Report

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Region of Waterloo

Green Municipal Fund Project Completion Report

Kitchener WWTP Centrate Management Treatment Upgrades

June 2013

This project was carried out with assistance from the Green Municipal Fund, a Fund financed by the Government of Canada and administered by the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are the personal views of the authors, and the Federation of Canadian Municipalities and the Government of Canada accept no responsibility for them.

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1 Project and Community Context

The Region of Waterloo is a blend of urban and rural centers. It is formed by three urban municipalities — the cities of Cambridge, Kitchener, and Waterloo — and four rural townships – North Dumfries, Wellesley, Wilmot and Woolwich. With a population of more than 545,000, the Region is one of the fastest growing areas in Ontario. It is internationally known for its leading-edge technology and manufacturing industries, educational institutions, agricultural communities, and the historically significant Grand River.

The Region's Wastewater Treatment Master Plan completed in 2007 recommended upgrades to the Kitchener Wastewater Treatment Plant (WWTP) to reduce ammonia and phosphorus loadings to the Grand River as well as toxicity due to chlorinated effluents. These upgrades include the installation of biosolids dewatering at the Manitou Drive site, commissioned in 2012, and other process upgrades to be completed by 2018.

The Region of Waterloo developed a Strategic Plan for 2011-2014 that identified several focus areas in order to achieve the vision of an inclusive, thriving, and sustainable community. Focus Area One is "Environmental Sustainability: Protect and Enhance the Environment". As part of this focus area, several strategic objectives were developed, including development of an integrated approach to environmental sustainability and protection of the quality and quantity of water sources. Action items are listed for each strategic objective and the first action item for protection of water quality is the completion of upgrades to the Kitchener and Waterloo WWTPs. This strategic objective, endorsed by Regional Council, demonstrates the Region's commitment to improved quality of water sources and the need for the completion of the centrate management project at the Kitchener WWTP to achieve this objective.

The Kitchener WWTP is the Region's largest wastewater treatment plant with capacity to treat approximately 122,000 m^3/day, and currently generates approximately 400 m^3/day of liquid biosolids. The new dewatering facility located at Manitou Dr, in Kitchener, uses centrifuges to dewater digested biosolids from the Kitchener WWTP and other smaller facilities within the Region. The dewatering process generates a side stream called centrate that is returned to the Kitchener WWTP for treatment as it contains significantly high concentrations of ammonia, phosphorus and organic matter.

The purpose of this project was to implement a new process to treat centrate generated at the dewatering facility and, at the same time, achieve significantly lower ammonia concentrations in the final effluent of the Kitchener WWTP, compatible with not only planned future upgrades to the wastewater treatment plant, but also improved water quality in the Grand River.

2 Project Team

The principal contact for this project is Trevor Brown. His contact is provided below:

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The project was implemented by the following team consisting of staff from the Region of Waterloo, Ontario Clean Water Agency (OCWA, wastewater operations contractor), CH2M Hill (engineering consultant), and King City Group (general contractor):

Name	Title	Affiliation	Involvement
Jo-Anne Ing	Senior Project Manager, Design and Construction	ROW	Overall project manager
Moorthy Darmalingum	Senior Project Manager, Design and Construction	ROW	Project manager during construction
Ian Young	Project Manager, Design and Construction	ROW	Assistance during construction
José Bicudo	Senior Project Engineer, Engineering and Planning	ROW	Technical process support during detailed design
Trevor Brown	Senior Project Engineer, Engineering and Wastewater Programs	ROW	Technical operations support during detailed design and construction
Brian Runstedler	Senior Operations Manager	OCWA	Operations support during construction
Warren Saint	Project Manager	CH2M Hill	Project manager during detailed design and construction
Ryan Connor	Assistant Project Manager	CH2M Hill	Assistance during detailed design
Sally Baldwin	Resident Engineer	CH2M Hill	Resident engineer services during construction
Jerry Weinberger	Project Manager	King City	Project manager during construction
Todd Cameron	Site Superintendent	King City	Site services during construction

The following sub-contractors worked as part of the King City Group: London Excavators, Selectra Contractors (Electrical), Gowing Contractors (Mechanical), and JMP Engineering (SCADA Integrators).

