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ST. THOMAS WATER POLLUTION CONTROL PLANT BIOSOLIDS MANAGEMENT OPTIONS

Prepared for:

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1. INTRODUCTION

1.1 Background

The St. Thomas Water Pollution Control Plant (WPCP) provides sewage treatment services to residential, commercial, industrial, and institutional users in the City of St. Thomas (City). The St. Thomas WPCP is a conventional activated sludge plant with a rated average daily flow capacity of 27.3 MLD. Current flows to the plant are approximately 18.1 MLD, representing 66% of the rated average daily plant capacity. The facility provides full secondary treatment of wastewater through pre-treatment (fine screens and aerated grit tanks), primary clarification, conventional activated sludge, and secondary clarifiers. Phosphorus removal is enhanced through alum addition, and ultraviolet disinfection is provided prior to discharge into Kettle Creek.

Waste activated sludge (WAS) from the secondary treatment processes is co-thickened in the primary clarifiers. Sludge consisting of both WAS and primary sludge has historically been digested in anaerobic digesters, dewatered with centrifuges and landfilled at the Green Lane Landfill site.

Components of the anaerobic digestion process are over 40 years old. In January 2014, the roof of Digester No. 3 was damaged due to line freezing. Digester No. 3 was subsequently taken offline. In addition, the City is currently paying market values for landfill tipping fees. The cost to rehabilitate and expand existing anaerobic digestion capacity, and continued landfill costs has led the City to initiate a review of alternative options for handling biosolids at the facility.

1.2 Objectives and Scope

Specifically, the objectives of this report was to:

- Review current and future sludge handling needs;
- Identify alternative biosolids handling disposal options; and,
- Review alternative options to the current digestion process.

For this review, a conceptual review of alternative biosolids treatment technologies was completed. The City has previously completed a study to evaluate future anaerobic digestion and energy recovery options for the St. Thomas WPCP (Steele et al, 2015). As such, onsite anaerobic digestion technologies were not evaluated as part of this review. The non-digestion alternatives evaluated included alkaline stabilization processes, composting, and heat drying. This review considered both onsite installations and dedicated offsite facilities to provide future biosolids treatment.

2. CURRENT AND FUTURE NEEDS

The St Thomas WPCP is a conventional activated sludge plant. Biological solids (i.e. WAS) are co-thickened in the primary clarifiers and combined biological and raw sludge is pumped to the anaerobic digesters for stabilization. Digested biosolids are dewatered using centrifuges and hauled offsite to landfill. Table 1 provides the average flow treated at the plant and the quantities of biosolids generated at the plant, as per the annual reports over the review period (2010 - 2014). On average, at a treated flow of 18.1 MLD, the plant hauls 2,664 tonnes/year of biosolids (or approximately 7,300 kg/d) to landfill. The cake concentration varied from 19.0 to 21.0 % total solids, averaging 20.5% for the same period.

Table 1 St. Thomas WPCP Treated Flow and Biosolids Quantities over the Review Period (2010 - 2014)

Year	Average Treated Flow (MLD)	Biosolids Quantity (tonnnes/year)	Biosolids Quantity (kg/d)
2010	16.5	2,771	7,592
2011	21.9	2,579	7,066
2012	17.0	2,880	7,890
2013	18.0	2,496	6,838
2014	17.1	2,596	7,112
Average	**18.1**	**2,664**	**7,300**

Historically, biosolids have been hauled to the Green Lane Landfill site, located approximately 15 km (one way) from the treatment plant. The City has a contract with the Landfill through 2019. Tipping rates at the landfill are updated as per the CPI adjustment for Ontario. From Table 1, the average yearly biosolids disposed at the landfill over the review period (2010 to 2014) was approximately 2,664 tonnes/year, for which the City paid over $180,000 per year in landfill tipping fees. The WPCP uses its own dump truck to haul the dewatered biosolids cake to the landfill, which results in approximately one roundtrip per workday per week, or a total of 5 trips per week. This results in about 260 roundtrips per year. Based on information provided by the City, the cost of a dump truck and operator is $75/hour. Assuming a one hour round-trip to the landfill, the estimated yearly cost for sludge hauling is $19,500. This does not account for filling time.

Continued anaerobic digestion will require a major upgrade to the digester complex to rehabilitate and expand existing digestion capacity. A study completed to discover options for digestion expansion identified three alternatives that included the construction of two new anaerobic digesters (Steele et al, 2015). Design volumes for each digester depended on the provision of separate mechanical WAS thickening and sludge holding tank options. Conceptual cost estimates for each of the three alternatives were within 6% and hence are the same given the expected degree of accuracy of the estimates.

The preferred alternative had an estimated capital cost of $20,280,000. Operating costs for the recommended digester upgrade alternative had a 20-year net present value (NPV) of $2,967,000, but do not appear to include disposal costs since these would be identical between reviewed alternatives. The previous review also identified two options for energy recovery: implementation of combined heat and power (CHP) facilities, and a vehicle alternative fuel option. Both options indicated a positive net present value for a 20-year program, but are still in the conceptual stage. For purposes of cost comparisons, the energy recovery option with the lowest NPV was used in this analysis (see Section 4), as this is the most common method used at wastewater facilities at the current time.

