



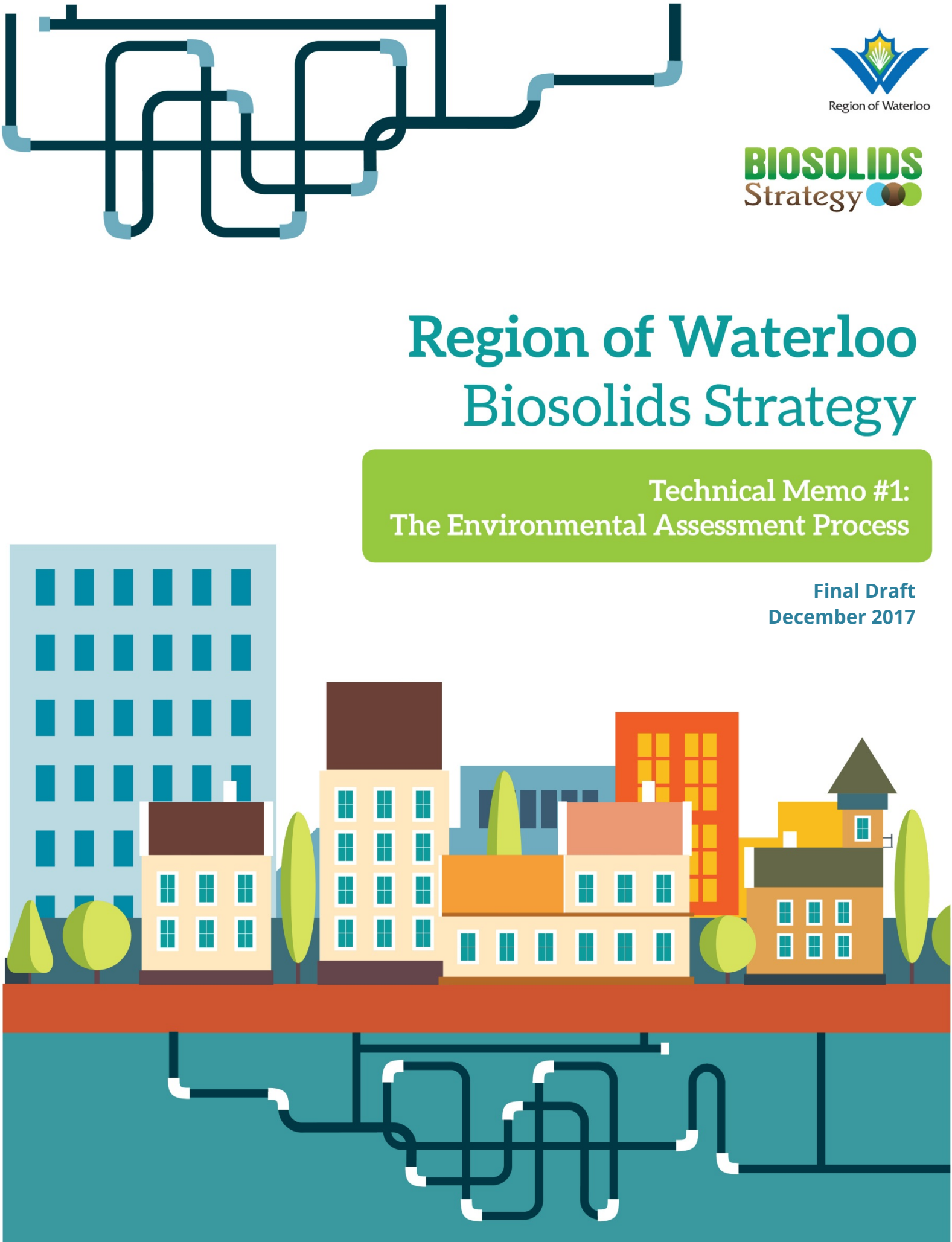
APPENDIX A:

**TM#1 – The Environmental
Assessment Process**

Region of Waterloo Biosolids Strategy

Technical Memo #1: The Environmental Assessment Process

Final Draft
December 2017



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Appendix A: Municipal Class EA Process in Ontario

1.0 Introduction

1.1 Project Purpose and Approach

The Region of Waterloo Biosolids Strategy was initiated in 2015, to develop an approach to manage biosolids in Waterloo Region to the year 2051. The strategy will take a critical look at current practices, and consider available and relevant technologies for processing biosolids. Alternative ways to manage biosolids will be evaluated against a range of criteria to develop a biosolids management strategy for the Region. This project will result with the selection of a preferred strategy that will be implemented in the Region over the next 25 years. The decision making process to select the preferred strategy will be documented in a report and be available for public review. Future projects will further refine the implementation details of the strategy including timing, sizing and location of any facilities.

The strategy is being developed in six stages, which will be outlined in a series of technical memos (TMs) as discussed in Section 3.1.

The Region is committed to public engagement throughout the development of the strategy. The project team will seek to understand the priorities and concerns of community residents across Waterloo Region, as well as technical experts and other stakeholders.

A **sustainable strategy** is one that considers the future growth of the Region and looks to minimize potential landfill disposal requirements of biosolids.

1.2 What are Biosolids?

Biosolids are the treated organic materials left over after wastewater has been processed to meet the Provincial Standard. The wastewater includes material that enters the wastewater system from the toilets, sinks, bathtubs, dishwashers, laundry machines, and other water-based appliances located in homes and

apartments, as well as wastewater from institutional, commercial and industrial activities across Waterloo Region. In short, biosolids are the resource materials removed from our water after it goes down the drain.

1.3 Context: Study Area and Strategy Horizon

The study area for this project is the Waterloo Region boundary, which includes the Cities of Kitchener, Waterloo, and Cambridge, and the Townships of Woolwich, Wilmot, Wellesley, and North Dumfries.

Given the rapid pace of technology change and the opportunities to explore innovative solutions to existing and future challenges, it is important that the strategy be forward thinking and be adaptable, flexible and sustainable. The planning horizon for this Strategy is to the year 2051, thus assumptions made in forecasting future needs will be carried out with this time frame in mind.

1.4 Biosolids Management: A Complex Issue

Waterloo Region is growing at a rapid pace. It is anticipated the Region will experience growth roughly equivalent to the population of the City of Kitchener over the next two decades. The Region of Waterloo currently manages biosolids in two ways:

- **Land Application:** Land application refers to the management of the material as a resource. For biosolids in Waterloo Region, this involves the transportation of biosolids for application on accepting farmers' fields, and for use in remediation of mine tailings ponds in Sudbury, Ontario. Where the biosolids are used varies throughout the year based on several factors, including demand from receivers and seasonal changes. For instance, agricultural land application is not possible in the winter.
- **Landfill Disposal:** When land application end uses are not available, biosolids are sent to provincially approved landfills for disposal.

Given the potential for outside factors to influence the Region's new management approach, it is crucial that a robust strategy be developed that considers a range of options and opportunities. The current biosolids management system is based on the processing capacity of the wastewater systems to accommodate growing population needs. As processing demands evolve over time, it will be necessary to adopt a robust management approach to adequately plan for contingencies and emergencies to provide the best level of service, protection and value to residents.

1.5 A Brief History of Biosolids in Waterloo Region

The Region has been managing biosolids since its inception, when it assumed responsibility for wastewater treatment. The first Biosolids Master Plan (BMP) was developed in 2003, and directed biosolids management activities to the year 2021.

The objective of the 2003 BMP was to develop a biosolids management strategy that would be environmentally sound, cost effective and able to adapt to changing requirements and conditions over the next 20 years. As part of the recommendations from the 2003 BMP, the Region investigated the potential for a storage facility for municipal biosolids in the Region; however, this Environmental Assessment was not completed due to challenges identifying a site. As a result, in 2009, the Region initiated a study to update the 2003 BMP. Many factors drove the need for the update, including:

- Population growth;
- Changes to the regulatory environment;
- Climate change drivers for improved resource management;
- Newly available treatment technologies and disposal alternatives;
- Adoption of a new Environmental Sustainability Strategy by the Region;
- and

- The 2003 BMP recommendation for regular reviews of the plan.

The update was completed in 2011. The new Region of Waterloo Biosolids Management Master Plan assessed the status of biosolids treatment, management and disposal facilities and developed a strategy to support the Region's needs. A number of technologies were evaluated and the preferred strategy for anaerobically digested biosolids, recommended by the 2011 Master Plan, was the development a new biosolids heat drying facility.

In 2013, the Region initiated a Municipal Class Environmental Assessment (MCEA) to determine the preferred location for the recommended facility. However, upon considering feedback from the public and stakeholders, it was determined that a review of this approach to implementation of the 2011 Master Plan be undertaken. In September 2013, Regional Council directed Regional Staff to step back and update the BMP with a special focus on enhanced communications and public engagement, while looking at new advances in biofuels and greenhouse gas reduction opportunities. The current project to develop a new strategy was initiated in June 2015, and is expected to be complete by 2018. **Figure 1-1** outlines the history of biosolids management in the Region including some of the initiatives from the respective plans.

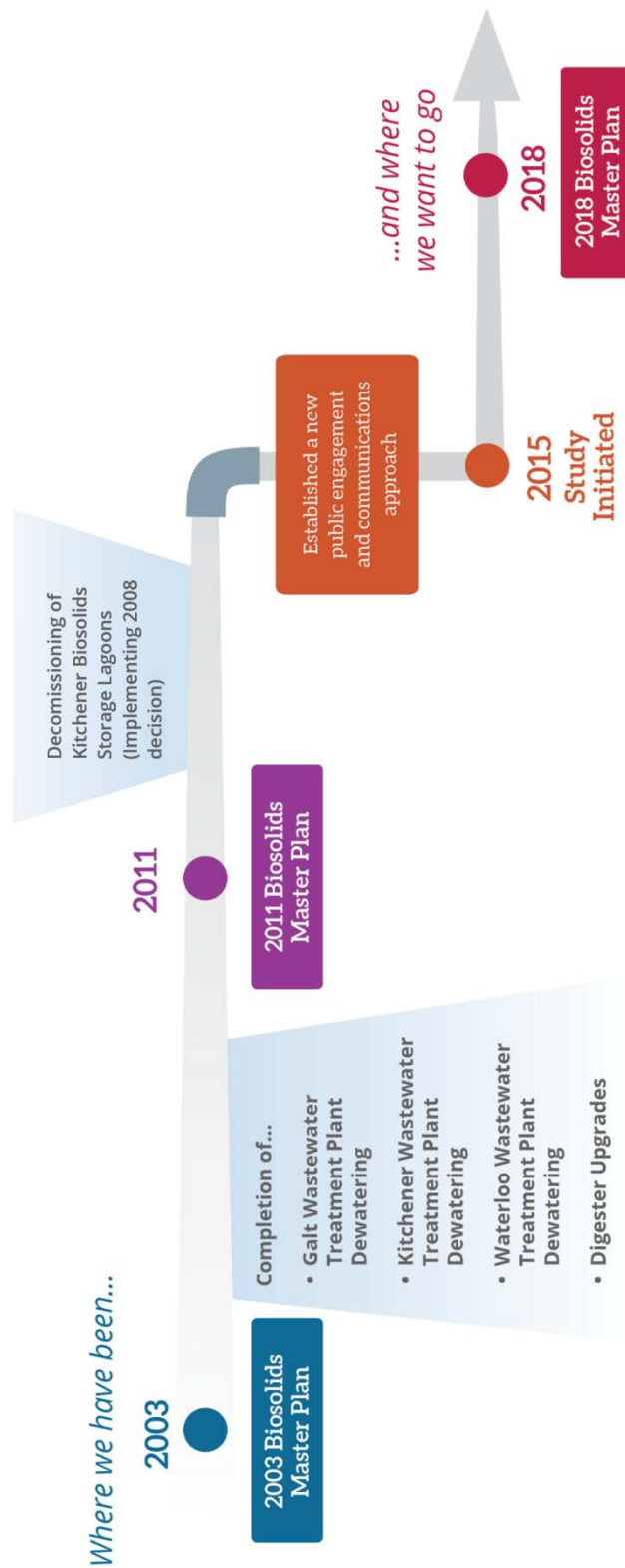


Figure 1-1 History of Biosolids Management in Waterloo Region

1.5.1 Review of Issues and Opportunities

The purpose of the Biosolids Strategy is to identify the preferred strategy for sustainably managing the biosolids produced in Waterloo Region. A number of different strategies will be considered and the preferred strategy selected based on a number of technical considerations as well as the community's input. Some of the important issues identified through early conversations with residents and key stakeholders include:

- Cost of various management approaches;
- Quality of life concerns, including noise, odour, and traffic cause by trucking of biosolids;
- Safety and human health considerations related to the treatment and use of biosolids;
- Community and economic impacts related to the siting biosolids processing facilities;
- Infrastructure needs to support future population growth, through either existing facilities or new ones;
- Environmental impacts related to the use and/or disposal of biosolids; and
- Logistics of transporting biosolids from processing facilities to sites selected for use or disposal.

In addition to these issues, some of the opportunities include:

- Emerging technologies for improving the quality of biosolids material;
- The changing regulatory framework related to biosolids use; and
- New avenues for biosolids use, for example in land reclamation projects or use as a biofuel.

The various issues and opportunities identified have been categorized into seven broad “issues that matter”:

- Environment
- Health and Safety

- What the Community Values
- Infrastructure Needs
- Logistics
- Quality of Life
- Economic Impact

These broad “issues that matter” were used to develop the Biosolids Strategy objectives outlined at the opening of this memo. These objectives provide the aspirational goals against which the final recommended strategy will be measured.

1.5.2 Guiding Policies and Plans

The Biosolids Strategy is guided by a number of important pieces of legislation and policy. The regulatory framework for agricultural land application is defined by:

- Ontario Nutrient Management Act, 2002, S.O. 2002, c. 4 (NMA);
 - o Ontario Regulation 267/03 as amended (O.Reg 267/03)
- Federal Fertilizers Act R.S.C., 1985, c. F-10 (Fertilizers Act);
 - o Canadian Fertilizers Regulation (C.R.C., c. 666) (Fertilizers Regulation); and
- Ontario Compost Quality Standards.

Transportation and infrastructure implemented for biosolids management must satisfy the requirements of environmental protection legislation including:

- Environmental Assessment Act, R.S.O. 1990, c. E.18;
- Environmental Protection Act, R.S.O. 1990, c. E. 19;
 - o O.Reg. 347: General Waste Management;
 - o Ontario Regulation 419/05: Air Pollution – Local Air Quality;
 - o Guideline A-7: Air Pollution Control, Design and Operation Guidelines for Municipal Waste Thermal Treatment Facilities;
- Ontario Water Resources Act, R.S.O. 1990, c. O.40;

- Green Energy Act;
- Safe Drinking Water Act; and
- Clean Water Act.

Biosolids and products incorporating biosolids that are used in non-agricultural applications, such as land reclamation, can be managed within the restrictions of the Environmental Protection Act (EPA).

The Safe Drinking Water Act requires communities in Ontario to develop source protection plans for municipal sources of drinking water. These plans may provide restrictions in addition to those identified by the Nutrient Management Act (NMA), such as set-backs from wells, surface water, and other reductions in the area available for biosolids application to land.

In addition, there are a number of plans developed by the Region of Waterloo that relate to the Biosolids Strategy. The Region has undertaken a Hauled Waste Strategy (completed in 2016), and is undertaking a Co-generation Renewable Energy Approval project and a Waste Water Treatment Master Plan both scheduled for completion in 2018. These projects that are being undertaken concurrently have an important impact on and contribution to the Biosolids Strategy. Coordination with these plans is an important element in developing the Biosolids Strategy.

This Biosolids Strategy is being developed following the Municipal Class Environmental Assessment process for Master Plans (MEA, October 2000, as amended in 2007, 2011, and 2015) that lays out a number of important requirements which are described in the following section.

1.6 Purpose of this Technical Memorandum

The purpose of this technical memorandum is to provide background to the project and outline the environmental assessment process that will be followed to develop the Biosolids Strategy.

1.7 Memo Structure

This memo is organized into four main sections:

1. **Chapter 1: Introduction** – Provides a background information, and a general overview of the strategy and process being followed for this project
2. **Chapter 2: What is an Environmental Assessment** – This section summarizes the environmental assessment process for this project
3. **Chapter 3: Developing the Strategy** - This section outlines the key stages of the strategy development process
4. **Chapter 4: Stakeholder Engagement** – This section outlines the comprehensive stakeholder engagement process for the project.

2.0 What is an Environmental Assessment?

An Environmental Assessment (EA) is a planning and decision-making process used to ensure that relevant engineering and environmental features are considered in the planning and design of municipal infrastructure. It is an open and transparent process, with public and agency consultation integrated throughout.

