds need to be spent prior to the June 30 deadline we will not be able to utilize these for an August cattail harvest. Therefore we will shift these funds to areas of the project that can add value in the timeframe allotted. We still intend to fund on our own a cattail harvest, barring favorable weather conditions.
 - Funds being shifted from Activity 3 – Service for Contract to harvest cattails \$15,003.60 is as follows:
 - a. \$250 to printing for final materials in June
 - b. \$5,753.90 to Julie's Salary – Activity 5 – This budget change request requires a backdate request to January 1. Unfortunately due to the time commitment required for this project we needed two staff to dedicate their time. There was a significant learning curve due to the specialized nature of this project. Two past employees that had this expertise are no longer with the RRBC.
 - c. \$5,396.08 to Leah's Salary – Activity 5 Unfortunately due to the time commitment required for this project we needed two staff to dedicate their time. There was a significant learning curve due to the specialized nature of this project. Two past employees that had this expertise are no longer with the RRBC.
 - d. \$3603.62 to Equipment – Activity 4: New monitoring equipment that will be purchased in the next several days. We want to make sure this request is approved prior to the purchase. This equipment will assist with the water quality monitoring for the remainder of the project and into the future.
2. Shift Activity 3 balance for UMN and RMB to Activity 4 same budget item in the amount of \$390.00 for additional water quality monitoring in the month of June.

This activity has been completed based on the allotted timeframe left in the funding cycle of the project.

Amendment Approved by LCCMR - June 18, 2018

Final Report Summary:

As this project has concluded over the past period from January 1 to June 30, 2018 the end date of the project, many things have been concluded. The most important being the need to continue monitoring the North Ottawa Impoundment for Water Quality benefits beyond the period of this grant. Due to many climatic variables, several outcomes in this project were impacted. We assumed this would happen based on the nature of this project and this type of science being conducted. Another variable in this effort was the management of this complex system and water management and movement within the impoundment to ensure we are meeting the needs of the local area upstream and downstream and that of the MN DNR for habitat accommodations. This multipurpose project is continuing to show that more research is needed to determine the best way to operate and manage projects like North Ottawa for this project and future projects such as Red Path and others. One thing that became a clear challenge is ensuring the consideration of the watershed district and MN DNR. They continue to work together to resolve how each cell within the impoundment is being utilized for farming and natural resource benefits. We continue to communicate with both entities on their desires and needs. As this evolves, and final operation plan is established, more monitoring will be needed to determine the water quality benefits being seen at North Ottawa.

In the months of May and June, the RRBC in partnership with UMN using funds through LCCMR and 319 were able to do additional soil, plant and water samples in 6 cropped cells. This is the first year in several that 6 cells in the impoundment were cropped versus the two cells in previous years. Sampling will continue through the rest of the growing period to determine the nutrient uptake by the crops in the interior cells.

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Design, Redesign, Construct and Operate Treatment Cells

Description:

Design the treatment cells to maximize the capture of nutrients. Retrofit the existing 640 acre Pool C within the North Ottawa Impoundment to allow all streamflow to enter this cell of the impoundment and be evenly distributed to flow through the cattails that are currently growing within this cell. This Pool C will be used as a primary settling pool. Two to four 160 acre treatment cells will be constructed within the Pool B area using an interior diking system and water distribution system that will enable the expansion of cattail growth in the Pool B treatment pools. We will harvest individual cells at different times of the year to evaluate the optimum time to harvest for maximum nutrient capture. We will work with equipment suppliers to find harvesting techniques that work in wet soils. See the attached detailed plan sheet of the interior diking proposed.

Summary Budget Information for Activity 1:

ENRTF Budget: \$ 27,004
 Amount Spent: \$ 27,004
 Balance: \$ 0

Activity Completion Date:

Outcome	Completion Date	
1. Design/Redesign North Ottawa Impoundment with additional cells	August 2014	
2. Drawdown and Harvest cattails within Existing Pool C	September 2014	

Activity Status as of January 1, 2015:

The design and construction of the interior dikes to partition off the North Ottawa Impoundment into cells began in August 2014. The water level control structures that will allow for the transfer and storage of water in the individual cells have been completed. The contractor has completed most of the dirt work and is scheduled to be completed with the construction project by September 2015. There is some compacting and reshaping of dikes and final seeding and vegetation establishment yet to be done. When completed, this interior dike construction will allow for the management of water within the 1920 acre impoundment in 160 acre treatment

cells. The four-160 acre Pool B cells will give us the ability to hold water for differing time periods and to manage vegetation differently within these cells to maximize nutrient capture. There are concrete structures with stop logs in place that will allow us to direct water from the Pool C main holding area into the Pool B cells. The Pool B cells are where the work funded under this LCCMR Grant will mostly occur.

When this Grant was funded, the Engineer's estimate for the construction of the interior dike system was \$2.2 million. At that time, the Bois de Sioux Watershed District was short money to fund the estimated costs so we included two line items in Activity 1. These were Outcome 1 and Outcome 2 above. Outcome 1 was for the design work and we proposed to pick up part of those costs and we budgeted \$20,000 towards this task. Outcome 2 was for the construction work on the interior dikes and some limited work in Pool C to redirect water flow through this cell. We budgeted \$40,000 for this task. The construction bids for the interior dike construction came in substantially under the Engineer's estimate and the Bois de Sioux had enough financing available to pay all the costs of the interior dike work. This will now free up the \$20,000 from Outcome 1 and \$30,000 of the \$40,000 budgeted Outcome 2 tasks that can be amended and reallocated to other proposed tasks of this project. This will be discussed in greater detail when we apply for an amendment request to reallocate funds from this task to different tasks in the work plan.

Outcome 3 in Activity 1 included \$20,000 to do some preliminary cattail harvest work in Pool C. This work was proposed to be completed in September 2014. The month of June 2014 was one of the wettest June months on record for the watershed that drains into this impoundment. In June 2014, the North Ottawa Impoundment was pretty much full for the whole month and resulted in most of the cattail vegetation being drowned out. This postponed our ability to do cattail harvesting work other than some extremely limited sampling work for nutrient analysis. The cattails did come back into Pool C and we will do harvesting activities there this coming season.

Activity Status as of July 1, 2015:

The interior dike dirt work is completed and the cell components are being shaped and seeded to provide the needed stability to the interior dike network. The lack of snow in the watershed this past winter resulted in no surface water run-off entering the entire North Ottawa Impoundment during spring snowmelt. This resulted in no water being held within the impoundment as a result of spring run-off event. This was a benefit for the overall project as it provided ideal spring conditions for completing interior dike work and allowed the University of Minnesota staff to install the automated sampling set ups at the inlet and outlet. The North Ottawa watershed drainage area did experience two rain events in May that provided run off to supply water to the impoundment. These events resulted in water diversion into the large Pool C holding area as directed from the current Bois de Sioux Watershed District, impoundment operating plan. This larger pool is being monitored to help meet our initial water quality planning needs and all current year vegetation harvest will be completed from within pool C where cattail vegetation is establishing well after two significant run-off events which resulted in the filling of the large pool C portion of the impoundment.

Activity Status as of January 1, 2016:

The interior dike work is substantially complete as of December 2015. This will allow for the interior dike network to be utilized for water management within the impoundment for spring run-off. An operating plan has been adopted to utilize two cells of the interior diking network A4 and B4 for nutrient capture. The first cell A4 will be used as a primary settlement cell for water coming into the impoundment and for water storage. The second cell will be managed to optimize cattail growth and nutrient uptake. Soils in this second nutrient capture cell will be saturated in the spring to allow for cattail establishment. Research conducted by NDSU suggested that even though the cells have been conventionally farmed in previous years an adequate cattail seed bank is present in the soils and by maintaining saturated conditions cattails should establish without additional seeding. After establishment of cattails and in an effort to treat as much water as possible, an increase in water levels will be desired while maintaining water levels throughout the growing season at levels optimizing growth. To maximize nutrient uptake we will conduct water and tissue sampling within the cell to understand the rates of

removal of nutrients by the cattails to manage flow/holding times within the cells. The management plan will also be dependent on climate and the amount of water we have to work with throughout the growing season. If flooding or drought conditions occur the management plan will be adjusted to best achieve project goals.

Stoplog structures along the Inlet channel to the A cells as well as the structures between the A and B cells will be manipulated to move water into and between different cells to maximize not only water quality benefits/nutrient capture, but to also maximize natural resource enhancement. Each fall the entire impoundment is drawn down to get ready for the next season spring runoff. The first water into the system will be put into cells A2 and A4.

Activity Status as of July 1, 2016:

The interior dike network was completed in early spring 2016 including final grading and seeding of dike surfaces. This work has allowed RRBC to manipulate inlet and interior structures for water management within the impoundment for 2016 according to the adopted operating plan. The limited inflow to the impoundment in the spring of 2016 has only allowed for minimum management according to the operation plan. To facilitate this minimum management it was determined that the MDNR would remove beaver dams from the Mud Lake area of the watershed. This resulted in an elevated base flow into the impoundment as Mud Lake was dropped by around a foot following dam removal. This elevated base flow has allowed both RRBC and MDNR to implement planned management of the interior pools for water quality and biomass harvesting and habitat enhancement as outlined in the operations plan. As of June 2016 the RRBC has been able to hold water in cell A4 for pretreatment and sedimentation and maintain mudflats in cell B4. The B4 cell was intermittently flooded to maintain saturated soils which has allowed for cattail establishment from the natural seed bank present in this region. Cattail establishment within B4 has been the main goal given the limited flow to the impoundment to ensure that future water management at the impoundment will allow for biological uptake of nutrients in this cell. The management plan will continue to be dependent on climate and the amount of water we have to work with throughout the growing season and in future years. If flooding or drought conditions occur the management plan will be adjusted to best achieve project goals.

Project Status as of December 22, 2016 submitted as *January 1, 2017 update*:

The limited inflow to the impoundment in the 2016 season only allowed for minimum management according to the adopted operation plan of the North Ottawa Impoundment. Cattail establishment within the B4 cell was the main goal given the limited flow to the impoundment to allow future water management at the impoundment to include biological uptake of nutrients in this cell. Cattail establishment in the B4 cell was successful and the RRBC is confident in the ability to manage this cell in 2017 for maximum nutrient capture.

Following a very dry spring and early summer the North Ottawa Impoundment received a large rainfall event on July 10th that resulted in the largest runoff event of the season. The runoff from this event brought the A4 holding cell to optimum capacity and the remaining runoff was channeled into the C cell which provides the primary function of the project of flood damage reduction. The operation capacity of control structures were further understood from this event in that we were able to finally manage the A and B cells with the additional runoff. Management of the interior control structures allowed us to shift water from one cell to another for the first time and gather valuable experience in flow rates and efficiency of the system. The B4 cell was incrementally flooded to maintain saturated soils then up to two feet of water which allowed for cattail establishment.

Limited water was exported from the system until the first drawdown in August that was conducted to facilitate harvesting of cattail biomass in the C cell. This drawdown period was conducted over a two week period where water was slowly flowing out of the C cell until the majority of the cell was drained and harvesting could be conducted. The remaining water in the impoundment was utilized for establishing cattails in B4 and providing habitat for wildlife in the A and B cells. A series of flooding was conducted in three of the other cells during the fall to provide resting and feeding area for migratory waterfowl. The mild fall weather allowed for an extended

holding time before drawdown was necessary for preparing the impoundment for next year's potential flood damage reduction goals. During this extended holding period the wildlife utilization of the impoundment was beyond expectations. Future updates and the final report will include data on this wildlife benefit of the management at the impoundment.