The purpose of this review was to evaluate alternative treatment technologies which have not been previously studied by the City and may not include any sludge digestion onsite. As such, generated solids will not undergo any destruction prior to disposal, causing the mass of waste solids to increase. Over the review period (2010 to 2014), the VSS of the raw sludge was 59% and the volatile solids destruction through the digesters was 55%. Assuming these conditions at future flows, the mass of raw (undigested) sludge is expected to increase by 20%, and the mass of solids would increase by about 4.5%. Hence the sludge quantity would be expected to increase from 2,664 to 2,789 tonnes/year.

For future sludge quantities, it is assumed that the sludge quantity will increase proportional to the flow treated by the plant. Therefore, the sludge quantities for the current rated capacity and future rated capacity (i.e. after the next expansion) are provided in Table 2.

Table 2 St. Thomas WPCP Current and Future Undigested Sludge Quantities

Description	Average Treated Flow (MLD)	Sludge Quantity (tonnes/year)	Sludge Quantity (kg/d)
Current	18.1	2,789	7,642
Current Rated Capacity	27.3	4,205	11,520
Future Rated Capacity	36.4	5,606	15,339

3. ALTERNATIVE TREATMENT TECHNOLOGIES

For the purposes of this report, the following technologies have been reviewed as alternative sludge treatment processes for the St. Thomas WPCP:

- Alkaline Stabilization;
- Composting;
- Heat Drying; and/or,
- Other locally available commercial options.

This section gives a brief introduction to each alternative treatment process considered, and presents the results of the preliminary analysis.

3.1 Alkaline Stabilization Processes

Generally, alkaline stabilization processes use a basic pH, sometimes in conjunction with an elevated temperature, to stabilize biosolids. Depending on the conditions of the reaction, pathogens in the stabilized product can be reduced or eliminated. However, the process will also slightly increase the volume of solids to be managed, and may result in the production of ammonia gas (US EPA, 2000).

Several alkaline stabilization processes have been commercialized for purposes of biosolids stabilization, including:

- Schwing Bioset™;
- Lystek™; and,
- N-Viro™.

A brief review of each process is included in subsequent sections.

3.1.1 Schwing Bioset™

In the Bioset™ process, dewatered sludges are combined with lime and sulphamic acid and mixed in a sealed reactor. Reaction of the lime with water increases the pH, resulting in the generation of ammonia and heat. Both of these factors help to reduce pathogens in the solids. The reaction occurs in a sealed reactor vessel, reducing odour and dust of the process. However, the process will generate ammonia that requires additional treatment, and will also use chemicals.

There is only one Bioset™ system in Canada, installed as a backup stabilization system in London, Ontario. There are no installations in Canada where Bioset™ is used as the primary method of biosolids stabilization. Examples of known installations in the United States include Ellsworth WI, and Stewartstown PA.

The Bioset™ process has a relatively high capital cost, and is not easily scalable. Therefore, other alkaline stabilization options were considered in lieu of this process.

3.1.2 Lystek™

The Lystek™ process was developed in Ontario, and has several full scale applications at wastewater treatment plants in Ontario, including at Guelph, Elora and St. Mary's. Dewatered solids are mixed with steam and potassium hydroxide in a high-shear reactor. The process is easily scalable, is carried out in a sealed reactor, and results in a pathogen-free material with a high viscosity and solids concentration (about 15%). Product biosolids can be pumped, but transfer pumps must be selected carefully to reflect the high viscosity of the processed sludge. As well, product biosolids volume is slightly greater than raw sludge volume due to steam and chemical addition. The process operates best with feed solids between 15% and 20% total solids. Current centrifuge operations at St Thomas would be on the high end of this range. As such, the centrifuges may be operated with reduced polymer to produce the ideal cake concentration.

There are two methods by which the Lystek™ process can be applied to waste sludge from the St. Thomas WPCP:

- Construct a Lystek™ process onsite to handle St Thomas waste solids; or,
- Transport waste solids to an existing Lystek™ treatment facility with excess capacity.

3.1.2.1 Onsite Lystek™ Treatment Process

Construction of an onsite Lystek™ facility would require installation of a reactor vessel, as well as provision of storage volume for chemicals and the stabilized liquid product. Some factors, such as the operating and disposal costs, will have a direct impact on the estimated net present value of the Lystek™ process. Lystek also provides a marketing service which assumes responsibility for sale of the Lystek product on local farms. Additional details are included in Section 4.

3.1.2.2 Offsite Lystek™ Treatment Process

In May 2013, a dedicated Lystek™ facility that is able to accept wastewater sludges generated in Ontario was opened in Dundalk, Ontario. The Organic Materials Recovery Centre (ORMC) currently has excess capacity and would be able to accept dewatered sludge from St Thomas. In 2015, the cost to process solids at the Dundalk facility was about $50 to $55 per wet tonne, not including shipping costs.

The distance between Dundalk and St Thomas is approximately 255 km, one way. This would increase shipping costs relative to disposal at the Green Lane Landfill (about 15 km from St Thomas). The Dundalk facility does accept biosolids from Orangeville, Halton Region and Toronto at the current time. Disposal costs will be dependent on the trucking costs from St. Thomas to the Lystek™ facility in Dundalk. To be feasible, it is likely that an upgrade of the truck loading facilities at the St. Thomas WPCP will be required, so larger trucks can be loaded. This would reduce both loading times and the number of trips required. A thorough cost analysis considering updated shipping costs and processing fees is required to determine if this option is economically viable.