The primary objective of an EA is to predict the impacts that can be expected, should the project proceed. EAs are used to identify the potential environmental impacts associated with infrastructure proposals during the planning stages. Once the potential impacts are identified, there is an opportunity to make changes to the design, construction methods, and operational approach, to avoid or reduce negative effects prior to their occurrence and avoid expensive mitigation measures or controversial actions that might be associated with the project.

The EA process provides an opportunity for technical specialists, government agencies, local residents and other stakeholders to have input into the decision-making process. The EA process includes public involvement throughout and requires that feedback received be considered in the decision making process.

At the end of the process, a report is produced to document the planning and decision-making process. The report also summarizes the input received throughout. It is made available for a public review period, at which time any individual may object to or comment on a portion or all of the proposed works.

EAs are completed using two different approaches:

- **Project-by-project basis:** This is the most common approach to completing an EA. An individual infrastructure project is assessed, such

as the construction of a new wastewater treatment plant, building a new bridge or widening an existing road.

- **Master Plans:** This approach begins the planning process by considering a group or related projects, or an overall system, such as a road network or wastewater system, prior to dealing with project specific issues. By using this approach, the need and justification for individual projects is better defined. The Biosolids Management Strategy is following this approach.

2.1 Ontario Environmental Assessment Act

In Ontario, EAs are governed by the Environmental Assessment Act (R.S.O. 1990), as well as a number of Regulations that outline the provincial rules related to such processes.

There are two types of assessments completed in Ontario:

- Individual EAs; and
- Streamlined EAs.

An Individual EA is required for large-scale, complex projects that have the potential for significant negative environmental effects. This type of assessment requires approval from the Ministry of the Environment and Climate Change (MOECC).

Streamlined EAs are generally used for routine projects that have predictable and manageable impacts. These projects follow a more simplified process compared to an Individual EA, and follow a self-assessment process. Part of the self-assessment includes a decision by the proponent to go above and beyond the requirements of the Class EA Process. The Municipal Class Environmental Assessment is one of the streamlined EA processes and covers most municipal infrastructure projects. Projects completed under the Municipal Class EA process are:

- Pre-approved, provided the process followed in the Class EA document is followed. MOECC approval is not required;
- Require a less extensive assessment process compared to an Individual EA; and
- At the completion of the project, there is an opportunity for anyone with significant environmental concerns regarding the project that cannot be resolved through discussions with the proponent (typically the Municipality), to request that the Minister consider elevating the project to an Individual EA.

2.2 What is meant by the “Environment”?

In general, the “environment” for the purposes of an EA includes the natural and man-made environment, as well as economic and cultural conditions.

“Environment” is defined in the *Environmental Assessment Act* as:

“(a) air, land or water,

(b) plant and animal life, including human life,

(c) the social, economic and cultural conditions that influence the life of humans or a community,

(d) any building, structure, machine or other device or thing made by humans,

(e) any solid, liquid, gas, odour, heat, sound, vibration or radiation resulting directly or indirectly from human activities, or

(f) any part or combination of the foregoing and the interrelationships between any two or more of them, in or of Ontario”

2.3 Municipal Class Environmental Assessment

The Municipal Class EA (October 2000, as amended in 2007, 2011 and 2015), outlines requirements for assessing municipal infrastructure projects including:

- Public roads and highways;
- Waste management projects;
- Water and wastewater works; and
- Flood protection projects.

The planning process includes:

- Public, government agency and Aboriginal community consultation;
- Assessing potential environmental effects;
- Assessing alternatives; and
- Documentation.

The Municipal Class EA defines four schedules under which projects may be planned and the associated processes required for each. The four types of projects are referred to as “Schedules”, with projects classed as Schedule A, A+, B or C, depending on the anticipated level of environmental impact, and for some projects, the anticipated construction costs. The Schedule that applies to a project determines the planning and design phases that must be followed.

- **Schedule A** projects are minor operational and upgrade activities and may go ahead without further assessment once Phase 1 of the Class EA process is complete (i.e., the problem is reviewed and a solution is confirmed).
- **Schedule A+** projects are limited in scale, have minimal adverse environmental impacts and require no documentation; however, the public is to be advised of the project prior to implementation.
- **Schedule B** projects must proceed through the first two phases of the process. Proponents must identify and assess alternative solutions to the

problem, inventory impacts, and select a preferred solution. They must also contact relevant agencies and affected members of the public. Provided that no significant impacts are found and no requests are received to elevate the project to a Schedule C, or undertake the project as an Individual EA through a Part II Order request, the project may proceed to detailed design (Phase 5).

- **Schedule C** projects require more detailed study, public consultation and documentation, as they may have more significant impacts. Projects categorized as Schedule C must proceed through all five phases of assessment. Schedule C projects may potentially result in adverse impact(s), and as such, a public consultation program is needed to ensure that stakeholders and local residents within the Study Area are provided with the opportunity to contribute meaningful input.

There are five phases in the Municipal Class EA process, as shown in Appendix A:

- **Phase 1 – Problem/Opportunity:** What is the problem or opportunity being studied?
- **Phase 2 – Alternative Solutions:** What is the best strategy to address the problem/opportunity?
- **Phase 3 – Alternative Design Concepts for Preferred Solution:** What is the optimal design to implement the strategy identified in Phase 2?
- **Phase 4 – Environmental Study Report:** Document the process completed during Phase 1 through 3 in a report for public review.
- **Phase 5 – Implementation:** Confirm design details and proceed to implementation.

Often, municipalities take the route of developing a Master Plan that satisfies some or all of the requirements of Phases 1 and 2. The various types of Master Plans are discussed in the next section.

2.2 Master Plans: What are they?

Many EAs are completed on a project-by-project basis. However, in some cases, it is beneficial to start the planning process by considering the needs of an overall system, such as a wastewater or transportation network. This approach takes into account whether several different systems are working in the same location, and whether there is a group of related projects that can be planned together. Using a Master Plan approach involves a long-range view of integrating infrastructure requirements with existing and future land uses and EA planning principles.

At a minimum, Master Plans follow Phases 1 and 2 of the Class EA process. Master Plans differ from typical EA projects in two main ways:

1. They are completed at a high level, with broad analysis of the system to develop a framework for future work. Master Plans generally do not address a site-specific issue.
2. They typically recommend a set of works or projects that will be implemented over a number of years. The Master Plan provides the basis for future projects, providing the background and justification as well as the selected strategy for the projects moving forward.

The details of how the future projects will be designed and determination of specific impacts and mitigation measures are developed as part of the future implementation phase. Depending on the scale and potential impacts of the future project, additional assessments following Phases 3 and 4 of the Class EA may be required.

The Master Plan is subject to the approval of Municipal Council, and does not require approval under the EA Act. During the stipulated review period members of the public may submit comments and/or objections only on the individual projects identified in the plan.

The Waterloo Biosolids Strategy is being completed as a Master Plan. At the end of Phase 2 of the process, the Master Plan may identify a number of infrastructure needs that, depending upon their nature, may require completion of Phases 3 and 4, as described in the next section.

2.3 Why is the Biosolids Strategy Being Completed as a Master Plan?

The Biosolids Strategy will focus on developing a sustainable biosolids management approach for Waterloo Region. A Master Plan provides a holistic, long-term view of the approach, and provides an avenue to explore opportunities for a range of mechanisms to use biosolids in the Region, including as a biofuel, towards reducing greenhouse gas emissions and ways to improve current processes to be more adaptable to future changes in regulations and innovations in the field of biosolids management.

The Master Plan will also provide the criteria for selecting the location for a new facility (if required). . Based on the strategy selected, additional environmental assessment(s) may be required for specific projects. The additional EAs would include:

- Schedule B “screening” for certain Schedule B projects. The screening would include completion of an impact assessment and outline of mitigation measures as part of the conceptual design of the project. A screening report would be prepared and available for public and agency review. Depending on the type of project, the screening process could be completed as part of the Master Plan.
- Environmental Study Report for any Schedule C projects. This would involve completing Phases 3 (Alternative Design) and Phase 4 (Environmental Study Report) of the Class EA process.

Both processes will include public and agency consultation and provide an opportunity for any member of the public to request a “Part II Order” be issued by the MOECC, elevating the Schedule B project to a Schedule C project or elevating the Schedule C project to an Individual EA. Alternatively, the MOECC may require the fulfillment of specific conditions in relation to the proposed project in order to allow the proponent to proceed.

3.0 Developing the Strategy

The Strategy development process is being led by the Project Team, consisting of Regional staff and a consortium of consultants led by Dillon Consulting Limited.

As described in the previous section, the Region must follow the Municipal Class EA process for developing the Region's Biosolids Strategy since the outcome of the strategy is anticipated to be some type of new or upgraded municipal infrastructure, including potentially a new facility. The siting of any new facility is not part of the Strategy, and would be the focus of a future Class EA. The intent is to develop the Strategy first and, once it has been subject to public review and Regional Council Approval, proceed to the next step of planning.

The Project Team has identified the following key principles that will guide the Strategy development process:

- Emphasize public engagement and active participation from the community;
- Identify a long term, flexible, secure, and sustainable Strategy for Waterloo Region; and
- Broadly consider all possible alternatives in developing the Strategy.

3.1 Key Decision Points

The Project is being completed in six stages. Each stage includes a round of public engagement activities, providing an opportunity for public input and comment on the materials developed. Technical Memoranda related to each stage will be provided for public review.

- 1. Stage 1: What are biosolids?** The kick-off stage of the Project focuses on educating the community on biosolids. This stage included preparing an overview of the Municipal Class EA Master Plan process.

Technical Report(s): TM#1 - The Environmental Assessment Process (this document)

- 2. Stage 2: Defining the problem:** The second stage includes a background review of existing biosolids management approaches and data collection that will be used in future stages. This stage also included preparing an overview of existing conditions and forecasting the future needs based on population and employment growth in Waterloo Region.

Technical Report(s): TM #2 - Existing Conditions

- 3. Stage 3: Alternative strategies and evaluation criteria:** This stage examines the technologies and strategies that are available for biosolids management and their applicability to the Region. Available technologies will be documented, and long list of biosolids strategy alternatives will be proposed along with criteria that will be used to evaluate the alternatives. The evaluation will take place in two parts:

- a.** The first is a 'screening' step to identify the strategies that are applicable for the Region's context. To do this, a set of 'Minimum Performance Questions' will be developed based on the Strategy Objectives, that highlight the core requirements for an eligible strategy. The outcome of this step would be a short list of potential alternatives for the Region to consider.
- b.** The second step involves a detailed evaluation of the short listed alternatives, utilizing a list of criteria that are once again based on the Strategy Objectives and capture the 'Issues that Matter' put forward by the community, stakeholders, and the project technical team.

Technical Report(s): TM #3- Evaluation Approach and Comparative Evaluation Criteria; TM #4 - Biosolids Technologies, End Uses and Disposal; and TM #5 - Long List of Biosolids Management Alternatives

- 4. Stage 4: Evaluating the long list of alternatives:** The long list of biosolids management alternatives identified in Stage 3 will be assessed using the Minimum Performance Questions developed in Stage 3 to identify a short list

of strategy alternatives.

Technical Report(s): TM #7 - Short List of Biosolids Management Alternatives

- 5. Stage 5: Evaluating the short list of alternatives:** The short list of alternatives identified in Stage 4 will be analyzed in more detail to determine the feasibility of each alternative in terms of logistical and infrastructure needs. Comparative evaluation criteria will be applied to assess the advantages and disadvantages of each of the short list alternatives for public review and input.

Technical Report(s): Technical Memo #8 - Evaluation of Short Listed Alternatives

- 6. Stage 6: Recommended Strategy:** A preferred Strategy will be identified that will meet the Region's needs to 2051. The Recommended Strategy will be submitted to the Region of Waterloo Council for consideration and approval. The Biosolids Strategy will then be available for a minimum of a 30-day public review period before being finalized. Going forward, the recommendations of the Strategy will be considered with respect to any new facilities that may be required, in which case a new Class EA would be initiated for specific projects drawn from the Strategy document. A detailed process would follow to select a site for the facility based on the criteria laid out in the Strategy, and a complete assessment of impacts and associated mitigation measures would be carried out. The community will be an important contributor to these later stages of implementing the Biosolids Strategy

Technical Report(s): Technical Memo #9 - Recommended Biosolids Strategy and Biosolids Strategy Document.

A summary of the Project process is shown on **Figure 3-1**.

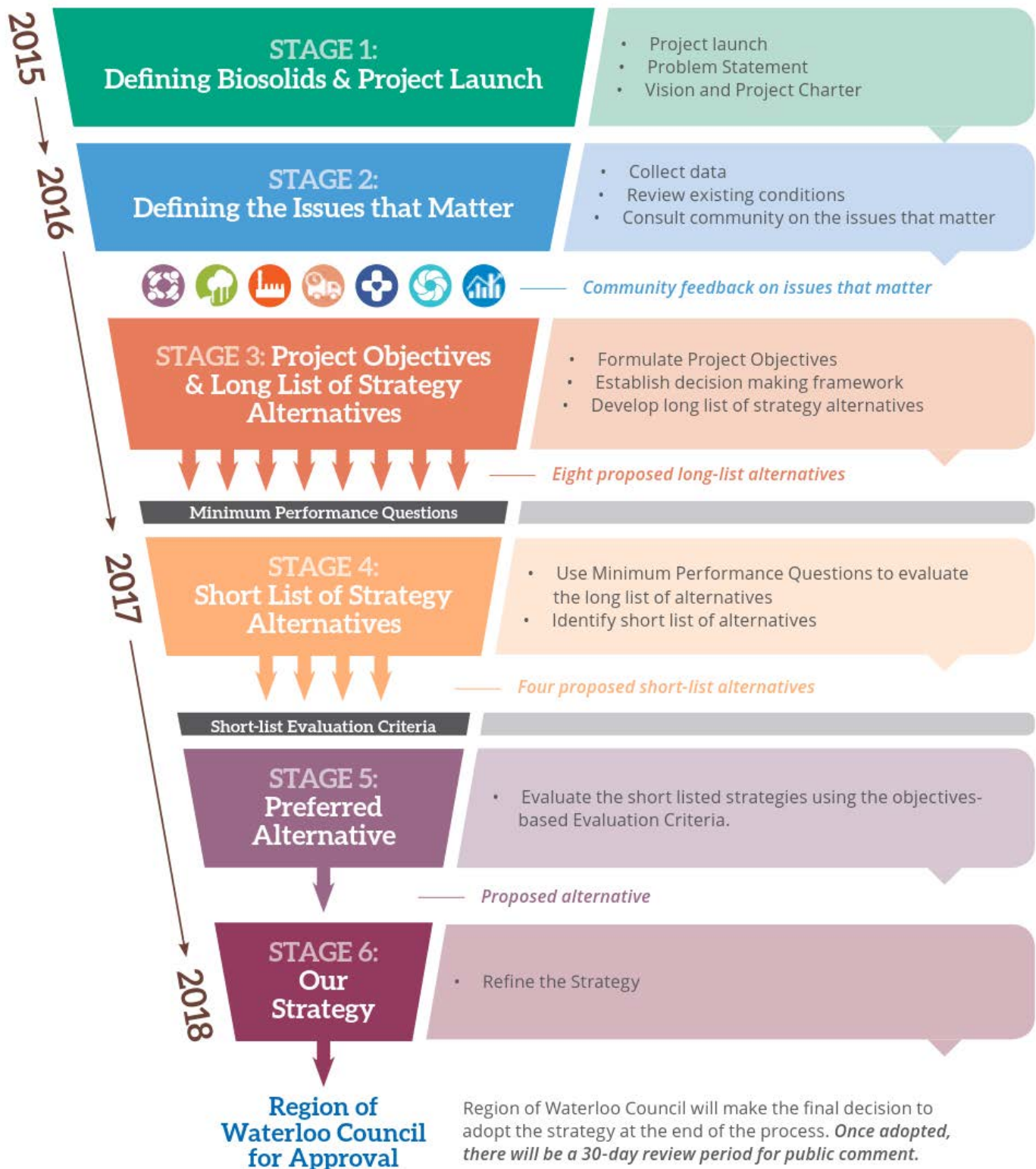


Figure 3-1 Roadmap to the Biosolids Strategy

4.0 Stakeholder Engagement

Early public engagement and engagement throughout the process is an important part of an environmental assessment. As outlined in the Class EA document, *“Consultation is a two-way communications process between the proponent and affected or interested stakeholders that provides opportunities for information exchange and for those consulted to influence decision-making”* (Page A-56). Stakeholder engagement is a key component in developing the Strategy and will be considered alongside technical aspects of the Project and taking into account best practices relevant to Waterloo Region.