Prior to a shift to colder weather in the end of October the outlets for the A and B cells were opened and a slow drawdown of the A and B cells was initiated. Due to a quick turn in forecasted temperatures in November the outlets were opened and the remaining water was quickly drained from the system to avoid freezing excess water within the impoundment. This accelerated drawdown at the end of the season was not ideal for water quality benefits of the project due to the "flushing" of large amounts of sediment during the higher flow period. This was a lesson learned the hard way and will influence future management to avoid higher flows contributing to sediment export. The management plan will continue to be updated and adapted based on experience, climate and the amount of water we have to work with throughout the growing season and in future years.

Project Status as of July 1, 2017:

The RRBC in collaboration with the project partners have been able to manipulate inlet and interior structures for water management within the impoundment for 2017 according to the adopted operating plan. The inflow to the impoundment in the spring of 2017 has exceeded 2016 annual inflows by almost three times the volume. While snow melt was minimal following the mild winter in the region early spring rains and a large runoff event in June produced the larger volume that the impoundment received. The result of this additional volume has allowed both RRBC and MNDNR to implement planned management of the interior pools for water quality and habitat enhancement as outlined in the operations plan.

As of June 2017 the RRBC has been able to hold water in cell A4 for pretreatment and sedimentation and establish abundant wetland vegetation in cell B4. The B4 cell was intermittently flooded to maintain saturated soils which allowed for wetland plant establishment from last year's growth and the natural seed bank present in this region. Cattail establishment within B4 has been the main goal to allow for biological uptake of nutrients in this cell. The management plan will include funneling water through the B4 cell from A4 to maximize nutrient removal until drawdown. In addition to this management to achieve water quality benefits the manipulation of water levels are being conducted to minimize impact on wildlife. The primary concerns with abrupt water level change is impact on nesting and feeding water birds in the A4 and B4 cells. During spring and early summer a wide variety of water birds have been seen utilizing these cells including species of significant management concern. The water birds of interest have included black necked stilts, western grebes, glossy ibis, snowy plover, snowy egret and juvenile blue heron. The presence of these species has also significantly increased the traffic of bird watchers to the project site. Managing water levels to achieve water quality benefits and maximize the habitat utility is a primary focus of the project team.

Project Status as of January 1, 2018: Utilizing cells A4 and B4 for pretreatment and sedimentation did establish wetland vegetation in cell B4. Significant precipitation in August upstream of the impoundment created significant operation challenges along with the fall draw down process eliminated the opportunity to get the necessary equipment into the B4 cell for harvesting. This accelerated drawdown from the significant rainfall events and the end of the season was not ideal for water quality benefits of the project due to the "flushing" of large amounts of sediment during the higher flow period.

During this period of higher than normal flows and the need to hold back water due to downstream concerns, a faster than typical drawdown for this time of the year was necessary. During this process it was noted that the wood stop logs for the A/B control structures were seeping and leaking. It was recommended that we may want to consider changing over the wood logs to aluminum as the wood logs work ok when submerged for along time, but when they are being moved often they tend to dry and warp.

This activity was completed in terms of the design, redesign and construction of the interior cells. Operation of the treatment cells is ongoing and is discussed above. The remaining balance from this activity will be shifted to salaries.

Final Report Summary:

From September of 2017 to spring of 2018, discussions were held between the BDSWD and MN DNR for the desire to farm up to 6 (versus 2 in previous years) interior cells in the impoundment. This left A4 and B4 left for both nutrient management and wildlife management along with cell C. The BDS and MN DNR agreed to allow the farming of 6 cells for this year only and then will continue discussion on how the impoundment will be operated for 2019 and beyond. The desired water levels for adequate habitat would likely lead to the drowning out of the cattails in those cells. The only option at this point in the discussion would be to conduct a harvest of cattails in cell C. The one and only harvest was conducted in cell C.

Following the 2016 cattail harvest in cell C, the harvest location was changed to A4 and B4. Cell C is the primary water storage cell for runoff events. Some of the challenges in harvesting in this cell are that the cattail stands in cell C were not uniform enough for chopping and harvesting purposes and there was also concern over the presence of noxious weeds in cell C. The noxious weeds do not create an issue with the harvest or removal of nutrients rather the appeal of the cattail mulch for biomass reapplication onto a field.

Significant challenges over the years have allowed for only one harvest in the impoundment. The RRBC and UMN acknowledge that harvesting within the impoundment is less than ideal due to the primary function of the impoundment (flood control). There have been several challenges including managing the impoundment for cattail growth; seepage and stop log issues; summer rain fall; and access to the cells with heavy machinery.

ACTIVITY 2: Evaluate Potential Uses of Cattail Biomass

Description:

Contract with Dr. Dan Svedarsky at U of MN-Crookston who is working on cattail utilization for bio-energy. Dr. Svedarsky also is recommended to receive LCCMR funding for work on cattail harvesting mostly for wildlife enhancement. We will collaborate with Dr. Svedarsky to evaluate energy potential of cattail biomass, and evaluate the potential additional markets that could be developed utilizing this material. We will also contract with Dr. David Ripplinger NDSU Fargo to develop a market analysis of cattail utilization.

Summary Budget Information for Activity 2:

ENRTF Budget: \$ 32,000

Amount Spent: \$ 31,917

Balance: \$ 83

Activity Completion Date:

Outcome	Completion Date
1. Evaluate energy potential and utilization of cattail biomass	July 2015- July 2016
2. Develop market analysis of cattail utilization	September 2016

Activity Status as of January 1, 2015:

As part of this Activity and part of our overall project management, RRBC has assembled a technical advisory group that includes Dr. Dan Svedarsky and Dr. Dave Ripplinger. This group also includes many different individuals who have some interest in cattail utilization. We met December 2, 2014 at U of MN Crookston for a summit to discuss different cattail activities people are currently involved with. The group included faculty and

scientists from U of MN Crookston, U of MN St. Paul, UND, UND-EERC, USFWS, MDNR, bio-energy companies and International Institute Sustainable Development (ISSD) scientists working on cattail harvest and utilization in Manitoba. We plan on meeting approximately four times per year to coordinate work between the various groups working on cattails. Dr. Svedarsky worked with us on the 319 funded effort where request for bidding interest were solicited from connected analysis activity at the Ag Utilization Research Institute (AURI), Natural Resources Research Institute (NRRI) and the Energy and Environment Research Center (EERC). Lab analysis prices are all competitive but the EERC, located 20 mile from the University of Minnesota campus, provide the most efficient location a samples are delivered to the site immediately after harvest. The distance to AURI, Waseca and NRRI, Duluth are problematic. The EERC is also the approved vendor for EPA funds managed through the Minnesota Pollution Control Agency for this project.

We have met separately with Dr. Svedarsky and Dr. Ripplinger to put together contracts for the work we are doing with them under this grant. We have a draft work plan with Dr. Ripplinger that will lay out in greater detail the market analysis work we will complete with him as part of this Activity. Under this activity we will also contract with Dr. Dan Svedarsky to work with us to further potential cattail utilization especially for energy. We have completed some discussions with Dr. Svedarsky and will continue to collaborate with him on several areas including equipment development for cattail harvesting. Dr. Svedarsky is working with a private company, Mattracks, on development of cattail harvesting equipment that could potentially also used at North Ottawa Impoundment for harvesting work we will be doing there.

Activity Status as of July 1, 2015:

We have been meeting and communicating regularly with Dr. Svedarsky from the University of Minnesota and Dr. Ripplinger from North Dakota State University to begin formulating a plan for testing potential utilization of the 2015 cattail crop that will be harvested. Dr. Ripplinger is developing a harvest management decision support tool to allow us to input fixed and variable costs associated with harvesting to determine the feasibility of managing cattails for utilization in the bio energy, agricultural or sorbent markets. Dr. Svedarsky has been researching harvest and utilization methods that are taking place in other regions of the country and building a network of potential resources we might bring to this region to support harvesting and product development. The University of Minnesota Crookston (UMC) faculty supporting this project have contacted an enterprise from Ada, MN that is turning plant residue into a bio-char product and the UMC bio engineering staff will be testing the potential of pelleting and liquid extraction of cattail with their bio-diesel programs twin screw press. If successful, the resulting products, a pressed pellet and extracted liquid will be analyzed for nutrient content and potential as a fertilizer and soil amendment product.

The RRBC in partnership with the University of Minnesota and North Dakota State University is organizing a team of faculty from both institutions who will be assisting with potential market options for harvested cattail and other wetland plant materials growing at the North Ottawa site. One product that shows potential is a pelleted product used for spill absorption. This is a high value product has strong demand because of all the oil production in North Dakota that has an influence and impact throughout this region.

Activity Status as of January 1, 2016:

We have continued to meet separately with Dr. Svedarsky and Dr. Ripplinger to continue collaborating with the work we are doing with them under this grant for cattail utilization. Dr. Svedarsky continues working on cattail utilization for bioenergy. He had previously harvested cattails from wildlife management areas. Sixty round bales of cattail were harvested and are in upland storage as he is attempting to have a farmer cooperater pelletize them with a recently purchased machine. A local pellet stove manufacturer is willing to test burn cattail pellets when we get a sufficient supply. Under direction of Dr. Svedarsky a student from the University of Minnesota, Crookston is conducting a Life Cycle Analysis of the use of cattails as a biofuel which is necessary to do a full cost accounting in evaluating the material as a viable energy source. The RRBC will continue to collaborate with Dr. Svedarsky and UMC staff on several areas including equipment development for cattail harvesting.

Dr. Ripplinger is currently developing a market analysis report and harvest management decision support tool to allow us to input fixed and variable costs associated with harvesting to determine the feasibility of managing cattails for utilization in the bioenergy, biofiber, agricultural, or sorbent markets. The report will be available this summer to help evaluate use of harvested biomass this fall. The RRBC will continue to collaborate with Dr. Ripplinger and NDSU staff on several areas for cattail utilization.

RRBC, Dr. Svedarsky, Dr. Ripplinger and Dr. Grosshans from IISD Manitoba attended a one day summit at Loyola University Chicago who have a group of researchers working on cattail issues around the Great Lakes. Besides the groups mentioned above there were participants from Oregon State, DePaul, Northeastern Illinois, and Wisconsin-Oshkosh Universities. Groups from Delta Waterfowl and USFWS were also in attendance. Each participant shared work that they are involved with. This was a very useful event to collaborate with others involved in cattail work.

Activity Status as of July 1, 2016

We have continued to collaborate with Dr. Svedarsky and Dr. Ripplinger to work on cattail utilization. Dr. Svedarsky continues working on cattail utilization for bioenergy. Cattail biomass bales are currently being processed into pellets for utilization for heating. This effort is a combined initiative with RRBC, UMC, a local farmer and a local stove manufacturing facility. The RRBC will continue to collaborate with Dr. Svedarsky and UMC staff on several areas including cattail management from harvesting.

Dr. Ripplinger is currently developing a market analysis report and harvest management decision support tool. The report will be available this summer to help evaluate use of harvested biomass this fall. The RRBC will continue to collaborate with Dr. Ripplinger and NDSU staff on several areas for cattail utilization.

Project Status as of December 22, 2016 submitted as *January 1, 2017 update*:

The RRBC is continuing to collaborating with Dr. Svedarsky to evaluate energy potential of cattail biomass. We were able to secure an opportunity to have four round bales of cattails hauled to the University of Minnesota Morris biomass burner and gasification plant. We will be utilizing their system to further understand and demonstrate the bioenergy potential of cattail biomass.

The RRBC collaborative work with Dr. Ripplinger to develop a market analysis of cattail utilization has resulted in interest to explore promising utilization opportunities beyond bioenergy to further evaluate the potential additional markets that could be developed utilizing this material. Specifically, the exploration of utilizing cattail biomass for biocomposites, fiber, and agricultural amendments. These additional utilization opportunities may develop into higher value products that would support future biomass harvesting activities and the resulting water quality benefit.