3.1.3 N-Viro™

In the N-Viro™ process, dewatered solids are mixed with an alkaline additive to increase the pH and the temperature of the mixture. Typically, the mixture is then heat-dried to increase the solids concentration. The product then remains in a "heat pulse" cell for 12 hours at temperatures between 52°C and 62°C at a pH greater than 12. Design of the system ensures no additional heat is required during this stage. The product is then moved to a final curing stage, where it remains with a pH greater than 12 for an additional 60 hours. Due to the addition of the alkaline additive and the heat dry process, off-gases created during the process must be treated. Dust can be removed using a bag house, and volatilized odorous compounds can be treated using a biofilter. However, the process can be operated without heat drying.

In Ontario, N-Viro™ has installed systems in Leamington, Sarnia and Thorold. Further, a new design-build-operate system is currently under construction in Sudbury.

Walker Industries acquired N-Viro™ Systems LP Canada, or the Canadian operations, in May 2014. The N-Viro™ process is also available without the dryer, which would reduce the energy requirements for the process, but increase haulage costs.

There are two methods by which the N-Viro™ process can be applied to waste sludge generated at the St. Thomas WPCP:

- Construct an N-Viro™ process onsite to handle St. Thomas waste solids; or,
- Transport waste solids to an existing N-Viro™ treatment facility with excess capacity.

3.1.3.1 Onsite N-Viro™ Treatment Process

Construction of an onsite N-Viro™ facility would require installation of a reactor vessel, drying area, and provision of storage volume for chemicals and the stabilized product. Some factors, such as the operating costs, will have a direct impact on the estimated payback period for the N-Viro™ process. Similar to Lystek, Walker Industries offers a marketing service which assumes responsibility for the sale of N-Viro™ product to local farms. Additional details are included in the subsequent section.

3.1.3.2 Offsite N-Viro™ Treatment Process

The Walker Environmental Group operates a regional waste facility in Thorold, ON, which is approximately 210 km one way. This would increase shipping costs relative to disposal at the Green Lane Landfill (about 15 km from St Thomas). To be feasible, it is likely an upgrade of the truck loading facilities at the St. Thomas WPCP will be required, so larger trucks can be loaded. This would reduce both loading times and the number of trips required. A thorough cost analysis considering updated shipping costs and processing fees is required to determine if this option is economically viable.

3.2 Composting Processes

Ontario has revised the composting guidelines, including the Ontario Compost Quality Standards (MOE, 2012). The standards outline the requirements for various categories, including Category AA, A and B compost. Category AA cannot include biosolids, while Category A can have 25% of its total feedstock as biosolids. Labeling for Category A must indicate the presence of biosolids in the compost. Category B may consist of 100% biosolids. In the new legislation, the definition of several compost product categories makes it practical to use biosolids in the compost production. Both the feedstock(s) and final composite products are subjected to limits on metal standards. The applicability of composting biosolids with other materials, such as leaf and yard waste, is generally feasible. Importantly, Category AA and Category A compost are exempt from all transport and use approvals, but still may require a non-agricultural source material (NASM) plan when applied as a nutrient to agricultural land. Under the new legislation, opportunity exists to generate a high quality compost material that is subject to less transport and use restrictions when being land applied.

However, open composting still requires a large footprint and is not commonly undertaken in Ontario for biosolids at this time. Recently, Walker Environmental opened an under-GORE open composting process at its Thorold location that incorporates some biosolids in the process. Ottawa biosolids have been composted in the past, but only in Quebec. The reviewers know of no other biosolids composting in Ontario at this time.

Composting biosolids generally involves the addition of a bulking agent. Bulking agents can be various materials such as wood or yard waste. Biosolids tend to have a high moisture content, high wet bulk density and low C/N ratio. Bulking agents are used to improve the characteristics of the mix to improve the composting process and final product. A bulking agent can improve the air-filled porosity, moisture content and Carbon:Nitrogen ratio of the compost. Ratios of biosolids to bulking agent are site specific but range between 1:1 and 1:3, averaging 1:2 (biosolids to bulking agent) in most cases. For Category A compost, the ratio would need to be 1:3. St. Thomas could consider a pilot composting operation in combination with its leaf and yard waste program to diversify its biosolids program. However, composting is unlikely to represent a feasible stand-alone solution for biosolids management at the St. Thomas WPCP.

3.3 Heat Drying

The objective of the Heat Drying process is to remove most of the water in dewatered biosolids through evaporation. The heat dried product typically has a solids content of between 90 to 95 percent. There are a number of heat drying technology classifications including direct/indirect drying and high/low operating temperatures. In direct drying, heat transfer is through direct contact of the feed with the hot gases generated in the drier.

A lower temperature operating system, such as a belt drier, can operate at low (< 50 °C) or medium temperatures (80 to 130 °C) and requires more floor space than a high temperature system. The Heat Drying process can produce an essentially pathogen free product that meets the requirements and guidelines prescribed by the Federal Fertilizer Act, and are typically land applied as a soil amendment. Since this allows the product to be applied with unrestricted use (e.g. public and private gardens), markets for the product may be beyond only agricultural application.

The dewatered cake is dried in a drying drum with the discharge settling to the bottom of an air filter unit. The product is then directed to a sizer, which divides the product into three paths. Particles that are too big are reduced in size by a crusher and returned to the drying system. Particles that are too small also returned to the drying system where they act as seed for the dewatered cake to adhere to and grow. Product which is considered to have desirable size is directed to storage.