The engagement process for the Strategy development process will be guided by the following key principles:

- Accountability;
- Transparency;
- Respect;
- Inclusivity and Accessibility;
- Responsiveness; and
- Clarity and Simplicity.

4.1 Engagement Approach

A number of engagement opportunities and communication channels with the public have been integrated into the Project process. These include:

- The Biosolids Bulletin Email Newsletter (distributed electronically to those signed up to the Project mailing list), issued on average on a bi-monthly basis;
- Progress updates issued via the Region’s Biosolids Strategy website (www.regionofwaterloo.ca/biosolids) and social media accounts on Facebook (www.facebook.com/ROWWaterServices) and Twitter (@RegionWaterloo);

- Surveys to capture public opinion on key issues and considerations related to biosolids management;
- The Open Town Hall engagement tool deployed by the Region, allowing community members to participate in the discussion via an online platform;
- Posting Planning and Works Committee reports to Regional Council and project information on the Region's website;
- Public consultation events, workshops, or other in-person meeting approaches for each stage in the Strategy development process. A range of locations across Waterloo Region will be selected for in-person events during each stage, so that community members may select the location most accessible for them; and
- Meetings with the Project Stakeholder Committee, Steering Committee, and Project Technical Advisory Committee, which are further described in Section 4.2.

These communication and engagement channels will be used to provide information related to the Project progress, and to obtain feedback from the public and stakeholders that will be used in the decision-making process. All comments related to the Project will be collected and recorded, and the Region is committed to considering queries and comments received and responding to these as appropriate. The consultation activities will provide for a comprehensive engagement program that far exceeds the minimum requirements of the Class EA process illustrated in **Appendix A**.

The input gathered through the various communication channels and engagement processes will be incorporated into the Strategy at a number of key points along the process. Public input will help advise on:

- Criteria used to evaluate alternatives;
- Evaluation of alternative approaches that will make up the Strategy, including technologies and final use of biosolids;

- Development of the short list of alternatives that will be analyzed; and
- Comments on the preferred alternative(s).

As the final decision to approve the recommended Biosolids Strategy rests with the Region of Waterloo Council, they will be a key part of the decision-making process throughout the project. Council feedback will be incorporated at all key decision points, and Council representatives hold positions on the Stakeholder Committee and Steering Committee for the Project, as described in further detail in the following section.

One of the primary objectives of consultation as part of the EA process is to achieve resolution of differing of points of view, and allow feedback on the material presented. The EA process requires all consultation activities, including input received be summarized in the final EA document.

4.2 Stakeholders for the Biosolids Management Strategy

A number of key stakeholder groups will be engaged in developing the strategy, including:

- Community members;
- Technical experts and scientists;
- Academic advisors;
- Municipal staff;
- Elected official;
- Advocacy groups;
- Community-based organizations;
- Not-for-profits;
- Industry experts;

- Businesses;
- Agricultural groups;
- Health experts; and
- Environmentalists.

There are three Committees that will provide advice, guidance, and input on behalf of this range of stakeholder groups, in addition to the wider public engagement process:

- **Stakeholder Committee**, comprised of various interest groups from the agricultural sector and business/industry representatives, community groups including environmental advocacy and not-for-profit organizations, academic experts, municipal staff, and community members;
- **Steering Committee**, consisting of Regional staff representatives and Regional Council members; and
- **Project Technical Advisory Committee**, consisting of Regional and municipal staff representatives from the area municipalities in Waterloo Region who have a strong technical background in the area of wastewater and biosolids processing, as well as representatives from the Grand River Conservation Authority and the MOECC.

Meetings will be held on a regular basis with each of the Committees and the Project Team. The relationship between all these groups and the Project Team, which consists of core Project Staff from the Region as well as the Consultant team, is illustrated on **Figure 3-2**.



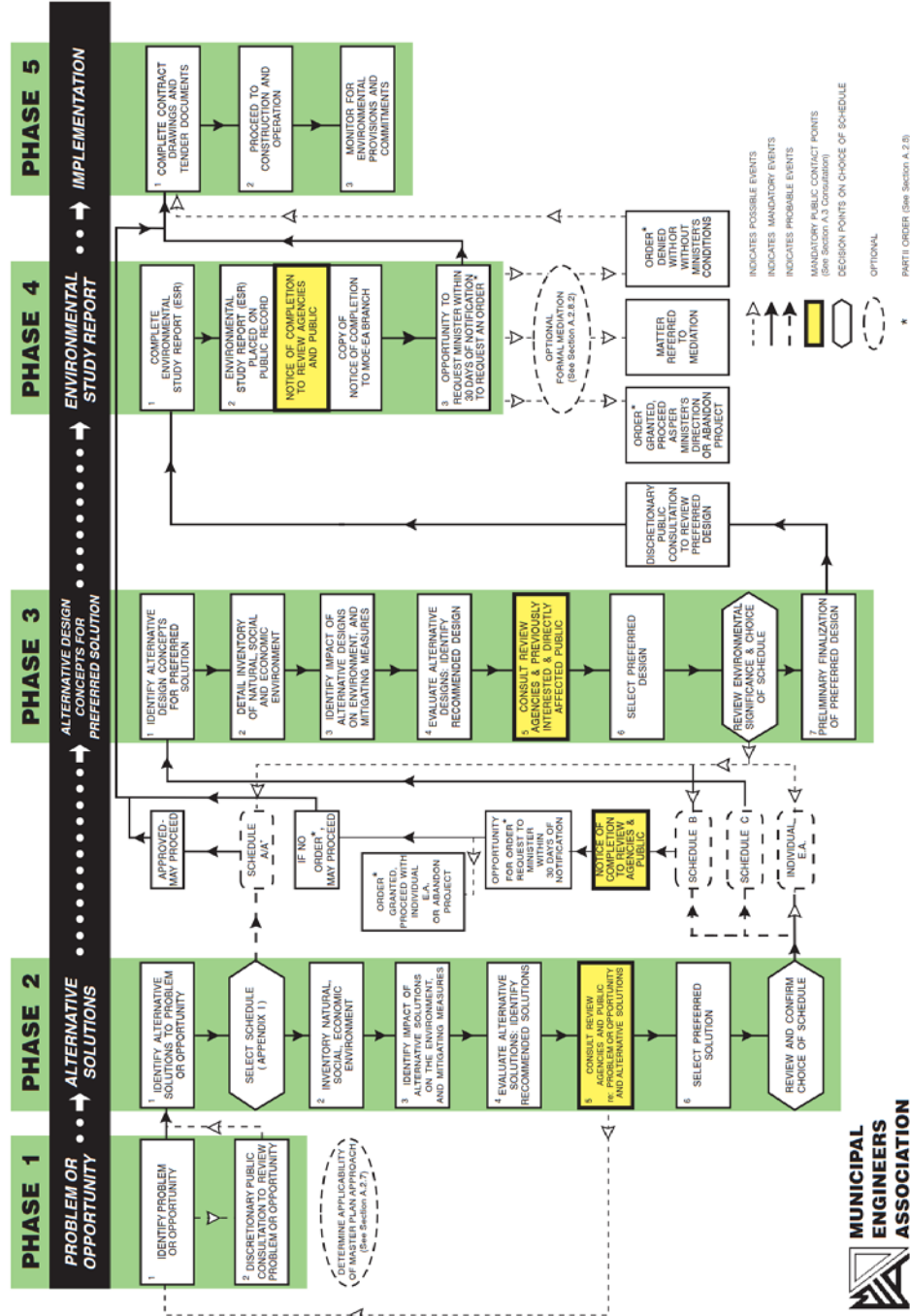
Figure 4-1 Biosolids Strategy Engagement Approach

Appendix A

A Municipal Class EA Process in Ontario

EXHIBIT A.2 MUNICIPAL CLASS EA PLANNING AND DESIGN PROCESS

NOTE: This flow chart is to be read in conjunction with Part A of the Municipal Class EA





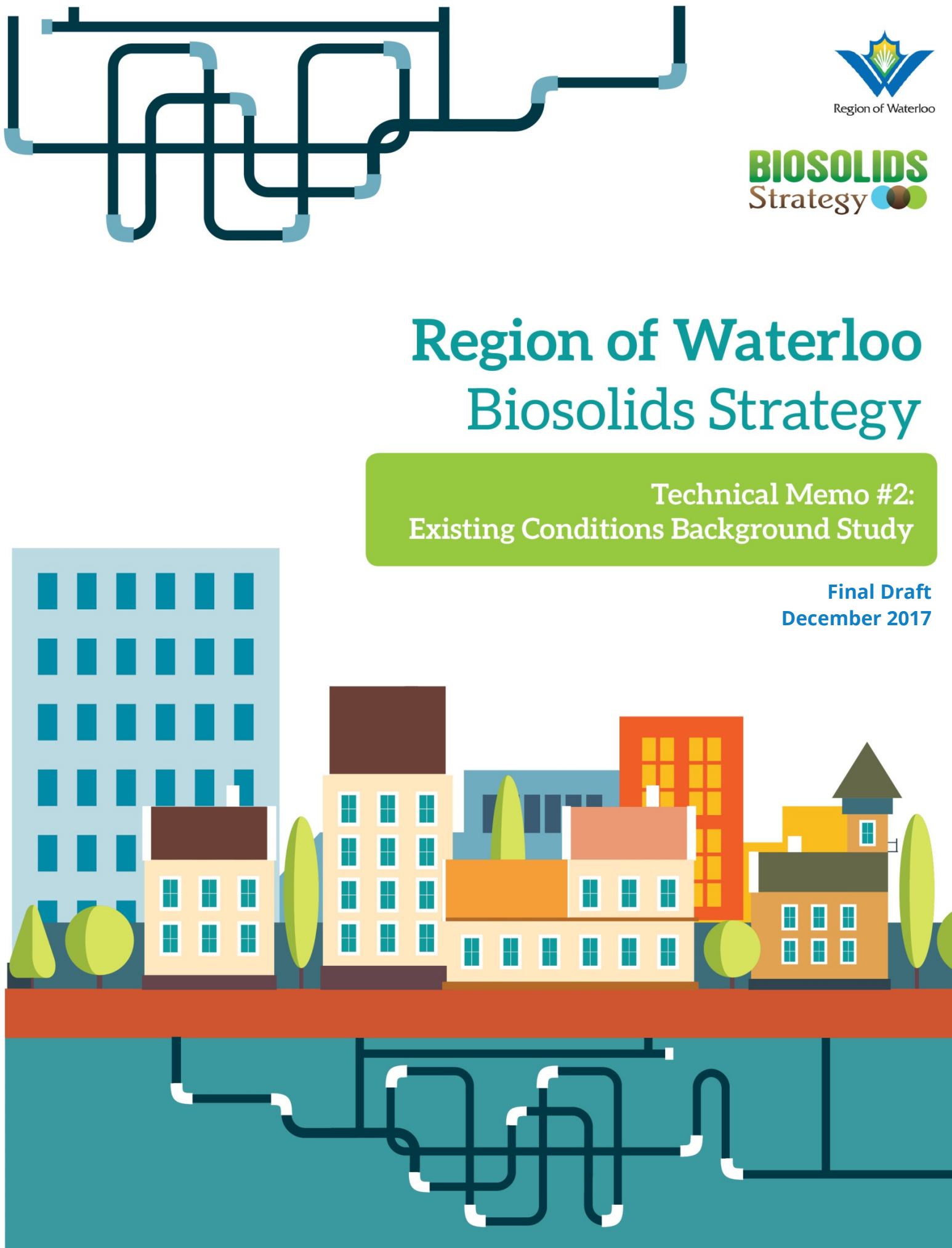
APPENDIX B:

TM#2 – Existing Conditions

Region of Waterloo Biosolids Strategy

Technical Memo #2: Existing Conditions Background Study

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Glossary of Terms

ASM	Agricultural Source Material
AS	Activated Sludge
BMP	Biosolids Master Plan
CAS	Conventional Activated Sludge
CCME	Canadian Council of Ministers of the Environment
CFU	Colony Forming Units
CM	Content of Metals
CP	Content of Pathogens
ECA	Environmental Compliance Approval
EPA	Environmental Protection Act
MEA	Municipal Class Environmental Assessment
MLD	Million Litres / Day
MOECC	Ministry of Environment and Climate Change
MPN	Most Probable Number
NASM	Non-Agricultural Source Material
NMA	Ontario Nutrient Management Act, 2002, S.O. 2002, c. 4
OMAFRA	Ontario Ministry of Agriculture, Food, and Rural Affairs
PAN	Plant Available Nitrogen
PAP	Plant Available Phosphorus
ROW	Region of Waterloo
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus

TSS	Total Suspended Solids
US EPA	United States Environmental Protection Agency
WAS	Waste Activated Sludge
WEAO	Water Environment Association of Ontario
WWTP	Wastewater Treatment Plant

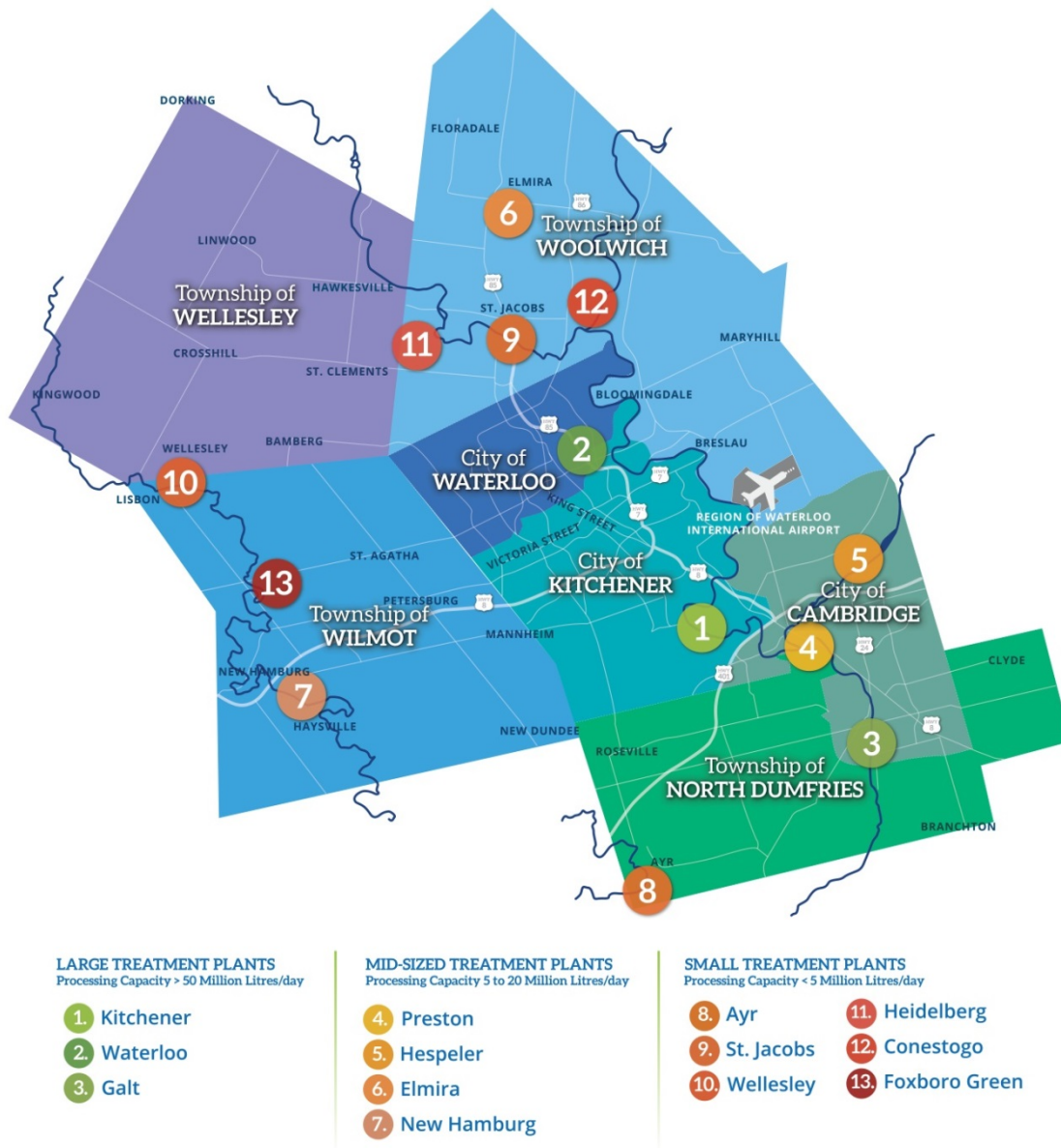
Executive Summary

The Region of Waterloo Biosolids Strategy was initiated in 2015 to develop an approach to manage biosolids in Waterloo Region to the year 2051. The strategy will take a critical look at current practices, and consider available and relevant technologies for processing biosolids. Alternatives will be evaluated against a range of criteria to develop a management strategy for the Region.

