ALGONQUIN COLLEGE | Office of Applied Research and Innovation

# Muskrat Lake Watershed Project

## Visualizing and Quantifying Sources of Nutrients in the Agriculturally Dependent Muskrat Lake Watershed

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# Executive Summary

The Muskrat Lake Watershed encompasses nearly 68,000-ha within central Renfrew County, including 1219-ha Muskrat Lake near Cobden, Ontario. The project, "Visualizing and Quantifying Sources of Nutrients in the Agriculturally Dependent Muskrat Lake Watershed", also known as the "Muskrat Lake Watershed Project", determined that nutrients and sediments from agriculturally dominated areas in the watershed are contributing to some of the high phosphorus levels, overall poor water quality, and blue-green algae blooms in Muskrat Lake. The presence of blue-green algae is cause for concern. Certain strains of blue-green algae release cyanotoxins into the water and air and can pose a serious health risk for those living on Muskrat Lake and for those that use the lake for recreational purposes. The Renfrew County Health Unit released health advisories for blue-green algae in the summer of 2014. This situation is not ideal, since Muskrat Lake is the raw water supply for the Town of Cobden's water treatment facility. It is very difficult for water treatment facilities to remove both the cyanobacteria and their toxins.[1] Extensive community beach closures due to *E. coli* also occurred in the summer of 2014, as well as during other past summers, and it is known that there are multiple sources contributing to the overall deterioration in water quality. The outdated Cobden Sewage Treatment Plant, antiquated septic systems, seasonal runoff, also represent potential sources for nutrient contribution.

The extent of agricultural contribution was difficult to determine with any of the available data collected prior to the Muskrat Lake Watershed Project. Partnering with the newly established Muskrat Watershed Council, Algonquin College's Applied Research program and Environmental Technician Diploma Program (E-Tech) delivered a suite of student-driven projects which all aimed to address these major data gaps. Overseen by a Project Coordinator and advised by a Steering Committee of local experts, students collected and analyzed water quality, water quantity, and land-use data. Extensive water quality and quantity information was collected through implementation of an extensive monitoring network. Quantitative and qualitative land-use data was generated using spatial tools, such as aerial video and photography, GIS, recent high resolution and historical aerial imagery, and through implementation of leading edge drone remote sensing technologies. These spatial assets were used to identify significant sources of nutrients, or "hot spots". Information and knowledge was shared with the local community and various stakeholders through events organized by the Muskrat Watershed Council and Algonquin College in the Ottawa Valley.

Ultimately, the kinds of data collected throughout the duration of this project led to a better understanding of the issues, helped to identify source points, and provided a foundation for ongoing development of effective nutrient management strategies with tailored best management practices. The information and knowledge generated from this project also opened up other innovative remediation options that could help reduce the amount of phosphorous loading in Muskrat Lake. Strong partnerships were formed as a result of this project and it is because of these partnerships that the first year of the Muskrat Lake Watershed Project proved to be so successful.

[1] Hewlett, T., Ndiongue, S., & Moore, L. (n.d). Challenges to Treat Cyanotoxins from Drinking Water on a Large, Small and Household Scale. *Walkerton Clean Water Centre*. http://www.wcwc.ca/en/news/recent/image/353675

## 1. Background

The Muskrat Lake Watershed occupies 67,836-ha in Renfrew County. It represents a significant drainage area for the City of Pembroke, the Town of Cobden, and large portions of Whitewater Region and surrounding municipalities. The Muskrat River itself arises near Renfrew, Ontario and flows along an ancient fault line through a chain of small lakes into 1219-ha Muskrat Lake, and eventually joins the Indian and Ottawa Rivers in the City of Pembroke. Its major tributary is the Snake River, whose basin comprises 58% of the total area of the Muskrat Lake Watershed. Headwater tributaries of the Snake River flow from the largely forested Boreal Shield Ecozone into 1516-ha Lake Dore. The Snake River exits Lake Dore, passes through natural wetlands and areas drained for agriculture in the Mixedwood Plains Ecozone, and discharges into Muskrat Lake. The transition from the Boreal Shield to the Mixedwood Plains Ecozone creates a unique and important mix of land use practices and water quality parameters within the watershed.

There is strong evidence of agricultural nutrient pollution in the lower-elevation portions of the Muskrat Lake Watershed. Ontario Ministry of Environment (MOE) data for 2005 and 2012 indicated elevated nitrite/nitrate, phosphorus, *E. coli*, and total suspended solids in the Snake River. Muskrat Lake itself is highly eutrophic with phosphorus levels averaging 20-45 ppm.