The Region's Project Champion is Thomas Schmidt, Commissioner of Transportation and Environmental Services at the Region of Waterloo. Thomas has been involved with the planning of

the Kitchener WWTP for a long time. He has participated actively in the development of the 2007 Wastewater Treatment Master Plan and since then worked diligently with the Project Team, Senior Managers, and Councilors to make sure the necessary resources were always available for the successful completion of this project. Thomas continues to be actively involved in all other Kitchener WWTP upgrades project to make sure improvements to treatment processes are completed according to commitments made by the Region to the public and regulatory agencies.

3 Project Implementation

It took approximately 4.5 years to complete this project. The initial study and conceptual design was completed in November 2008. The detailed design phase started in May 2009 and was completed in December 2010. Construction started in January 2011 and it took approximately 24 months for the commissioning of the upgrades.

Full cost accounting and fully competitive pricing methods were used in this project as with most major construction projects managed by the Region of Waterloo. Budget and accounting databases capture all project costs in terms of general administration, design, survey, geotechnical, permits and fees, specialized consultants, construction, construction contingency, general contingency, specialized equipment, security, advertising, and staff resources. Construction budgets and cost estimates were further refined and confirmed by the consultant engineer at regular intervals during the design process to ensure that no costs had been missed. The project budget, along with forecast expenditures and spending commitments were input into a central database and it was actively managed by the Region's Project Manager. Each new contract or purchase order was entered in the system and compared to the estimated cost and the remaining budget. This on-going financial management technique allowed for close monitoring of project finances and allowed the Project Manager to recommend appropriate adjustments when required.

The project was implemented as outlined in the GMF funding proposal. The estimated 24 months for construction and commissioning was accurate in the GMF proposal, but the completion date of February 2012 indicated in the original proposal was not accurate. This was identified early in the project and communicated to the FCM's Project Officer so that an amendment to the agreement was signed in 2012 to change the completion date to February 2013. There were approximately 30 inclement weather days and a few construction challenges and equipment delivery delays that did not impact the overall construction schedule.

4 Project Budget and Financial Savings

The project cost approximately $17.9 million (excluding HST) and it was financed primarily by Regional Development Charges ($5.4 million), Water Reserve Fund ($1.3 million) and debentures ($9 million). The unfinanced portion ($2.2 million) is to be covered from the GMF Loan and Grant.

Aeration systems can consume between 25 and 60% of the total energy in a wastewater treatment plant. Mechanical aerators, which are energy intensive, were replaced with diffused aeration systems at both Plant 1 (through a different project) and Plant 2 (as part of this project). In addition,

the new blowers installed at the Kitchener WWTP as part of this project are considered to be one of industry's most energy efficient blowers available in the market. Therefore, it is expected energy use will be reduced in the long-term as compared to the pre-upgrades situation. Total annual electrical consumption per m^3 of sewage treated at the Kitchener WWTP was slightly lower in 2012 (0.19 kWh/m^3) as compared to 2010 and 2011 (0.22 and 0.23 kWh/m^3), but at this point it is difficult to ascertain if this reduction was directly affected by the installation of the new, more energy efficient aeration system.

There are also potential financial savings related to building heat costs. The new Blower Building was designed such that waste heat produced by air blowers is captured and used to heat the building during cold weather conditions. A number of other sustainable design practices were during construction of the Blower Building, including diversion of approximately 50% of construction waste from landfills, natural lighting, motion sensor lights, etc.

The Region will continue to monitor electrical consumption at the Kitchener WWTP in order to identify long-term reductions due to upgrades installed as part of this and other projects.

5 Environmental Benefits

Current water quality issues in the Grand River include elevated phosphorus and nitrogen throughout the watershed, as well as low dissolved oxygen (DO) in the early morning, which can frequently be below provincial objectives to protect aquatic life, downstream of the Region's larger WWTPs, particularly at low flow conditions. A strong link between DO and nitrogen cycles has been identified through intensive monitoring by the Region, Grand River Conservation Authority, and local Universities conducting research on the Grand River. Nutrient enrichment and prolific aquatic weed growth in the river, particularly during summer, contribute to significant diurnal fluctuations in DO. These DO fluctuations affect the nitrogen cycle and related conversion of ammonia to nitrites and nitrates.

