M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 04a;
M.L. 2019, First Special Session, Chapter 4, Article 2, Subd. 11b
Project Abstract
For the Period Ending June 30, 2021

PROJECT TITLE: Pilot Program to Optimize Local Mechanical and Pond Wastewater-Treatment Plants
PROJECT MANAGER: Joel Peck
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FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 04a;
M.L. 2019, First Special Session, Chapter 4, Article 2, Subd. 11b

APPROPRIATION AMOUNT: $ 1,200,000
AMOUNT SPENT: $ 1,155,699
AMOUNT REMAINING: $ 44,300

Sound bite of Project Outcomes and Results
Wastewater treatment systems are critical infrastructure to manage waste effluent within hundreds of communities throughout Minnesota. Optimization means getting better results through existing infrastructure. This project determined that both mechanical and pond wastewater treatment systems can be optimized, and new effluent limits met, without adding substantial new infrastructure.

Overall Project Outcome and Results
Achieving better nutrient treatment in wastewater treatment facilities serves to reduce the likelihood of algal blooms in Minnesota's water bodies resulting in cleaner lakes and rivers.

This project found that Minnesota's mechanical wastewater treatment plants can achieve better biological nutrient removal (BNR) through low-cost operational changes. These improvements were modeled using the Activated Sludge SIMulation Model (ASIM) in order to determine the specific plant operational parameters required to achieve BNR. On average, mechanical plants in this pilot were modeled to have average nitrogen reduction of 14.14 mg/L, average phosphorus reduction of 1.84 mg/L (most sites already treat phosphorus chemically to 1 mg/L) and chemical reductions of 886 lb chemical/Million Gallons (MGal) flow.

Wastewater ponds can achieve much better nutrient treatment by utilizing the 'Steady-State Primary' strategy developed during this project. This strategy involves holding the first pond at six feet, or the maximum depth permitted) with a slide gate. Raw influent continues flowing into pond 1, while treated effluent from pond 1 is used to fill pond 2. Meanwhile, pond 3 is also held full. This strategy maximizes treatment time and drastically improves nutrient treatment quality. The two developed case studies showcase a 69% reduction in phosphorus and 43% reduction in nitrogen when compared to the prior year's effluent. Secondary recommendations to wastewater ponds is to reduce inflow and infiltration, reduce fecal loading from waterfowl, and to encourage the growth of aquatic plants, with a specific emphasis on the growth of coontail.

By quantifying the role that optimization has in effective wastewater treatment, Minnesota's lakes and streams can meet standards in a more cost effective means.

Project Results Use and Dissemination

The project and its results have been presented in 17 different events and conferences by members of this team, including Minnesota Rural Water Association's annual conference, Minnesota Pollution Control Agency's annual conference, the Conference on the Environment, and many others. However, only one mechanical treatment plant has elected to move ahead with a pilot study, and one additional has expressed interest in doing so in the near future. The team has heard from staff and consultants of participating facilities that without a nitrogen standard as a driver, they feel little urgency to adopt optimization recommendations. Other facilities are meeting phosphorous limits under current flow, but would face difficulty at increased flow. Additionally, BNR design and operation is not a common treatment system in our Minnesota climate, and there may be some trepidation to moving toward that form of treatment until other facilities lead the way.

We have seen eight pond systems adopt the steady-state-primary flow regime in their operations, with more hoping to do so in the near future. Those that have done so already have reported roughly 50 percent reduction in nutrient discharge. The flow regime still needs additional validation. But, more discharge events will add more confidence with additional datasets from daily monitoring reports. Better flow management through infrastructure maintenance – making sure the control structures function as designed – is going to continue to be an area of importance in order to prevent short circuiting of the treatment in isolated pond cells.

The final report, the final work product of operator field guides for mechanical and pond treatment facilities, case studies of participating facilities, and additional findings, can all be found here, at the Minnesota Technical Assistance Program's wastewater webpages.

Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2018 ENRTF Final Report (Main Document)

Date of Status Update: October 19, 2021

Final Report

Date of Work Plan Approval: 06/05/2018 and 6/17/2019

Project Completion Date: June 30, 2021 ($700,000) June 30, 2021 ($500,000)

Does this submission include an amendment request? No

PROJECT TITLE: Pilot Program to Optimize Local Mechanical and Pond Wastewater-Treatment Plants

Project Manager: Joel Peck

Organization: Minnesota Pollution Control Agency

College/Department/Division: Municipal Wastewater Division

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Location: Multiple locations throughout the state of Minnesota

	M.L. 2018	M.L. 2019
Total Project Budget:	$700,000	$500,000
Amount Spent:	$655,699	$500,000
Balance:	$44,300	$0

Legal Citation: M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 04a

Appropriation Language:

$89,000 the first year and $611,000 the second year are from the trust fund to the commissioner of the Minnesota Pollution Control Agency, in partnership with the Minnesota Rural Water Association and the University of Minnesota's Technical Assistance Program, to implement a pilot program to optimize existing local mechanical and pond wastewater-treatment systems to increase nutrient removal and improve efficiency without requiring costly upgrades.

M.L. 2020 - Sec. 2. ENVIRONMENT AND NATURAL RESOURCES TRUST FUND; EXTENSIONS. [to June 30, 2021]

Legal Citation: M.L. 2019, First Special Session, Chapter 4, Article 2, Subd. 11b

Appropriation Language:
$500,000 the first year is from the trust fund to the commissioner of the Pollution Control Agency for the pilot program created under Laws 2018, chapter 214, article 4, section 2, subdivision 4, paragraph (a). This appropriation is available until June 30, 2021, by which time projects must be completed and final products delivered.

I. PROJECT STATEMENT:

Effective wastewater treatment systems are critical infrastructure to manage waste effluent within hundreds of communities throughout Minnesota. Optimization, in general, means getting better results through existing infrastructure. This proposal will determine how both mechanical and pond wastewater treatment systems can be optimized, and new effluent limits met, without adding substantial new infrastructure. Infrastructure improvements should be the last resort when new or more restrictive effluent limitations are required to meet water quality standards. The goal is to optimize existing wastewater treatment processes to improve nutrient (phosphorus and nitrogen) removal.

The primary purpose of wastewater treatment is to protect the environment from contamination and preserve water sources for residential, industrial and recreational use as well as minimizing impact on wildlife and aquatic species. Cities throughout the state are responsible for providing effective, affordable wastewater treatment services for residents and businesses within their communities. Effective operation of wastewater services is vital to preserve the environment, maintain public health, and support regional economic development.

To ensure communities manage their environmental impact, wastewater effluent discharged to Minnesota waterways are subject to federal and state regulation. These regulations continue to become more stringent over time as treatment demands increase and as negative environmental impacts to receiving waters are better understood. This proposal would add a new option for municipalities – wastewater facility optimization – that may help many communities meet new pollutant limits without requiring expensive new infrastructure. This will result in lower costs for communities and cleaner water for all Minnesotans.

The outcomes of these projects will be:

- Increased nutrient removal and improved operational efficiencies at mechanical and pond wastewater treatment plants,
- Ability of at least some cities to comply with new water quality limits without needing expensive new construction,
- Cost savings to cities and to the state, as the useful life of optimized wastewater systems is extended.
- This project will allow the Minnesota Technical Assistance Program (MNTAP), Minnesota Rural Waters, Metropolitan Council Environmental Services (MCES), City of St. Cloud and the Minnesota Pollution Control Agency (MPCA) to collaboratively work together to help rural communities save money and resources to assure that wastewater effluent limitations are met and maintained.
- This project will establish mentoring relationships that will foster learning and the exchange of knowledge for years to come.

II. OVERALL PROJECT STATUS UPDATES:

First Update January 31, 2019
The project started slow, due primarily to MPCA's internal contracting process. So, while the money for this project became available on July 1, 2018, actual work was not possible until November 1, 2018. The long delay was caused by available staff time in MPCA's Contract Unit, their fiscal-year-end workload, and lack of consensus

on the structure of the contracts. This was a significant challenge. Even through the long project delay, however, MPCA was able to communicate well with project partners, so that when signatures were signed, they could proceed under full momentum.