The 2014-2015 Muskrat Lake Watershed Project funded under WAMQI focused on Muskrat Lake, and its contributing tributaries. Muskrat Lake is within the Township of Whitewater Region and is the source of drinking water for its major population center, the Town of Cobden, Ontario. Water and sewage treatment facilities for the Town of Cobden are located adjacent to the lake and both cottages and permanent residences surround the water body. The lake is well known by both local and non-local residents for its recreational fishery as it supports highly sought after bass, walleye, smelt, pike, and lake trout populations. People also frequent the watershed throughout the summer for other recreational purposes, such as swimming, sailing, and boating. Unfortunately, Muskrat Lake is also one of the most nutrient enriched lakes in all of Ontario for its size and periodically reports beach closures due to bacterial contamination and also extensive blue green algal blooms.

Farming represents an important economic sector within Renfrew County and a long-time cultural practice that defines the identity of many in the region. Local farmers employ various tillage, land clearing, and manure application practices. With the vast geographical reach of the Muskrat Lake Watershed, it is to be expected that agricultural practices will in some way intersect with, and have an impact on, the biophysical components of the watershed's various ecosystems. Unlike most parts of Southern Ontario, the Muskrat Lake Watershed lacks a Conservation Authority to provide a coordinated approach to nutrient management and water quality initiatives vis-à-vis farming practices, although local organizations are working in these areas and making significant progress.

## 2. Purpose

The overall purpose of the project was to document water quality issues in the Muskrat Lake Watershed in relation to current land-use practices. By gathering and analyzing data regarding water quality and quantity, and using spatial tools to classify the landscape and visualize impacts, the project aimed to both address and mitigate agricultural impacts by raising awareness and assisting local farmers to better manage nutrients and minimize

off-site impacts of nutrients on water quality. Specifically, the information gathered would be used to identify and tailor management strategies in the future that would assist farmers in implementing best management practices (BMPs) specific to the geographical, biophysical, and socio-economic characteristics of the area. Future application of the identified BMPs would thus mitigate, or significantly reduce, nutrient and sediment loading in certain key areas of the watershed.

Funding for this project supported the quantitative and qualitative research necessary to eventually create a solution-based management strategy that would aim to lessen nutrient and sediment loss from farms and other potential contributing factors. Aerial video, photos, and geospatial analysis permitted visual representation of the sampling data and allowed for more effective communication with local residents and landowners. Data on agricultural practices adjacent to major waterways in the watershed could enable stakeholders to target BMPs in highest priority areas. Our goal was to present interpreted, scientifically defensible data in conjunction with the knowledge of local stakeholders (e.g., farmers, waterfront landowners, etc.), as this will be crucial for creating a sustainable long-term set of management strategies that take into account the specific issues faced by the Muskrat Lake Watershed as well as the broader geographical, biophysical, and socio-economic characteristics of Renfrew County.

## 3. Methodology

### 3.1 Sampling and Measuring

The project assessed water quality and quantity issues by sampling and analyzing water quality and quantity every week from May 2014 to November 2014 at 28 key sites along the watershed, including 3 additional sites located on Muskrat Lake. The 3 additional lake sites were each monitored with HOBO conductivity loggers and sampled every 2 weeks. These sites were more difficult to access and for this reason the HOBO loggers proved to be invaluable. Site selection was a collaborative and deliberative effort, decided by our Steering Committee of local experts, including local farmers. We also chose a background site – Black's Creek – on the watershed located above and away from agricultural influence. This site helped to determine what water parameters were occurring naturally in the watershed.

Two E-Tech students were hired as summer co-op Field/Lab Technicians. These students worked full-time throughout the summer with the support of the Project Coordinator and community partners to sample, measure, and analyze water quality and quantity on the watershed and in Algonquin College's lab facility. A third E-Tech student was hired to help conduct sampling in the fall 2014 term, on a part-time basis. Upon returning to school in the fall, all other E-Tech students were involved in the Muskrat Lake Watershed Project, but did so as part of their course work.

Water quantity was measured using a handheld Acoustic Doppler Velocimeter (Sontek/FlowTracker) and field water quality parameters were measured on-site using a YSI multi-meter probe. Grab samples were collected biweekly and were analyzed for nitrogen, phosphorus, and total suspended solids both internally, using lab facilities located at Algonquin College, Pembroke, and by shipping samples to the Ontario Ministry of Environment certified laboratory. Samples sent to the MOE lab were analyzed monthly for a full suite of nutrients, major ions, and metals. The E-Tech program was able to have additional samples analyzed for cations and anions at the environmental branch of the Canadian Nuclear Laboratories (CNL), formerly Atomic Energy

of Canada Ltd., located in Chalk River, Ontario. The E-Tech program also provided some of the field sampling and measuring tools and technology, while new equipment, such as the HOBO conductivity loggers and other lab materials, were purchased through the Muskrat Lake Watershed Project.