The system is considered to be closed loop with respect to the drying air since the exhaust air in the drying drum is re-circulated after being re-heated in the heat exchanger. The closed loop configuration reduces the oxygen level in the drying air thereby reducing the potential for the dried product to burn.

The density of a heat dried product is reported to range from 300 kg/m^3 to 600 kg/m^3. Based on the high solids content and the potential for it to combust, temperature sensors and a nitrogen purging system are typically utilized in storage facilities.

Some of the advantages of the heat dry process include:

- Produces an essentially pathogen free product;
- Considerable reduction in volume of product to manage after heat drying; and
- Can utilize digester gas that may otherwise be flared off.

Some of the disadvantages of the heat dry process include:

- Large surface area with high ceilings required to accommodate dryer and dust control systems;
- High energy requirement for dryer; and
- Due to high carbon content and dryness of product, safety precautions are required.

Examples of known locations utilizing the Heat Drying process can be found in:

- Smiths Falls, Ontario;
- City of Windsor, Ontario;
- Milwaukee, Wisconsin;
- City of Montreal, Quebec; and,
- Communite Urbaine de L'Outauais, Quebec.

3.4 Alternative Locally Available Commercial Options

The previously discussed Lystek™ facility located in Dundalk, Ontario and the N-Viro™ facility located in Thorold, Ontario are both commercial regional processing facilities. As such, they accept liquid sludge or cake from the surrounding area for processing at the plant. Harvest Power, located in London, Ontario, represents a similar commercial operation which accepts and processes waste from the surrounding area. Details of the Harvest Power operation are presented below.

Harvest Power

Harvest Power is a commercial company that accepts various biological feedstocks and stabilizes these materials to produce energy and a nutrient material. In October 2010, Harvest Power, Inc., acquired the anaerobic digestion project under development in London, Ontario from StormFisher Biogas. The facility, which has an environmental permit and power purchase agreement with the Ontario Power Authority, is designed to generate 2.8 megawatts of renewable electricity from biogas, enough to power over 1,400 homes, as well as produce several thousand tonnes per year of an organic-based fertilizer.

Harvest Power has provided the following description of their treatment process:

"…through innovative technologies and unparalleled industry experience, Harvest is ushering in a new era of organics recycling. Harvest develops, builds, owns and operates state-of-the-art facilities that produce renewable energy and compost from discarded organic materials. Deploying best-in-class technologies, Harvest provides capital for projects and top-tier talent to finance, engineer, construct and operate the facilities. By harnessing the energy and nutrients of organic materials, Harvest enables communities to increase their energy independence, reduce their environmental impact, and harvest valuable resources."

The Harvest Power facility in London utilizes a thermophilic anaerobic digestion process to produce a pathogen-free product. Biogas is captured from the digestion process and used to generate electricity. Digested biosolids are dewatered using a centrifuge and heat dried. The entire process illustrates Harvest's approach to using best-in-class technologies to extract the maximum value from the unique waste stream in a given area. Harvest Power has submitted an application to the MOECC to accept biosolids for processing at the facility.

3.5 Summary of Alternative Treatment Technologies

A summary of processes evaluated during this technical review is shown in Table 3. The table also presents the key conclusions drawn for each technology, including a recommendation of which technologies should undergo a conceptual-level life cycle cost analysis for implementation at the St. Thomas WPCP.

Table 3 Summary of Reviewed Processes

Process	Discussion	Conclusion
Open Composting	• Definition of several compost classes allows for use of biosolids in composting process. • Not common in Ontario at current time for biosolids. • Other feedstocks needed.	• Could consider piloting with leaf and yard waste program. • Not considered a feasible solution for all biosolids.
Bioset™	• No process installations in Canada for use as primary solids treatment option. • Not easily scalable.	• Not recommended for application at the St Thomas WPCP, in lieu of other alkaline stabilization options.
Lystek™ (Onsite installation)	• Feasible solution could be located on site. • Configuration of onsite facilities needs consideration.	• Potential solution. Requires further economic analysis.
Lystek™ (Regional Processing Facility)	• Excess capacity at facility in Dundalk, ON. • Reduced processing cost relative to landfill tipping fees. • Significant shipping distance (255 km one way).	• Potential solution. Requires further economic analysis.
N-Viro™ (Onsite installation)	• Feasible solution could be located onsite. • Process variations removes dryer requirement (reduces energy and land needs). • Amount of storage onsite needs consideration.	• Potential solution. Requires further economic analysis.
N-Viro™ (Regional Processing Facility)	• Excess capacity at regional facility in Thorold, ON. • Significant shipping distance (210 km one way).	• Potential solution. Requires further economic analysis.
Harvest Power	• Excess capacity at regional facility in London, ON. • Actively seeking biosolids material for processing at the plant. • Close proximity to St. Thomas WPCP.	• Potential solution. Requires further economic analysis.
Heat Drying	• Product is pathogen-free. • Process requires a large surface area and has high energy requirements.	• Potential Solution. Requires further economic analysis.