The Kitchener WWTP used to discharge relatively elevated levels of ammonia to the Grand River as high as 30 mg/L before completion of this project. High concentrations of ammonia-nitrogen in freshwater can be toxic to aquatic life under certain conditions of temperature and pH. In addition, there is high consumption of oxygen by bacteria responsible for the conversion of ammonia to nitrites and nitrates, which may result in low DO levels at certain periods of the day.

The Kitchener WWTP upgrades for centrate management project is already providing significant improvements to the quality of the effluent discharged to the Grand River as show in Figure 1 below.

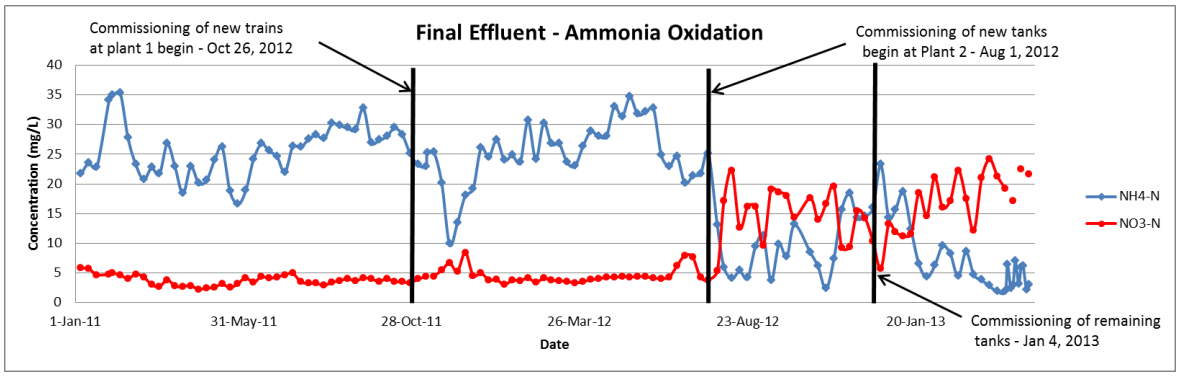

Figure 1. Ammonia and nitrate concentrations in the final effluent before and after upgrades

The concentration of ammonia dropped significantly since the commissioning of 1/3 of Plant 2 in the summer of 2012. With the commissioning of the remaining tanks in Plant 2 in early January 2013, the concentration of ammonia dropped to less than 5 mg/L. As a consequence of the oxidation process, nitrates are formed.

Biological oxygen demand (BOD) levels in the final effluent have also dropped significantly after commissioning of the Plant 2 upgrades. Although there was no noticeable decrease in total suspended solids (TSS) levels (approximately 8 mg/L), BOD levels dropped by approximately 50% after completion of the upgrades (from 8.2 to 4.7 mg/L).

Water quality in the Grand River is monitored periodically upstream and downstream of the Region's major WWTPs. Samples collected downstream of the Kitchener WWTP outfall in the spring of 2013 indicate unionized ammonia levels to be the same for both upstream and downstream sampling stations. This is a significant change from previous years when the downstream unionized ammonia levels were two and three times higher than levels measured at the upstream station (Figure 2).

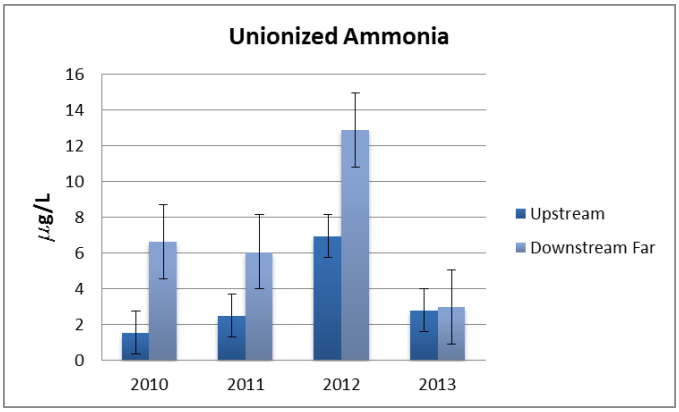

Figure 2. Median unionized ammonia levels upstream and downstream of the Kitchener WWTP

In addition, unionized ammonia levels downstream of the Kitchener WWTP in the spring of 2013 are well within the Provincial Water Quality Objective (PWQO) of 20 µg/L. Measured values ranged from 2 to approximately 9 µg/L. In previous years, unionized ammonia levels observed in the spring were as high as 75 µg/L.