A short list of facilities were all selected from the 2017 Discharge Monitoring Report data on the basis of nitrogen and phosphorus effluent. All 239 mechanical plants within the scope of the study were ranked based on total nitrogen effluent concentration, total annual nitrogen discharge, total phosphorus effluent concentration, and total phosphorus effluent discharge. Plants that ranked in the top 20% of each of these categories were given a score of 1 for each specific criteria, for a maximum of 4. Plants were also evaluated for simultaneous biological and chemical treatment methods for phosphorus removal, and if they were found to possess both of these capabilities, the plant was given an additional 1 point, bringing the maximum score to 5. Plants that aggregated a total score of 2 or more were placed on a short list to target for inclusion in the optimization program.

Project partners then began to promote the Optimization Pilot Program by calling facility operators and providing a description of the program. If the municipality elected to participate, a site visit was scheduled, and an initial facility assessment was conducted. Using that initial assessment, University of Minnesota engineering students built theoretical models of the facilities using modeling software that can predict effluent concentrations under different treatment process scenarios. To date, models for one wastewater treatment plant (New Ulm) and one wastewater treatment pond (Gaylord), are under development using the modeling software.

Amendment Request May 30, 2019:
We seek an amendment to the work plan to add an additional $500,000 that was appropriated through laws of 2019. With this new funding, substantially more operator training, instruction, and development will be accomplished. The following outcomes were updated accordingly:

- Learn if the municipality has completed an adequate phosphorous management plan, and an inflow and infiltration (I & I) plan. And if not, to assist them in doing so.

- Complete an assessment of the integrity of the systems structures, gates, and assets to make sure we have the ability to use optimization strategies.

- Gain better understanding of the current influent flow using composite sampling for accurate data: What businesses served by the collection system have a reasonable potential to impact the system's ability to treat as industrial and commercial contributions such as, high-strength septage, B.O.D., salts, and metals can have significant impact on treatment system.

- Increase sampling events in the spring or fall, prior to discharges, for two- and three-cell pond systems. We can measure how algae, macrophytes, and the conditions of "old water" to implement a time schedule to determine when optimal treatment has been met or ready to discharge. This can be weather dependent and onsite operations may be a factor. But this activity will inform operators who discharge the same time, year-after-year, because this is "when we always discharge." Conditions should drive discharge events, not habit.

Amendment Approved by LCCMR 9/23/2019

Second Update June 30, 2019

On Wednesday, March 27, 2019, the team contracted with Grant Weaver, a nationally-known treatment plant optimization expert to present his theories of optimization to the Minnesota Pollution Control Agency's Annual Wastewater Conference. The contract with Weaver also secured his availability and expertise for the team for the duration of the pilot project period.

For the period from February 1 to June 30, 2019, the team has remained busy as it has completed the initial site assessment of the 30 pilot pond facilities, gathering baseline data and conducting review of existing infrastructure. Notable among the facilities included Sandstone where the pond expert and University of Minnesota students met with city staff to understand the influent contribution for the State Corrections Facility. This particular case will include involvement from the staff of the correctional facility, site visits within, and a strategy to minimize the significant phosphorous loading coming from it. This is an example of how upstream pollution prevention will have significant optimization potential.

Continued effort on wastewater treatment plants was delivered to facilities New Ulm and New London-Spicer facilities, where we found opportunities to both increase nutrient treatment and decrease energy consumption.

Third Update January 31, 2020
MnTAP has coordinated with five wastewater treatment plants across the state to build computer models of each facility using modeling software that predicts outcomes after calibrated inputs are built. This high-tech method of optimizing wastewater treatment has identified savings from cost-avoidance of $184,700 per year, and potential phosphorous loading of 4,172 kilograms per year to our lakes and streams.

Using the same modeling software to build theoretical pond systems has proven problematic. The model simply could not translate the process treatment plants employ to the way pond systems function. After much alternative review to develop an ersatz model for ponds, the team came to the conclusion that a better understanding of the dynamics of the aerobic/anoxic zones within the water column is the best way to optimize a pond systems treatment capabilities.

This is research that has not been done before. Understanding these dynamics will be critical for pond optimization going forward. The research needed requires gathering data every two weeks and analyzing the dynamic changes in the water column in three well-functioning ponds, as well as three poorly-functioning ponds. These datasets will effectively identify under what conditions microbial phosphorous reduction and the nitrification/denitrification cycle occur. Comparing these conditions in the water columns will allow us to predict, with confidence, how to optimize treatment.

Amendment Request January 31, 2020
We request to re-program the $50,000 previously budgeted for vehicle acquisition to capital equipment necessary in data gathering, sample handling, analysis. Two personal water crafts are necessary to venture out onto the wastewater ponds. These are in the range of $500, each ($1,000). Transportation racks are required to be installed on the Minnesota Rural Water vehicles, at $2,000, each ($4,000), installed. Sondes, ($30,000) data-logging devices ($11,000), bottles, coolers, and other instruments amount to ($4,000).

Amendment Approved by LCCMR 2/8/2020

Project extended to June 30, 2021 by LCCMR 6/18/20 as a result of M.L. 2020, First Special Session, Chp. 4, Sec. 2, legislative extension criteria being met.

Fourth Update June 30, 2020
The most significant update to provide in this term is the impact of COVID-19-related Executive Orders. Since mid-March, both the MnTAP team at the University of Minnesota, and the Minnesota Rural Water Association have been limited in their efforts because of travel restrictions. Despite these restrictions, the project has been making advancements.

MnTAP has performed considerable follow-up conferences with facilities for which optimization recommendations have already been made. This has been an important task as follow-up conferences identify hurdles to implementing the recommendations; phases that implementation can be performed, first on a pilot-scale, and then full implementation; and finally next steps with participating facilities.

MnTAP has hired four additional students to work through the summer months on the mechanical scope of the project. These students have already modeled an additional four wastewater treatment plants, and are adjusting the models to achieve biological nutrient removal.

Further, the MnTAP students and staff have been coordinating their efforts with MRWA staff to develop the research plan to gather data on the water columns of three well-performing, but low hydraulic retention time ponds and three lower-performing, low hydraulic retention ponds. This is the scope of work introduced in the January 2020 update that will seek to understand what dynamics are at play in low-retention time ponds that are achieving good treatment of nutrients. In addition to the plan, the team worked with MPCA staff to develop a Quality Assurance Protection Plan to support and add rigor to the data collection and analysis. The data collected with further the optimization potential, but also be made available to one additional doctorate-level research projects, as well as EPA's nutrient reduction efforts to repair the hypoxia zone in the Gulf of Mexico.

Besides their participation in the water column research, the staff at MRWA, while limited in their physical reach because of the travel restrictions, have been active in their engagement with municipal pond system operators.

Fifth Update January 31, 2021
At this point in the project, all participating wastewater treatment plants and ponds have been selected and initial site assessments have been conducted. We are primarily following up on optimization recommendations; including drafting pilot study plans and identifying hurdles to implementation.

Another major activity in the study at present is our study of six small pond facilities (three that have high treatment percentages and three that have low treatment percentages) to find positive correlations that explain the dynamics within the water columns where high treatment exists.

The team is quite far into drafting the final field guide – the final work product – of this three-year project. We expect to meet the final deadlines and come in on budget.

Final Update June 30, 2021
<u>Overall Project Outcome and Results</u>

Achieving better nutrient treatment in wastewater treatment facilities serves to reduce the likelihood of algal blooms in Minnesota's water bodies resulting in cleaner lakes and rivers.

Mechanical Wastewater Plants:

This project found that Minnesota's mechanical wastewater treatment plants can achieve better biological nutrient removal (BNR) through low-cost operational changes. These improvements were modeled using the

Activated Sludge SIMulation Model (ASIM) in order to determine the specific plant operational parameters required to achieve BNR. Only one mechanical plant is proceeding with BNR piloting. The barriers to implementation include:

- *Complacency* – Effluent nitrogen limits are extremely rare in Minnesota; plants are meeting their limits and have no reason to change operations.
- *Lack of understanding* – Few plants in Minnesota are currently using biological nutrient removal; many wastewater operators and engineers in the state lack information on how to successfully run this process.
- *Split incentives* – The current standard wastewater design in Minnesota does not utilize BNR; engineering firms are more comfortable meeting existing limits with the traditional design.
- *Lack of regulatory grace* – Wastewater plant managers risk penalties and fines for piloting a new operational strategy should the change not immediately work as planned, resulting in a permit violation.