This review provides a high-level analysis of several solids treatment technologies. In summary:

- Although composting legislation in Ontario has recently changed, a significant amount of bulking agent would be required for composting with biosolids. Such a program is not considered feasible for all biosolids produced at the St. Thomas WPCP. However, a future pilot project may diversify the biosolids management plan.
- The Bioset™ process has limited installations in Ontario, and is not easily scalable. This process is not considered feasible for application at the St. Thomas WPCP in lieu of other alkaline stabilization options.
- Some technologies, such as the onsite Lystek™ and N-Viro™ processes, have significant history in the industry and provide marketing of the final fertilizer product. These processes have been recommended for economic analysis.
- Both Lystek™ and N-Viro™ have Regional processing facilities. These locations are a long distance from St Thomas. Economic analysis of these options have been recommended.
- One process (Harvest Power) is located nearby (London, Ontario), and is actively looking for biosolids as a feedstock to its commercial process. Economic analysis of this option has been recommended.
- Heat drying can produce a Class A biosolids product (US EPA designation). Further, this process removes a large percentage of the water from the biosolids product, thereby reducing the disposal costs. Economic analysis of this option has been recommended.

4. LIFE CYCLE COST ANALYSIS

From the preceding analysis, six technologies/deliver methods were selected for further conceptual-level costing analysis. Specifically, these are:

- Lystek™ - Onsite Installation;
- Lystek™ - Regional Processing Facility;
- N-Viro™ - Onsite Installation;
- N-Viro™ - Regional Processing Facility;
- Harvest Power; and,
- Thermal Drying

From the six identified technologies/deliver methods, eight options were developed for future treatment of waste sludge from the St. Thomas WPCP. This included two sub-options: an alternative chemical for the onsite Lystek™ option and thickening prior to sending raw sludge to Harvest Power.

As noted, the City has previously completed a study to evaluate future options for anaerobic digestion and energy recovery from sludge produced at the WPCP (Steele et al. 2015). The study identified a preferred alternative for the anaerobic digestion of future sludge, which required the construction of two new anaerobic digesters. This report uses the previously identified preferred alternative as a baseline to compare all other options to.

Table 4 provides a brief description of all options considered for conceptual-level life cycle cost analysis: eight options developed as part of this analysis, and one option identified as the preferred alternative during previous study.

Table 4 Summary of Conceptual Cost Estimations

Option	Process	Description (1)
1	Lystek™ - Regional Processing Facility	• Co-thickened waste sludge from the primary clarifiers is dewatered in the existing centrifuges, and stored onsite. • Dewatered sludge is trucked to the Lystek™ processing facility in Dundalk, Ontario.
2a	Lystek™ - Onsite Installation (Alkali)	• Co-thickened waste sludge from the primary clarifiers is dewatered in the existing centrifuges, and further processed in an onsite Lystek™ reactor. Processed sludge is stored onsite, and land-applied to local fields. • NaOH and KOH are the primary chemicals used in the Lystek™ process.
2b	Lystek™ - Onsite Installation (CKD)	• Co-thickened waste sludge from the primary clarifiers is dewatered in the existing centrifuges, and further processed in an onsite Lystek™ reactor. Processed sludge is stored onsite, and land-applied to local fields. • Cement kiln dust (CKD) is the primary chemical used in this option of the Lystek™ process.
3	N-Viro™ - Regional Processing Facility	• Co-thickened waste sludge from the primary clarifiers is dewatered in the existing centrifuges, and stored onsite. • Dewatered sludge is trucked to the N-Viro™ processing facility in Thorold, Ontario.

Table 4 Summary of Conceptual Cost Estimations

Option	Process	Description (1)
4	N-Viro™ - Onsite Installation	• Co-thickened waste sludge from the primary clarifiers is dewatered in the existing centrifuges, and further processed in an onsite N-Viro™ reactor. Processed sludge is stored onsite, and land-applied to local fields.
5a	Harvest Power - Without pre-thickening	• Co-thickened waste sludge from the primary clarifiers is hauled for disposal at the Harvest Power processing facility in London, Ontario.
5b	Harvest Power - Pre-thickening	• Co-thickened waste sludge from the primary clarifiers is thickened in a new mechanical thickening process and hauled for disposal at the Harvest Power processing facility in London, Ontario.
6	Thermal Drying	• Co-thickened waste sludge from the primary clarifiers is dewatered in the existing centrifuges, and further processed in a new thermal dryer installed onsite. • Dried sludge is stored onsite, then trucked offsite for disposal.
7	Baseline Option - Anaerobic Digestion	• Two new primary digesters, approximately 1,550 m^3 each, are constructed to meet future rated capacity. • A new sludge holding tank with effective storage volume of about 615 m^3 is constructed. • Sludge is co-thickened in the existing primary clarifiers.

Notes:
1. Options 1 to 6 include the conceptual level cost to rehabilitate Digester No. 3, and provide sludge mixing in Digester No. 2 and No. 3.

Conceptual-level life cycle costs, including capital and operations and maintenance (O&M) costs, were developed for all options presented in Table 4 over a 20-year planning period. The following factors were taken into consideration when developing conceptual-level costs:

- Previous investigations did not include estimations of O&M labour costs for the solids handling processes (i.e. for Option 7). As such, on-site labour (City staff) costs have also been eliminated as part of this investigation for Options 1 to 5. It is expected that additional on-site labour for non-digestion options can be accommodated by similar labour needed as for the digestion process, except for Option 6 (thermal drying). Option 6 is considered to be more labour intensive, and therefore includes a labour component;
- Options 1 to 4, Option 6, and Option 7 all include dewatering of biosolids using existing centrifuges. It is assumed centrifuge operational costs were not included in Option 7 during the previous study. As such, centrifuge operating costs have similarly been excluded for Options 1 to 4, and Option 6;
- Options 5a and 5b do not use existing centrifuges to dewater waste solids prior to disposal. Estimations of the centrifuge operating cost have been developed based on information provided by the City, and credited to the operational costs for these options;
- It is assumed sludge generation will increase consistently. At the end of the 20-year planning period, it is assumed sludge generation rates will be equal to the projected rate

at the existing plant capacity (i.e. liquid train average flow of 27.3 MLD), as defined in Table 2;