6 Social and Economic Benefits

The health and sustainability of the Grand River is of integral importance to a significant number of communities that rely on the watershed for safe drinking water, recreation and wildlife habitats. The Grand River watershed encompasses all the land drained by the Grand River and is the largest watershed in southern Ontario. It is 6,800 square kilometers (2,800 square miles). The north and south reaches of the watershed are heavily farmed due to the temperate climate and good soils, so agriculture is a major industry.

A major challenge for the future is coping with significant population growth and climate change. Most watershed cities rely on rivers or wells for their potable water supplies, and all of them discharge their treated wastewater into these rivers. The public relies on the river for maintaining its quality of life.

Maintaining or improving the quality of our waterways while conserving the natural infrastructure of wetlands, woodlands and wildlife habitat, will be a major challenge in light of the expected growth within the watershed.

The previous biosolids management processes at the Kitchener WWTP using lagoons for liquid biosolids storage, resulted in numerous odour complaints due to its close proximity to residential areas. The new dewatering facility built at Manitou Drive together with the centrate management process that has been recently commissioned allowed for the on-going decommissioning of the biosolids storage lagoons at the Kitchener WWTP and replacement of mechanical aeration systems (which can potentially generate more odours than diffused air systems) with diffused aeration. These changes resulted in improved quality of life for those living in close proximity to the plant due to the significant reduction in odour potential from the site. The number of odour complaints reduced significantly since the operation of the biosolids storage lagoons were suspended for the construction of the Blower Building as part of this project.

The Kitchener WWTP upgrades for centrate management provide a significant improvement to the effluent discharged to the Grand River and therefore ensure that this watershed remains viable for all communities that depend on it.

There are direct and indirect economic benefits of this project. The indirect benefits are due to the reduction of biosolids volume through dewatering, which in turn results in less transportation costs. The direct benefits of the centrate management upgrades are not known yet. However, it is anticipated there will be a reduction in energy consumption as described previously under Section 4 - Project Budget and Financial Savings.

7 Lessons Learned

7.1 What the Region would do again

- Pre-selection of major equipment to mitigate concerns related to equipment delivery schedule.
- Pre-qualification of general contractors.

- Use a similar design for future aeration, with RAS reaeration, anoxic selector, and fine bubble diffusers.

7.2 What the Region would do differently

Issue: Blower building size

- The current blower building size limits the selection of equipment to be installed as part of the upcoming Plant 3 project. Increasing the blower buiding footprint would have provided greater flexibility in the design.

Issue: Blower building construction

- Coordination and planning of constructability issues related to sludge management and berm separation in the existing biosolids storage lagoons. Additional time was spent in the beginning of the construction phase to come up with the appropriate strategy for the new berm construction.
- Allow for additional contingency for sludge management and berm construction in the biosolids storage lagoons.

Issue: Construction of new aeration cells in Plant 2

- Impose time limitation on aeration tank sections given to the general contractor for re-construction so that the Region and OCWA could better manage the plant's operation and minimize issues related to environmental compliance.

Issue: Construction of south side aeration passes in Plant 2

- There was little communication among all parties (Region, OCWA, Contractor, and Consultant Engineer) when the Contractor took over the south side of Plant 2 for the construction of the second and third aeration passes, which resulted in significant biological process upset in the remaining of the plant. In the future, the Region will work diligently with OCWA and Consultant Engineer to identify the risks associated with plant shutdowns and start-ups required by the Contractor and develop a detailed sequence of tasks to minimize process upsets.

7.3 Barriers

The main barriers encountered in implementing the project and actions taken to overcome them are listed below:

Barriers	*Actions to overcome*
• **Construction of berm separation in the existing biosolids lagoon**	• Several attempts were made by the contractor to try and isolate the liquid portion in the lagoon at the beginning of the project without success. The Region developed a plan for the construction of the berm and discussed with both CH2M Hill and King City. The plan was implemented successfully by King City with minor impacts on the schedule.
• **Provision of standby power was initially planned for the next phase of upgrades, but OCWA requested that a back-up transformer was installed in this contract**	• The Region worked with CH2M Hill and AECOM (Consultant Engineer for the next phase of upgrades) to design and install the required back-up transformer

7.4 Advice to other communities

This project is part of a series of upgrades that have been planned for the Kitchener WWTP for the next five years and, as such, may impact future construction contracts. It is also noted this project was implemented with on-going plant operations and not as *greenfield* construction. Therefore, for similar projects it is important to consider present and future uses of the facility and carefully review additional building footprint to ensure all equipment (for this and other planned upgrades) can be adequately accommodated without significant changes in design or building construction. Proper coordination among all parties involved (owner, plant operator, contractor, different consultant engineers working on different projects) and efficient project management is critical for the success of a project of this magnitude.