Project Status as of July 1, 2017:

The RRBC is continuing to collaborating with Dr. Svedarsky to evaluate energy potential of cattail biomass. The University of Minnesota Morris demonstrations were only partially explored before mechanical failure of the system halted additional analysis. It is anticipated that additional testing will be conducted this fall when the heating system is operational.

The RRBC collaborative work with Dr. Ripplinger to develop a market analysis of cattail utilization has resulted in exploring promising utilization opportunities of utilizing cattail biomass for biocomposites, fiber, and agricultural amendments.

An exploration of biocomposites with C2Renew allowed for production and analysis of a cattail composite. This first phase project focused on the development of cattail filled injection molding grade polylactic acid biocomposites for use in a wide range of injection molded products (i.e. agricultural and outdoor recreational bio-based components). Overall, it appears using cattail as a filler in plastics has some potential for injection

molding applications such as outdoor sporting goods and agricultural parts. However, to improve the properties of the biocomposite further it is recommended that a heat treatment be applied to the cattail biomass, such as torrefaction, to convert the crude protein content to carbon char or use some sort of chemical extraction method, thereby reducing the off gassing and odor produced when compounding cattails into plastics such as PLA. The report on the phase I project is included as an attachment to this update.

Masonite is a door manufacturer with a production facility located in Wahpeton, ND within 30 miles of the North Ottawa Impoundment. Masonite produces a variety of manufactured door materials including acoustic and thermal door interiors. Traditionally these door interiors are produced from wheat straw sourced from local producers. Over the past decade the supply of wheat straw in this area has continued to decline. With the decline in local supply for manufacturing Masonite has begun to investigate substitutes and supplements to maintain production. RRBC has begun to collaborate with Masonite to explore the opportunity to utilize cattail biomass as a supplemental fiber in their manufacturing process. Investigation in viability for cattail biomass to meet feedstock characteristics have begun with the greatest challenge being the necessary reduction in moisture levels. Alternative timing and mechanical processing of harvested biomass could assist in meeting this utilization challenge. Additional exploration is ongoing and will influence planned harvesting activities.

Harvested biomass in 2016 was analyzed for nutrient content and fiber characteristics. The results of these tests have indicated the biomass has multiple agriculture utilization opportunities including as a forage feedstock, animal bedding and as a soil amendment for nutrient cycling. The green cattail biomass has high levels of protein and in-vitro organic matter digestion which are two key factors in feed value of cellulosic materials. This opportunity of blending the cattails with other traditional feedstocks like corn or alfalfa silage for livestock is still being pursued. Additionally, the dry raw cattail biomass has significant adsorption capacity making it an ideal bedding material for livestock operations. The RRBC will continue to collaborate with Dr. Ripplinger and NDSU staff on these cattail utilization opportunities.

Project Status as of January 1, 2018: Dr. Dan Svedarsky retired in May and notified RRBC that he would not be able to contract with us for the work that was allocated in the current budget. After meeting with the Bois de Sioux Watershed District last month it was requested that UMN do additional soil samples and water quality monitoring in the upper watershed and downstream of the project. This is due to the watershed's change in operation plan to crop 6 interior cells versus 2 and determine what water quality benefits will occur and how they compare and/or complement the harvesting of cattails. We intend to use 319 funds to complete the monitoring for the remainder of the monitoring season beyond the LCCMR funding deadline of June 30th. The RRBC is continuing to collaborate with Dr. Ripplinger and NDSU to create materials that provide education and information on the cattail utilization opportunities and outcomes of this effort. As of June 1 much work is being done at North Ottawa in terms of soil testing and monitoring in cooperation with UMN and NDSU. They will be developing marketing pieces and a video that details what is going into this effort. The pieces will be created with the intent to educate the non-technical individual whether it be a legislator, grass roots citizen or producer about how these types of projects can provide multiple benefits for many stakeholders. It was determined that additional funds would be needed to complete this activity.

Final Report Summary:

Please see attached reports from UMN and NDSU's final products mentioned above. These products are a result of the cumulative work that has been done over the last few years and research reviewed by each entity as it relates to evaluating the energy potential and utilization of cattail biomass. These tools will be used to identify opportunities for further analysis and education of water quality BMPs in the Red River Basin.

ACTIVITY 3: Harvest Cattails Pool B Cells

Description:

Manipulate water levels to Pool B treatment cells to maximize cattail growth. Harvest cattails in Pool B Cells during differing parts of the growing season to evaluate nutrient content earlier in growing season vs later and to allow us to maximize our nutrient removal with harvesting.

ENRTF Budget: \$ 37,210

Summary Budget Information for Activity 3:

Amount Spent: \$ ~~303~~,182.61

Balance: \$ 74,027.41

Activity Completion Date:

Outcome	Completion Date
1. Harvest Cattails from Pool B Treatment Areas once annually	Dec. 2016
2. Evaluate Nutrient content of harvested cattails	Dec. 2016

Activity Status as of January 1, 2015:

Samples of vegetation were collected and nutrient analysis completed. Initial cattail samples were harvested August 20, 2014 with a follow up sampling on September 25, 2014. The September sampling included both cattail and soft stem bulrush as plant matter samples as well as a sample of cattail roots to determine early fall phosphorus levels in the root systems. June 2014 high inflow volumes into the North Ottawa Impoundment created an abnormally high water level within the impoundment resulting in limited cattail growth within the impoundment. We are proposing to add \$10,000 to this activity area to allow for additional vegetation sampling including five thousand dollars for analysis of samples to help determine the feasibility of extracting phosphorous and nitrogen in a liquid form for use as agricultural fertilizer and five thousand to support harvesting associated activities at North Ottawa and other potential small scale harvest at up to two additional pilot sites as identified in project statement overview.

Large scale cattail harvesting in Pool B will be completed during the summer and fall periods in 2015 and 2016. The harvesting of Cattails within Pool B and other available impoundment pools is estimated at 160 acres per year, based on comparable custom harvest handling and hauling rates for agricultural forages from the University of Minnesota which calculates a cost per acre of \$105 based on agricultural forage harvesting equipment, the adjusted budget of five thousand added to harvesting associated activity, will allow for ample funds to expand lab analysis efforts and harvest through the two seasons.

The overall project outcome is to capture and remove 50- 100 percent of the phosphorus and nitrogen nutrients found in surface drainage water from the 75 square mile agricultural watershed above the North Ottawa flood impoundment. Based on work completed in Manitoba we can expect to remove between 10 – 20 pounds of phosphorus for each acre of cattails harvested. We were able to obtain short term funds to complete more detailed analysis of the vegetation growing in the North Ottawa site. Our sample data indicated that phosphorus content level from the harvested samples yields enough phosphorus to capture/recover 17 – 18 pounds of elemental Phosphorus from an acre of cattails, based on a projected harvestable yield of 7 tons/acre. This amount of Phosphorus removal falls within the high end of the range of work completed in Manitoba by ISSD, one of our project partners. The North Ottawa site collects all the surface water runoff from a 75 square mile area that is predominately Red River Valley Ag land. At the 17-18 pound recovery rate, 600 acres of harvested cattails from this watershed would remove 100% of the phosphorous from all drainage water sources entering the North Ottawa site.

Activity Status as of July 1, 2015:

The RRBC is planning for the harvest activities to take place in late August and early September. The cattails we plan to harvest will be for maximum nutrient capture and direct agricultural land application. We will also be planning for a second harvest in late October and early November for cattail materials that will be pelleted and used for energy and other markets requiring a dried product. We have sent out information requesting bids for harvest and anticipate interest from several local farmers near the North Ottawa site. This year's harvest will be completed from the larger Pool C portion of the impoundment. Pool B will not be flooded and used for nutrient capture until the 2016 season so anticipated harvesting and nutrient management from pool B cells will not be possible until next year's harvest season. The expanded nutrient analysis work will begin around mid-July so no additional update is available with this reporting period.

Activity Status as of January 1, 2016:

The fall 2015 planned harvest was not completed from the larger Pool C portion of the impoundment as anticipated. The RRBC was not able to line up either a contractor nor a cooperating adjoining farmer to work with in this harvesting effort. The RRBC is planning for the 2016 harvest activities to take place in late August and early September to optimize removal of biomass/nutrient content. An adjoining landowner/farmer has been secured to take all cattail material harvested. This year's harvest will be completed within the approximate 100 acre B4 secondary treatment cell portion of the impoundment. The harvested cattail will be chopped, hauled, and spread as a green manure on agricultural land within the upstream drainage area in an effort to recycle nutrients and improve soil health. Harvested biomass will be analyzed for nutrient content and quantified to develop a detailed nutrient budget for removal of phosphorous and nitrogen.

The RRBC along with the University of Minnesota-Crookston conducted pilot testing of the potential for separation of liquids from plant solids in green harvested cattail biomass. We wanted to evaluate the potential of the separated liquids to be land applied as an agricultural fertilizer. Cattails were harvested from the C cell of the North Ottawa impoundment and run through a forage chopper. A screw press was then used to remove the liquids from the plant solids. The liquids and pressed products were analyzed for nutrient content along with the green harvested cattail biomass at the Energy and Environmental Research Center at UND. The screw press did reduce the moisture content of the green cattails from 84% to 8% for the pressed cattails. The nutrient content of the extract was low compared to the green cattail material before the press. Most of the nutrients stayed with the cattail solids. This press process was not as effective in extracting the phosphorus, nitrogen and potassium from the green cattail material as we had expected.

The nutrient value of the green cattails were found to be as high in Nitrogen, Phosphorus and Potassium (NPK) as any literature data for plant materials normally land applied to cropland. The values we found for green cattail NPK were in line with typical values of cattle or poultry manure. This information will be used in the economic work to be completed by Dr. Ripplinger. This evaluation work also greatly helped us determine nutrient content and application rates for the green cattails to cropland that we will be doing summer 2016.

Activity Status as of July 1, 2016:

The RRBC is planning for the 2016 cattail biomass harvest activities to take place within the B4 and C cells of the impoundment. Harvesting activities will target two intervals for biomass collection to determine optimal harvest windows for both nutrient capture and utilization opportunities.

The first round of harvested cattail will be utilized as green manure on agricultural land within the upstream drainage area. We have partnered with a family farmer who we will collaborate with to chop, haul, and spread the cattail biomass on agricultural land within the upstream drainage area in an effort to recycle nutrients and improve soil health. Harvested biomass will be analyzed for nutrient content and quantified to develop a detailed nutrient budget for removal of phosphorous and nitrogen. This will allow for nutrient cycling within the watershed and for potential reductions in fertilizer needs in areas of biomass application.

The second round of harvested material will be on a smaller scale to collect cattail biomass at a lower moisture content for identifying utilization opportunities as fiber and bioenergy. We are currently exploring additional utilization opportunities through Dr. Svedarsky and Dr. Ripplinger. The goal of the additional exploration is to identify a feasible higher value utilization opportunity to support continued and expanded harvesting activities.

Project Status as of December 22, 2016 submitted as *January 1, 2017 update*:

The RRBC successfully harvested cattail biomass from the North Ottawa Impoundment in the end of August and utilized the harvested material as a green manure on agricultural land within the upstream drainage area. The system was able to be drained and the conventional forage harvester and trucks were able to complete the chopping and hauling without navigation issues associated with flooding throughout the summer months. We partnered with a local farmer and spread the cattail biomass in an effort to recycle nutrients and improve soil health. Harvesting was accomplished using conventional forage chopping equipment and resulted in a 4.76 tons per acre biomass yield. Harvested biomass was analyzed for nutrient content and quantified to develop a detailed nutrient budget for removal efficiency of phosphorous and nitrogen. Nutrient analysis of the harvested biomass equated to 48 lbs. nitrogen and 6.6 lbs. phosphorus captured per acre harvested. During this pilot harvest a total of 10 acres were harvested resulting in 480 lbs of Nitrogen and 66 lbs of Phosphorus removed from the system. Given the pilot harvest effectiveness at removing nutrients we can estimate that by scaling up the harvesting we could accomplish the overall project outcome to capture and remove 50 - 100 percent of the phosphorus and nitrogen nutrients found in surface drainage water from the 75 square mile agricultural watershed above the North Ottawa flood impoundment. Based on 2015 water quality monitoring we could remove 100% of the nitrogen load into the impoundment by harvesting 375 acres of cattails and 100% of the phosphorus load into the impoundment by harvesting 480 acres of cattails. This scaled up harvesting is well within the possible management of the North Ottawa Impoundment which has a 2,000 acre footprint.