Wastewater Ponds:

Wastewater ponds can achieve much better nutrient treatment by utilizing the 'Steady-State Primary' strategy developed during this project. This strategy involves holding the first pond at six feet with a slide gate. Raw influent continues flowing into pond 1, while treated effluent from pond 1 is used to fill pond 2. Meanwhile, pond 3 is also held full. This strategy maximizes treatment time and drastically improves nutrient treatment quality. The two developed case studies showcase a 69% reduction in phosphorus and 43% reduction in nitrogen when compared to the prior year's effluent. Eight additional project sites are implementing this solution over the summer of 2021.

Amendment Request as of 10/19/2021
We request to amend M. L. 2018 appropriation re-programing $46, 793 from budget line 18, "Civil Engineering Students" to budget line 15, "Mechanical Plant Technical Assistance: MnTAP, MCES, and St. Cloud staff through Sole-source contract, which their technical and operational experience affords." This gives M.L. 2018, line 15 a new total of $225,993.

Additionally, we request to amend M.L. 2019 by increasing line 15 by $72,317 for a new total of $200,318 by transferring the remaining balances from lines 18, 21, 22, 23, 25, and 26.

This amendment will balance the budget that underspend in the Civil Engineering Students category, due to the unavailability of students through the University of Minnesota's COVID-19 pandemic academic year restrictions, which required additional MnTAP staff time to keep the project moving toward completion. The Civil Engineering Students category was over-estimated in cost, and the students who participated in the project cost less per hour than we anticipated in 2018, when we developed the initial budget.

Adjustments to the Activities and Outcomes are not needed, as the scope of the work did not change, though the rates of the people who performed the work did.
Amendment Approved by LCCMR 10/25/2021

III. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Instruction and Selection of Pilot Participants
Description:

To pique the interest of prospective facilities, we need to tell those who operate them what we want to do, what optimization is, and what it has done elsewhere. To that end, two seminars that describe the activities and

possible benefits – one for wastewater treatment plants, and one for wastewater treatment ponds – will be conducted.

The seminar for *mechanical systems* will cover what WWTP optimization is and why it may be a viable alternative to infrastructure improvements to meet nutrient effluent limitations. We will select three to five candidate-WWTP from seminar attendees to participate in the pilot program.

A seminar for *pond systems* with project partners MRWA and MnTAP will show what is already being done well by ponds, but also what opportunities exist for further nutrient reductions. In addition, asset management protocols and Minnesota Water/Wastewater Utilities Agency Response Network (MnWARN) training will be offered to participating facilities. We will select approximately 30 candidate pond facilities from seminar attendees to participate in the pilot program.

The objective is to help wastewater operators who say, "I operate the plant this way because I was trained to operate the plant this way," to a position of confidence where they can say, "I operate the plant this way because this is what the effluent data indicates."

ENRTF BUDGET: $7584

Outcome	Completion Date
1. Provide a seminar to transfer knowledge from experts to interested parties about wastewater treatment plant optimization.	12/01/2018
2. Provide a seminar to transfer knowledge on pond system optimization. Seminar to include also demonstration of Rural Water Association's asset management tool.	12/30/2018
3. Identify facilities that express an interest in optimizing their operations, after hearing from seminar presenters, what those activities might involve. 4 or 5 treatment plants, and as many as 30 pond facilities will be selected.	12/30/2018

First Update January 31, 2019
On July 27, 2018, Jon Vanyo with MnTAP and Joel Peck, and Brian Fitzpatrick with MPCA, gave a presentation to the Minnesota Wastewater Operators Association general conference in Grand Rapids, MN, on the topic of wastewater optimization for both ponds and for mechanical plants. The intent was to generate interest in the pilot program. However, presentations were made on the last day of the conference, and many attendees had already left. Further, because contracts were not available for signatures, official work could not begin, and some opportunity was lost until November 1, 2018, when both project partners were able to fully engage in outreach and engagement. So, while we met the completion date identified in Activity 1, Outcome 1, we believe a second opportunity to better fulfill the objective to transfer knowledge is available.

Second Update June 30, 2019
A nationally recognized expert in optimization techniques, Grant Weaver of Clean Water Ops, has been engaged for MPCA's Wastewater Annual Conference over March 27 and 28, 2019. Weaver has worked in Montana, Tennessee, and Massachusetts optimizing wastewater plants, and will be giving the plenary address, and a half-day session on optimization. We believe this will also boost the interest among wastewater treatment plant operators to participate in the pilot program.

Third Update January 31, 2020
With the 2019 appropriation of an additional $500,000, MnTAP has been able to bring on additional students and has committed to performing optimization assessments, model development, and to develop optimization recommendations for four more wastewater treatment plants, totaling nine. These will include Melrose, Olivia, Otsego, and Norwood-Young America. Further, the MnTAP team will be able to perform additional wastewater pond optimization recommendations for an additional four ponds

The additional appropriation has allowed MRWA to hire an additional pond expert as well. The additional pond expert has already allowed us to fully engage 29 ponds in optimization efforts, and an additional 103 on-site assessments. Fully 33 percent of our 395 pond systems have been reviewed evaluated for optimization as of January 30, 2020. As this is a pilot project, our hopes of gathering data that is representative of Minnesota's wastewater facilities are well underway.

Fourth Update June 30, 2020
To date, all ten mechanical plants have been engaged to participate in the optimization pilot effort. Project partners have conducted site assessments and ASIM modeling of nine of the ten facilities that will result in the final work product of a user-friendly field guide to optimization. A tenth has committed to participate in the project, but requested to delay the team's work for administrative reasons.

The MRWA efforts have been extensive, using email and telephone to enlist pond facilities in their optimization, asset management, and MnWARN services. Because of COVID-19 travel restrictions, few new facilities have been visited for initial site assessments.

Fifth Update January 31, 2021
This outcome has been completed.

Final Update June 30, 2021
This outcome has been completed.

ACTIVITY 2: Operator Mentorship and Technical Assistance
Description:
Technical assistance will commence with a site visit to the participating WWTP and pond systems to understand the plants process, existing components, and general capability of both the facility and the operator. Additional instruction will likely occur at program partner facilities.

The *mechanical system* pilot facilities will enter into an agreement under which program partners, namely wastewater operators from the Met Council's and City of St. Cloud's wastewater systems, will act as mentors for pilot cities undertaking optimization. Mentors will provide technical assistance such as: evaluating each pilot plant's treatment processes, making adjustments through process control, training and mentoring operators, and increasing or decreasing wastewater detention time.

Optimization in *pond systems* is by definition more labor intensive, due to complex biological processes occurring within ponds and because most pond system operators have multiple jobs within the government of a small city. This activity will provide "one on one" optimization tailored to each pond facility, so that municipalities can operate pond systems ongoing with low-level labor input. Optimization will entail detailed analysis of a given pond system, followed by developing and establishing an ongoing protocol to achieve maximum pollution reduction in pond system effluent. This work will be provided by subcontract with Minnesota Rural Water Association and will include enhanced coagulation and flocculation, and discharge window optimization

Technical assistance will also include upstream pollution prevention activities, asset management training, and emergency preparedness training and will include connecting site staff with external resources as needed to assist with implementation of recommendations.

Data will be collected for each of the pilot systems for analysis and compilation into a report as part of Activity 3.

ENRTF BUDGET: $585,550, June 30, 2021: $388,000

Outcome	Completion Date
1. Develop protocol for facility assessment including treatment process and inputs	12/31/2018
2. Learn if the municipality has completed a phosphorous management plan, and an inflow and infiltration (I & I) plan. And if not, to assist them in doing so.	08/30/2021
3. Assessment of the integrity of the systems structures, gates, and assets to make sure we have the ability to use optimization strategies.	11/30/2020
4. Assess impact of commercial and industrial S.I.U.s and develop strategies for upstream pollution prevention	07/30/2021*
5. Increase sampling events in the spring or fall, prior to discharges, for two- and three-cell pond systems.	07/30/2021*
6. Work with partners to make low cost recommendations to optimize treatment process at both mechanical and pond pilot locations	06/30/2019
7. Additional training and technical assistance completed, including conducting upstream pollution prevention assessments to reduce load coming to each facility	06/30/2020
8. Generate report outlining operational actions to reduce effluent contamination.	08/30/2020
9. All project results fully analyzed for efficacy and detailed reports published, and made available for further academic and technical applications.	08/30/2021

*denotes activities made possible by 2019 appropriation which can now begin in the sequence order, but be completed in 2021.