The Region is committed to public engagement throughout the development of the strategy. The project team will seek to hear the priorities and concerns of community residents across Waterloo Region, as well as technical experts and other stakeholders. The Biosolids Strategy aims to address the key issue of how to manage the biosolids produced in the Region of Waterloo in a sustainable manner. The approach(es) ultimately selected will align with the main priorities and concerns of the community.

Biosolids are the treated organic materials left over after wastewater has been processed to meet Provincial Standards. The Region of Waterloo currently manages biosolids in two ways; land application / land reclamation and landfill disposal. The legislative framework defines the management, use and disposal of biosolids. The Nutrient Management Act (NMA) provides the framework for biosolids use in agriculture. For non-agricultural use of biosolids, the NMA does not apply. An Environmental Compliance Approval (ECA) for a Waste Disposal Site is required under Part V of the Environmental Protection Act (EPA). Biosolids that are sent for disposal in Ontario must be transported to a landfill site that has been approved under Section V of the EPA and operates under the conditions and restrictions defined within an ECA (Waste Disposal Site) that is approved by the Ministry of the Environment and Climate Change (MOECC). The current management approach has provided stable operations and contracts are in place that would allow the approach to continue until the end of 2022.

Figure 3-1 presents the locations of the treatment facilities throughout the Region.



The majority of biosolids in the Region are handled at WWTPs with anaerobic digestion and dewatering. Smaller facilities with limited or no capacity to stabilize biosolids typically transfer material to the larger facilities for reprocessing. The Ayr and New Hamburg Wastewater Treatment Plants (WWTPs) have capacity to manage aerobically digested biosolids using storage with periodic land application. The Elmira WWTP dewateres sludge and transfers the cake directly to a provincially approved landfill.

The biosolids generated from the treatment facilities throughout the Region currently have value as a source of nitrogen and phosphorous and have been demonstrated to have acceptable quality for land application under the NMA.

This technical memorandum (TM - 2) documents the Region's existing biosolids management program as well as the regulatory requirements for operating the system. The technical memo contains a summary of the data provided by the Region and an assessment of this data as it pertains to the current management of biosolids in the Region.

1.0 Introduction

1.1 Project Purpose and Approach

The Region of Waterloo Biosolids Strategy was initiated in 2015, to develop an approach to manage biosolids in Waterloo Region to the year 2051. The strategy will take a critical look at current practices, and consider available and relevant technologies for processing biosolids. Alternative ways to manage biosolids will be evaluated against a range of criteria to develop a biosolids management strategy for the Region. This project will result with the selection of a preferred strategy that will be implemented in the Region over the next 35 years. The decision making process to select the preferred strategy will be documented in a report and be available for public review. Future projects will further refine the implementation details of the strategy including timing, sizing and location of any facilities.

The strategy is being developed in six stages, which will be outlined in a series of technical memos (TMs). The memos will form the basis for the final study document. The project stages include:

- Stage 1 – What are biosolids and what process is being followed to develop the strategy?
 - o TM: The Environmental Assessment Process
- Stage 2 – What is the current situation related to biosolids in the Region and how will it change as the Region grows?
 - o TM: Existing Conditions
 - o TM: Biosolids Management Needs Forecast
- Stage 3: What are the project objectives, what technologies and strategies are being considered and how will a decision be made to select the recommended strategy?
 - o TM: Evaluation Approach and Comparative Evaluation Criteria
 - o TM: Biosolids Technologies, End Uses, and Disposal

- o TM: Long List of Biosolids Management Alternatives
- Stage 4 – What alternatives from the long list could work in the Region of Waterloo? How can they be refined based on the project objectives? This stage involves evaluating the alternatives to identify a shorter list that will be evaluated in more detail
 - o TM: Short List of Biosolids Management Alternatives
- Stage 5 – Based on the project objectives and evaluation criteria, what is the recommended strategy? The short listed alternatives are evaluated at this stage and a recommended strategy is brought forward for public input.
 - o TM: Evaluation of Short Listed Alternatives
- Stage 6 – What is the best strategy to meet the project objectives?
 - o TM: Recommended Biosolids Strategy
 - o Biosolids Strategy Document

The Region is committed to public engagement throughout the development of the strategy. The project team will seek to understand the priorities and concerns of community residents across Waterloo Region, as well as technical experts and other stakeholders.

Additional background information regarding the context of biosolids management in the Region of Waterloo is included in **TM1**.

A **sustainable strategy** is one that considers the future growth of the Region and looks to minimize potential landfill disposal requirements of biosolids.

1.2 Purpose of this Technical Memorandum

This Existing Conditions memorandum (TM2) documents the Region's existing biosolids management program, as well as the regulatory requirements for managing biosolids under the current approach. This technical memo contains a summary of the data provided by the Region and an assessment of this data as it pertains to the current management of biosolids in the Region.

1.3 Report Structure

Technical Memo 2 is organized into four sections:

- 1. Chapter 1: Introduction**
- 2. Chapter 2: Legislative Framework**
- 3. Chapter 3: Region of Waterloo Context**
- 4. Chapter 4: Biosolids Quantity and Quality**

The first Chapter introduces the memo and outlines the purpose and history of biosolids management in the Region. The second Chapter provides an overview of the legislative framework applicable to the existing management of biosolids. The third Chapter describes the local context for biosolids management in the Region. The fourth and final Chapter outlines the current quality and quantity of biosolids.

2.0 Legislative Framework

The legislative framework defines many aspects of biosolids management, end use and disposal. The Region retained D.C. Damman and Associates in 2014 to develop a comprehensive update of legislation and policy since the 2011 BMP prior to commencement of this Biosolids Strategy (DC Damman, 2014). This section summarizes the most relevant aspects of regulations, amendments and updates to legislation applicable in the Region as they relate to current operations. The broader regulatory framework as it applies to biosolids was described in Section 1.5.

2.1 Biosolids Management

The NMA, EPA, OWRA and the regulations made under the acts set the requirements for protection of the environment when managing biosolids. Municipalities and contractors that transport biosolids between wastewater treatment facilities, non-agricultural land application, and disposal sites require an Environmental Compliance Approval (ECA) under Section 27 of the EPA for a Waste Management System. Facilities that process biosolids require approval under Section 9 of the EPA for a plant or production process and Section 27 of the EPA for a Waste Management System or Waste Disposal Site. In addition, emissions to air from these processes must comply with the appropriate limits as defined by O.Reg 419/05 to protect local ambient air quality. Wastewater effluent discharged to receiving water requires an ECA under Section 53 of the OWRA. An approved Non-Agricultural Source Material (NASM) Plan under the NMA and O.Reg 267/03 is required for biosolids application to agricultural land.

2.2 Agricultural Land Application

A portion of the Region's biosolids are applied to agricultural land. The NMA provides the framework for biosolids use in agriculture. The Region's biosolids are considered a NASM under the NMA. All NASMs are categorized based on a language definition for Categories 1 – 3. O.Reg 267/03 includes specific restrictions, sampling, notification, and report requirements for each Category. Biosolids are considered a Category 3 NASM. Table 3 in Schedule 4 of O.Reg 267/03 provides clarification that when Category 3 NASMs are blended with other material, the new product remains a Category 3 material.

2.2.1 Quality Criteria for NASMs

In addition to category definitions in the NMA, nutrients, metals and pathogen content are key aspects of biosolids quality that restrict potential end use. Before land application, biosolids must be subjected to quality testing to confirm that the quality is appropriate for the intended use. The NMA requires that samples of the processed biosolids are analyzed for the following parameters:

- Total solids;
- Total Kjeldahl nitrogen;
- Ammonia and ammonium nitrogen;
- Nitrate and nitrite nitrogen;
- Total phosphorus;
- All regulated metals; and
- Pathogens.

Nutrients measured as part of this testing are used to determine application rates in a NASM Plan. The person preparing the plan must have a NASM Plan Development Certificate, and is required to ensure the biosolids application rate is based upon site specific conditions and the biosolids quality.

The quality, in terms of the content of metals (CM) is defined as either CM1 or CM2 based on O.Reg 267/03 Schedule 5. Material meeting CM1 contains metals at concentrations less than indicated in Table 2-1. Material meeting CM2 contains metals at concentrations less than indicated in Table 2-2. NASMs that do not meet CM2 thresholds are considered a waste, require an ECA for use in Ontario, and are typically not applied to agricultural land.

Table 2-1: Regulated Metal Content of NASM for CM1

Item	Column 1 Regulated metal	Column 2 Concentration in aqueous material (containing less than 1% total solids, wet weight), expressed as mg per litre	Column 3 Concentration in non aqueous material (containing 1% or more total solids, wet weight), expressed as mg per kg of total solids, dry weight
1	Arsenic	0.13	13
2	Cadmium	0.03	3
3	Cobalt	0.34	34
4	Chromium	2.1	210
5	Copper	1	100
6	Lead	1.5	150
7	Mercury	0.008	1
8	Molybdenum	0.05	5
9	Nickel	0.62	62
10	Selenium	0.02	2
11	Zinc	5	500
Table is adapted from O.Reg. 267/03 Schedule 5 – REGULATED METAL CONTENT OF NASM– Table 1 — CM1 NASM			

Table 2-2: Regulated Metal Content of NASM for CM2

Item	Column 1 Regulated metal	Column 2 Concentration in aqueous material (containing less than 1% total solids, wet weight), expressed as mg per litre	Column 3 Concentration in aqueous material (containing less than 1% total solids, wet weight), expressed as mg per litre
1	Arsenic	1.7	170
2	Cadmium	0.34	34
3	Cobalt	3.4	340
4	Chromium	28	2,800
5	Copper	17	1,700
6	Lead	11	1,100
7	Mercury	0.11	11
8	Molybdenum	0.94	94
9	Nickel	4.2	420
10	Selenium	0.34	34
11	Zinc	42	4,200
Table is adapted from O.Reg. 267/03 Schedule 5 – REGULATED METAL CONTENT OF NASM– Table 2 — CM2 NASM			

In order to complete a comparison with the NASM standards for metals, biosolids from each Region of Waterloo facility must be tested regularly. For large sewage treatment plants with approved rated capacity greater than 45,400 m³/day, such as Waterloo, Kitchener and Galt, the concentrations of metals compared to standards are the averages of all samples taken during the four-month period before the transfer date. Four samples must be taken during the two-month period before the transfer date, with at least two taken during the one-month period before the transfer date. In the Waterloo Region context, the transfer date means the date when the biosolids are removed from the treatment facility where they were generated.

For small treatment plants, defined by the NMA as having approved rated capacity of less than 45,400 m³/day, that ship biosolids directly to an agricultural operation for land application, the concentration of each parameter must be calculated as the average of the results from all samples taken during the four-month period before the transfer date. Two samples must be taken during the two-month period before transfer, with at least one during the one-month period before transfer. This requirement applies to all of the Region's wastewater treatment facilities other than Waterloo, Kitchener and Galt.

To transfer biosolids from the storage lagoons at the Ayr and New Hamburg facilities, the concentration of each parameter must be calculated as the average of the results from a minimum of four composite samples taken during the four-month period before the transfer date. For facilities with more than one cell, such as New Hamburg, all samples must be taken from the cell from which the NASM is to be obtained.

Biosolids cannot be applied where measured metals concentrations in soil are greater than column 3 of Table 2-3, below unless the OMAFRA Director is satisfied that the application will not result in a measurable increase in the concentration of any regulated metal in the soil and approves the NASM Plan. The application rate is limited by column 2 of Table 2-3 in terms of a 5 year application cycle.

Table 2-3: Maximum Application Rates, Regulated Metals

Item	Column 1 Regulated metal	Column 2 Maximum addition to soil (in kilograms of regulated metal per hectare/per five years)	Column 3 Maximum concentration in soil (in milligrams per kilogram of soil, dry weight)
1	Arsenic	1.4	14
2	Cadmium	0.27	2
3	Cobalt	2.7	20
4	Chromium	23.3	120
5	Copper	13.6	100
6	Lead	9	60
7	Mercury	0.09	1
8	Molybdenum	0.8	4
9	Nickel	3.56	32
10	Selenium	0.27	2
11	Zinc	33	220
Table is adapted from O.Reg. 267/03 Section 98.0.12 (3) – TABLE — MAXIMUM APPLICATION RATES, REGULATED METALS			

Biosolids quality, in terms of content of pathogens (CP), is defined by the criteria in Table 2-4 and Table 2-5 as either CP1 or CP2. Material meeting CP1 contains pathogens at concentrations less than indicated in Table 2-4. Material meeting CP2 contain *E. coli* at concentrations less than indicated in Table 2-5. NASMs that do not meet CP2 thresholds have not been adequately stabilized and cannot be land applied in Ontario.

Table 2-4: CP1 for NASM that is Sewage Biosolids

Item	Column 1 Pathogen	Column 2 Level in aqueous material (containing less than 1% total solids, wet weight)	Column 3 Level in non aqueous material (containing 1% or more total solids, wet weight)
1	<i>E. coli</i>	1,000 CFU per 100 ml	1,000 CFU per gram of total solids, dry weight
2	Salmonella	3 CFU or MPN per 100 ml	3 CFU or MPN per 4 grams of total solids, dry weight
3	Viable Helminth ova	No detectable level in 100 ml	No detectable level in 4 grams of total solids, dry weight
4	Total culturable enteric virus	No detectable level in 100 ml	No detectable level in 4 grams of total solids, dry weight
Table is adapted from O.Reg. 267/03 Schedule 6 – TABLE 2 — CP1 NASM THAT IS SEWAGE BIOSOLIDS OR CONTAINS HUMAN BODY WASTE			

Table 2-5: CP2 NASM

Item	Column 1 Pathogen	Column 2 Geometric mean of samples of aqueous material (containing less than 1% total solids, wet weight) taken during the 4 months before transfer date	Column 3 Geometric mean of samples of non aqueous material (containing 1% or more total solids, wet weight) taken during the 4 months before transfer date
1	<i>E. coli</i>	2 million CFU per 100 ml	2 million CFU per gram of total solids, dry weight
Table is adapted from O.Reg 267/03 SCHEDULE 6 – TABLE 3 — CP2 NASM			

Facility size definitions and sample frequency are the same for pathogens as they are for metals; however, the level of each pathogen is calculated as the geometric mean of the measurements in the four month period prior to the transfer date.

Odour is another characteristic of biosolids that is considered, and although it does not limit the application rate per hectare, it can limit the number of hectares available for application based upon setbacks from receptors for odorous NASMs. The odour categories (OC) are OC1, OC2 and OC3, and any NASMs with an odour detection threshold greater than the OC3 limit of 4500 OU / m³ are considered a waste and require an ECA for transportation and use. The setbacks and land application management options are less stringent for OC1 and increase progressively for OC2 and OC3.

The NASM Odour Category Table (OMAFRA, 2012) defines liquid aerobically digested biosolids as Category OC2, which would apply to Ayr and New Hamburg. Dewatered biosolids produced at the Kitchener, Waterloo, and Galt facilities are defined as OC2 or OC3 depending on the operating revolutions per minute (rpm) of the centrifuge. The categories can be adjusted for biosolids where odour emissions sample results support a different category.

2.2.2 Storage Prior to Agricultural Use

A restriction of interest as part of the NMA for sewage biosolids or materials that result from the processing of sewage biosolids is that these materials shall not be applied to land during the restricted period, December 1st to March 31st, or when the ground is frozen or snow covered. The restricted period generates the need for substantial storage or alternate management over winter. In terms of storage at the site of application, the maximum duration allowed for dewatered biosolids is 10 days. Off-site storage capacity, and non-agricultural land reclamation uses are options in Ontario, as is disposal to landfill during the restricted period.

2.2.3 Application Rate

The application rate for biosolids is a critical aspect of land application. The application rate determines the inventory of agricultural land required to support the use of a given mass of biosolids. The maximum application rate for Category 3 NASMs is 22 dry tonnes per hectare per five year period (NMA, 2013). There are a number of criteria that may reduce the application rate below the maximum including:

- Crop nutrient requirements, mainly plant available nitrogen (PAN) and plant available phosphate (PAP)
- Metals content

In most cases phosphate limits the five year application rate for municipal biosolids. The available area for application is reduced by setbacks required for wells, surface waters and odour receptors.