Wetland vegetation within the C cell was targeted for harvesting in 2016 due to established stands of cattail species. Harvesting in the B4 cell was not pursued in 2016 to allow for abundant cattail establishment to insure future management of the system would allow for nutrient capture from the established cattails. Future harvesting at North Ottawa will be targeted in the B4 cell.

There were challenges in harvesting the cattail biomass. Most notably the difficulty of cutting through low lying plant litter that was present from previous years of growth and breakdown. This dense litter forced a higher than ideal cutting height for the forage harvester and reduced the overall biomass yield. A mature cattail has a majority of its above ground biomass within this lower foot of the plant. Based on field measurement and literature review we could expect 7 to 8 tons of biomass per acre harvested. In future harvesting at North Ottawa in the B4 cell there will be much less ground level biomass litter due to the recent establishment of the wetland species. By overcoming this issue the nutrient capture and removal efficiency will significantly increase.

Additionally, the cattail seeds were mature during the harvesting period of the growing season. By chopping the vegetation including the cattail spikes the seeds were widely dispersed. This added to harvesting challenges for chopping and hauling equipment by building up of seeds on air intakes and radiators. We were able to manage this challenge and continue harvesting but it posed risk for continued operations and could limit a larger harvest. The cattail seed maturity is going to influence future harvesting efforts including targeting a more optimal cattail maturity to maximize efficiency and avoid these challenges. Based on field observation it was noted that two weeks prior to harvest the cattail seeds were still green and would not have widely dispersed during harvesting.

A smaller harvest was conducted in October to gather cattail biomass at a lower moisture content for identifying additional utilization opportunities. The goal of the additional harvested material will be to identify a feasible higher value utilization opportunity to support continued and expanded harvesting activities.

Project Status as of July 1, 2017:

The RRBC is planning for the 2017 cattail biomass harvest activities to take place within the A4 and B4 cells of the impoundment. Harvesting activities will target two intervals for biomass collection to determine optimal harvest windows for both nutrient capture and utilization opportunities. The first round of harvested cattail will be utilized as green manure on agricultural land within the upstream drainage area. This harvesting initiative will reflect the challenges from last year's harvest including moving the target date earlier to avoid cattail seed concerns with machinery. The second round of harvested material will be to collect cattail biomass at a lower moisture content for identifying utilization opportunities as fiber and bioenergy. This second harvest is on a smaller scale than the green harvest but with plans to harvest bales of dry cattail material to explore challenges of utilizing the lower moisture material.

Project Status as of January 1, 2018: Significant rainfall in the drainage area upstream of the impoundment created operational issues of the A and B cells including holding and releasing water and seepage of water through the stop logs. Other options for cattail harvesting are being evaluated due to the difficulties in meeting the ideal conditions and timing of the optimal cattail maturity with any rainfall and seasonal drawdown activities.

Currently the BdSWD and MN DNR are working together to determine an acceptable path forward for both entities in regards to how many and which cells are being farmed and which cells should be designated for wildlife habitat and shore birds. For the remainder of 2018, it was decided that MN DNR would be utilizing cells A4 and B4 wildlife habitat and shore birds. Due to these cells requiring a certain level of water, it was determined that growing and sustaining cattail growth would not be ideal with the required water levels needed for wildlife habitat. Discussions are ongoing in regards to the opportunity of harvesting in the C cell in which was the location of the one and only harvest so far conducted in this project. The RRBC has had numerous discussions with the Bois de Sioux Watershed District regarding further cattails harvests. A cattail harvest is planned to be funded and executed by the RRBC in August. Due to this harvest not being able to be conducted within the necessary timeframe of the June 30th deadline we will be shifting this money into the additional time RRBC staff and administrative expenses that have been invested in this effort.

Final Report Summary:

Significant challenges over the years have allowed for only one harvest in the impoundment. The RRBC and UMN acknowledge that harvesting within the impoundment is less than ideal due to the primary function of the impoundment (flood control). There have been several challenges including managing the impoundment for cattail growth; seepage and stop log issues; summer rain fall; and access to the cells with heavy machinery.

Wetland vegetation within the "C" pool was targeted for harvesting in 2016 due to established stands of cattail species. Harvesting was successfully conducted on 10 acres of dense cattails for biomass removal and habitat management. Harvesting was accomplished using conventional forage chopping equipment and resulted in a 4.76 tons per acre biomass yield. Harvested biomass was then land applied as an agricultural soil amendment. Nutrient analysis of the harvested biomass equated to 48 lbs. Nitrogen and 6.6 lbs. Phosphorus captured per acre harvested.

Due to the challenges mentioned above along with the end of the grant period, a scheduled cattail harvest is not anticipated this year. Based on ongoing communications with the Bois de Sioux Watershed District Board, we have been taking details soil and plant samples for analysis alongside the water quality samples to determine the benefits of nutrient uptake from the cropped cells. The cells each are cropped with either wheat, beans or corn. With that, each cell is being analyzed to show the nutrient capture capabilities of these crops within the impoundment.

ACTIVITY 4: Nutrient Monitoring

Description:

Develop detailed monitoring system to track nutrient inputs, outputs and nutrient storage within the impoundment. All water coming in from the upstream watershed will be sampled, soil samples will be collected within the impoundment area and all water leaving the impoundment will be sampled as well. A detailed nutrient budget will be developed and reported to clearly establish the total mass of nutrients removed from the system and to determine the capture rate of the North Ottawa Impoundment with the new treatment cells.

Summary Budget Information for Activity 4:

ENRTF Budget: \$ 172,873
Amount Spent: \$ 159,561
Balance: \$ 13,313

Activity Completion Date:

Outcome	Completion Date
1. Soil Sampling within the impoundment	September 2014
2. Install inlet/outlet automated water sampling equipment	June 2015
3. Water quality sampling for nutrients above and below the impoundment	June 2017, 2018

Activity Status as of January 1, 2015:

Baseline soil sampling from the impoundment has been completed to monitor formation of the organic layer on the surface and absorption and desorption of P in the soil column. Soil samples were collected at 15 and 30 centimeter depths. A permanent sampling grid has been established to allow for ongoing soil analysis from established station sites as nutrient budget activities are carried out over the life of the project. As expected the concentration of P in the shallow samples was much greater than the deeper samples.

A contract with detailed work plan was developed with Dr. Joe Magner, U of MN to monitor water quality above, within and below the treatment cells and to document the nutrient capture achieved within the North Ottawa Impoundment. Several site visits were completed with Dr. Magner and his staff, Bois de Sioux Watershed District and WSN Engineering to develop the monitoring plan and determine locations for the placement of recommended automated water quality sampling equipment needed for inlet and outlet monitoring. The request will support monitoring equipment and supplies to retrofit the current outlet structure and setup the inlet infrastructure and equipment that will allow for monitoring of flow, dissolved oxygen, temperature, turbidity, barometric pressure and nutrients (phosphorus and nitrogen) from drainage water entering and leaving the impoundment. The dynamics of phosphorous cycling as the basin matures and changes over time requires adjustments to accurately measure phosphorous loading in relation to climate, rainfall and changing agricultural drainage practices. The automated systems at the inlet and outlet enables daily monitoring to collect data necessary for the impoundment and contributing drainage area. The preliminary costs to retrofit the existing outlet are \$16,425 and estimates to set up the inlet monitoring station are \$23,575.

Additional locations where water samples will be collected both upstream and downstream from the impoundment will be with portable SONDE units approved through state of Minnesota contract. Sampling equipment needed will be ordered once amendment is approved with planned installation prior to spring melt. Dr. Magner is managing all soil sampling efforts through the University of Minnesota soils lab.

Grab samples were taken on 5 dates during the summer 2014 at the inlet, within the pool and at the outlets (when water was running out of the impoundment) as part of a 319 project funded from the MPCA. All water samples have been analyzed by RMB Environmental Labs in Detroit Lakes. Both RMB Labs and the University of Minnesota have been listed as the approved vendors for lab analysis work for MPCA managed 319 funds and will be used to support uniformity and integrity of collected soil and water data and will help form the design for the future sampling work that will be completed under this grant. A copy of the final report completed for the 319 project is *attached*. Initial sampling completed in 2014 at the North Ottawa Impoundment, prior to any the treatment cell development, demonstrates that the impoundment during this sampling season captured 38% of

the phosphorus, 70% of the nitrogen and 84% of the total suspended solids that entered the structure after treatment through pool C and measured at the outlet site.

Activity Status as of July 1, 2015:

The monitoring activities have become more extensive and now include automated monitoring at both the inlet and outlet of the North Ottawa site using an ISCO sampler. The inlet sampling schedule includes a twenty-four hour collection regime (1 sample per hour / 24hr period) after any major rain event that creates enough run-off to increase water in the North Ottawa impoundment. The region experienced limited snow fall this year and so no water entered the impoundment as a result of spring melt. The region did however experience to May rain events that prompted inlet sampling with results collected and delivered to the lab for analysis. The outlet sampling schedule is based on release of water from the impoundment to augment flow in the downstream Rabbit River drainage. The release of water prompted our first outlet sampling event on June 22, 2015. Release water samples will be collected from the ISCO on the outlet side every seventy two hours on the twenty-four hour regime with a 2 hour interval between samples. This collection period will run for a two week period and will help determine the relationship over time of the quality of the water leaving the impoundment after a holding and settling process within the existing impoundment. As a part of this project we are also monitoring ten sites upstream of the impoundment that are within the seventy five square mile drainage area. The intent of this monitoring is to help develop nutrient loading influences based on where the water is draining from the landscape. The monitoring sites includes drainage coming directly from agricultural areas, drainage that travels through wetland systems and drainage where some vegetative filtering like grassed waterways may influence loading. Two sites have been selected that have direct influence from sub-surface water from tile drainage. Understanding where drainage water influences are coming from within the watershed will help us determine the best practices to promote to help reduce non-point source (NPS) phosphorous and nitrogen entering the watershed from both private and public lands.

Activity Status as of January 1, 2016:

Summer 2015 was dryer than normal during the growing season, April 1 to November 1. The amount of runoff that made it to the impoundment was below normal. There were very few rainfall events that produced enough runoff to sample. Nutrient loading to the impoundment is currently being calculated as best we can. ISCO water samples were collected at the inlet and outlet to the impoundment in 2015. Samples were sent to the RMB Environmental Laboratories, Inc., in Detroit Lakes, MN and analyzed for dissolved oxygen, nitrate (N+N), orthophosphate (OP), total Kjeldahl nitrogen, total phosphorus (TP), total suspended solids, total suspended volatile solids, turbidity, temperature, pH and specific conductance. Nitrate, orthophosphate, total phosphorus, and total suspended solids data from 2015 suggest that storage of water in the North Ottawa Impoundment lowers the concentration of these nutrients between inflow and outflow water. Soil samples were also collected from the cells of the impoundment and analyzed for phosphorus content. The soil samples from within the cells will allow us to monitor how phosphorus is moving within the impoundment when treatment cells are operating.