- Digester No. 2 was rehabilitated in 2012, and it is assumed that this digester requires no additional work to be used as a holding tank. Conceptual-level costing of Options 1 to 6 in Table 4 assume Digester No. 3 will be retrofitted to provide sludge storage (i.e. at a similar cost as rehabilitating Digester No. 2), and that alternative means of mixing (i.e. mechanical mixing) will be provided for both Digester No. 2 and No. 3. Mixing only has been assumed adequate for odour control;
- As indicated above the existing digesters would be retrofitted as holding tanks and mixing would be provided. Alternatively, a new sludge storage tank could be provided for a similar cost, but potentially with reduced volume. Decommissioning of the existing digesters has not been included;
- All onsite alkaline stabilization options (Options 2a, 2b and 4) include odour control for all new facilities, inclusion of existing dewatering building could also be considered for additional cost if deemed necessary;
- Storage onsite has been budgeted for the Lystek onsite options (Options 2a and 2b) and the 3,000 m^3 of storage should accommodate about 3 months of storage at design flows. Final biosolids storage has been provided with a lined and covered storage unit, alternatively, concrete tanks with mixing could be provided but potentially at a higher cost;
- Storage for N-Viro and heat drying options (Options 4 and 6) is based on temporary storage only for weekly operations;
- All options include removal of final solids/biosolids from the plant and for land application options this would include marketing and supplier fees; and,
- Where possible, cost estimations were obtained directly from process vendors, and life cycle cost parameters were assumed identical to previous investigations completed at the St. Thomas WPCP (Steele et al. 2015). A summary of important life cycle cost parameters is given as Table 5.

Table 5 Life-Cycle Cost Parameters

Parameter	Units	Value
Inflation Rate	-	3%
Discount Rate	-	6%
Natural Gas Price	$/m³	$0.25
Electricity Price	$/kWh	$0.16
Tipping Fee - Green Lane Landfill	$/wet tonne	as per current contract
Tipping Fee - N-Viro™ Regional Processing Facility	$/wet tonne	$130.00
Tipping Fee - Lystek™ Regional Processing Facility	$/wet tonne	$52.50

All capital costs include an allowance for: contractor mark-up (15%), contingency (30%), engineering fees (12%), and taxes (13%). A summary of life-cycle costs for all options is presented as Table 6. Costs developed for Table 6 are conceptual level, and provide a high-level comparison between sludge management alternatives. Actual costs should consider a detailed evaluation of labour costs, and will also depend on site-specific factors, such as: soil and groundwater conditions, the engineering design applied, construction conditions at the time of tendering, etc. Detailed conceptual cost information for Options 1 to 6 is presented in Appendix A.

For comparison, costs for upgrading the anaerobic digestion at the St. Thomas WPCP, as defined in previous studies, have also been included in Table 6. Previous investigations defined two potential energy recovery options when considering future anaerobic digestion facilities: CHP facilities, and the creation of an alternative vehicle fuel from digester gases (Steele et al., 2015). The previous study estimated the 20-year NPV for each energy recovery option, and found both to be positive. For the alternative vehicle fuel option it is unclear whether re-fitting the bus fleet was included and therefore, this report has conservatively applied the combined heat and power option NPV values (CHP). Currently, CHP is the most common co-generation alternative used at wastewater facilities. Further, this report has added estimations of sludge disposal costs to the anaerobic digestion O&M costs.

The following observations can be made from results presented in Table 6:

- Offsite treatment (Option 1, Option 3, Option 5a and 5b) is primarily dependent on sludge hauling and tipping costs. For this report, it was assumed both costs will increase with the rate of inflation. Actual increases in these costs above the rate of inflation would increase the estimated life-cycle cost. Further, these options provide no sludge stabilization capability onsite at the St. Thomas WPCP;
- For all considered options, Option 1 (Lystek™ treatment at a regional processing facility in Dundalk, Ontario) provides the lowest estimated life cycle cost over the 20-year evaluation period. Of the alternative options reviewed, N-Viro onsite, Harvest power with co-thickened sludge only and heat drying appear to have the highest life-cycle cost; and,
- All considered options (Options 1 to 6) are estimated to have a lower 20-year life cycle cost relative to the preferred solution for anaerobic digestion.

Figure 1 provides a bar chart of the estimated NPV for each option. The figure also includes a yellow bar representing the ± 10% range of the average of the eight alternatives developed for this report (i.e. Options 1 to 6). The average NPV for these options is $14,330,000 (rounded to the nearest $10,000). The figure shows that all alternatives are potentially more cost effective than continued anaerobic digestion and landfilling, given the upgrades required for the anaerobic digestion process. Options 4, 5 and 6 are potentially more expensive than Options 1, 2 and 3. However, on a conceptual cost level, all options are relatively similar. As such, a complete evaluation including consideration of site-specific issues should be undertaken. Site-specific issues would include risk issues, backup solid handling options, and environmental direction of the City etc.