2.2.4 Municipal By-law

The metals content in biosolids is a function of the wastewater quality influent to the WWTP. In the Region of Waterloo, wastewater quality is regulated using Sewer Use By-law 1-90, as amended by By-law 92-050 and By-law 14-012. The by-law includes concentration limits for all metals analyzed for biosolids quality. The limits in the by-

law are comparable to the limits for metals in the CCME model by-law (CCME, 2009) and comparable jurisdictions (Hamilton and Toronto). The limits for certain metals are slightly higher in the Region of Waterloo by-law. Mercury is the exception where the Region of Waterloo limit is 0.1 mg/L compared with 0.01 mg/L in the other by-laws referenced.

2.3 Non-Agricultural Land Application and Landfill Disposal

The existing anaerobically digested and dewatered biosolids have historically been primarily applied to agricultural land. The current digested and dewatered product must be stored over winter at an off-site approved bulk storage facility, landfilled, or managed in a non-agricultural setting using a waste ECA.

In terms of non-agricultural use, the NMA does not apply. An ECA for a Waste Disposal Site is required under Part V of the EPA. For reclamation and rehabilitation sites, the application rates and other restrictions on the use of biosolids are based on site specific characteristics. The limitations on biosolids application rates and other restrictions are defined within an ECA (Waste Disposal Site) that is approved by the MOECC.

Characteristics of the site that affect biosolids application rate include the current soil and ground cover ranging from:

- Some vegetation
- Some topsoil with limited vegetation
- Exposed tailings
- Exposed sub soil
- Exposed rock

Site water management is also an important factor where sites with limited or no water management and potentially sensitive surface water cannot accept high

biosolids applications rates. Conversely, sites with active water management and/or controls in place may accept much higher biosolids application rates.

The application rates vary based on existing soil conditions, where a rate similar to the NMA may be used to fertilize existing plant growth, ranging in application rates up to 150 dry tonnes per hectare to generate pseudo soil where topsoil has been completely removed. The highest biosolids application rates are appropriate in extreme conditions such as bare rock with no soil. In these situations, biosolids are often blended with a carbon substrate such as saw dust or leaf and yard waste. The combination of high carbon substrate and biosolids can support the establishment of vegetation on these degraded sites.

Biosolids that are sent for disposal in Ontario must be transported to a landfill site that has been approved under Section V of the EPA and operates under the conditions and restrictions defined within an ECA (Waste Disposal Site) that is approved by the MOECC. The quality and quantity of biosolids accepted at a landfill site must meet the conditions and restrictions identified on the ECA.

3.0 Region of Waterloo Context

The current biosolids processing infrastructure and management approach in the Region of Waterloo provides the foundation for planning. This section provides a summary of the infrastructure in place at the wastewater treatment facilities, and the current approach to managing biosolids in the Region.

3.1 Existing Wastewater Treatment

Wastewater generated in the Region is collected by a complex network of sewers and pump stations. It is treated at 13 facilities across the Region of Waterloo, including:

- Large Facilities (>45.4 Million Litres / day)
 - o Kitchener (City of Kitchener)
 - o Waterloo (City of Waterloo)
 - o Galt (City of Cambridge)
- Mid-sized facilities (5 – 20 Million Litres / day)
 - o Preston (City of Cambridge)
 - o Hespeler (City of Cambridge)
 - o Elmira (Township of Woolwich)
 - o New Hamburg (Township of Wilmot)
- Small Treatment Facilities (<5 Million Litres / day)
 - o Ayr (Township of North Dumfries)
 - o St. Jacobs (Township of Woolwich)
 - o Wellesley (Township of Wellesley)
 - o Heidelberg (Township of Wellesley and Woolwich)
 - o Conestogo (Township of Woolwich)
 - o Foxboro Green (Township of Wilmot)

Figure 3-1 presents the locations of the treatment facilities throughout the Region.

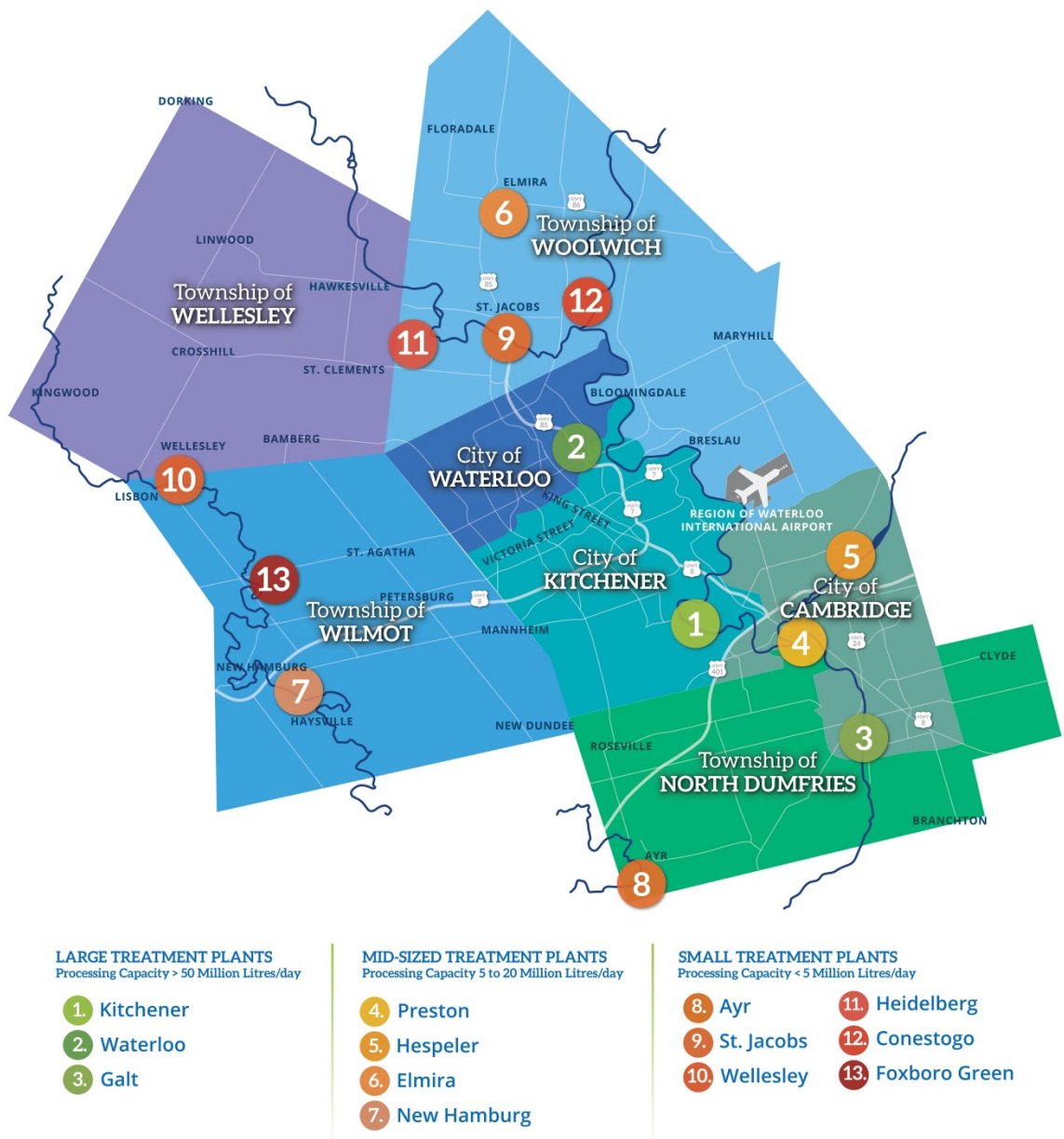


Figure 3-1: Location of Wastewater Treatment Facilities within the Region of Waterloo

Table 3-1 presents the facilities, population served, the projected flow rate of wastewater treated for the 2015 operating year, and the uncommitted hydraulic reserve capacity.

Table 3-1: Region of Waterloo Wastewater Treatment Plant Population Served, Wastewater Flow Rate, and Available Capacity

Wastewater Treatment Plant	Rated Capacity (m ³ /day)	Population Served in 2015	Average Wastewater Generation 2015 ¹ (m ³ /day)	Available Remaining Capacity (m ³ /day)	% of Capacity ²
Kitchener	122,700	241,924	70,092	41,246	66%
Waterloo	57,500	137,347	46,952	5,440	91%
Galt	56,800	86,634	34,886	20,631	64%
Preston	16,820	21,030	7,679	4,993	70%
Hespeler	9,320	25,767	7,375	1,701	82%
Elmira	7,800	10,154	4,436	1,773	77%
St. Jacobs	1,450	1,888	955	489	66%
New Hamburg	5,200	12,851	3,809	1,053	80%
Ayr	3,000	5,083	1,379	1,374	54%
Wellesley	1,100	3,323	765	292	73%
Heidelberg	130	ND	ND	ND	ND
Conestogo	148	ND	ND	ND	ND
Foxboro Green	150	ND	ND	ND	ND
1 - 5-year average projected flow from Water and Wastewater Monitoring Report (ROW, 2015) 2 - Percentage of Rated Capacity currently in use based upon 5-year average projected flow plus commitments ND – no data					

Each treatment facility includes different infrastructure based upon the size or rated capacity of the treatment facility and the unique requirements of discharge. The mass and quality of residuals generated are affected by the technology utilized at each wastewater treatment facility. The treatment processes at each treatment facility are presented in Table 3-2.

Table 3-2: Current Region of Waterloo Wastewater Treatment Plant Unit Processes

	Facility Name	Preliminary Treatment	Primary Treatment	Secondary Treatment	Tertiary Treatment	Disinfection	Biosolids Processing Technology
Large (>45.4 MLD)	Kitchener	Bar Screens, Detritus tank for grit removal (Fine screening to be installed 2018)	Clarifiers	Conventional AS, Secondary clarifiers, Chemical precipitation for P removal	None (Disk Filters to be installed in 2018)	UV	Anaerobic digestion, Centrifuge dewatering
	Waterloo	Fine screening, Vortex grit removal	Clarifiers	Conventional AS, Secondary clarifiers, Chemical precipitation for P removal		UV	Rotary Drum Thickening (WAS), Anaerobic digestion, Centrifuge
	Galt	Mechanical screening, Aerated grit chamber	Clarifiers	Conventional AS, Secondary clarifiers, Chemical precipitation for P removal	Shallow bed automatic backwash filters	UV	Rotary Drum Thickening (WAS), Centrifuge, Anaerobic digestion

	Facility Name	Preliminary Treatment	Primary Treatment	Secondary Treatment	Tertiary Treatment	Disinfection	Biosolids Processing Technology
Mid-sized (5 – 20 MLD)	Preston	Bar screens, Vortex grit removal	Clarifiers	Conventional AS, Secondary clarifiers, Chemical precipitation for P removal		UV	Anaerobic digestion,
	Hespeler	Aerated grit chamber		Extended aeration, Secondary clarifiers, Chemical precipitation for P removal		Chlorination / Dechlorination	Aerobic digestion
	Elmira	Bar screens, Vortex grit removal; EQ tank	Clarifiers	BNR, Secondary clarifiers, Chemical precipitation for P removal	Shallow bed automatic backwash filters	UV	Centrifuge
	New Hamburg	Bar screens, Vortex grit removal.		SBR, Chemical precipitation for P removal	Continuous upflow deep granular media filter,	UV	Aerobic digestion, Lagoon storage

	Facility Name	Preliminary Treatment	Primary Treatment	Secondary Treatment	Tertiary Treatment	Disinfection	Biosolids Processing Technology
Small Facilities (<5 MLD)	St. Jacobs	Grinder / auger screening, Vortex grit removal		Extended aeration, Secondary clarifiers, Chemical precipitation for P removal	Continuous upflow deep granular media filter	UV	Aerated storage tank
	Ayr	Grinder, Bar screen, Grit channels		Extended aeration, Secondary clarifiers, Chemical precipitation for P removal	Shallow bed dual media filters	UV	Aerobic digestion, Lagoon storage
	Wellesley	Bar Screen		Extended aeration, Secondary clarifiers, Chemical precipitation for P removal	Continuous downflow deep granular media filter (cloth media filters to be installed in 2017)	Ozonation	
	Heidelberg	Bar screens, EQ tank		Extended aeration, Secondary clarifiers, Chemical precipitation for P removal	Multi-media filters	UV	Aerobic digestion
	Conestogo	Grinder		SBR, Chemical precipitation for P removal	Continuous downflow deep granular media filter (replace in Fall 2016)	UV	Aerated storage tank

	Facility Name	Preliminary Treatment	Primary Treatment	Secondary Treatment	Tertiary Treatment	Disinfection	Biosolids Processing Technology
	Foxboro Green*		Settling tank	RBC with Anoxic Chamber, Chemical precipitation for P removal			Holding tank (cleaned out and hauled to New Hamburg)
* Foxboro Green is the only treatment facility with a subsurface discharge rather than direct discharge to receiving water in the Grand River watershed. LEGEND AS = activated sludge EQ = equalization P = phosphorus RBC = rotating biological contactor RDT = rotating drum thickener SBR = sequencing batch reactor UV = ultraviolet							

Wastewater treatment removes suspended and dissolved solids from wastewater, which generates residual material that must be managed. Residuals collected from preliminary treatment such as screenings and grit are typically managed as solid waste and do not become a component of biosolids. Primary and secondary treatment clarifiers are the main sources of sludge that contribute to biosolids, and are present at all of the larger and some mid-sized facilities in the Region, including Kitchener, Waterloo, Galt, Preston, and Elmira. Small and some midsized facilities in the Region, including Hespeler, New Hamburg, St. Jacobs, Ayr, Wellesley, Heidelberg and Conestogo, collect solids using secondary clarification only because of the extended aeration configuration.

Tertiary treatment will also contribute to biosolids. The objective of tertiary treatment at facilities in the Region is total suspended solids (TSS) and total phosphorus (TP) removal by filtration. The solids collected during tertiary treatment are returned to the beginning of the treatment process at the plant, and are removed from the system through primary and secondary clarifiers.

Sludge collected at the larger facilities is processed further to become biosolids. Sludge collected at the four largest wastewater treatment plants, Waterloo, Kitchener, Galt and Preston, are processed through anaerobic digesters. Digested solids are dewatered. Some mid-sized and smaller facilities, including Hespeler, New Hamburg, Ayr and Heidelberg, have aerobic digesters. Aerobically digested biosolids at the New Hamburg and Ayr WWTPs are stored in lagoons prior to use. The remaining facilities transfer residuals to larger facilities, because they do not have processing capacity on site to generate a stabilized biosolids product.