### 3.2 Geospatial Data Collection and Analyses

The project provided a unique opportunity to explore the use of advanced geospatial tools, including a partnership with two local companies in the acquisition of infrared, multispectral, and true color 20cm resolution imagery along stretches of Muskrat Lake and the Cobden Wetland using drone technologies. Only a small portion of the data collected has been analyzed and ongoing work to improve the product is planned. The long term goal of this advanced work will be to categorize the landscape based on tillage practices, provide information on land-use, trends/patterns, and further identify hotspots with respect to nutrient and sediment loading. Geospatial analysis was done in conjunction with the Ontario Ministry of Natural Resources and Forestry (OMNRF), Ontario Resource Management Group (ORMG), and NGF Geomatics. Three different dates of videos were also collected using a camera mounted on a fixed wing aircraft.

By collecting aerial video and photos along identical high priority pathways on multiple occasions: 1) Spring aerial video showing some freshet runoff 2) Summer aerial video and photography; and 3) Fall aerial photography, we were able to perform qualitative analysis of spatial information regarding water quality, quantity, and agricultural practices, providing information on practices and landscape characteristics. The side-by-side video and photos provided comparison points between the seasons as well as information on agricultural practices most utilized and/or most likely to cause erosion and runoff of nutrients into surface and ground water. These data and interpretive products provided a foundation to eventually develop recommendations and strategies for BMPs and watershed management. It is critically important that the results are represented in a way that can be easily communicated to farmers and the public. For this reason, a focus on spatial and visual products enabled a more accessible and/or "user-friendly" transference of knowledge at various stakeholder engagement events, such as the Muskrat Watershed Council's Annual General Meeting, monthly "Science Night", and Algonquin College's "Muskrat Lake Watershed Student Symposium".

Given the historical and cultural significance of agriculture in Renfrew County and the ecosystem services provided by the Muskrat Lake Watershed, we used historical maps of the watershed dating back to the 1930s to understand some of the past land-uses (e.g., clearing woodland for pasture, wetland drainage, etc.) and for some sites were able to link them to current maps and land-use practices observed through aerial imagery and field observation. Linking quantitative and geospatial analyses with this historical context will offer farmers a more culturally significant perspective on agricultural practices and their impacts on the watershed.

### 3.3 Partner and Stakeholder Engagement

Long-lasting partnerships were enhanced and/or developed as a result of the Muskrat Lake Watershed Project. Our partners were so diverse and experienced that they also functioned as a Steering Committee of local experts and were involved from the project's beginning-to-end. The scope of their support related to decision-making related to community engagement/outreach, networking, selecting site locations, proposing remediation technologies, contributing to the analysis and interpretation of data, and providing future management strategy recommendations. These partners include: Muskrat Watershed Council, Ontario Ministry of Environment,

Canadian Nuclear Laboratories, Ontario Ministry of Natural Resources and Forestry, Ottawa River Institute, Renfrew County Federation of Agriculture, and the Renfrew County Cattlemen's Association.

Monthly meetings were held with our partners. We worked closely together throughout the entire duration of the project. The Muskrat Watershed Council organized multiple events, such as their Annual General Meeting and their monthly Science Nights, in which Algonquin College presented its scientific information in an accessible manner through visual imagery as well as calling on the public to share their local knowledge of past and current land-use practices as well as of past/current algal bloom outbreaks. We also hosted a demonstration site at the Muskrat Watershed Council's Annual General Meeting. The Algonquin College Applied Research solar powered mobile lab was parked near to the main community beach in Cobden. Sampling equipment and methods were demonstrated to passer-byers as well as to those attending the Annual General Meeting. Information about the project was also distributed.

Other partnerships were developed throughout the duration of the Muskrat Lake Watershed Project. Seven projects led by the E-Tech program and the Applied Research program were undertaken from September 2014 to December 2014. Five of these involved community partners wherein they approached Algonquin College and/or the Muskrat Watershed Council with project ideas to help improve the watershed, or, in the very least, to help to raise awareness of the issues existing along the watershed. Approximately 30 E-Tech students worked on these community projects as part of their Land and Water Stewardship and Environmental Issues courses. The project partners were: Muskrat Lake Association, Muskrat Watershed Council, Shaw Woods Outdoor Education Centre, and the Lake Dore Property Owners Association. Additionally, the Ottawa River Institute had students sample the Snake River more in-depth by monitoring the Snake River marsh, an important wetland for the Muskrat Lake Watershed, one that has greatly been transformed and impacted by land-use practices. As well, a local farmer allowed students to conduct a riparian species inventory of a regenerated shoreline along his agricultural property on Muskrat Lake. The Muskrat Lake Watershed Student Symposium was organized to showcase these fall projects. Below is a list of the project titles:

- Conducting a riparian plant and fauna inventory for a restored agricultural shoreline along Muskrat Lake
- Constructing a Bioswale for the Shaw Woods Outdoor Education Centre
- Lake bottom sediment sampling on Muskrat Lake
- Determining nutrient "hot spots" along the Snake River
- Investigating potential contaminants at Biederman's Creek
- Summarizing the Muskrat Lake Watershed monitoring data
- E-Tech Solutions website design: Reporting on the Muskrat Lake Watershed

The Muskrat Lake Watershed Project conducted a large sampling blitz throughout the spring, summer, and fall of 2015 while also delivering these 7 sub-projects. This allowed us to incorporate various kinds of quantitative and qualitative data in order to create a future comprehensive report outlining results and strategies for nutrient management, water quality enhancement, and sustainable agricultural practices.

## 4. Findings

### 4.1 Sites of Concern on the Muskrat Lake Watershed

There were certain sites that experienced consistent high levels of phosphorous and conductivity throughout the seasons, or some sites that displayed abnormal peaks in phosphorous and conductivity, as well as very low levels of dissolved oxygen. Accurate assessment of trend information for all of the stations requires a three year investment in sampling. A review of the network of stations is now underway to determine if the sampling program needs refinement and if potential hot spots are being missed.

Delineation of hot spots has seasonal implications. Sites experience elevated phosphorus concentrations during certain seasons and not all during the same season. Implementation of BMPs needs to take these seasonal fluctuations into account.

The Cobden Water Pollution Control Plant, located on Muskrat Lake upstream from the Cobden Water Treatment Facility, is known as a potential source for nutrients entering into Muskrat Lake. The Cobden Water Pollution Control Plant 2013 Annual Report recorded 4 primary bypasses from heavy rainfall and spring melt wherein, due to the overcapacity situation, raw sewage entered the Cobden Marsh – a wetland designated as "Significant" by the OMNRF – before entering Muskrat Lake[2]. A berm exists around the Cobden Marsh to increase the holding, decomposition, and filtering time of the sewage treatment plant discharge; however, currently there are two known berm breaks that are compromising the functionality of the berm and thus the functionality of the wetland as an effective sewage treatment option. The College is seeking additional funding which may support the repair and restoration of that wetland.

### 4.2 Land-Use Issues

Many agricultural properties displayed serious slope and erosion issues wherein sediment travels easily into the watershed. Additionally, inadequate or non-existent buffers were common between crops and water sources, including tile drains and municipal drains. Several observations were of sites that did not present any fencing to separate livestock from the water. Livestock was observed in the water on more than one occasion. Many of these qualitative observations were made during the collection of water quality grab samples within the water quality network.

### 4.3 Larger Mitigation Measures

The main purpose of the Muskrat Lake Watershed Project was to document water quality issues in the watershed in relation to current land-use practices in order to both address and mitigate impacts by raising awareness and assisting local farmers to better manage nutrients and minimize off-site impacts of nutrients on water quality. Specifically, the information gathered would be used to identify and tailor management strategies in the future that would assist farmers in implementing best management practices (BMPs).

However, as our knowledge widened about the issues facing Muskrat Lake and the watershed as a whole, we realize that improving the lake quality will require greater intervention in terms of larger scale mitigation measures beyond the implementation of upstream BMPs. In light of this information, the Muskrat

[2] The Cobden Water Pollution Control Plant 2013 Annual Report

Watershed Council has recently taken on the challenge of assessing some of the newly emerging technologies that could be implemented in-stream or in-lake to specifically enhance phosphorus reduction. These technologies include solar powered in-lake oxygenation systems, biofilm treatment option using BioCord Reactors, enhanced filtration systems, and chemical binding systems. Algonquin College E-Tech students are now working with several companies to assess those options.

There is also evidence that outdated septic systems along the watershed are contributing to phosphorous levels in the watershed. The investigation of outdated septic systems was beyond the scope of the Muskrat Lake Watershed Project. It is important to note, however, that to adequately understand the sources of nutrients negatively impacting Muskrat Lake, and to subsequently conduct mitigation strategies, it will be necessary to implement some kind of plan that involves evaluating septic systems and implementing the necessary measures to ensure the septic systems of shoreline inhabitants comply with current septic codes.