Table 6 Summary of Estimated Life Cycle Costs

Cost	Option 1 - Lystek Remote	Option 2a - Lystek Onsite (Alkali)	Option 2b - Lystek Onsite (CKD)	Option 3 - N-Viro Remote	Option 4 - N-Viro Onsite	Option 5a - Harvest (No Thick)	Option 5b - Harvest (Thick)	Option 6 - Heat Drying	Option 7 - Digester Upgrade
Capital Costs (1)	$3,006,000	$9,238,000	$10,064,000	$3,006,000	$13,679,000	$1,581,000	$4,966,000	$10,692,000	$20,280,000
NPV O&M Costs	$5,529,000	$2,208,000	$1,585,000	$9,543,000	$4,053,000	$18,320,000	$12,865,000	$7,379,000	$6,703,000 (3)
NPV of Credits (2)	($0)	($0)	($0)	($0)	($0)	($1,554,000)	($1,554,000)	($0)	($1,380,000)
Total 20-year Life Cycle Cost	$8,873,000	$11,446,000	$11,649,000	$12,381,000	$17,732,000	17,732,000	$16,307,000	$18,071,000	$25,603,000

Notes:

1. Includes 30% allowance for contingency, 12% allowance for engineering fees, and 13% allowance for taxes.
2. Considers the estimated NPV of combined heat and power (for anaerobic digestion) or the estimated NPV of centrifuge operation (Options 5a and 5b).
3. Estimations of sludge hauling and dumping costs have been added to costs reported by Steele et al. (2015).

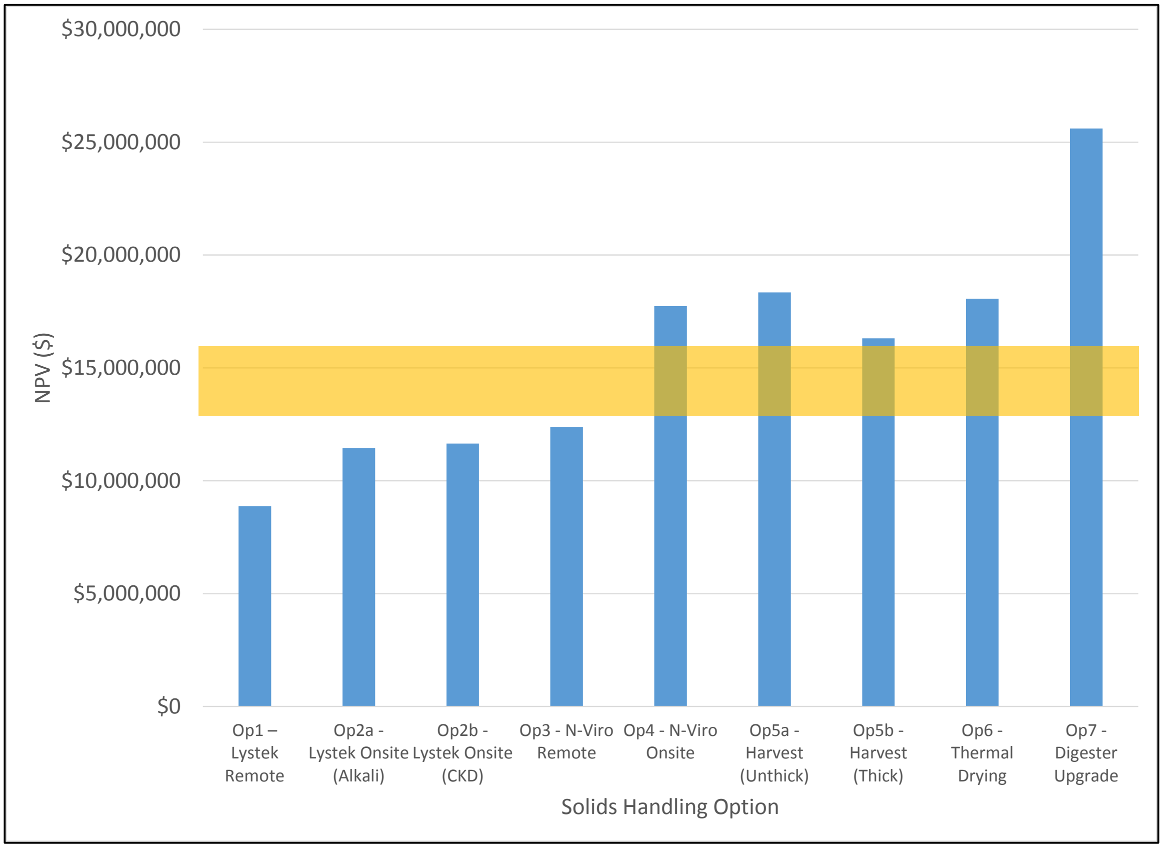

Figure 1 Comparison of Net Present Value for all Biosolids Management Options at the St. Thomas WPCP

5. CONCLUSIONS AND RECOMMENDATIONS

The purpose of this report was to review current and future biosolids handling needs, and to identify and review alternative options to the current digestion process. Based on available information, the following conclusions and recommendations are made.