First Update January 31, 2019

MPCA and project partners identified a set of criteria on which to objectively score interested permittees to avoid any selection disputes, meeting the objective of Activity 2, Outcome 1. These criteria included a five-point system comprised of a sum of 5 Boolean values each indicating whether or not the plant fell into one of these five categories:

1. The plant has biological-phosphorous removal capability, but is using chemical removal instead.
2. The plant is in the top 20% in regards to P effluent concentration.
3. The plant is in the top 20% in regards to N effluent concentration.
4. The plant is in the top 20% in regards to total P effluent mass.
5. The plant is in the top 20% in regards to total N effluent mass.

All of these values are averaged for the year of 2017. Criteria score was calculated by adding the rank for each plant in regards to the categories 2-5 used in the 5-point system as described above. Maximum possible score is 857. Minimum possible score is 4. Average would be 428.

Pond Facilities Selected for the Optimization Pilot Program include:

1. Taylors Falls	11. Deer River	21. Bird Island
2. Winthrop	12. Wheaton	22. Morton
3. Gaylord	13. Edgerton	23. Butterfield
4. Nicollet	14. Beaver Creek	24. Evansville
5. Sandstone	15. Round Lake	25. Lynd
6. Moose Lake	16. Adrian	26. Balaton
7. Osakis	17. Warroad	27. Minneota
8. Clearbrook	18. Good Thunder	28. Wahkon
9. Newfolden	19. Stockton	29. Belview
10. Littlefork	20. Geneva	30. Rice

Second Update June 30, 2019

The pond system at Gaylord is an example of how MRWA, MnTAP, and U of M engineering student interns worked together to make recommendations to improve the treatment that occurs between seasonal discharges. That report was delivered to the city of Gaylord on March 1, 2019, and provided recommendations that would achieve reduction of 1,000 pounds total nitrogen and 300 pounds of total phosphorous.

Additional pond activities include:

- Provided project status update to the Minnesota Wastewater Operators Association (MWOA) SE & SW wastewater section meeting;
- Conducted operator training for Class C & D operators;
- Went on site with U&M interns at Onamia and Willow River for data collection and infrastructure assessment;
- Conducted second site visit to 16 of the original 30 sites to gather more data and partner with student interns for spreadsheet analyses;
- Seeding of coontail in Sandstone pond systems to determine nutrient removal potential;
- Worked on gathering data from additional systems that were not the original 30 for more assessment;
- Conducted two Sustainable Utility Management trainings.

The five mechanical plants selected to participate in the pilot program include

1) New Ulm (completed)
2) Glacial Lakes Sanitary Sewer District (New London-Spicer) (completed)
3) Hutchinson (in progress)
4) Dover-Eyota-Saint Charles (Autumn 2019)
5) Minnesota River Valley Public Utility Commission (Autumn-Winter 2019)

Third Update January 31, 2020
The technical assistance provided to Minnesota municipal wastewater systems is found in the Research Addendum of this document. We have completed assessments, modeling, and made recommendations to five mechanical wastewater treatment plants. We have made further optimization recommendations to six wastewater treatment pond systems. A total of 23 of the 30 pond facilities are engaged in the pilot program, with more than 100 initial site assessments performed on facilities whose operators are waiting for assistance.

Site assessments are comprised of a standardize field-notes format that establish verified conditions. A frequent problem the team has experienced is that assumptions many operators have formed about their facilities do not match reality. An example is assumed-versus-actual pond depth. We have experienced situations where the operator's assumed pond depth is not correct, which can affect the amount of water each pond cell can hold. The longer the water can be held back, the greater nutrient treatment can be achieved. So verifying the actual site conditions has proven a necessary step on the optimization process.

Fourth Update June 30, 2020
Pond sludge samples were taken in January and February through the ice for the research being completed for the U of M. Many systems request sludge depth checks for treatment pond for future planning. This is a great time, while on the ice, to perform in-depth sludge measurements, understanding treatment and assisting with future planning and optimization of the pond systems.

MRWA partners emphasized visits to systems not already involved with the project and gathered data and operating information from pond systems. The team has developed a list of questions to get detailed information with all the systems that were visited, looking at a multitude of different parameters and operational strategies to assist communities in better optimization of nutrient removal through operational changes.

MRWA's technical conference was held in March and the pond optimization team was able to give a presentation in front of 150 pond operators to help them understand the mission of our stabilization Pond nutrient removal optimization strategies. MRWA partners developed a wastewater treatment exam prep session for operators taking their wastewater license test, this was the 15th year of exam preparation classes taught.

March typically is very flood prone month in Minnesota with winter snow melt. MRWA partners responded through the MNWARN network to systems concerned with high water levels in the ponds and possible damage. They delivered and set up a MRWA pump to lower the levels in the pond systems to prevent high water levels.

March 18th to May on site work was put off due to the Governor's stay at home order. At this time MRWA partners worked remotely from home offices to further collect data. Travel was conducted in emergencies only due to the stay at home restrictions in March through April. This slowed on-site assistance, however conference calls and meetings were common. They also researched equipment for use at wastewater systems to reduce nutrients and worked with a new technology in Motley, MN, with a rare earth element for phosphorus reduction pilot project that is currently still in testing.

After the COVID travel was lifted further set up of equipment was completed to be on-site in boats equipment to record information to assist in better nutrient removal. Minnesota pond system operators have shown enthusiasm about this opportunity to focus on operations and work with the wastewater pond optimization partners. The team and facilities are looking forward to all systems getting technical support to better understand operational strategies at low cost or no solutions to better protect the environment in Minnesota.

In respect to metrics, the MRWA partners have worked with 53 additional wastewater pond systems since January 2019, and have developed strategies that should optimize their performance. They have conducted on-site visits with another 93 pond systems.

The MnTAP team has conducted site assessment and modeling for four additional mechanical wastewater treatment plants. Like the MRWA team's work on pond systems, the MnTAP team's effort on mechanical treatment plants has been remote. But the modeling can be done if the plant's treatment components, flow data, and historical monitoring data is made available to the students. So this effort has moved ahead apace.

With the new modeling now complete, nine of the planned ten sites have been assessed. The work then moves into implementation, or as is sometimes the case, convincing the operators to believe the recommended optimization activities will actually work – that they can get better treatment without extensive infrastructure overhaul. This requires continued discussion, and trust building. It has been beneficial to the team to identify the hurdles that exist to implementing the recommendations, and these will be included in the final work product.

Fifth Update January 31, 2021
All site assessments have been identified, with Le Sueur

Final Update June 30, 2021
All 10 student-led mechanical wastewater treatment facility assessments are complete. All 14 student-led wastewater pond assessments are complete. The 23 total engaged wastewater pond sites have had the best practices identified through this work shared with them. The wastewater pond testing portion of the project is complete, samples have been collected for summer, fall, winter, and spring. The data is being made public for future researchers to analyze.

ACTIVITY 3: Academic Analysis, Assessment and Knowledge Transfer
Description:
Academic analysis and assessment is necessary to both quantify the data gathered of the project duration, and to understand the results of the data. We will work with students supervised by the University of Minnesota's MN TAP program engineers to collect data, analyze datasets, draw conclusions, and publish findings. The additional appropriation authorized under M.L. 2019, First Special Session, Chapter 4, Article 2, will make possible an additional cohort of four engineering students, supervised by staff at University of Minnesota, to work hand-in-hand with project partners to quantify baseline conditions, and evaluation of treatment alternatives, with a goal of more pilot facilities enrolled in the program.