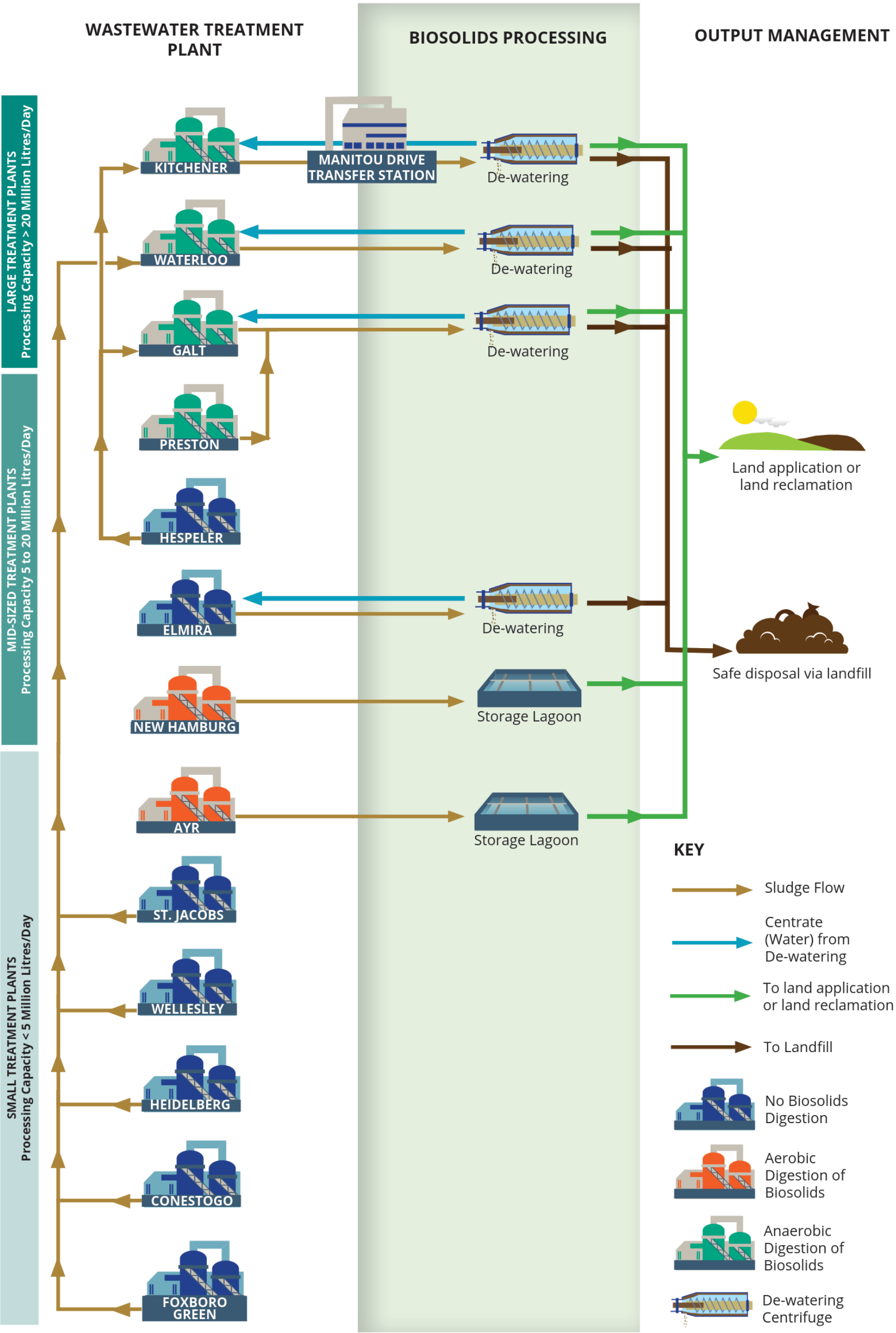
3.1.1 Current Biosolids Management Practices

The Region of Waterloo's current management approach for biosolids is dependent on the size of treatment plant and the related infrastructure for sludge processing. The majority of biosolids in the Region are handled at four facilities with anaerobic digesters: Kitchener, Waterloo, Galt and Preston WWTPs. Biosolids from these facilities are managed as dewatered cake and sent for use through land application / land reclamation, or sent to for disposal in a landfill. Each of the four plants has infrastructure available to allow truck transfer between plants as a contingency for biosolids management. The Preston WWTP transfers digested material to the Galt WWTP by truck for dewatering. The Kitchener WWTP digestate is transferred through a forcemain to the Manitou Drive facility for dewatering. Centrate from Manitou Drive is returned by sewer to the Kitchener WWTP. Dewatering infrastructure at these facilities was commissioned between 2009 and 2014, and is therefore relatively new. The Region's operating team has not identified any capacity or equipment issues related to dewatering for current operations. The load-out facilities for dewatered biosolids have storage capacity for approximately three days of operations. The Region does not control contingency storage capacity for dewatered cake in the event that trucking is disrupted. The operating team has identified the lack of Region controlled storage, or alternative contingency as a risk in the event that typical biosolids trucking is disrupted.

In terms of the facilities that do not have anaerobic digesters, the largest producer of biosolids is the Hespeler WWTP, where sludge is aerobically digested and then sent to the Kitchener and Galt WWTPs for re-processing. Ayr and New Hamburg WWTPs have available aerobic digester capacity and available biosolids storage capacity in lagoons. Some transfers of biosolids from the New Hamburg WWTP to the Waterloo WWTP occurred in 2015 in specific instances to create additional capacity in the lagoons; however aerobically digested biosolids from the lagoons at both facilities are typically transferred directly for land application. The Conestogo, Heidelberg, St. Jacobs, and Wellesley WWTPs have transferred sludge to the New Hamburg WWTP

over the last number of years; however in 2015 these facilities shifted the preferred transfer location to the Waterloo facility for re-processing. Sludge from the Elmira WWTP is dewatered and sent to a provincially approved landfill. The relatively low rated capacity combined with the wastewater treatment approach at Foxboro Green, including rotating biological contactors and subsequent anoxic tankage generate sludge at a low rate. Solids are collected from this system once or twice per year and transferred to Waterloo. Figure 3-2 presents the mass flows between facilities and end-uses.

Figure 3-2: Mass Flows of Biosolids within the Region



The Region of Waterloo has contracts with vendors to remove biosolids from the wastewater treatment facilities. These contracts prioritize use of biosolids, with the current alternative being disposal in a landfill. **Figure 3-3** summarizes end uses of the biosolids produced from the Region's facilities in 2015.

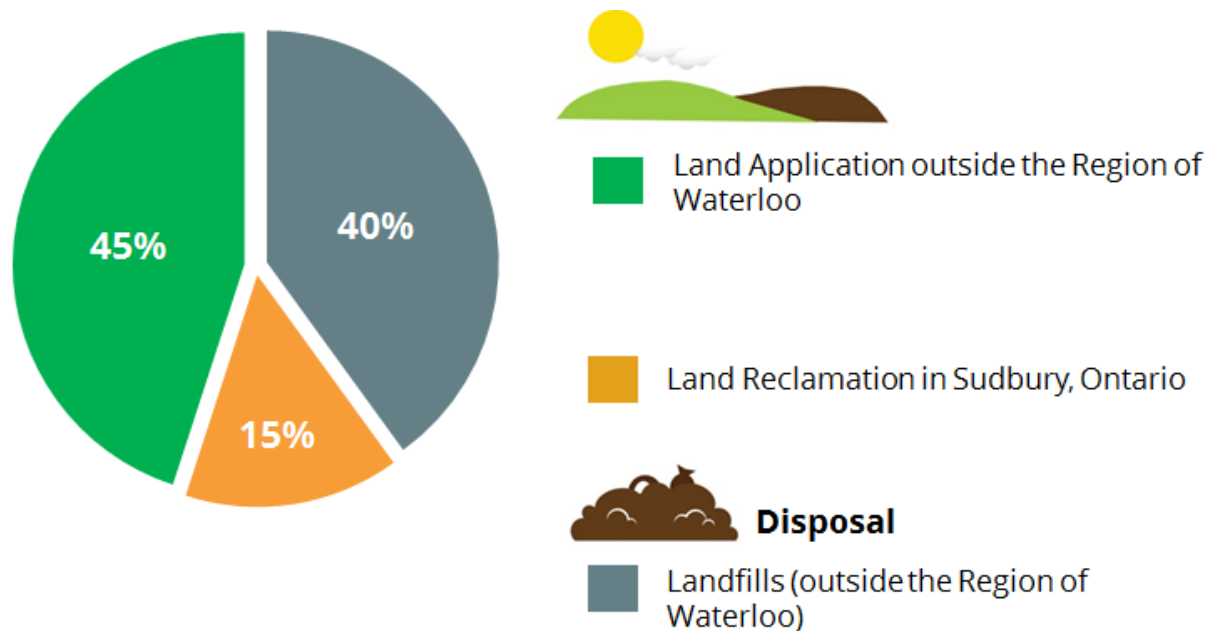


Figure 3-3: End Use and Disposal Breakdown of Biosolids for 2015

A number of provincially approved landfills outside the Region are used for disposal of biosolids. The Waterloo landfill does not accept biosolids.

Land application has been the preferred use historically; however, the current contractor that handles anaerobically digested and dewatered biosolids was unable to store biosolids during the restricted period, which is defined as the period from December 1st to March 31st, and when the ground is frozen or snow covered. During the restricted period in 2014, when land application could not occur, biosolids had to be delivered from the Region's wastewater treatment facilities directly to landfill. This highlights a risk related to operational flexibility during the restricted period that does not facilitate agricultural land application.

A mine tailings pond reclamation program that was able to accept biosolids during the restricted period was identified for 2015. This approach allowed additional biosolids use when agricultural land application was not available during the restricted period, and provided an alternative to landfill. Approximately 15% of biosolids were used to assist the reclamation of a mine tailings pond area near Sudbury.

Another key aspect of agricultural uses is the application rate. The contractor, who manages the majority of biosolids for the Region of Waterloo, reported managing 30,189 wet tonnes of dewatered biosolids during 2015. Of this, 11,023 wet tonnes were applied to agricultural land. The application rate ranged from 15 to 31 wet tonnes per hectare of land available at each site. The average application rate was 26 wet tonnes per hectare of land available at each site. This application rate of biosolids, which have an average solids content of approximately 26% is equivalent to between 4 and 8 tonnes dry solids per hectare of land available at each site, which is well below the maximum rate of 22 dry tonnes per hectare every five years allowed under O.Reg 267/03. It is important to note that site specific conditions can often limit the application rate for a site well below the 22 dry tonnes per hectare maximum, which may explain part of the reason that application rates in practice are below the legislative maximum. The actual application rate is defined in a NASM Plan specific to the site. Figure 3-4 presents the percentage of the total tonnage land applied by municipality from the 2015 annual report from the anaerobically digested biosolids management contractor. The contractor also reported a current land bank with approved NASM plans and Environmental Compliance Approvals of 10,063 hectares for the 2016 and 2017 operating years (Terratec, 2015).

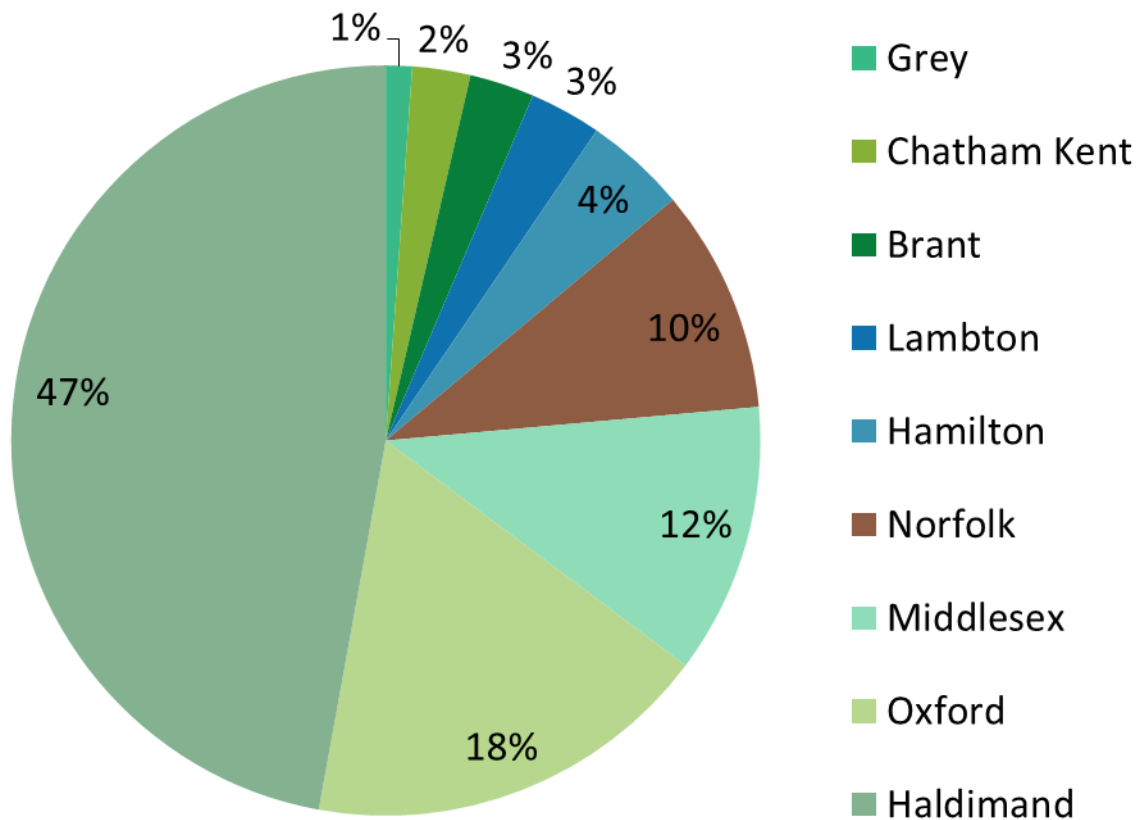


Figure 3-4: Percentage of Anaerobic Biosolids Applied by Municipality in 2015

The contractor who manages aerobic biosolids from the Ayr and New Hamburg facilities, reported 9,818 m³ of liquid (<6% TS) biosolids were applied to land in 2015. All biosolids were applied to land within Blandford-Blenheim Township in Oxford County.

The application locations in 2015 biosolids were outside the Region of Waterloo, at least in part because biosolids compete with commercial fertilizer, and other Agricultural Source Materials (ASMs) like manure that contribute to nutrient management planning. The 2011 Master Plan (CH2M, 2011) estimated that ASMs including manure are available within the Region to serve 98% of the agricultural demand for nitrogen. Given that farmers must manage their manure and that land application is typically preferred, there was limited capacity identified for the application of biosolids to agricultural land within the Region.

Livestock population within the Region has been decreasing over time. In addition, the Nutrient Management Act has been revised since the 2011 Master Plan was completed to increase the maximum allowable application rates for biosolids. These changes may increase the potential for agricultural use of biosolids within the Region. There is a risk that farmers will not choose to use biosolids, which would reduce the number of hectares available for biosolids as part of nutrient management planning. A more detailed evaluation of the potential to use agricultural land for the application of biosolids in the future will occur once projections of future biosolids quantities over the planning period to 2051 are complete.

3.1.2 Summary of Biosolids Management

The current management approach has provided stable operations and contracts are in place that would allow the approach to continue until the end of 2022. The majority of biosolids in the Region are handled at facilities with anaerobic digestion and dewatering. The biosolids from these facilities are used in agricultural applications and mine tailings reclamation, or disposed in a provincially approved landfill. Smaller facilities with limited or no capacity to stabilize biosolids typically transfer to larger facilities for reprocessing. The Ayr and New Hamburg WWTPs have capacity to manage aerobically digested biosolids using storage with periodic land application. The Elmira WWTP dewateres sludge and transfers the cake directly to a provincially approved landfill.

There are opportunities for the Region to consider that would increase flexibility of current operations and available contingencies. For example the Region-controlled dewatered biosolids storage is limited and additional short term storage would provide flexibility to continue processing biosolids normally during a disruption to transportation for use or disposal.

The limited capacity for current land application of biosolids within the Region's boundary presents another type of risk where the existing management approach relies on use or disposal outside the Region. To date, agricultural land and mine tailings reclamation opportunities, or disposal to provincially approved landfills outside the Region have accommodated the necessary mass of biosolids.

4.0 Biosolids Quantity and Quality

The biosolids quantity and quality generated in the Region of Waterloo are presented in this section to identify the baseline conditions. The concentrations presented are compared to relevant standards for NASM. Characterization of the quantity and quality in this document will inform the technical assessment of alternatives during future steps in the development of the Biosolids Strategy.

4.1 Biosolids Quantity

The biosolids generation rate is related to the volume of wastewater treated at each facility. The sludge generation rate that forms the feedstock for each facility's biosolids processing is presented for the last five years in Table 4-1 for facilities with anaerobic digesters, and Table 4-2 to those without anaerobic digestion.

Table 4-1: Sludge Generation Rate 2011 – 2015 for Region of Waterloo Wastewater Treatment Plants with Anaerobic Digestion

Wastewater Treatment Plant	Volume of Sludge Generated (m ³ /year)				
	2011	2012	2013	2014	2015
Kitchener	209,460	195,889	189,536	218,747	203,633
Waterloo	88,639	109,276	108,411	80,115	77,674
Galt	82,357	82,836	87,867	96,405	109,320
Preston	25,534	24,465	26,950	26,296	28,220
Total	405,990	412,466	412,764	421,563	418,847

Table 4-2: Sludge Generation Rate 2011 – 2015 for Region of Waterloo Wastewater Treatment Plants without Anaerobic Digestion

Wastewater Treatment Plant	Volume of Sludge Generated (m ³ /year)				
	2011	2012	2013	2014	2015
Hespeler	72,359	88,064	74,036	103,874	92,346
Elmira	21,302	17,541	9,825	12,635	14,062
St. Jacobs	1,946	2,100	2,281	2,444	2,244
New Hamburg	17,568	18,259	15,022	14,931	15,081
Ayr	2,409	3,069	2,344	2,288	2,957
Wellesley	4,502	3,674	3,367	4,054	3,928
Heidelberg	458	701	312	375	354
Conestogo	162	285	181	215	204
Foxboro Green	1,037	1,313	352	0	0
Total	121,743	135,006	107,720	140,816	131,176
Notes:					
Sludge generated at Ayr and New Hamburg is reported as biosolids transferred from lagoon storage.					

Sludge volumes have varied within a relatively consistent range over the last five years for each treatment facility, based on the above tables.

The majority of biosolids in the Region of Waterloo are generated at the Kitchener, Waterloo, Preston, Galt, and Hespeler WWTPs. Aerobically digested sludge at the Hespeler facility is reprocessed at the Galt and Kitchener facilities; therefore it is handled and accounted for twice in the data presented above.