A number of unknown variables have limited the ability to complete a detailed nutrient budget. Many of these variable have been addressed to allow for future load determinations to be made. An increased sampling plan has been adopted to allow for a detailed nutrient budget to be measured for 2016. The detailed nutrient budget will clearly establish the total mass of nutrients in the system and determine the capture rate of the North Ottawa Impoundment and biomass harvesting activities.

Activity Status as of July 1, 2016:

Monitoring of water entering the impoundment and upstream within the watershed has been ongoing this spring. Sampling gaps identified from 2015 monitoring have been addressed to help develop detailed nutrient loading of the watershed and impoundment. With funds from the MPCA 319 grant we have gathered three rounds of watershed samples following rain events which will continue to help delineate where and how nutrients are flowing from the watershed to the impoundment. The sampling system setup at the inlet to the

impoundment is setup to capture rain events resulting in flow to the impoundment as well as collecting base flow samples. This monitoring strategy will allow us to better determine when nutrients are entering the impoundment and how to manage water levels to optimize water quality benefits.

Summer 2015 nutrient loading to the impoundment has been determined using empirical and synthetic methods. The calculation of inflow to the impoundment and outflow from the impoundment required some modeling to complete the load analysis. With the limited data available, loads for 2015 have been calculated using models that average flow and concentration between sampling intervals which may introduce a degree of uncertainty. The calculations indicate a total phosphorus load reduction of 11%; a dissolved orthophosphate reduction of 86% and a Total suspended solids load reduction of 24%. The load calculations for total nitrogen showed an overall export of nitrogen in 2015 of 70%. This may likely be due to the limited sampling conducted during periods of flow into the impoundment which did not capture concentrations of nitrogen frequent enough and during various flow conditions. A Nitrate-Nitrite load reduction of 97% was calculated. These load reduction calculations have allowed us to better design and implement our monitoring initiative to develop the detailed nutrient budgets the project desires.

Project Status as of December 22, 2016 submitted as *January 1, 2017 update*:

Detailed nutrient monitoring of the inflowing surface waters from the watershed above the North Ottawa Impoundment and water discharged from the impoundment was conducted during the 2016 season. Nutrient loading to the impoundment was minimal during the very dry spring and early summer months. The base flows that were sustained from management of Mud Lake early in the year were relatively low in nutrients. Summer rain events resulted in observed increase nutrient loading to the impoundment. The first significant loading occurred during a June 12-14th rain event which produced a small surface runoff event in portions of the watershed. The watershed received a large rainfall event on July 10th that resulted in the largest runoff event of the season. The runoff from this event brought the majority of the season's nutrient loads and a large portion of the runoff was channeled into the C cell.

The monitoring that was conducted during 2016 has allowed us to better understand nutrient loading from the watershed and how management of the impoundment can maximize the capture of the nutrient loads. During larger spring and summer runoff events we see the majority of the nutrient loading to the impoundment. By diverting these runoff events into the holding and nutrient uptake cells we will be most effective in capturing the nutrients. During periods of low flow and low nutrient loading the efficiency in capturing nutrients will be lower. By releasing the water during these periods we can provide more capacity to holding the larger runoff events. Additional analysis of the 2016 data is being conducted to better understand the trends in loading and how they can affect the capture efficiency of the system.

Limited water was exported from the system until the first drawdown in August that was conducted to facilitate harvesting of cattail biomass in the C cell. This drawdown was conducted over a two week period where water was slowly flowing out of the C cell until the majority of the cell was drained and harvesting could be conducted. The remaining water in C cell was then slowly drawn down during October to provide maximum holding capacity for next spring. Nutrient load reductions were calculated for the C cell from quantifying nutrients loads into and out of the C cell. The C cell management produced nutrient load reductions of 27% for total phosphorus, 56% for total nitrogen, and 57% for Total Suspended Solids.

The early summer base flows that were sustained from management of Mud Lake were utilized for implementing the NRE management plan for the A and B cells. This base flow was relatively low in nutrients but in an effort to establish cattails in the B4 cell the water was held for the entire season. Through maintaining a mud flat and then later holding up to two feet of water in the B4 cell a cattail stand was established that will function as a primary nutrient capture mechanism in future management. The remaining water in the impoundment was utilized for providing habitat for wildlife in the A and B cells. A series of flooding was conducted in three of the other cells during the fall to provide resting and feeding area for migratory waterfowl.

The mild fall weather allowed for an extended holding time before drawdown was necessary to insure holding capacity for next spring. Prior to a turn to colder weather in the end of October the outlets for the A and B cells were opened and a slow drawdown was initiated. This slow drawdown resulted in relatively low nutrient concentrations in the outflow. A water sample taken during this slow drawdown period had total phosphorus concentrations of 0.07mg/L, total nitrogen concentrations of 1.66 mg/L, and total suspended solids of 6 mg/L. Due to a quick change in forecasted temperatures in November the outlets were opened and the remaining water was quickly drained from the system to avoid freezing excess water within the impoundment. This expedited drawdown at the end of the season was not ideal for water quality benefits of the project due to the “flushing” of large amounts of sediment during the higher flow period. A water sample taken during this fast drawdown period had total phosphorus concentrations of 0.40 mg/L, total nitrogen concentrations of 2.85 mg/L, and total suspended solids of 61 mg/L. This was a lesson learned the hard way and will influence future management to avoid higher flows contributing to nutrient export. Overall load reduction calculations for the impoundment are currently being analyzed which will capture this nutrient export from the accelerated drawdown.

Summer 2015 nutrient loading to the impoundment had been determined using empirical and synthetic methods which introduced a degree of uncertainty. This degree of uncertainty influenced exploration of alternative methods for calculating flows and loads into, within, and out of the system. Through collaboration with University of Minnesota personnel and delivery of accurate Stage to Storage curves for the impoundment we were able to reduce the level of uncertainty in the method. This new approach was employed in the 2016 C cell load reduction calculations and is currently being utilized for the A and B cell system for 2016 as well as recalculating the 2015 load reductions. This additional analysis will be included in future updates and in a final report.

Project Status as of July 1, 2017:

Monitoring of water entering the impoundment and upstream within the watershed has been ongoing this spring. The sampling system setup at the inlet to the impoundment is programmed to capture runoff events resulting in flow to the impoundment as well as collecting base flow samples. This monitoring strategy will allow accurate determination of when nutrients are entering the impoundment and how to manage water levels to optimize water quality benefits. Management strategies include plans for drawdown timing and velocity, water retention time for settling of sediments, and optimizing vegetation for nutrient reduction. The results of this monitoring effort have been used to identify the pollutant reduction potential of the impoundment. When comparing pollutant concentrations between North Ottawa’s inlet and outlet values, both ortho-phosphate (OP) and turbidity stood out. OP data was compiled from all sampling years at the inlet and outlet to get a better comparison between inflow and outflow trends. The average inflow value for OP entering the impoundment was 0.19 mg L⁻¹. Comparing the average inflow OP concentration to the outflow average of 0.05 mg L⁻¹, shows a major pollutant reduction being provided by the impoundment. Comparing inflow and outflow turbidity values shows an even larger change. The inflow average for turbidity was calculated to be 57.64 Nephelometric Turbidity Units (NTU), with the maximum value being 262.00 NTU. The outflow average for turbidity was calculated to be 17.89 NTU, with a maximum value of 43.50 NTU. These values show that the North Ottawa impoundment is very effective at reducing both OP and water turbidity from water entering the system. Several additional years of monitoring will help to better characterize the water treatment performance of the impoundment. Management of the impoundment has also varied in the past three years in terms of vegetation and crops planted, water storage and movement, and impoundment construction. All of these factors may have had significant impacts on total suspended solids and nutrient processes. A summary of the monitoring activities conducted to date have been outlined in the attached report *North Ottawa Impoundment Water Quality Summary*. The monitoring and nutrient budget data will be used to advise management of the impoundment to maximize water quality benefits.

Analyzing the monitoring activities and management conducted at the North Ottawa Impoundment a turbidity outlet target has been developed to advise management that enhances the water quality benefit. This turbidity target was developed by comparing observed outlet turbidity values as they relate to management activities.

Under most management conditions outlet turbidity values are under 10 NTU. Only under accelerated outlet operation, during high wind events and following runoff events resulting in elevated pool turbidity were outlet values in exceedance of 10 NTU. Based on this trend outlet values will be monitored and under conditions of turbidity exceeding 10 NTU manipulation of the outlet structure will aim to slow or stop outflows to reduce suspended solids export. This management to enhance water quality will only be implemented when flood damage reduction goals allow. To implement this target a conversion of 10 NTU to a turbidity tube measurement of 53cm will serve as the field measurement of the target. The target value will continue to be evaluated as additional monitoring is conducted at the impoundment and treatment performance under various conditions are characterized.

Most of the runoff supplying the impoundment typically would occur during spring snowmelt. Spring runoff events are extremely variable in terms of runoff volume. This typical snowmelt dominated pattern was not observed in 2017. Spring rain events have resulted in most of the runoff to the impoundment. A June 14, 2017 rain event resulted in a significant runoff event in the watershed following approximately 4 inches of precipitation in a 24 hour period. The runoff event produced approximately 1,500 acre feet of water that entered the impoundment. During the peak of this runoff event turbidity was measured at 389 NTU which represents a significant sediment load entering the system. These types of runoff events during periods of the year when agriculture lands are susceptible to erosion will significantly change to loading patterns of nutrient and sediment. Additional analysis of the monitoring during this event is being conducted. The analysis will be used to advise management of the impoundment to maximize water quality benefits.

Project Status as of January 1, 2018 Detailed nutrient monitoring of the inflowing surface waters from the watershed above the North Ottawa Impoundment and water discharged from the impoundment was conducted during the 2017 season. Nutrient loading to the impoundment was minimal during the very dry spring and early summer months. The base flows that were sustained from management of Mud Lake early in the year were relatively low in nutrients. Summer rain events resulted in observed increase nutrient loading to the impoundment. The first significant loading occurred during a June 12-14th rain event which produced a small surface runoff event in portions of the watershed. The watershed received a large rainfall event on July 10th that resulted in the largest runoff event of the season. The runoff from this event brought the majority of the season's nutrient loads and a large portion of the runoff was channeled into the C cell.

The monitoring that was conducted during 2016 has allowed us to better understand nutrient loading from the watershed and how management of the impoundment can maximize the capture of the nutrient loads. During larger spring and summer runoff events we see the majority of the nutrient loading to the impoundment. By diverting these runoff events into the holding and nutrient uptake cells we will be most effective in capturing the nutrients. During periods of low flow and low nutrient loading the efficiency in capturing nutrients will be lower. By releasing the water during these periods we can provide more capacity to holding the larger runoff events. Additional analysis of the 2016 data is being conducted to better understand the trends in loading and how they can affect the capture efficiency of the system.

Limited water was exported from the system until the first drawdown in August that was conducted to facilitate harvesting of cattail biomass in the C cell. This drawdown was conducted over a two week period where water was slowly flowing out of the C cell until the majority of the cell was drained and harvesting could be conducted. The remaining water in C cell was then slowly drawn down during October to provide maximum holding capacity for next spring. Nutrient load reductions were calculated for the C cell from quantifying nutrients loads into and out of the C cell. The C cell management produced nutrient load reductions of 27% for total phosphorus, 56% for total nitrogen, and 57% for Total Suspended Solids.

The 2018 monitoring season has begun with deployment of equipment and ongoing water quality monitoring in the watershed and within and downstream of the impoundment. During the deployment of the equipment it

was determined that the equipment was not functioning as it should and was recommended that new equipment be purchased to continue sampling the inlet and outlet of the impoundment. Currently manual samples are being taken but require UMN students to drive from St. Paul when automated equipment can do that for us. The equipment also measures flow and precip data which is a critical data component for this project. The new equipment will be deployed as soon as possible.