ENRTF BUDGET: $106,866, December 31, 2021: $112,000

Outcome	Completion Date
1. "Before" data collected from each pilot system (3-5 mechanical, ~30 ponds)	Beginning 7//30/2018
2. "After" data collected from each pilot system (3-5 mechanical, ~30 ponds)	Beginning 7/30/2019
3. Evaluation of datasets, assessment of results, and final recommendations	6/30/2020
4. Additional student workers hired to continue site assessments	9/30/2019

5. Final reports published as field guides to optimization practices and processes, transfer of knowledge completed through publication on MPCA web site and shared broadly with other facilities across the state	6/30/2020
6. ~~Capital Expenditures: $50k vehicle for Minnesota Rural Waters Association provided this is demonstrated by MPCA to be cost effective compared to other options and repayment commitment is added to work plan~~.	12/31/2021

First Update January 31, 2019
Because of MPCA contracting developments, Initial site assessments began on November 1, 2018, missing the date identified in the Activity 3, Outcome 1. Minnesota Rural Water's (MRWA) pond expert went on site to explain the program. If the municipality was willing to be part of the project, MRWA obtained general information, including primary contact person name and number, size and number of ponds, operation depth, sludge depth in the ponds if that was reliably known. It not, MRWA drilled holes in the pond ice to "sludge judge" the depth of the sludge blanket, and to assess the dissolved oxygen levels in the pond systems. The information that was gathered was then transferred to University of Minnesota where students began the process of building the model of the ponds in modeling software.

The site assessment for the first wastewater treatment plant began on November 1, 2018, when MnTAP staff and student workers visited New Ulm Wastewater Treatment Plant. The site assessment was completed on December 1, 2019 with full complement of data acquired to begin modeling the wastewater treatment plant and operations.

Second Update June 30, 2019
To date, the team has completed full optimization models and reports for New Ulm, and Glacial Lakes, with data collection and assessment on Hutchinson in progress. Using an activated sludge simulation modeling software, the team has been able to synthesize the treatment plant process, adjusting for influent constituents, to generate predicted outcomes. When celebrated with actual data, the team can adjust influent, add or deplete oxygen, increase or decrease recirculation rates, and more, to predict outcomes in the effluent. The data was then presented to project partners at Met Council and Saint Cloud Reclamation Plants for quality control.

The team met again with the participating facility staff to discuss the reports and the recommendations made therein. The reports that have been presented to the City of New Ulm and Glacial Lakes have been well received. Both facilities indicated they would take the recommendations of the team and implement them, first on a trial basis, then more permanently if results proved out.

Third Update January 31, 2020
The $50,000 previously budgeted for vehicle acquisition, is requested to be reprogrammed to additional capital areas supporting research and development for wastewater optimization. The expenditure did not prove to be in the best interest of Minnesota Rural Water Association, and the State of Minnesota.

Additional students were hired to work on mechanical treatment plant optimization projects, as well as further study on pond systems, with the outcome of optimization techniques that will be tailored to pond systems. To develop these techniques, we must first understand the dynamics of the water column within a wastewater pond. We have developed additional sampling and lab analysis plans to see what conditions treatment occurs best. Through discharge monitoring report (DMR) data, we can see that some wastewater ponds in Minnesota are naturally getting good phosphorus removal, while others are not. The sites with good phosphorus treatment

have phosphorus removal efficiency from 65% to 97%, while the sites that are struggling have phosphorus removals ranging from 0% to 40%. The plan is to choose three ponds from each category for comprehensive testing to learn whether there are specific patterns in the characteristics of these ponds that may help us to achieve better phosphorus removal in pond systems throughout Minnesota.

As of January 21, 2020, MRWA has confirmed that Belaton, Lismore, and Sandstone have given verbal approval for testing. The tentative plan is to run testing with six sites, although this is still subject to be reduced to four sites based on budgeting considerations, in the event that a budget amendment is not granted. Testing will run from March 2020 to March 2021.

Fourth Update June 30, 2020
The necessary equipment to perform the scope of work described above for the analysis of the water columns in wastewater ponds has been acquired, the research plan developed, and the quality assurance protection plan is in place. Data collection for this scope will being on July 1, 2020 and extend through to the conclusion of the project in June 2021. The subject ponds will be selected for their low hydraulic retention time and either high treatment ability or low treatment ability. They include: Sandstone, Middle River, Winthrop, Balaton, Rushmore, and Jeffers.

Additional Modeling of mechanical plants continues at Otsego West, Albert Lea, Willmar, and Olivia have been performed and draft optimization reports prepared. The reports are undergoing quality assurance review with St. Cloud Resource Recover Plant staff and MPCA engineers.

Students have begun to review the daily monitoring data, flaw schemes, and the initial site visit questionnaire to establish the baselines for pond systems in Warroad, Roseau, Breckenridge, and Karlstad. Waterfowl continue to show a significant presence in a few of these ponds sufficient enough to attribute internal phosphorous loading to their presence. Project partners will include US Fish and Wildlife, MnDNR, and Department of Agriculture permits where necessary to manage these migratory waterfowl numbers.

The budget amendment having been approved in January provided the acquisition of a sonde, and related analytical equipment, as well as necessary boat, and sampling equipment to move forward with the better understanding of water columns in wastewater treatment ponds.

Fifth Update January 31, 2021
All site assessments have been identified, with Le Sueur completed in the autumn of 2020. The task now is to follow up with all pond and mechanical treatment plants to gauge the capacity and interest in implementing the recommended optimization activities. It is important that we ensure local control is primary, leaving the power to change in the hands of those who are responsible to perform the treatment.

The team has delivered optimization recommendation letters to nine of ten mechanical plants, and 12 of 13 pond facilities. Our practice has been to draft the recommendations in memo form for review and comment by the managers of the facilities, with consultation from their consulting engineers.

We have several pilot tests scheduled to begin in the spring of 2021, which will prove out the recommended optimization activities. The team has worked with MPCA review engineers to ensure the pilot testing plans pose no risk to the environment, and detail how the activities can be reversed if the recommendations do not perform as expected, so as not avoid permit violations and/or harm to the environment and human health.

The team has continued to meet with consulting engineers who represent the managers of the facilities, as well as the operators who will turn the valves and open the switches of the recommended optimization activities. Where the concern involves capital funds to purchase replacement equipment, the team has compiled

resources. And where the recommendations have included additives to the treatment train, the team has found resources as well.

The team has gone so far as to construct prototype equipment to meet the needs of participating facilities. Stockton, MN, had a significant problem with duckweed over-propagating, covering the ponds with inches of thick, opaque layer of aquatic vegetation. The team used materials on hand to fabricate a duckweed harvesting process that removed the duckweed, taking with it significant internal loading of phosphorous from the pond.

Several facilities, after receiving the recommendation letters and reviewing it, have elected to pursue construction of new facilities, for various reasons. Age and condition of the existing facilities, discomfort with biological nutrient removal (BNR) as a treatment process is another.

The analysis of water column dynamics throughout six select pond facilities is producing promising datasets. The students who are the data analysis team are already seeing positive correlations between conditions within the water column and sludge blanked, and the percent removal rate for phosphorous and nitrogen. Because of weather-related delays to sampling, the team has completed nine of 15 sampling events, or 63 percent. The data analysis has already begun to show positive indications that we will be able to draw correlations between water dynamics and rates of treatment. Each additional dataset will add more certainty to the conclusions.

Final Update June 30, 2021
All objectives are complete. Nutrient optimization field guides are complete both for mechanical wastewater treatment facilities and for wastewater pond sites. All assessments and follow-ups are complete, with project outcome summaries included as an attachment to this report. The overall project overview, results, key findings, barriers, and next steps are summarized in the Research Addendum.

IV. DISSEMINATION:

Description: The raw data and results of optimization activities will be available for all interested parties. The final report, comprising of academic data analysis and evaluation of optimization activities should have some rigor applied to it.

As many as three upper-class engineering students will be working on this project to evaluate the results of the treatment-plant and the treatment-pond tracks. Their work products should be in a format that is capable of serving as a field guide for any future operator who has an interest in improving treatment without adding infrastructure costs. These field guides will be available for down load on the MPCA wastewater web pages at https://www.pca.state.mn.us/water/municipal-wastewater and/or Minnesota Technical Assistance Program website at http://www.mntap.umn.edu/industries/facility/potw/wastewater/wastewater-nutrient-optimization/

The Minnesota Environment and Natural Resources Trust Fund (ENRTF) will be acknowledged through use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and other communications per the ENRTF Acknowledgement Guidelines.

First Update January 31, 2019
No activity during this reporting period.

Second Update June 30, 2019
Three optimization reports: New Ulm Wastewater Treatment Plant, Glacial Lakes Wastewater Treatment Plant, and Gaylord Wastewater Pond System, have been completed and presented to each respective municipality. Two additional reports: Sandstone Wastewater Treatment Pond System, and Hutchinson Wastewater Treatment

Plant are nearing completion, but are still in progress. These reports to individual facilities will be compiled into case studies for the final field-guide report.