The concept and design of the centrate management process installed at the Kitchener WWTP can be adapted by other municipalities trying to minimize centrate loads originated from the dewatering of biosolids.

The Region also recommends the following:

- Bump-up contingencies for any *greenfield* construction, demolition of existing buildings, and for the installation of temporary controls and process units;
- Conduct constructability reviews and establishing the appropriate sequencing in order to maintain continuous operations per plant operations needs as much as possible;
- Develop detailed work plans, complete with contingency planning, when taking major process units in and out of service to minimize the possibility of process upsets during construction;
- Provide temporary facilities/controls as required for the continuous operation of the plant during construction;
- Consider current and future standby power requirements when dealing with implementation of different phases of a larger project.

8 Publicity and Photos

A pre-construction Public Information Centre (PIC) was conducted on May 26, 2010. The PIC was advertised in the local newspaper on May 4 and 21, 2010 and notices were mailed to local residents as well. The objective of the PIC was to provide a forum for the public to discuss any questions and concerns they had with Region and other Project Team representatives. The PIC was attended by 10 people who were generally supportive of the project. The Region also received e-mails from the general public expressing their appreciation for the work that is being done to improve and upgrade the Kitchener WWTP. Neighbours to the plant are mostly concerned with odours, which is being addressed through this and other on-going projects.

On October 14, 2011, Berry Vrbanovic, now Past President of the Federation of Canadian Municipalities (FCM) and councillor for the City of Kitchener, and Harold Albrecht, member of Parliament for Kitchener-Conestoga, announced a total of $2,200,000 in Green Municipal Fund (GMF) support for the Region of Waterloo. The following news was released to the media:

“FCM’s Green Municipal Fund offers a range of resources and services that specifically address the sustainable community development needs of municipal governments,” said Mr. Vrbanovic. “The financing and knowledge provided by the Fund supports the development of communities that are more environmentally, socially and economically sustainable.”

“The Government of Canada is assisting municipalities across the country in achieving their goal of a cleaner and healthier environment for Canadians through the Green Municipal Fund,” said Mr. Albrecht. “Today’s announcement is another example of how our government — in partnership with FCM — is helping the Region of Waterloo build a greener future for our citizens.”

The Kitchener Wastewater Treatment Plant upgrade will improve the process by which air is added to the water, and ammonia and organic nitrogen are processed into nitrate. Construction is being done in stages to reduce the impact to plant operations. Other upgrades involve the design and building of new facilities to process the biosolids created during the treatment process. The new facility will convert the biosolids into cake form rather than liquid form.

The upgrade will also reduce the amount of ammonia-nitrogen in the treatment plant effluent by about 75 per cent. Higher quality effluent will improve water quality in the Grand River; in turn protecting the health of communities that rely on the Grand River watershed, and supporting population growth by ensuring the watershed’s sustainability. The creation of cake-form biosolids will produce a lesser volume needing storage, and will reduce greenhouse gas emissions associated with transportation. The biosolid process will also decrease the risk of runoff from fields following the application of liquid biosolids.

“Protecting the quality of the Grand River as a source of drinking water is a priority for the Region of Waterloo”, said Ken Seiling, Regional Chair. “Our residents have expressed strong support for this goal in their input to our Regional strategic plan and wastewater treatment master plan. Upgrading the Kitchener Wastewater Treatment Plant will help us achieve this goal.”

The following photos show the different phases of construction of the centrate management upgrades at the Kitchener WWTP up to completion.

Construction of berm in the existing biosolids storage lagoon (summer of 2011)

Retrofitting of aeration tanks (fall of 2011)

Construction of blower building (winter of 2012)

Construction of blower building and south side of Plant 2 (north side commissioned, summer of 2012)

Plant 2 aeration and blower building (winter of 2013)

HSI (Atlas-Copco) blowers in blower building (summer of 2012)

Blower building (fall of 2012)


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