Activity 4 is the primary activity remaining in this project as we continue to sample and analyze the data being collected at the site. We continue to update the RRBC stakeholders, Bois de Sioux Watershed District and others about the outcomes of this project on a regular basis.

Final Report Summary:

Monitoring of water entering the impoundment and upstream within the watershed has been ongoing this spring. Detailed nutrient monitoring of the inflowing surface waters above North Ottawa and water discharged from the impoundment was also conducted. The ongoing monitoring strategy is critical to and allows an accurate determination of when nutrients are entering the impoundment and how to manage water levels to optimize water quality benefits. Management strategies have included plans for drawdown timing and velocity, water retention time for settling nutrients, and optimizing vegetation for nutrient reduction. Most of the runoff supplying the impoundment typically would occur during spring snowmelt. Spring runoff events are extremely variable in terms of runoff volume. The past few years there has not been significant spring runoff. There have been a few rain events that have prompted runoff. This is a significant conclusion in that the need to continue monitoring the North Ottawa Impoundment for water quality benefits beyond the period of this grant. Due to many climatic variables, several outcomes in this project were impacted.

Because of continued outreach, education and communication with the Bois de Sioux Watershed District Board, additional monitoring at the site would be beneficial to this project and the board itself. This year the impoundment is being cropped in 6 cells versus the 2 cells in the past few years. As RRBC staff, Dr. Joe Magner and his team have collected significant water quality data from the past few years of 2 cropped cells the board and UMN felt it was important to evaluate the nutrient uptake and harvest capability of the crops versus the amount of the nutrients being removed by cattail harvest and the natural settling of nutrients in the impoundment. With funds from 319, RRBC Staff, Dr. Joe Magner and the UNM have been able to continue the monitoring and analysis through this growing season. This information will answer many initial questions.

ACTIVITY 5: Outreach and publications

Description:

The results of this work will be published to inform Watershed District managers within the Red River Basin (RRB) and elsewhere about the success of this treatment technology. The results will be shared and if successful the technique will be used in multiple locations in the RRB to reduce nutrient loads to the waterways. Outreach will include numerous meetings within the RRB to discuss the progress and outcomes of this work.

Summary Budget Information for Activity 5:	ENRTF Budget: \$ 30,913
	Amount Spent: \$ 30,913
	Balance: \$ 0

Activity Completion Date:

Outcome	Completion Date
1. Host meeting to discuss interim and final results	June 2017
2. Publish papers to summarize project findings	June 2017

Activity Status as of January 1, 2015:

Limited work has been completed on Activity 5. RRBC was successful in receiving a grant from the Bush Foundation to assist with the outreach work included under Activity 5 plus some other work RRBC is doing within the Red River Basin on nutrient reduction strategies. The Bush Foundation awarded the RRBC a Community Innovations Grant in the amount of \$198,000 through 2017 to hold community meetings to help develop a nutrient reduction strategy for the basin. This strategy will include the work we are completing here.

Activity Status as of July 1, 2015:

The RRBC and University of Minnesota staff have been meeting with the Bois de Sioux Watershed District, North Ottawa Natural Resources management team which includes representatives from MPCA, MNDNR, SWCD, BWSR, USFWS and watershed engineers to develop the management and operating plan for the site. This plan will set long term goals for Natural Resource Enhancements including, water quality, wildlife enhancement, perennial native plantings and public use of the site. The team will be presenting a draft plan to the watershed district for review by the fall of 2015. Additional outreach activities include site visits to impoundments in four additional watersheds, communication with the managing watershed staff and board and future discussion at the watershed board level to support expanded nutrient capture efforts within impoundments in the northern half of the Red River basin.

Activity Status as of January 1, 2016:

The North Ottawa Nutrient Capture Through Water Management and Biomass Harvesting updates have been presented at most RRBC events including RRBC Board meetings and the annual conference that was held January 2016. The attached project summary dated December 2015 has been utilized during water quality workshops and conferences as preliminary data is available for managing impoundments beyond flood mitigation for water quality improvements.

Activity Status as of July 1, 2016:

The RRBC continues to work with the Bois de Sioux Watershed District to develop outreach and education material for the North Ottawa Impoundment Project. The operations plan and preliminary observations of how the impoundment is able to be manipulated are being used to develop a multi-benefit focused project summary for education and outreach focused on future watershed and impoundment management. This project summary highlights the capacity to manipulate water levels within the impoundment that then allows for multi-benefit management of the site. Flood damage reduction is the primary goal of the impoundment to mitigate cropland damage and downstream flooding. The management plan also outlines water quality, habitat enhancement, crop production, and downstream flow augmentation as goals of the impoundment operation. Significant reductions in sediment and nutrients have been documented during detailed monitoring conducted as part of the project. A moist soils and shallow wetland rotation has been adopted and resulted in compelling habitat creations for migratory waterfowl and shoreline bird communities. Two cells are utilized as traditional crop production when flood damage reduction management is not required. This multi-benefit management plan will continue to be developed and shared as the project moves forward.

Activity Status as of January 1, 2017:

The RRBC continues to develop outreach and education material for the North Ottawa Impoundment Project. The goals and outcomes of this project continue to be presented and shared at most events in the Red River Basin including; Red River Retention Authority Meetings, Red River Watershed Management Board Meetings, Board of Water and Soil Resources Board meetings, and Red River Basin Commission Board meetings. The RRBC had booth presentations and distributed information about the North Ottawa Nutrient Capture project at the Prairie Grains Conference, Minnesota Association of Watershed Districts Conference, and the North Dakota water Conference. The RRBC also participated and disseminated project information at the Minnesota Farm Bureau Ag Water Forums, regional Minnesota Soil and Water Conservation District and Watershed District Events, Minnesota Water Resources Conference, nutrient reduction workshops and many more Red River Basin events.

Project Status as of July 1, 2017:

The RRBC continues to develop outreach and education material for the North Ottawa Impoundment Project outlining goals and outcomes of this project. The RRBC presented on the project during the Red River Watershed Management Board March meeting, the Izaak Walton League spring meeting, the 3rd International Sustainable Wetland Plant Management Conference and the Red River Basin Commission Conference and board meetings.

Project Status as of January 1, 2018:

Dr. David Ripplinger and Dr. Joe Magner are preparing documentation that supports the biomass piece of this project and brings together the science and outcomes. The marketing materials will be project specific and apply the science that is currently know with what is needed for the future.

Final Report Summary:

With the assistance of RRBC staff, Dr. David Ripplinger (NDSU), has created several marketing materials that outline the work that has been done and overall science perspective and what we know has been done around the country as it relates to cattail biomass.

Because of continued outreach, education and communication with the Bois de Sioux Watershed District Board, additional monitoring at the site would be beneficial to this project and the board itself. This year the impoundment is being cropped in 6 cells versus the 2 cells in the past few years. As RRBC staff, Dr. Joe Magner and his team have collected significant water quality data from the past few years of 2 cropped cells the board and UMN felt it was important to evaluate the nutrient uptake and harvest capability of the crops versus the amount of the nutrients being removed by cattail harvest and the natural settling of nutrients in the impoundment. With funds from 319, RRBC Staff, Dr. Joe Magner and the UNM have been able to continue the monitoring and analysis through this growing season. This information will answer many initial questions.

RRBC Staff have presented to many entities as part of the RRBC's larger outreach strategy around the basin about this effort and conclusions and recommendations for the future. We are diligently working to communicate the excellent data that has come out of this effort to other entities to garner future financial support to continue monitoring for the foreseeable. This would allow an opportunity to understand the system and the uncontrollable variables that impact the functioning of this impoundment. It will also speak to the longevity of these types of projects and the life of nutrient capture in impoundments. We will be able to use this information and apply to projects of this nature and hopefully one day be provide quantitative data in proposed retention/detention project cost benefit ratios.

V. DISSEMINATION:**Description:**

The results of this work will be published to inform managers within the RRB and elsewhere about the success of this treatment technology. The results will also be shared and the technique will be used in multiple locations in the RRB to reduce nutrient loads to the waterways. Currently MPCA, ND Dept. of Health and Manitoba Conservation Water Stewardship are all developing nutrient reduction strategies. These strategies will likely result in a goal of reducing nutrient loads within the RRB by up to 50%. This project will potentially provide a new strategy that will utilize the distributed storage locations being built to address the significant flood damages and expand the uses of these impoundments to capture and reduce nutrient loads as well. Results and information about the new strategy will be distributed through a series of informational meetings throughout the basin and by presentations at the RRBC Annual Conference that is attended by up to 500 individuals working in water management.

Activity Status as of January 1, 2015:

RRBC continues to participate in the development of nutrient reduction strategies that the MPCA, North Dakota Department of Health and Manitoba Conservation Water Stewardship are currently formulating for the Red

River Basin. We were successful in obtaining a grant from the Bush Foundation to assist with an outreach project where the RRBC will host community meetings to gather citizen input to develop a Red River Basin nutrient reduction plan. The limited work completed so far indicates that the Flood Damage Reduction impoundments are beneficial in capturing nutrients being discharged from nonpoint sources. The RRBC 32nd Annual Conference will be held January 20-22, 2015 in Winnipeg, Manitoba. This conference has a water quality theme and will feature several presentations on the work being completed under this grant as well as the overall nutrient reduction work being completed by the two states and province.

Activity Status as of July 1, 2015:

Initial results from 2014 work were presented at the RRBC 32nd Annual Conference will be held January 20-22, 2015 in Winnipeg, Manitoba and regular updates are being provided to the Red River Watershed Management Board. The preliminary results of early monitoring were presented at the Red River Basin Monitoring Advisory Committees June 2015 meeting. We have also recently shared information at a regional Bio mass workshop (Courneya, Ripplinger and Svedarsky) at Loyola College in Chicago. The nutrient capture work coming out of this project is unique in that the efforts within the Red River Basin are leading the way in developing nutrient budgets and management strategies from vegetative bio mass harvest and utilization.

Activity Status as of January 1, 2016:

The results from 2015 were presented at the RRBC 33rd Annual Conference held January 18-20, 2016 in Grand Forks, ND. The RRBC has begun a series of farmer input meetings to discuss methods that can be used to reduce the nonpoint nutrient runoff that is currently leaving cropland. The early results of this project are being widely discussed as a potential significant tool to incorporate distributed flood water storage impoundments to help meet our proposed goal of a Basinwide 50% nutrient runoff reduction. The Red River Basin was successful in obtaining \$12 million in the current US Farm Bill that is being used to evaluate 22 watershed areas for future impoundments. This effort includes 14 in Minnesota and 8 in North Dakota. The water quality information we learn from this project will help us design these future impoundments that are currently being developed. The RRBC was appropriated \$200,000 from the 2015 Minnesota Legislative session to coordinate the development of a Red River Basin Nutrient Reduction Strategy. Again this work under the LCCMR Grant will help shape the development of that overall nutrient reduction work for the Red River Basin.

Activity Status as of July 1, 2016:

The goals and outcomes of this project continue to be presented and shared at most RRBC events including RRBC Board meetings and many other meetings across the basin in the spring of 2016.

Activity Status as of January 1, 2017:

The goals and outcomes of this project continue to be presented and shared at most events in the Red River Basin including; Red River Retention Authority Meetings, Red River Watershed Management Board Meetings, Board of Water and Soil Resources Board meetings, and Red River Basin Commission Board meetings. The RRBC had booth presentations and distributed information about the North Ottawa Nutrient Capture project at the Prairie Grains Conference, Minnesota Association of Watershed Districts Conference, and the North Dakota water Conference. The RRBC also participated and disseminated project information at the Minnesota Farm Bureau Ag Water Forums, regional Minnesota Soil and Water Conservation District and Watershed District Events, Minnesota Water Resources Conference, nutrient reduction workshops and many more Red River Basin events.