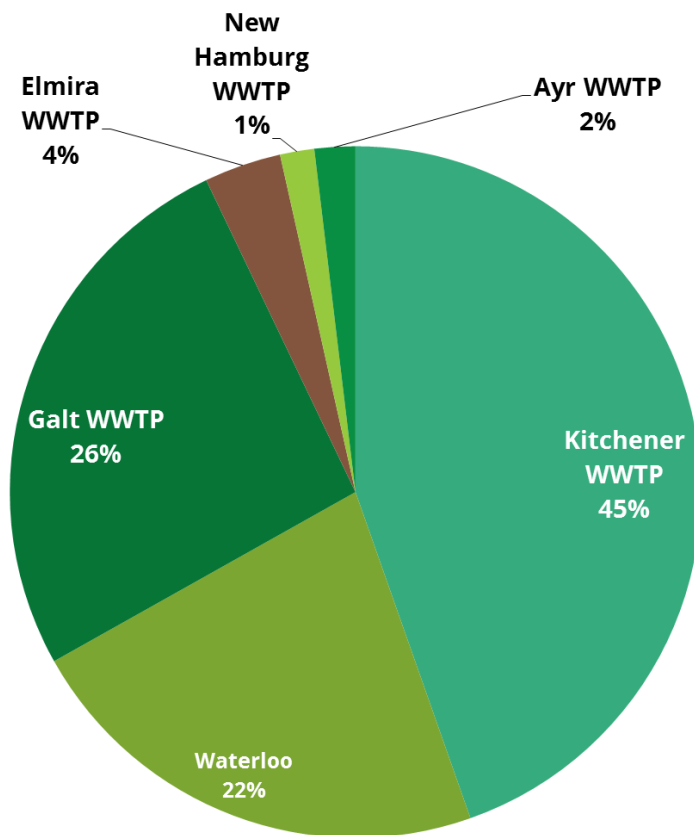
The transfers between facilities, end-uses and disposal in 2015 are summarized in Table 4-3.

Table 4-3: Sludge Generation, Transfers Between Facilities, End Use, and Disposal in 2015

Wastewater Treatment Plant	Volume of Sludge Generated (m³ / year)	Transferred to Kitchener (m³ / year)	Reprocessed at Waterloo (m³ / year)	Transferred to New Hamburg (m³ / year)	Reprocessed at Galt (m³ / year)	Dewatered And Used (Wet Tonnes / Year)	Dewatered And Landfilled (Wet Tonnes / Year)	Total Dewatered (Wet Tonnes / Year)	Total Applied to Land Without Dewatering (m³/year)	Total Biosolids Used or Disposed (Dry Tonnes / Year)
Kitchener	203,633					7,167	7,353	14,520		3,761
Waterloo	77,674						6,450	6,450		1,877
Galt	109,320					3,940	4,980	8,920		2,194
Preston	28,220									
Hespeler	92,346	64,267			28,079					
Elmira	14,062						1,215	1,215		304
St. Jacobs	2,244		1,720	525						
New Hamburg	15,081		7,220						7,862	135
Ayr	2,957								2,957	161
Wellesley	3,928		3,004	923						
Heidelberg	354		274	80						
Conestogo	204		140	64						
Foxboro Green	0									
Total	550,023	64,267	12,358	1,592	28,079	11,107	19,998	31,105	10,819	8,431
Notes: Sludge generated at Ayr and New Hamburg is reported as biosolids transferred from lagoon storage										

Dewatering at Kitchener, Waterloo, Galt, and Elmira increases the solids content of sludge from typically 1 – 3 % to greater than 25%. The dewatered cake represents approximately fifteen times less weight that requires transportation from the wastewater treatment facilities.

Figure 4-1 presents the relative contributions for each facility in terms of dry solids transferred for land application / Land reclamation or disposal during the 2015 operational year.



Notes:

The Preston WWTP transferred about 8% of the total dry solids for Region for dewatering at the Galt WWTP, which contributes to the 26% reported for the Galt WWTP.

The Hespeler WWTP transferred about 9% of the total dry solids for Region, where one third (3%) were reprocessed at the Galt WWTP, and two thirds (6%) were reprocessed at the Kitchener WWTP.

The combination of the smaller WWTPs transferred about 3% of the total dry solids primarily to the Waterloo WWTP for reprocessing.

Figure 4-1: Biosolids transferred for Use or disposal in 2015 (Dry Tonnes / Year) from Region of Waterloo WWTPs

The mass of dry solids from each facility is important because the NMA application rates are referenced in dry solids. It is also useful in terms of allowing the relative contribution of biosolids products from different facilities with different moisture content to be compared. The data from 2015 demonstrates that anaerobically digested and dewatered biosolids from the Kitchener, Waterloo and Galt facilities represented about 93% of the total dry solids for the Region in 2015. Solids from Elmira are dewatered and sent directly to a provincially approved landfill, which represents about 4% of the total, while the remaining 3% is aerobically digested liquid biosolids from Ayr and New Hamburg.

4.2 Biosolids Quality

The biosolids quality is presented in this section as it is measured prior to use or disposal at the Kitchener, Waterloo, Galt, Ayr, and New Hamburg facilities.

4.2.1 Kitchener WWTP

Since 2012, digestate from Kitchener has been dewatered by centrifuges at the Manitou Drive facility. The quality of anaerobically digested and dewatered biosolids is presented in Table 4-4.

Table 4-4: Kitchener WWTP Biosolids Metals Quality Statistics Summary for the years 2012 to 2015

Metal	NMA CM2 NASM	Kitchener Dewatered Cake		
	Non Aqueous	Maximum	Average	Maximum 4 Month Average
	(mg / kg dry weight)	(mg / kg dry weight)	(mg / kg dry weight)	(mg / kg dry weight)
Arsenic	170	3.0	1.9	2.5
Cadmium	34	1.7	1.1	1.3
Cobalt	340	44	4.2	9.2
Chromium	2,800	108	76	97
Copper	1700	1,600	1290	1440
Lead	1100	45.4	36.6	41.3
Mercury	11	0.74	0.24	0.37
Molybdenum	94	17	11	14
Nickel	420	123	80	107
Selenium	34	2.1	1.6	1.8
Zinc	4200	904	736	795

The geometric mean of *E. coli* ranges from 185,000 to 470,000 CFU/g, which is below the CP2 limit. Other quality parameters of interest for biosolids management are presented in Table 4-5.

Table 4-5: Kitchener WWTP Biosolids Nutrient Quality Statistics Summary for the Years 2012 to 2015

Parameter	Maximum (mg / kg dry weight)	Average (mg / kg dry weight)	Maximum 4 Month Average (mg / kg dry weight)
Ammonia	6,150	3,930	4,840
Nitrate	13	2.4	4.2
Nitrite	53	9.1	18
TKN	73,300	48,900	54,300
Phosphorus	51,600	34,200	40,800
Total Solids	30%	26%	28%
Total Volatile Solids	71%	63%	69%

The data presented demonstrate that biosolids from the Kitchener facility have nutrient value and have been of acceptable quality for land application under the NMA as a Category 3 NASM over the period assessed.

4.2.2 Galt WWTP

The current approach to management is that biosolids from the Preston and Galt facilities are dewatered by centrifuges at the Galt facility. This approach has been in place since 2009. The quality of anaerobically digested and dewatered biosolids at Galt is presented in Table 4-6.

Table 4-6: Galt WWTP Biosolids Metals Quality Statistics Summary for the years 2012 to 2015

Metal	NMA CM2 NASM	Galt Dewatered Cake		
	Non Aqueous	Maximum	Average	Maximum 4 Month Average
	(mg / kg dry weight)	(mg / kg dry weight)	(mg / kg dry weight)	(mg / kg dry weight)
Arsenic	170	4.3	2.5	3.4
Cadmium	34	1.7	1.0	1.2
Cobalt	340	9.0	5.1	6.9
Chromium	2,800	431	162	250
Copper	1700	1,240	913	1130
Lead	1100	32.3	25.1	30.3
Mercury	11	0.58	0.21	0.37
Molybdenum	94	25	14	17
Nickel	420	97	55	80
Selenium	34	2.3	1.7	2.0
Zinc	4200	2370	1610	2010

The geometric mean of *E. coli* ranges from 16,500 to 193,000 CFU/g which is below the CP2 limit. Other quality parameters of interest for biosolids management are presented in Table 4-7.

Table 4-7: Galt WWTP Biosolids Nutrient Quality Statistics Summary for the Years 2012 to 2015

Parameter	Maximum (mg / kg dry weight)	Average (mg / kg dry weight)	Maximum 4 Month Average (mg / kg dry weight)
Ammonia	6,930	4,750	5,580
Nitrate	7.0	2.7	4.1
Nitrite	29	7.0	12
TKN	56,800	45,000	50,200
Phosphorus	40,100	34,800	36,800
Total Solids	31%	24%	26%
Total Volatile Solids	66%	60%	65%

The data presented demonstrate that biosolids from Galt have nutrient value and have been acceptable quality for land application under the NMA as a Category 3 NASM over the period assessed.

4.2.3 Waterloo WWTP

Anaerobically digested biosolids have been dewatered by centrifuge at the Waterloo WWTP since 2014, and the quality is presented in Table 4-8.

Table 4-8: Waterloo WWTP Biosolids Metals Quality Statistics Summary for the Years 2014 to 2015

Metal	NMA CM2 NASM	Waterloo Dewatered Cake		
	Non Aqueous	Maximum	Average	Maximum 4 Month Average
	(mg / kg dry weight)	(mg / kg dry weight)	(mg / kg dry weight)	(mg / kg dry weight)
Arsenic	170	3.7	2.3	3.3
Cadmium	34	7.2	1.0	1.5
Cobalt	340	15	7.3	12
Chromium	2,800	100	58.0	82.3
Copper	1700	1,570	1010	1270
Lead	1100	48.5	28.9	37.0
Mercury	11	0.47	0.19	0.28
Molybdenum	94	17	8.1	13
Nickel	420	47	24	33
Selenium	34	1.9	1.3	1.6
Zinc	4200	1040	652	846

The geometric mean of *E. coli* ranges from 10,000 to 67,200 CFU/g which is below the CP2 limit. Other quality parameters of interest for biosolids management are presented in Table 4-9.

Table 4-9: Waterloo WWTP Biosolids Nutrient Quality Statistics Summary for the Years 2012 to 2015

Parameter	Maximum (mg / kg dry weight)	Average (mg / kg dry weight)	Maximum 4 Month Average (mg / kg dry weight)
Ammonia	5,790	2,900	3,770
Nitrate	12	2.5	4.6
Nitrite	40	5.5	14
TKN	56,100	44,400	52,000
Phosphorus	49,200	33,100	42,300
Total Solids	34%	27%	32%
Total Volatile Solids	83%	60%	78%

The data presented demonstrate that biosolids from Waterloo have nutrient value and have been acceptable quality for land application under the NMA as a Category 3 NASM over the period assessed.

4.2.4 Ayr WWTP

Aerobically digested biosolids are stored in a lagoon at the Ayr WWTP prior to land application as a liquid with average solids content of approximately 5%. The quality of the material from 2013 to 2015 is presented in Table 4-10.

Table 4-10: Ayr Lagoon Biosolids Metals Quality Statistics Summary for the Years 2013 to 2015

Metal	NMA CM2 NASM	Ayr Lagoon Biosolids		
	Non Aqueous	Maximum	Average	Maximum 4 Month Average
	(mg / kg dry weight)	(mg / kg dry weight)	(mg / kg dry weight)	(mg / kg dry weight)
Arsenic	170	30	6.4	8.9
Cadmium	34	2.0	0.8	0.9
Cobalt	340	10	5.8	6.9
Chromium	2,800	136	95.2	115
Copper	1700	500	379	432
Lead	1100	30.4	18.0	22.0
Mercury	11	1.35	0.30	0.42
Molybdenum	94	14	10	12
Nickel	420	39	26	30
Selenium	34	10	2.9	3.7
Zinc	4200	770	494	584

The geometric mean of *E. coli* ranges from 1,500 to 24,000 CFU/g which is below the CP2 limit. Other quality parameters of interest for biosolids management are presented in Table 4-11.

Table 4-11: Ayr WWTP Biosolids Nutrient Quality Statistics Summary for the Years 2013 to 2015

Parameter	Maximum (mg / kg dry weight)	Average (mg / kg dry weight)	Maximum 4 Month Average (mg / kg dry weight)
Ammonia	80,000	9,500	22,000
Nitrate	1,000	100	300
Nitrite	600	100	100
TKN	130,000	35,000	54,000
Phosphorus	54,000	35,000	41,000
Total Solids	14%	4.7%	6.2%
Total Volatile Solids	68%	57%	62%

The data presented demonstrate that biosolids from Ayr have nutrient value and have been of acceptable quality for land application under the NMA as a Category 3 NASM over the period assessed. The data presented in Table 4-10, focus on the period of data from 2013 – 2015. The analytical approach used for Ayr was adjusted in 2012, and therefore concentrations measured are not comparable before and after change for some metals. The data collected since the beginning of 2013 is considered representative of the current quality and appropriate for planning purposes.

4.2.5 New Hamburg WWTP

Aerobically digested biosolids are stored in a lagoon at the New Hamburg WWTP prior to land application as a liquid with average solids content less than 2%. St. Jacobs, Wellesley, Heidelberg, and Conestogo all contributed sludge to the New Hamburg Facility in 2015. The quality of biosolids from the aerobic digesters from 2013 to 2015 is presented in Table 4-12.

Table 4-12: New Hamburg Aerobically Digested Biosolids Metals Quality Statistics Summary for the Years 2013 to 2015

Metal	NMA CM2 NASM	New Hamburg Digestate		
	Non Aqueous	Maximum	Average	Maximum 4 Month Average
	(mg / kg dry weight)	(mg / kg dry weight)	(mg / kg dry weight)	(mg / kg dry weight)
Arsenic	170	20	11	13
Cadmium	34	2.0	0.8	1.2
Cobalt	340	10	3.4	5.7
Chromium	2,800	76	42	64
Copper	1700	683	532	602
Lead	1100	47	16	20
Mercury	11	2.86	0.72	1.6
Molybdenum	94	10	5.9	7.4
Nickel	420	22	15	18
Selenium	34	8.0	3.7	5.0

Zinc	4200	750	446	526

The geometric mean of *E. coli* ranges from 40,000 to 1,200,000 CFU/g which is below the CP2 limit. Other quality parameters of interest for biosolids management are presented in Table 4-13.

Table 4-13: New Hamburg Aerobic Digester Biosolids Nutrient Quality Statistics Summary for the Years 2013 to 2015

Parameter	Maximum (mg / kg dry weight)	Average (mg / kg dry weight)	Maximum 4 Month Average (mg / kg dry weight)
Ammonia	60,000	8,000	14,000
Nitrate	1,200	300	500
Nitrite	300	100	200
TKN	80,000	45,000	58,000
Phosphorus	42,400	29,200	35,800
Total Solids	3.9%	1.8%	2.6%
Total Volatile Solids	73%	63%	68%

The data presented demonstrate that biosolids from New Hamburg have nutrient value and have been acceptable quality for land application under the NMA as a Category 3 NASM over the period assessed. The analytical approach used for New Hamburg was adjusted in 2012, and therefore concentrations measured are not comparable before and after change for some metals. The data collected since the beginning of 2013 are considered representative of the current quality and appropriate for planning purposes. Therefore the data presented in Table 4-12, and the analysis below focus on the period of data from 2013 – 2015, which is considered representative of the baseline quality and appropriate for planning purposes.

4.2.6 Biosolids Quality Summary

The data presented in this section is intended to set the baseline quality of biosolids for planning purposes. The data presented demonstrate that biosolids used have value as a source of nitrogen and phosphorous and have been acceptable quality for use under the NMA as a Category 3 NASM over the period assessed.

5.0 References

- Canadian Council of Ministers of the Environment (CCME). 2009. Model Sewer Use Bylaw: Model Sewer Use Bylaw Guidance Document. PN1421. Available Online:
http://www.ccme.ca/files/Resources/municipal_wastewater_effluent/pn_1421_model_sewer_use_bylaw_guidance_doc_e.pdf. Last accessed: March 22, 2016.
- Ontario Ministry of Agriculture, Food and Rural Affairs. 2012. 2012 Nutrient Management Tables for Ontario Regulation 267/03 Made under the Nutrient Management Act, 2002 - Table 3. NASM Odour Category Table. Available Online: <http://www.omafra.gov.on.ca/english/nm/regs/nmpro/nmtab03-12.htm>. Last Accessed: March 22, 2016.
- Ontario Regulation 267/03 made under the Nutrient Management Act. Consolidation period: January 1, 2015. Available Online:
<https://www.ontario.ca/laws/regulation/030267>. Last Accessed: March 22, 2016.
- Region of Waterloo (ROW). 2015. Water and Wastewater Monitoring Report. Available Online:
<http://www.regionofwaterloo.ca/en/aboutTheEnvironment/resources/WaterServices/WS2015WaterAndWastewaterMonitoringReport2.PDF>. Last Accessed: March 22, 2016/
- Terratec Environmental. 2015, 2015 Year End Report: Region of Kitchener/Waterloo Biosolids Utilization Program.