Third Update January 31, 2020
Optimization reports have been drafted and submitted to the respective participating pilot facilities. To date five mechanical treatment plants have received optimization recommendation letters from the team; and six pond-systems have received optimization letters. The details of the recommendations and the status of them are found in the Research Addendum. As well, savings calculations for nutrient loading, energy savings and chemical costs are also detailed.

One facility, LeSueur WWTP (Formerly Minnesota River Valley Public Facilities Commission (MRVPUC)), has requested a delay in its participation, and has been replaced in the schedule with Melrose WWTP.

Fourth Update June 30, 2020
To date, the project partners have completed seven of 10 mechanical plant optimization reports, and have shared the results with each facility staff, and consulting engineer. Eight of 10 pond systems have been evaluated and optimization reports have been issued and reviewed. Progress toward documenting all case studies, both mechanical and pond systems, is advancing and on pace for final completion in June 30, 2021.

Fifth Update January 31, 2021
The work of drafting the final report is well underway and is expected to meet the project deadline of June 30, 2021. The team is assembling case studies from the group of participating facilities, showing success stories and detailing where success has not been possible. But the amount of learned material will be exceptionally useful for academic study, as well as practical information for wastewater professionals. The final field guide and report will be a resource for municipalities who need options to meet permit compliance.

Final Update June 30, 2021
The project team has completed the following resource materials which are posted on the MnTAP website and can be accessed at this link.

Case Study, Baudette MN Pond Nutrient Optimization
Case Study, Gaylord MN Pond Nutrient Optimization
Pond Nutrient Optimization Presentation Video
Stockton Duckweed Harvesting Pilot Project Video
Overall Nutrient Optimization Pilot Project Video
Wastewater Simulation Modeling Tutorial Video 1
Wastewater Simulation Modeling Tutorial Video 2
Wastewater Simulation Modeling Tutorial Video 3
Summer Intern Project Summary 1
Summer Intern Project Summary 2
Summer Intern Project Summary 3
Summer Intern Project Summary 4
Summer Intern Project Summary 5
Summer Intern Project Summary 6
Mechanical Plant Nutrient Optimization Operator Guide
Wastewater Pond Nutrient Optimization Operator Guide
Comprehensive Pond Testing Data
Comprehensive Pond Testing Data Observations

The team has completed the following list of 17 presentations to share project results:
MWOA Presentation 7/27/18

St Cloud Innovations 2/5/19
MPCA WW Operator Conference 3/28/19
LCCMR Presentation Nutrient 6/17/19
Intern Symposium Presentation 1 8/21/19
Intern Symposium Presentation 2 8/21/19
Present to LCCMR committee 10/15/19
St Cloud Innovations, 2/4/20
Intern Symposium Presentation 3 8/19/20
Intern Symposium Presentation 4 8/19/20
Intern Symposium Presentation 5 8/19/20
Intern Symposium Presentation 6 8/19/20
Water Resources Conference, 10/20/20
MPCA Engineers Presentation, 11/3/20
MPCA WWTP Presentation, 3/17/21
MRWA WW Training, ADA MN, 5/25/21
MRWA WW Training, Wahkon MN, 6/22/21

V. PROJECT BUDGET SUMMARY:

A. Preliminary ENRTF Budget Overview:

See attached spreadsheet

Explanation of Capital Expenditures Greater Than $5,000:
The sonde and data logger, fully equipped, totaled $26,747.69. The YSI EXO2 Multiparameter sonde itself cost a base price of $6,270. However, the eight additional probes used to gather data on eight separate parameters, totaled an additional $12,813.60. These probes measure conductivity and temperature, turbidity, dissolved oxygen, pH values, rhodamine, algae, ammonia, and nitrate. The Hand-held data-logger that organizes the data collected cost $2,626.75. The remaining items associated with this capital expenditure comprise consumables necessary to calibrate the probes to each parameter, as well as various cables, guards, and protective cases.

Explanation of Use of Classified Staff: N/A

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

Enter Total Estimated Personnel Hours:	Divide by 2,080 = TOTAL FTE: 0

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

Enter Total Estimated Personnel Hours: 5450	Divide by 2,080 = TOTAL FTE: 2.6

B. Other Funds:

SOURCE OF AND USE OF OTHER FUNDS	Amount Proposed	Amount Spent	Status and Timeframe
Other Non-State $ To Be Applied To Project During Project Period:			

MPCA Municipal Liaison labor expected over a period of 180 hours.	$ 9448	$	
Other State $ To Be Applied To Project During Project Period:			
	$	$	
Past and Current ENRTF Appropriation:			
	$	$	
Other Funding History:			
	$	$	

VI. PROJECT PARTNERS:

A. Partners receiving ENRTF funding

Name	Title	Affiliation	Role
Ruth Hubbard	Executive Director	Minnesota Rural Water	Pond Expert
Laura Babcock	Executive Director	MnTAP	Plant-Expert
Tracy Hodel	Assistant Public Utilities Director	St. Cloud WWTP	Plant-Expert
Larry Rogacki	Assistant General Manager, Support Services	Met Council Environmental Service	Plant-Expert

B. Partners NOT receiving ENRTF funding

Name	Title	Affiliation	Role
Joel Peck	Municipal Liaison	MPCA	Project Manager
Brian Fitzpatrick	Wastewater Engineer	MPCA	Technical Supervision

VII. LONG-TERM- IMPLEMENTATION AND FUNDING: The project will have an immediate impact on the pilot projects selected by reducing nutrient levels into waters and by extending the use of treaments systems without having to pay for additional capital improvements. The results and protocols will also be shared with other operators throughout the state. This proposal also sets the table for future research on denitrification in wastewater pond systems, to define the biological processes by which nitrogen is removed from pond water and evaporates into the air. Anammox and ammonia volatilization, as well as biological indicators in ponds are also worthy areas of study that will lead to better pond performance. While sufficient time to develop and plan this study is not available at this time, we fully believe the activities outlined here will facilitate the next phase of understanding the microbiology of denitrification within these ponds.

VIII. REPORTING REQUIREMENTS:

- **The project is for three years, will begin on 7/1/19. The activities funded with ML 2018 funds will end on 6/30/21; activities funded with ML 2019 funds will end on 6/30/21.**
- **Periodic project status update reports will be submitted 1/31 and 6/30 of each year.**
- **A final report and associated products will be submitted between June 30 and August 15, 2021.**

IX. SEE ADDITIONAL WORK PLAN COMPONENTS:

A. Budget Spreadsheet
B. Visual Component or Map
C. Parcel List Spreadsheet N/A
D. Acquisition, Easements, and Restoration Requirements N/A
E. Research Addendum

Research Addendum

Project Overview

The purpose of this project was to work with 6-10 mechanical wastewater treatment plants and 6-10 wastewater pond sites in order to identify low and no-cost strategies to achieve better treatment for nutrient pollution. Additionally, this project completed a series of comprehensive testing in six Minnesota wastewater pond sites in each season in order to gather information to compare characteristics between ponds that naturally achieve good nutrient treatment and those that do not. Nutrient pollution in environmental water bodies can cause algal blooms through a process called eutrophication. If left unchecked, these algal blooms will consume the oxygen in the water, creating a dead zone which is not suitable for life of typical aerobic organisms such as fish. Better nutrient treatment will result in cleaner lakes and rivers in Minnesota, and help to reduce eutrophication issues for waterbodies downstream of Minnesota.

Savings Numbers Explanation

Many of the mechanical plant sites that were worked with are already treating a portion of their phosphorus chemically. By implementing these recommendations to promote BNR, these plants will largely have nitrogen savings and chemical savings, as phosphorus is being removed biologically instead of chemically. The most common chemical used for phosphorus treatment in mechanical plants is ferric chloride, so this chemical reduction will also result in chloride reduction. There may be modest additional phosphorus savings in cases where biological removal removes more phosphorus than the existing chemical process.

Results

The project team successfully completed one-on-one technical assistance assessments with 10 mechanical wastewater treatment facilities and 14 wastewater pond sites. The suggested saving, implemented savings, and other project outcomes are shown in the following tables.