Project Status as of July 1, 2017:

The goals and outcomes of this project continue to be presented and shared at most events in the Red River Basin. The RRBC presented on the project during the Red River Watershed Management Board March meeting, the Izaak Walton League spring meeting, the 3rd International Sustainable Wetland Plant Management Conference and the Red River Basin Commission Conference and board meetings. The RRBC continues to work

with multiple groups in the basin on water quality and flood damage reduction activities where the information from this project is shared.

Project Status as of January 1, 2018:

The goals and outcomes of this project continue to be presented and shared at most events in the Red River Basin. The RRBC is presently working closely with the Bois de Sioux Watershed District Managers and Administrative staff to provide all the information and outcomes from the work being done at their North Ottawa Impoundment. The BDS also is interested in establishing a project team specific to this effort to look at future tasks and work that could be evaluated at the impoundment site.

Final Report Summary:

The goals and outcomes of this project continue to be presented and shared at most events in the Red River Basin. The RRBC is presently working closely with the Bois de Sioux Watershed District Managers and Administrative staff to provide all the information and outcomes from the work being done at their North Ottawa Impoundment. The BDS also is interested in establishing a project team specific to this effort to look at future tasks and work that could be evaluated at the impoundment site.

The marketing materials and videos produced will be distributed as a part of our larger basin outreach strategy. These materials will also be showcased at our upcoming Ex Officio board meeting and annual conferences. Manitoba is also doing research with cattail bio mass and nutrient reduction but on a much smaller scale than North Ottawa. They are extremely interested in the results and continued data that will come out of this project.

VI. PROJECT BUDGET SUMMARY:

A. ENRTF Budget Overview:

Budget Category	\$ Amount	Explanation
Personnel:	\$ 79,500	RRBC staff to operate treatment cells, work with partners on utilization, conduct monitoring
Professional/Technical/Service Contracts:	\$ 173,000	Contract with WSN for design and construction, contract with Svedarsky for energy utilization, contract with Ripplinger for market analysis, contract with Magner for monitoring work, contract for cattail harvesting, contract for lab analysis
Inlet & Outlet Monitoring Equipment	\$ 40,000	Purchase and install Sonde water monitoring Equipment
Printing	\$ 1,500	Project Reports to be used in outreach
Travel Expenses in MN:	\$ 6,000	RRBC Staff for site work and outreach
TOTAL ENRTF BUDGET:	\$ 300,000	

Note: When original proposal was submitted we had not yet finalized how the monitoring work would be completed. We began discussions with Dr. Joe Magner, Research Professor, from the University of Minnesota Bioproducts and Biosystems Engineering who has had extensive experience in designing and operating monitoring systems in wetlands and agricultural areas including drainage ditch systems. Dr. Magner has since found a new graduate student who is very interested in working with us to develop this project into a research project that should result in research publications in refereed journals. A contract will be developed with Dr. Magner to develop the monitoring system, guide research on nutrient capture and publication of findings. We are requesting that Dr. Magner be added to our list of contractors for this project.

Explanation of Use of Classified Staff: N/A

Explanation of Capital Expenditures Greater Than \$5,000: Amended February 18, 2015

The request will support monitoring equipment and supplies to retrofit the current outlet structure and setup the inlet infrastructure and equipment that will allow for monitoring of flow, dissolved oxygen, temperature, turbidity, barometric pressure and nutrients (phosphorus and nitrogen) from drainage water entering and leaving the impoundment. The preliminary costs estimates to retrofit the existing outlet are \$16,425 and \$23,575 to set up the inlet monitoring station. Attached is a detailed list of the proposed equipment to be installed and deployed at the inlet and outlet of the North Ottawa site. Once installed the equipment will be maintained and used after ENRTF project through intended life expectancy of equipment.

Number of Full-time Equivalent (FTE) Directly Funded with this ENRTF Appropriation: 0.3 FTE for three years

Number of Full-time Equivalent (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation: 1.0 FTE for three years (estimate)

B. Other Funds:

Several funding sources are pending. University of Minnesota and RRBC have applied for funding from Minnesota Corn Growers Association to assist with the monitoring components of this project. RRBC will be applying for MPCA/EPA 319 funding later this spring. RRBC with the International Institute for Sustainable Development have applied for funding through the Lake Winnipeg Basin Stewardship Fund (LWBSF) to fund work at additional sites within the RRB.

Source of Funds(Pending)	\$ Amount Proposed	\$ Amount Spent	Use of Other Funds
Non-state			
<u>Bush Foundation(Issued)</u>	<u>\$ 198,000</u>	<u>\$ 198,000</u>	<u>Community Outreach planning meetings</u>
<u>EPA 319(Issued)</u>	<u>\$ 27,930</u>	<u>\$ 12,348</u>	<u>Initial nutrient reduction sampling</u>
<u>EPA 319(Issued)</u>	<u>\$ 290,000</u>	<u>\$ 251,874</u>	<u>Sampling in watershed and in the impoundment</u>
State of Minnesota	<u>\$200,000</u>	<u>\$ 192,279</u>	<u>Red River Basin Nutrient Reduction</u>
TOTAL OTHER FUNDS:	<u>\$ 715,930</u>	<u>\$ 654,501</u>	

Note: The funding request to the Minnesota Corn Growers was not approved. The original request to the Lake Winnipeg Basin Stewardship Fund was not approved. A subsequent request was submitted for nutrient reduction outreach to match the Bush Foundation Grant. The LWBSF funding is not central to the Minnesota based project work, it has been targeted to support expansion of promising practices to new impoundment sites as they are being planned for the Manitoba, North Dakota and Minnesota border watersheds that are contributing to the basin wide phosphorous and nitrogen nutrient loading from the landscape. The Minnesota Corn Growers as well as additional Agricultural associations will be solicited again to support long term study planning needs resulting from agricultural related water quality impacts. This request to LWBSF was for \$200,000 and is still pending. A grant was received from the Bush Foundation to do citizen/community outreach meetings on a Basin wide nutrient reduction strategy. We did receive EPA 319 grant funds in the amount of \$27,930 to complete water quality data review and initial sampling work at the North Ottawa Impoundment. This grant ended September 30, 2014 and resulted in a report that we have attached to this first status report. A second EPA 319 grant request was approved for \$290,000 and work under this grant will begin March 2015 and

run through August 2018. Total other non ENTRF received to date are \$515,930 with one pending LBWSF of \$200,000. The RRBC and Cattail summit group are continually seeking other funding sources to expand this work within the Red River Watershed and anticipate future other fund updates will reflect additional funds leveraged to support a long term strategy for nutrient capture in flood retention reservoirs.

Activity Status as of January 1, 2016:

The RRBC was successful in obtaining \$200,000 authorized as part of the Minnesota 2015 legislature. This appropriation is for the RRBC to facilitate a water quality/nutrient reduction strategic plan for the entire Red River basin. The information we learn in the LCCMR funded project will be used in the overall basin nutrient reduction strategy.

VII. PROJECT STRATEGY:

A. Project Partners:

The project team will include Joe Courneya, RRBC as the project lead field staff, Jon Roeschlein Administrator, Bois de Sioux Watershed District, in-kind, Jeff Lewis RRBC in-kind, Charlie Anderson, WSN Engineering contract to design, construct and operate treatment cells. The project Team will also include Dr. Dan Svedarsky U of MN-Crookston under contract to work with us on energy utilization and Dr. David Ripplinger NDSU Fargo under contract to develop market analysis of cattail utilization and Dr. Joe Magner U of MN-St. Paul under contract to guide the monitoring activities and analyze nutrient capture efficiencies and consult on treatment cell operation. Dr. Dan Svedarsky also has a separate LCCMR proposed funded project to work on cattail harvesting mainly for wildlife enhancement. RRBC and Dr. Svedarsky are also working with International Institute for Sustainable Development Winnipeg Manitoba who have completed earlier work on cattail harvesting and continue to work on cattail nutrient removal as well as utilization potential for energy.

The RRBC has met with the Minnesota Agricultural Water Research Council about partnering with us on the citizen/community input meetings. We are in discussions with MAWRC about this work that will include the tasks under Activity 5 as well as the outreach work we are doing in addition to complete the work plan for the Bush Foundation Grant.

Activity Status as of January 1, 2016:

Joe Courneya is no longer employed by the RRBC. He has been replaced with Aaron Ostlund who will be the RRBC lead staff working on this grant.

B. Project Impact and Long-term Strategy:

This project will develop a new and additional tool to try and reduce the nutrient impairments common to the agricultural regions of our state. The RRB is currently in the process of developing a nutrient reduction strategy that will likely result in a goal of a significant nutrient reduction of somewhere around 50%. We need to develop new techniques if we ever want to be able to reach this potential goal. It has been determined by Dr. Magner and the University that installation of automated real time infrastructure will be a necessary component for both existing and new system design to accurately measure and manage for nutrient reduction strategies at the watershed level. This tool could be used on many existing and proposed flood retention reservoirs that currently exist or are being built in the RRB. Based on current nutrient load estimates and the number of retention sites planned for the RRB this tool could provide a significant amount of the nutrient reduction needed to reach the 50% goal.

C. Spending History:

Funding Source	M.L. 2008 or FY09	M.L. 2009 or FY10	M.L. 2010 or FY11	M.L. 2011 or FY12-13	M.L. 2013 or FY14

VIII. ACQUISITION/RESTORATION LIST: N/A

IX. VISUAL ELEMENT or MAP(S):


See the three attachments. These include an aerial photograph of the existing North Ottawa Impoundment, a location map and information brochure and a detailed plan sheet of the proposed treatment cells to be constructed within the current impoundment area.

X. ACQUISITION/RESTORATION REQUIREMENTS WORKSHEET: N/A

XI. RESEARCH ADDENDUM: N/A

XII. REPORTING REQUIREMENTS:

Periodic work plan status update reports will be submitted no later than January 1, 2015, July 1, 2015, January 1, 2016, July 1, 2016, January 1, 2018, July 1, 2017 and January 1, 2018. A final report and associated products will be submitted between June 30 and August 15, 2018.