Strategies for implementing BMPs and/or larger scale mitigation measures are not within the scope of our current WAMQI funding. The hope was that with additional funding for 2015, we could implement a second phase of the project that would continue monitoring water quality and quantity as well as adding in sediment analysis (e.g., paleo-limnology) while beginning to develop BMPs and other mitigation measures.

## 5. Conclusions

### 5.1 Local Action

The lack of a clearly defined management strategy and Conservation Authority within Renfrew County to tackle the issues/challenges related to water adaptation, water quality, and agricultural impacts demonstrates an obvious gap and necessary need for a series of well-rounded initiatives that provide baseline research, spatial perspectives, and strategies for land-use and water adaptation. These initiatives look to touch on the scientific/environmental side of the issues, as well as the economic and social aspects, by participating in effective stakeholder engagement as well as running cost-effective projects and tailoring management strategies to the specific needs of the region. The current state of the Muskrat Lake Watershed vis-à-vis local agricultural practices has been an important area of concern for the local environmental sectors, including agriculture.

This project is a crucial step toward a sustainable, long-term plan for nutrient management and BMPs for farmers living on the Muskrat Lake Watershed. However, this is only the beginning – a drop in the bucket – of what needs to be done to solve, or at least significantly improve, the issues faced by the Muskrat Lake Watershed and its inhabitants.

### 5.2 Sustainability

This project adopted a holistic approach to addressing the issues on the watershed. It considered: 1) A sustainable economic model that could provide valuable and crucial information in a cost-effective manner as well as creating a foundation for future management strategies meant to reduce negative externalities resulting from unsustainable agricultural practices; 2) An ecological model that looked to improve the overall aquatic and soil ecosystems through well researched empirical evidence and remediation strategies; 3) A collaborative and deliberative social model wherein information and knowledge is generated and shared between various stakeholders (e.g, farmers, politicians, cottagers, scientists, etc.) with the goal of raising awareness around the

issues and improving the quality of the water and soil for farmers and the public in the long-term. We believe this model facilitates the flow of information and the incentive for people to act, to be informed, and take the necessary steps to improve their community. These end goals, we believe, directly contribute to water security and food security within Renfrew County.

### 5.3 Looking Ahead

More research is required in order to paint a clearer picture of the issues facing the Muskrat Lake Watershed. As with any reliable, scientifically defensible research project, we require more time in order to collect more data on a consistent basis in order to compare seasons and years. This will allow us to decipher natural vs. unnatural occurrences, as well as begin to understand at a deeper level the source problems. As with most environmental problems, this issue is multifarious in nature – with many contributing factors – and additional resources and time would allow for us to honestly and genuinely make a positive impact on the surrounding ecosystem communities and human communities along the watershed. Effective management strategies and BMPs cannot be created without a solid foundation of information and knowledge collected first-hand. The goal for 2015-2016 is to thus secure additional funding to move toward Phase 2 of the Muskrat Lake Watershed project.

### 5.4 A Smaller Model for Bigger Problems

Muskrat Lake is one of the most eutrophic lakes for *its size* in Ontario. Of course, it is difficult to compare scales when looking at the issues faced by, for example, Lake Erie and Lake Simcoe, two of Canada's Great Lakes also experiencing very serious eutrophication problems. Muskrat Lake is but a fraction of their size, and yet, to deny the importance of Muskrat Lake's eutrophication issues is to imply that environmental decisions are solely decisions of political will. Politically, it makes sense to focus on major waterways. However, designating priority areas may only exacerbate the issues by allowing more ecosystems on the periphery to degrade. As these peripheral watersheds degrade, they could eventually cover more square kilometers than Lake Erie and Lake Simcoe combined, thus creating a much larger, complex, and costly environmental challenge for the future.

An important commonality between Muskrat Lake and the Great Lakes is that the integrity of the ecosystems have been compromised as a result of mismanagement, poorly regulated industry and out-of-date infrastructure. These unfortunate circumstances are beginning to greatly impact the lives of those inhabiting these areas, municipal infrastructure, and tourism.

Muskrat Lake, though smaller, has the advantage of fewer jurisdictional complexities as well as less territory to cover for data collection. As well, the surrounding communities of Whitewater Region are close-knit and thus partnerships and networking evolved very quickly over the span of one year. Our presentation to OMAFRA and Conservation Ontario in October 2014 in Guelph, Ontario was that our watershed is an excellent model for larger watersheds. The difference between our context and that of the Great Lakes is we have a chance to see changes in our lifetime; changes that could help other watersheds tailor their own models to tackle their own unique challenges related to watershed health. This, anyway, is our hope.

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