Table 1: Total Recommended Project Savings

Total Recommended Project Savings					
	Total N (lb)	Total P (lb)	Chemical Reduction (lb)	Energy (kWh)	Annual Savings ($)
M1	7,352	212	245,650	580,000	89,200
M2	6,270	2,375	27,100	150,000	16,500
M3	109,600	1,100	271,000	393,000	79,000
M4	56,500	3,680	0	412,700	33,000
M5	87,811	0	3,855,415	35,000	260,800
M6	51,100	2,286	487,000	1,300,000	253,590
M7	9,311	1,190	50,400	0	16,800
M8	7,800	1,350	40,000	0	13,000
M9	300,000	79,000	0	1,300,000	98,000
M10	88,500	3,000	461,600	-557,200	9,800
P1	2,948	884	0	0	0
P2	4,349	6,724	-205,011	60,000	-56,703
P3	1,872	2,102	-56,947	0	-17,084
P4	830	2,236	-43,280	0	-12,984
P5	127	463	0	0	1,900
P6	1,253	1,242	30,752	0	9,225
P7	498	1,545	-54,372	0	-16,309
P8	1,957	1,521	-51,477	0	-15,440
P9	4,779	3,079	-18,606	0	-5,580
P10	350	706	-4,824	0	-1,447
P11	10,655	6,306	-179,171	0	-53,700
P12	11,080	4,304	-41,347	0	-12,402
P13	4,364	1,362	-9,648	0	-2,894
P!4	673	1,966	75,410	0	22,000
Project Total	769,979	128,633	4,879,644	3,673,500	708,272

Table 2: Total Implemented Project Savings

Total Implemented Project Savings					
	Total N (lb)	Total P (lb)	Chemical Reduction (lb)	Energy (kWh)	Annual Savings ($)
M1	0	0	0	0	0
M2	0	0	0	0	0
M3	0	0	0	0	0
M4*	0	0	0	0	0
M5	0	0	0	0	0
M6	0	0	0	0	0
M7	0	0	0	0	0
M8	0	0	0	0	0
M9	0	0	0	0	0
M10	0	0	0	0	0
P1	1948	584	0	0	0
P2*	0	0	0	0	0
P3	0	0	0	0	0
P4*	0	0	0	0	0
P5	0	0	0	0	0
P6*	0	0	0	0	0
P7	0	0	0	0	0
P8	0	0	0	0	0
P9*	0	0	0	0	0
P10*	0	0	0	0	0
P11*	0	0	0	0	0
P12*	0	0	0	0	0
P13*	1764	512	0	0	0
P14	673	1,966	75,410	0	22,000
Project Total	4,385	3,062	75,410	0	22,000

*Sites implementing 'Steady-State Primary' method over the summer of 2021, and will require further follow-up over future discharge events to validate the flow regime

Table 3: General Project Outcomes

General Project Outcomes		
# Students	# Presentations	# Resources Generated
11	17	18

Project resources can be accessed at the MnTAP Project Webpage located here.

Table 4: Student Assessment Outcomes

Student Assessment Outcomes		
# Sites Engaged	# Sites Visited	# Recommendations
28	23	61

Key Findings

Mechanical Wastewater Treatment Plants

Through modeling using the Activated Sludge SIMulation Model (ASIM) software, the team was able to identify low-cost operational changes for each pilot site to achieve better nutrient treatment through biological nutrient removal (BNR). Typically, the modifications include converting some treatment tank volume currently used for aeration to low-oxygen tank volume instead. A simple solution for operators is to simply purchase and install diffusor caps to prevent airflow into the tank. A three-hole punch can be used to punch ¼'' holes in some of the diffusors in order to create course bubble mixing in the tank while minimizing oxygen transfer. This strategy allows operators to create a low-oxygen, mixed tank for low-cost. This strategy was used by the St. Cloud Wastewater Treatment Facility team in their initial BNR pilot. Some sites will also benefit from reducing aeration to the secondary aeration tanks in order to prevent excess oxygen from recirculating back to the low-oxygen zones. Finally, some plants will greatly benefit from accepting a readily bioavailable source of industrial chemical oxygen demand (COD) – it is believed that brewery and dairy waste tend to be particularly good for this purpose. Adding a COD source will help drive the BNR microbial processes to completion, but will also increase aeration energy requirements. Computer simulation modeling will help plants to develop an operational modification that will allow their plants to achieve BNR.

On average, mechanical plants in this pilot were modeled to have average nitrogen reduction of 14.14 mg/L, average phosphorus reduction of 1.84 mg/L (most sites already treat phosphorus chemically to 1 mg/L) and chemical reductions of 886 lb chemical/MGal flow. If all of that chemical is ferric chloride (the most common chemical used in Minnesota mechanical plants in this study) this also results in a reduction of chloride of 221 lb / MGal flow.

Scaling these findings up to statewide implementation reduction results in the following statewide potential savings:

Table 5: Statewide Savings Estimate for Statewide Biological Nutrient Removal Implementation in Minnesota Mechanical Wastewater Treatment Facilities

Statewide N savings estimate (lb)	Statewide P savings estimate (lb)	Statewide Chemical Solution Savings Estimate (lb)	Statewide chloride savings estimate if ALL mechanical plant chemical reduction is ferric chloride (lb)
18,041,759	2,347,086	135,507,305	33,779,261

Wastewater Ponds

For wastewater ponds, the core recommendation is for wastewater pond operators to implement an operational strategy currently referred to as the 'Steady-State Primary' method. The 'Steady-State Primary' operational strategy will be explained for a typical three pond Minnesota system. For this system, primary pond 1 will be referred to as P1, primary pond 2 will be referred to as P2, and the secondary pond (pond 3) will be referred to as S1. In this method, influent wastewater from the lift station flows directly into P1. P1 is being held at a constant depth of 6 ft, and the slide gate between P1 and P2 is set at an elevation of six feet. This pond is acting as a continuously stirred reactor, with influent coming in and being naturally mixed and distributed throughout the pond. The water that is leaving the pond should be the stirred, mixed, and treated effluent which is a result of the detention time associated with the full volume of pond 1. Water slowly overflows the 6 foot slide gate from P1, and is allowed to fill P2. As P2 fills, there is no flow between P2 and S1. While influent flows into P1, and water flows through P1 into P2, S1 is being held at full depth. When P2 is nearly full, S1is discharged. Once S1 is discharged, water is transferred from P2 to S1. At this point, the flow-through method pattern is ready to start again with a full P1, filling P2, and full S3.

Secondary recommendations to wastewater ponds is to reduce inflow and infiltration, reduce fecal loading from waterfowl, and to encourage the growth of aquatic plants, with a specific emphasis on the growth of coontail.

As of 6/30/21, two pond sites have piloted the Steady-State Primary method. Case studies were developed for these sites and are included as attachments. On average, these two sites reduced effluent phosphorus concentrations by 69%, and reduced effluent nitrogen concentrations by 43%. Eight additional pond sites are implementing this strategy over the summer of 2021.

A statewide savings estimate was created by assuming that the percent reduction in phosphorus and nitrogen as identified in the case studies will hold for all pond sites in Minnesota.

Table 6: Wastewater Pond Potential Statewide Savings

Statewide Pond Nitrogen Reduction Potential (lb)	Statewide Pond Phosphorus Reduction Potential (lb)
1,031,800	1,655,679

Individual site summaries are included as an attachment to this report.