Environment and Natural Resources Trust Fund																									
M.L. 2014 Project Budget																									
Project Title: Nutrient Capture Through Water Management and Biomass Harvesting																									
Legal Citation: M.L. 2014, Chp. 226, Sec. 2, Subd. 06h																									
Project Manager: Aaron Ostlund																									
Organization: Red River Basin Commission																									
M.L. 2014 ENRTF Appropriation: \$ 300,000																									
Project Length and Completion Date: 3 Years, June 30, 2017 - 1 year Extension to June 30, 2018																									
Request Date = 10/3/2018																									
FINAL REQUEST - July 1, 2017 to June 30, 2018																									
ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Revised Activity 1 Budget (6-7-2018)	Beginning Balance	Amount Spent	Activity 1 Balance	Revised Activity 2 Budget (6-7-2018)	Beginning Balance	Amount Spent	Activity 2 Balance	Revised Activity 3 Budget (6-7-2018)	Beginning Balance	Amount Spent	Activity 3 Balance	Revised Activity 4 Budget (6-7-2018)	Beginning Balance	Amount Spent	Activity 4 Balance	Revised Activity 5 Budget (6-7-2018)	Beginning Balance	Amount Spent	Activity 5 Balance	TOTAL BUDGET	TOTAL Revised BUDGET	TOTAL AMOUNT SPENT	TOTAL BALANCE	
BUDGET ITEM	Design/Redesign/Operate North Ottawa Impoundment .				Evaluate Potential Uses of Cattail Biomass				Harvest Cattails.				Monitoring				Outreach Project Management								
Personnel (Wages and Benefits): Joe Courmeya, Red River Basin Comm. : \$89,500 (66% salary, 34% benefits) 0.3 FTE for 3 years	\$8,614.62	\$0.00	\$ -	\$0.00	\$4,990.33	(\$0.00)	\$ -	(\$0.00)	\$1,916.89	\$0.00	\$ -	\$0.00	\$20,329.25	\$0.00	\$ -	\$0.00	\$7,473.08	\$0.00	\$0.00	\$0.00	\$43,324.17	(\$0.00)	\$0.00	(\$0.00)	
Personnel (Wages and Benefits): Aaron Ostlund, Red River Basin Comm. : \$36,250 (66% salary, 34% benefits) 0.3 FTE for 17 months	\$5,919.60	\$0.00	\$ -	\$0.00	\$1,844.96	\$0.00	\$ -	\$0.00	\$11,719.50	\$ 3,499.62	\$ 3,499.62	\$0.00	\$17,611.33	\$2,457.18	\$ 2,457.18	\$0.00	\$2,362.93	\$ -	\$ -	\$0.00	\$39,458.32	\$5,956.80	\$5,956.80	\$0.00	
Personnel (Wages and Benefits): Julie Goehring, Red River Basin Comm. : \$6967 (66% salary, 34% benefits) 0.3 FTE for 9.75 months - START - 9/9/2017	\$ -	\$ -	\$ -	\$ -	\$ 164.71	\$ 164.71	\$ 164.71	\$ -	\$ 863.61	\$ 863.61	\$ 449.30	\$ 414.31	\$ 1,668.67	\$ 1,668.67	\$ 1,668.67	\$ -	\$ 8,274.42	\$ 8,274.42	\$ 8,274.42	\$ -	\$ 10,971.41	\$10,971.41	\$10,557.10	\$414.31	
Project Manager - Leah Thvedt - Salary & Benefits - Jan - Jun 2018 (216 hour)	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 1,443.90	\$ 1,443.90	\$ 1,443.90	\$ -	\$ 8,952.18	\$ 8,952.18	\$ 8,952.18	\$ -	\$ 10,396.08	\$10,396.08	\$10,396.08	\$0.00	
Professional/Technical/Service Contracts: WSN Engineering Charlie Anderson Design treatment cells within existing North Ottawa Impoundment. Operate interior cells to maximize capture of nutrients and installation and maintenance support of equipment.	\$12,469.93	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$12,469.93	\$0.00	\$0.00	\$0.00	
Professional/Technical/Service Contracts: Dr. Dan Svedarsky to evaluate energy potential of cattail biomass.	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	
Professional/Technical/Service Contracts: (TBD) Contract to evaluate biocomposite potential of cattail biomass	\$0.00	\$0.00	\$0.00	\$0.00	\$2,080.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$2,080.00	\$0.00	\$0.00	\$0.00
Professional/Technical/Service Contracts: (TBD) Contract to evaluate fiber potential for cattail biomass	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	
Professional/Technical/Service Contracts: (TBD) Contract to evaluate agricultural amendment potential for cattail biomass	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	
Professional/Technical/Service Contracts: Dr. David Ripplinger - Develop market analysis of cattail biomass utilization	\$0.00	\$0.00	\$0.00	\$0.00	\$22,920.00	\$12,920.00	\$12,837.04	\$82.96	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$22,920.00	\$12,920.00	\$12,837.04	\$82.96
Professional/Technical/Service Contracts: Dr. Joe Magner - Develop monitoring system, analysis of monitoring data, guide research and publication of findings	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$60,000.00	\$10,000.00	\$10,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$60,000.00	\$10,000.00	\$10,000.00	\$0.00
Service Contract: (TBD) Competitive bid to harvest cattails from project site. Cut, remove and apply to adjoining cropland.	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$13,600.02	\$6,643.02	\$39.40	\$6,603.62	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$13,600.02	\$6,643.02	\$39.40	\$6,603.62
Service Contract: University of Minnesota , Twin Cities and RMB Environmental Labs, Detroit Lakes for lab analysis of soil and water samples	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$7,610.00	\$0.00	\$0.00	\$0.00	\$30,390.00	\$12,693.25	\$3,762.00	\$8,931.25	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$38,000.00	\$12,693.25	\$3,762.00	\$8,931.25
Equipment/Tools/Supplies Tech Sales, Minneapolis thru MPCA state approved equipment contracting. To purchase inlet/outlet automated water sampling equipment.	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$36,000.00	\$4,505.72	\$124.11	\$4,381.61	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$36,000.00	\$4,505.72	\$124.11	\$4,381.61
Printing: Interim reports and final report for distribution throughout the basin. Fulfill grant requirements.	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,750.00	\$950.00	\$950.00	\$0.00	\$0.00	\$1,750.00	\$950.00	\$950.00	\$0.00
Travel expenses in Minnesota: Mileage expenses to complete site work and related activities.	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,500.00	\$568.69	\$559.21	\$9.48	\$5,430.07	\$430.07	\$430.07	\$0.00	\$2,100.00	\$1,100.00	\$1,100.00	\$0.00	\$0.00	\$9,030.07	\$2,098.76	\$2,089.28	\$9.48
COLUMN TOTAL	\$27,004.15	\$0.00	\$0.00	\$0.00	\$32,000.00	\$13,084.71	\$13,001.75	\$82.96	\$37,210.02	\$11,574.94	\$4,547.53	\$7,027.41	\$172,873.22	\$33,198.79	\$19,885.93	\$13,312.86	\$30,912.61	\$19,276.60	\$19,276.60	\$0.00	\$300,000.00	\$77,135.04	\$56,711.81	\$20,423.23	

Harvesting Cattails

Harvesting cattails can be challenging and costly, if not impossible, depending on conditions. Removal from controlled environments like the North Ottawa Impoundment in West Central Minnesota provide greater certainty in cattail harvesting dates, cattail condition and composition, required equipment, and harvesting costs.

Harvest Conditions

Harvesting cattails from traditional wetlands presents a number of risks. Depending on moisture levels, harvest may not be possible or difficult as equipment may become stuck. The effort required, including labor and removal equipment, to free equipment may make cattail harvest in a given year or as an ongoing enterprise uneconomical.

Green Cattail Harvest

We focus here on green cattail harvest as it best provides the desired benefit of removing nutrients from the watershed. Using traditional agricultural equipment requires a controlled environment so that moisture levels can be quickly reduced making the field accessible to equipment and trapping nutrients in the biomass for removal. Waiting for dryer conditions will typically result in harvesting dead cattails that have much lower nutrient content and poorer characteristics for certain uses. Green cattail harvest would typically occur in late summer when cattail biomass and nutrient retention is greatest.



Two Harvesting Alternatives

We consider two types of green cattail harvest under controlled conditions: chopping and spreading of cattail as a soil amendment, and baling for use as animal feed. Green cattail moisture levels would likely be too high for long-term storage, long-distance transportation, and certain uses.

Equipment

Traditional forage crop harvest equipment should be suitable for green cattail harvest. The system including machinery needed is similar to corn silage harvest and traditional forage haying. Equipment to chop, haul, and spread or to cut, condition, bale, and feed cattail is necessary.

Harvest Costs

The cost to harvest cattail can be estimated using existing chopping or baling knowledge; using decision tools or custom rates for chopping or baling available from university Extension or a calculator developed specifically for cattail harvest by NDSU Extension available at <https://www.ag.ndsu.edu/bioeconomics>. The cost to chop and spread one ton of green cattail is estimated to be about \$20 while the cost for baling is about \$10.

Other Concerns

Beyond concerns about moisture, high quantities of dust can be expected. This was the situation for the 2016 demonstration harvest at the North Ottawa Impoundment which resulted in challenges for the following truck to operate.

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With support from

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Feeding Green Cattails

Use of cattail as a feedstuff has generally been limited to emergency feeding of standing cattail in winter after most nutrients and energy have returned to the soil.

Harvest and feeding of green cattail, especially as that made possible by controlled environments like the North Ottawa Impoundment in North Central Minnesota change the economics.

With the ability to quickly reduce the water table, the cattail becomes much easier to harvest while retaining its energy and nutrient composition. This is advantageous in increasing nutrient removal from the watershed as well as dramatically improving the material's value as a feedstuff.

Green cattails, like crop residues, are candidates for ammoniating to improve its feed value. Furthermore the use of crop residue, especially corn stover, has been found to readily complement distillers grains, a co-product from corn-ethanol refining, in feed rations. This presents a unique opportunity given the availability of distillers grains across the Upper Midwest.

Given the structure of Upper Midwest beef cattle production, it is expected that cattail would be cut, field-dried, and baled, then stored and fed in winter, as cattle would be grazing in summer. Alternatively, it could be chopped and spread in late summer.



	Green Cattail	Corn Stover	Wheat Straw
Dry Matter	91	90	90
Crude Protein	6.4	4.8	3.6
Undegradable Intake Protein	-	30	30
Total Digestible Nutrients	45	45	43
Net Energy for Maintenance	0.45	0.44	0.4
Net Energy for Gain	0.11	0.19	0.02
Acid Detergent Fiber	50	46	52
Calcium	-	0.49	0.19

Source: NDSU Extension Animal Science

The Feed Value of Green Cattail

Green cattail has a feed profile similar to corn stover. Consequently, using the current market price for stover should serve as a reasonable proxy for the feed value of corn stover. In spring 2018, the USDA Agricultural Marketing Service reported market prices of \$25 for large round corn stover bales, or about \$42 per ton.

References

Alternative Feeds for Ruminants. Lardy, G., Anderson, V., and C. Dahlen. 2015. NDSU Extension AS1182.

National Hay, Feed, & Seed Weekly Summary. USDA Livestock, Poultry, & Grain Market News. March 2, 2018.

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Cattail Nutrient Removal

Cattails store nutrients at different levels throughout the year. Nitrogen and phosphorus levels peak in late summer when plants are largest, before returning to the roots in the fall. While harvesting cattails can be used to remove or relocate nutrients that at high levels can be harmful, harvest timing is critical to maximizing nutrient removal.

In natural wetlands, the benefits of harvesting cattail may not outweigh the risk-adjusted costs as acceptable harvesting conditions may not be present when nutrient content is sufficient to justify removal. For controlled environments, like the North Ottawa Impoundment in West Central Minnesota, there is less risk to harvesting cattail for nutrient removal as water levels can be reduced. This can allow for the capture and removal of nitrogen- and phosphorus-rich green cattails in late summer.

Nitrogen and Phosphorus Rich Water

High levels of nitrogen and phosphorus in water present concerns for drinking water and eutrophication, where excessive plant growth can lead to fish kills.

WasteWater Treatment

There are a variety of alternatives to reduce the presence of nitrogen and phosphorus from water. The cost of treating water varies greatly with water quality, technology, and scale.



Nutrient Removal Benefits

A decision tool available at <https://www.ag.ndsu.edu/bioeconomics> developed by North Dakota State University Extension can be used to estimate the per-ton benefit of using cattail to remove nitrogen and phosphorus as opposed to wastewater treatment plant.

Given the significant variability in cattail nutrient content and cost of removal by wastewater treatment facilities users are encouraged to find the best up-to-date, localized data.

	Nutrient %	Cost per Pound to Remove	Nutrient Pounds per Ton	Removal Cost by Nutrient
Nitrogen	2.02	\$ 3.41	40.4	\$137.76
Phosphorus	0.8	\$ 4.49	16	\$71.84
Total Removal Benefit per Ton of Cattail Removed				\$209.60

A 2010 Utah wastewater treatment facility study estimated the cost of nitrogen and phosphorus removal at \$3.41 and \$4.49 per pound. With 2.02% nitrogen and .8% phosphorus content, the avoided water treatment costs are \$210 per ton of harvested cattail, which would likely cost less than \$30 to harvest.

References

Utah Statewide Nutrient Removal Cost Impact Study. CH2MHill. 2010.

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