5.1 Conclusions

- Based on historical plant records, anaerobic digestion at the St. Thomas WPCP achieves 55% VSS destruction. Implementation of an alternative biosolids management plan would eliminate VSS destruction, and will increase solids leaving the plant;
- Future sludge quantities are assumed to be proportional to the treated flow at the St. Thomas WPCP. Further, it was assumed that the plant will reach the current design capacity (27.3 MLD) and produce 4,205 wet tonnes of solids per year at the end of the 20-year design period;
- Several alternative treatment technologies were identified to be feasible for application at the St. Thomas WPCP. These included: Lystek™ and N-Viro™ alkaline stabilization processes, thermal heat drying, and Harvest Power (a local, alternative commercial option using anaerobic digestion/co-generation/heat drying); and,
- Conceptual-level 20-year life cycle cost analysis, including capital and O&M costs, show that all alternative technologies evaluated during this report may have a positive economic impact relative to the anaerobic digestion options previously considered. Offsite treatment at the Lystek™ facility in Dundalk, Ontario may be the most economically viable option, although at this conceptual level a number of the options reviewed are similar in cost (i.e. NPV). Overall, all options reviewed appear to be more cost-effective than upgrading the anaerobic digestion process. However, the infrastructure built as part of the digester upgrade would have useful life beyond the 20-year review period of this analysis.

5.2 Recommendations

- The City should confirm the basis for conceptual-level cost estimation is consistent between this report, and previously completed studies of biosolids management options (i.e. Steele et al. 2015);
- The City may consider conducting a thorough review of all or a selected number of options for the management and disposal of biosolids at the St. Thomas WPCP. All management options contain unique risk factors. The City should evaluate which risk factors are most important moving forward, and give consideration to the stability of the process technology and cost factors. Other site specific criteria in addition to cost may also need to be considered; and,
- The City could consider a strategic plan for biosolids that could include continued digestion and dewatering and partial diversion of biosolids to an offsite location, such as Harvest Power or either alkaline stabilization options.

6. REFERENCES

Ontario Ministry of the Environment. (2012). *Ontario Compost Quality Standards.* (Ontario MOE Publication Number: PIBS 8412).

Steele, P et al. (2015). *St. Thomas WPCP - Planning Digester Upgrades and Energy Recovery Options*. Presented at WEAO 2015 Technical Conference, Toronto, Ontario.

US EPA. (2000). *Biosolids Technology Fact Sheet - Alkaline Stabilization of Biosolids*. (US EPA Publication Number: EPA 832-F-00-052). Washington, D.C.

APPENDIX A
DETAILED CONCEPTUAL LEVEL COSTING INFORMATION

Conceptual Level Capital Costs								
	Option 1	Option 2a	Option 2b	Option 3	Option 4	Option 5a	Option 5b	Option 6
Process Capital	$0	$3,167,700	$3,617,700	$0	$6,643,000	$0	$1,861,000	$5,015,000
Co-thickened Sludge Storage	$761,000	$761,000	$761,000	$761,000	$761,000	$761,000	$761,000	$761,000
Processed Sludge Storage/Loading	$877,000	$1,105,000	$1,105,000	$877,000	$50,000	$100,000	$100,000	$50,000
Sub Total	$1,638,000	$5,033,700	$5,483,700	$1,638,000	$7,454,000	$861,000	$2,722,000	$5,826,000
General Requirements and Contractors Profit (15%)	$245,700	$755,055	$822,555	$245,700	$1,118,100	$129,150	$408,300	$873,900
Contingency (30%)	$491,400	$1,510,110	$1,645,110	$491,400	$2,236,200	$258,300	$816,600	$1,747,800
Project SUBTOTAL	$2,375,100	$7,298,865	$7,951,365	$2,375,100	$10,808,300	$1,248,450	$3,946,900	$8,447,700
Estimated Engineering (12%)	$285,012	$875,864	$954,164	$285,012	$1,296,996	$149,814	$473,628	$1,013,724
HST (13%)	$345,815	$1,062,715	$1,157,719	$345,815	$1,573,688	$181,774	$574,669	$1,229,985
Estimated Capital Cost TOTAL	$3,006,000	$9,238,000	$10,064,000	$3,006,000	$13,679,000	$1,581,000	$4,996,000	$10,692,000

Conceptual Level Operating Costs								
	Option 1	Option 2a	Option 2b	Option 3	Option 4	Option 5a	Option 5b	Option 6
Trucking Costs	$130,100	$0	$0	$102,221	$0	$275,690	$173,897	$4,089
Tipping Costs	$149,615	$0	$0	$370,474	$0	$689,225	$434,742	$43,260
Stored Sludge Mixing Costs	$52,252	$52,252	$52,252	$52,252	$52,252	$52,252	$52,252	$52,252
Operating Costs	$0	$47,962	$13,690	$0	$110,000	$0	$68,000	$382,374
Marketing/Disposal Costs (1)	$0	$30,398	$30,398	$0	$0	$0	$0	$0
Marketing, QA/QC, CFIA Label Costs (2)	$0	$0	$0	$0	$108,000	$0	$0	$0
Centrifuge Operation Costs (Credit)	$0	$0	$0	$0	$0	$85,494	$85,494	$0
Estimated Operating Costs (Year 1)	$331,966	$130,612	$96,340	$524,947	$270,252	$931,672	$643,396	$481,974
Estimated 20-Year NPV Cost	$5,867,252	$2,207,815	$1,584,957	$9,374,515	$4,053,337	$16,766,395	$11,311,275	$7,379,204

Notes:
1. Specific to Lystek™ prices
2. Specific to N-Viro™ prices

	Option 1	Option 2a	Option 2b	Option 3	Option 4	Option 5a	Option 5b	Option 6
20-Year Life Cycle Costs	$8,873,000	$11,446,000	$11,649,000	$12,381,000	$17,732,000	$18,347,000	$16,307,000	$18,071,000