Barriers

Mechanical Plants

There is considerable opportunity for mechanical wastewater treatment facilities to achieve much better nutrient treatment through low and no-cost operational changes resulting in biological nutrient removal. Through observations made over the course of this project, several key barriers to the implementation of biological nutrient removal have been identified:

- *Complacency* – Effluent nitrogen limits are extremely rare for Minnesota wastewater treatment facilities. For this reason, there is little reason for plant operators and their consulting engineers to seriously consider modifying the existing operations to achieve BNR. The current most common design in Minnesota meets the current permit limits. The current design is one that both operators and wastewater engineers in Minnesota are very experienced and comfortable with using. This lack of driving force is the most critical barrier in the way of the broad use of biological nutrient removal to achieve both nitrogen and phosphorus treatment which would result in much better treatment of nutrient pollution here in Minnesota.
- *Lack of understanding* – The current industrial standard design in Minnesota does not utilize biological nutrient removal. Our perception is that there is lack of deep understanding of the pros and cons of the biological nutrient removal design, and the relative ease with which the current typical design can be retrofitted to achieve BNR. This team has heard concerns related to the re-release of phosphorus from phosphorous accumulating organisms (PAOs), to this type of retrofit reducing treatment capacity, to other possible issues which tend to have fairly trivial solutions but may not be immediately obvious without experience or training in BNR.
- *Split incentives* – As the current typical wastewater plant design in Minnesota does not utilize BNR, it would take some effort for the design engineering teams to learn to design for BNR. Because of this, there is a perception that some design engineers would prefer to maintain the status quo. This relates to complacency but also has financial motivations, as it will take considerable effort and training to learn this more efficient treatment process. Furthermore, modifying operations to achieve biological nutrient removal can often be achieved through low-cost operational changes, but a design engineering firm has financial incentive to promote the design of a new plant. Additionally, fully implementing BNR for both nitrogen and phosphorus treatment will also likely hurt the sale of chemical phosphorus removal chemicals, and therefore may also be discouraged by those who sell them.
- *Lack of regulatory grace* – Champion wastewater plant managers who do want to pilot operational changes to achieve biological nutrient removal would greatly benefit from a prescriptive process to achieve a period of regulatory grace or variance for peace of mind while piloting an operational change from a traditional treatment system to one that achieves biological nutrient removal. Whenever something is changed, there is risk that the change will not work as planned. Prescriptive regulatory grace would help encourage plant managers to know that they will not receive punishment if their work towards a better treatment strategy does not immediately work as planned. Knowing that they would not be punished if something failed would make optimization piloting much safer and more accessible for wastewater plant managers.

Wastewater Ponds

Wastewater pond systems have fewer barriers to implementation, but there are two critical barriers to be addressed in future work.

- *Failing Infrastructure*– Implementing the 'Steady-State Primary method' requires working transfer structures and slide gates. For this project, the team specifically chose plants with mostly working transfer structures as those sites would be able to implement recommendations regarding modifications to the flow of water through the ponds. The MRWA portion of the project team strongly believes that many sites have transfer structures which are not working well enough to implement this method.
- *Lack of knowledge* – The 'Steady-State Primary' method was developed over the course of this project. The project team has been able to share the concept with most of the project sites, and has created two case studies to showcase the benefits, however, most pond operators in the state are still unaware of it as an operational strategy to achieve better nutrient treatment. Additional assessments, presentations, and case studies would help to spread this operating strategy to operators throughout the state.

Next Steps

Wastewater Ponds:

The first objective moving forward as a result of this project is to drive implementation of the 'Steady-State Primary' method with more of the pilot project sites. Several sites are in the process of implementing this method over the summer of 2021. Continued guidance, technical assistance, and follow up will help these sites to complete their pilot test of the method, quantify the results and develop additional case studies to continue highlighting the savings opportunity for Minnesota ponds.

A second objective is to determine whether this method or a slightly modified version of it is suitable for winter operation in addition to warm weather operation, and whether it has a positive impact when used over the winter.

A third objective will be to continue reaching out to additional wastewater pond systems to share the findings of this project and to provide technical assistance to sites interested in modifying operations to utilize the 'Steady-State Primary' method. This project provided assessments to 14 of the 391 wastewater pond systems in the state. A subsequent project could sort the pond systems from highest to lowest in terms of effluent nutrient concentrations, and schedule one-on-one consultations with site operators in order to discuss this strategy as an option to improve nutrient treatment.

The team is also aware that there are many wastewater pond sites with failed infrastructure used to control the movement of water between the pond systems. The team would like to acquire a source of funding to help cities with wastewater pond sites to have these control structures repaired, and then to connect that repair process with improved operational strategies that are made possible through these repairs. Having control structures repaired and then teaching operators how to utilize the repaired structures to achieve better nutrient treatment would help these wastewater pond systems to achieve great nutrient treatment moving forward.

Mechanical Wastewater Plants:

There is benefit in having funding available to complete computer simulation models of mechanical wastewater treatment facilities that are specifically interested in the opportunity to achieve biological nutrient removal through relatively low-cost operational change. The project has shown that implementation rates have been low through simply reaching out to facilities and offering a no-cost biological nutrient removal assessment. As the barriers to biological nutrient removal are reduced, sites that do not want to completely redesign their mechanical wastewater plants would benefit from having the option to explore low-cost operational change options. Should wastewater treatment facilities begin to receive total nitrogen limits, biological nutrient removal is the only commonly used strategy to remove nitrogen from the wastewater. Additionally, should regulatory grace be put in place for wastewater operators interested in exploring biological nutrient removal to empower operators to start achieving nitrogen treatment before it is mandated, that would also likely spur interest in low-cost options for operators to achieve biological nutrient removal. Regardless, as these barriers are reduced, there is benefit in having a statewide resource that can complete wastewater simulation modeling and provide guidance on nutrient optimization strategies for wastewater treatment plants.
In terms of increasing the interest of wastewater plant operators in this type of operational modification to improve nutrient treatment, there are some options. First, if plants are assigned total nitrogen limits that require nitrogen removal, this will need to be accomplished using biological nutrient removal. If the project sites from this project are representative of the state, most sites can accomplish this for relatively low cost through operational changes, primarily by reallocating some secondary aeration tank volume for use as low-oxygen volume.

Alternatively, or perhaps as an interim incentive, perhaps plant operators can be rewarded for achieving lower total nitrogen concentrations in the effluent. An award or special recognition for operators who successfully implement biological nutrient removal may help to promote a culture of improvement surrounding wastewater treatment.

Regulatory grace from the MPCA to operators that choose to pursue biological nutrient removal pilot projects would also help empower operators to make changes that are expected to improve long term treatment quality.

It would also be beneficial if there was full or partial infrastructure upgrade funding that could be made available to mechanical wastewater treatment facilities that would benefit from some funding for equipment similar to tank mixers or baffles in order to facilitate the creation of conditions required for BNR.

Attachment A:
Environment and Natural Resources Trust Fund
FINAL M.L. 2018 Budget Spreadsheet

Project Title: Pilot Program to Optimize Local Mechanical and Pond Wastewater-Treatment Plants
Legal Citation: M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 04a; M.L. 2019, First Special Session, Chapter 4, Article 2
Project Manager: Joel Peck
Organization: MPCA
College/Department/Division: Municipal Wastewater
M.L. 2018 ENRTF Appropriation: $700,000; M.L. 2019 appropriation $500,000
Project Length and Completion Date: 6/30/21
Date of Report: October 19, 2021

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Revised ML 2018 Budget 10/25/2021	ML 2018 SPENT	ML 2018 BALANCE	Revised ML 2019 Budget 10/25/2021	ML 2019 SPENT	ML 2019 BALANCE	TOTAL BUDGET	TOTAL SPENT	TOTAL BALANCE
BUDGET ITEM									
Professional/Technical/Service Contracts									
Mechanical Plant Technical Assistance: MnTAP, MCES, and St. Cloud staff through Sole-source contract, which their technical and operational experience affords	$225,993	$225,993	$0	$200,318	$200,318	$0	$426,311	$426,311	**$0**
MRWA Pond Expert through sole-source contract, which MRWA's technical and operational experience affords	$390,000	$386,844	$3,156	$260,000	$260,000	$0	$649,999	$646,844	**$3,156**
Optimization Venue, Presentations, and Materials	$7,584	$5,000	$2,584				$7,584	$5,000	**$2,584**
Civil Engineering Students	$60,073	$28,394	$31,679	$1,681	$1,681	$0	$61,754	$30,075	**$31,679**
Equipment/Tools/Supplies									
Sample handling				$1,882	$1,882	$0	$1,882	$1,882	**$0**
Water craft and transport racks				$4,047	$4,047	$0	$4,047	$4,047	**$0**
Five portable lab spectrophotometers for rapid wastewater analysis	$16,350	$9,468	$6,882	$0	$0	$0	$16,350	$9,468	**$6,882**
Capital Expenditures Over $5,000									
Data-logger and supplies				$4,526	$4,526	$0	$4,526	$4,526	**$0**
Sondes				$27,547	$27,547	$0	$27,547	$27,547	**$0**
~~*MRWA Vehicle*~~					$0				
COLUMN TOTAL	**$700,000**	**$655,699**	**$44,300**	**$500,000**	**$500,000**	**#REF!**	**$1,200,000**	**$1,155,699**	**$44,300**