APPENDIX C:

TM#3 – Evaluation Criteria

Region of Waterloo Biosolids Strategy

Technical Memo #3:
Evaluation Criteria

FINAL DRAFT
December 2017



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Appendix A: Issues that Matter

Acronyms

CCME	Canadian Council for Ministers of the Environment
GHG	Greenhouse Gas
MCEA	Municipal Class Environmental Assessment
MOECC	Ministry of Environment and Climate Change
WEF	Water and Environment Federation
WERF	Water Environment Research Foundation
TM	Technical Memo

Executive Summary

The Region of Waterloo Biosolids Strategy was initiated in 2015 to develop an approach to manage biosolids in Waterloo Region to the year 2051. The strategy will take a critical look at current practices, and consider available and relevant technologies for processing biosolids. A number of alternative strategies will be considered and a preferred management strategy identified at the conclusion of this project.

To guide the decision making process for the strategy, a number of project objectives were developed, against which each alternative will be evaluated. This memo outlines the seven objectives developed for this project as well as the evaluation criteria that will be used to assess each alternative. The objectives are to:

1. Work collaboratively to find solutions. Many stakeholders want to be involved in the decision making process, both now and as the strategy is implemented. Consistent with the Region's Strategic Plan, the decision making process should provide enhanced opportunities for public engagement, input and involvement in the decision making process beyond regulatory requirements.
2. Align with existing infrastructure. The Region has significant investment in infrastructure and a strategy which maximizes this investment is preferred.
3. Protect the natural environment. The preferred strategy should seek to make that natural environment better, rather than focussing solely on minimizing negative impacts. This project provides an opportunity to improve the existing ecosystem.
4. Protect Health and Safety. Consistent with the Region's Strategic Plan, the strategy should promote and support healthy living and prevent disease and injury, for both workers and the public.

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5. Minimize and manage operational risk. The preferred strategy must be robust and limit the potential for complications during the operations that would compromise the Region's ability to provide on-going biosolids services.
6. Protect quality of life. The existing quality of life for citizens should be maintained, regardless of where a new facility is planned.
7. Be cost effective and provide value. The preferred strategy must be affordable to the Region, both now and in the future.

The memo also outlines the decision making process that will be followed through the six stages of the project, as highlighted in **Figure 1-1**.

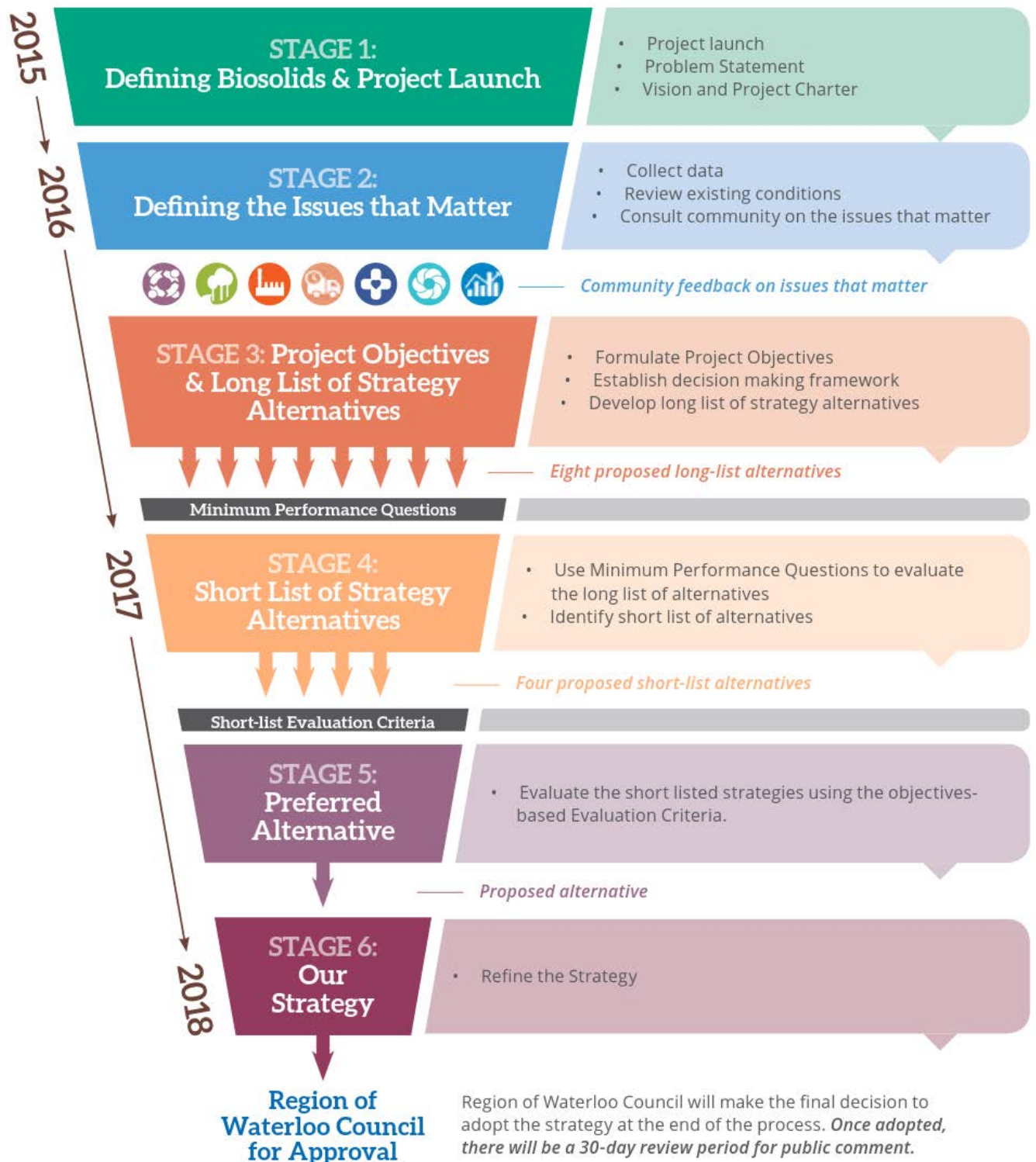


Figure 1-1 Key Stages in the Decision Making Process

1.0 Introduction

1.1 Project Purpose and Approach

The Region of Waterloo Biosolids Strategy was initiated in 2015, to develop an approach to manage biosolids in Waterloo Region to the year 2051. The strategy will take a critical look at current practices, and consider available and relevant technologies for processing biosolids. Alternative ways to manage biosolids will be evaluated against a range of criteria to develop a biosolids management strategy for the Region. This project will result with the selection of a preferred strategy that will be implemented in the Region over the next 35 years. The decision making process to select the preferred strategy will be documented in a report and be available for public review. Future projects will further refine the implementation details of the strategy including timing, sizing and location of any facilities.

The strategy is being developed in six stages, which will be outlined in a series of technical memos (TMs). The memos will form the basis for the final study document. The project stages include:

- Stage 1 – What are biosolids and what process is being followed to develop the strategy?
 - o TM: The Environmental Assessment Process
- Stage 2 – What is the current situation related to biosolids in the Region and how will it change as the Region grows?
 - o TM: Existing Conditions
 - o TM: Biosolids Management Needs Forecast
- Stage 3 – What are the project objectives, what technologies and strategies are being considered and how will a decision be made to select the recommended strategy?
 - o TM: Evaluation Approach and Comparative Evaluation Criteria

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- o TM: Biosolids Technologies, End Uses, and Disposal
 - o TM: Long List of Biosolids Management Alternatives
- Stage 4 – What alternatives from the long list could work in the Region of Waterloo? How can they be refined based on the project objectives? This stage involves evaluating the alternatives to identify a shorter list that will be evaluated in more detail
 - o TM: Short List of Biosolids Management Alternatives
- Stage 5 – Based on the project objectives and evaluation criteria, what is the recommended strategy? The short listed alternatives are evaluated at this stage and a recommended strategy is brought forward for public input.
 - o TM: Evaluation of Short Listed Alternatives
- Stage 6 – What is the best strategy to meet the project objectives?
 - o TM: Recommended Biosolids Strategy
 - o Biosolids Strategy Document

The Region is committed to public engagement throughout the development of the strategy. The project team will seek to understand the priorities and concerns of community residents across Waterloo Region, as well as technical experts and other stakeholders.

A **sustainable strategy** is one that considers the future growth of the Region and looks to minimize potential landfill disposal requirements of biosolids.

Additional background information regarding the context of biosolids management in the Region of Waterloo is included in **TM1**.

1.2 Purpose of this Technical Memorandum

The purpose of this technical memorandum is to outline the process that will be used to evaluate the various strategies developed for biosolids management and to select the preferred strategy. This project is being completed following the Municipal Class Environmental Assessment (MCEA) process, which requires the

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consideration of alternatives through a traceable decision –making process. The MCEA enables the planning of municipal infrastructure to be undertaken in accordance with an approved procedure designed to protect the environment, where ‘environment’ includes natural, social, economic, and cultural considerations. Cost and engineering/technical considerations are also important. The process requires the proponent to develop criteria to evaluate alternatives, recognizing the decision making process and methods for each project are unique. The alternatives are assessed against the evaluation criteria. The MCEA also requires public and agency input be incorporated into the evaluation and selection of the preferred alternative. The evaluation approach and criteria laid out in Section 2 and Section 3 of this memo have been reviewed following public events to consult on these components, with feedback received integrated as appropriate.

1.3 Memo Structure

This memo is organized into three main sections:

1. **Chapter 1: Introduction** – Provides a general overview of the strategy and process being followed for this project
2. **Chapter 2: Public and Stakeholder Consultation to date** – This section summarizes key consultation activities completed to date in the project and highlights the input received on key project issues
3. **Chapter 3: Evaluation Approach** - This section outlines the proposed process, objectives of the study, and criteria for how the alternative strategies will be evaluated and the preferred strategy identified. The evaluation will be documented in two TMs:
 - TM7: Biosolids Strategy Alternatives Short List. The long list of strategies will be reduced to a shorter list that will be evaluated in greater detail
 - TM8: Evaluation of Short Listed Alternatives. The detailed evaluation of short-listed strategies will be documented and a recommended strategy identified.

2.0 Public and Stakeholder Consultation to Date

Public and stakeholder engagement is a guiding principle for the Biosolids Strategy. The initial phase of this project focused on education on biosolids and asking what issues should be considered in the decision making process. This section summarizes the stakeholder consultation activities carried out this far, and how the feedback received was distilled into the “issues that matter”. These issues then informed the development of the overarching objectives for the Biosolids Strategy.

Key consultation activities included:

- Steering Committee Meeting: The committee includes technical and communications staff from the Region of Waterloo, as well as representatives from the Region of Waterloo Council
- Stakeholder Committee Meeting: The committee includes representatives from a range of sectors, as well as community groups, academic experts, and industry representatives
- Public Project Launch Event
- Online and telephone surveys (2)
- Pop-up Consultation Events (10)

Based on input received through all the above consultation opportunities as well as technical input from the Project team, a complete list of issues that matter was generated as shown in **Figure 2-1. Appendix A** of this memo outlines how input received from various stakeholders during Stage 1 and Stage 2 of the project based on ‘issues that matter’ was collected and used to formulate the objectives and criteria for the Biosolids Strategy.

PUBLIC AND STAKEHOLDER CONSULTATION TO DATE

Figure 2-1 Biosolids Management - Issues that Matter Regarding Biosolids Management



3.0 Evaluation Approach

3.1 Objectives Based Evaluation Methodology

3.1.1 Description of Method

An objectives-based evaluation approach is being used to select the preferred strategy. This is a holistic, multi-disciplinary approach to completing the evaluation. It reflects a desire to develop a sustainable management strategy for biosolids by evaluating the alternatives against integrated environmental, social and economic objectives.

The objectives were developed based on initial consultation with key stakeholders (the “issues that matter”) and members of the community, alignment with the Region’s Strategic Plan and input from the project’s technical team (see Section 2.0).

3.1.2 The Strategy Objectives

Seven objectives were identified for the Region’s Biosolids Strategy:

1. Work collaboratively to find solutions. Many stakeholders want to be involved in the decision making process, both now and as the strategy is implemented. Consistent with the Region’s Strategic Plan, the decision making process should provide enhanced opportunities for public engagement, input and involvement in the decision making process beyond regulatory requirements.
2. Align with existing infrastructure. The Region has significant investment in wastewater and biosolids processing infrastructure and a strategy which maximizes this investment is preferred.
3. Protect the natural environment. The preferred strategy should seek to make that natural environment better, rather than focussing solely on minimizing

negative impacts. This project provides an opportunity to improve the existing ecosystem.

4. Protect health and safety. Consistent with the Region's Strategic Plan, the strategy should promote and support healthy living and prevent disease and injury, for both workers and the public.
5. Minimize and manage operational risk. The preferred strategy must be robust and limit the potential for complications during the operations that would compromise the Region's ability to provide on-going biosolids services.
6. Protect quality of life. The existing quality of life for citizens should be maintained, regardless of where a new facility is planned.
7. Be cost effective and provide value. The preferred strategy must be affordable to the Region, both now and in the future.

3.1.3 Developing Evaluation Criteria from the Objectives

To carry out the evaluation of alternatives developed in Stages 4 and 5 of the Biosolids Strategy, specific criteria were developed based on the objectives, as outlined below.

Objective 3, Work collaboratively to find solutions,

is an overarching objective of the Biosolids Strategy and has been used to shape the design of this project. The stakeholder engagement program for this study exceeds the minimum requirements of the MCEA process. As outlined in the Project Charter: *"The Region of Waterloo is committed to engaging citizens and collaborating with community partners to foster meaningful and open conversation about Regional programs and services. The project has an emphasis on community input and participation at multiple points throughout the development of the Strategy, to help identify values important to the community. Throughout the Strategy development process, the Region will endeavour to provide a wide range of event types and opportunities for public engagement and involvement."*

The ability to meet this objective will be assessed as the project proceeds, both during the Strategy development project as well as subsequent projects during the implementation phase, and will therefore not form part of the evaluation criteria.

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Each objective has a number of criteria that are considered. Each criterion identified has a number of corresponding indicators that will be held to measure performance of the alternatives against the criteria, as a way to distinguish the preferred alternative. There are both quantitative and qualitative indicators, depending on the criteria. The criteria are described in this technical memo, while the indicators are being developed with technical and community input, and will be detailed in a future technical memo (TM8).

At this point it is assumed that all criteria will be considered equally. Consultation on the evaluation approach will seek to obtain input on whether any of the objectives or criteria should be considered more important in the evaluation than others. Criteria will not be weighted with any type of numerical or empirical measurement, rather weighting will be qualitative, based on the input provided by the community and from the Region.

3.2 Stages of the Evaluation Process

As noted in **Section 1.1**, there are **six key stages** being undertaken to develop a Biosolids Strategy for the Region. **Figure 3-1** and the following text explain the evaluation in each of the stages. **Stage 1 and 2** of the project deal with laying out the project process and clarifying the scope of the Region's long-term Biosolids Strategy and the problem it seeks to address. Technical Memo #1 (The Environmental Assessment Process) and Technical Memo #2 (Existing Conditions) lay out the background for the Strategy, and Technical Memo #6 (Biosolids Forecast) provides an overview of the projected quantities of biosolids that the Region will need to manage at each of the wastewater treatment plants as the population grows. These technical laying the groundwork for the development of the Biosolids Strategy.

Stage 3 of the project focuses on what available technologies should be considered, how can the various technologies be combined into different strategies and how will

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the decision be made on which strategy is preferred. Stage 3 is documented in a series of three technical memos.

The first of these is this memo, Technical Memo #3 (Evaluation Approach and Comparative Evaluation Criteria), which outlines the project objectives as well as the decision making process. As described in Section 2, the objectives are based on input on the issues that matter that were gathered from the Waterloo Region community, as well as the project team and project advisors via the Steering Committee and Stakeholder Committee. This input was used to develop the seven objectives and the criteria that are described in this Technical Memo.

The second technical memo is a review of available technologies and consideration of how they can be incorporated into management strategies. **Stage 3** of the project provides an overview of the biosolids technologies, end uses, and disposal options currently available, which will be documented in Technical Memo #4 (Biosolids Technologies, End Use and Disposal). The third technical memo in this stage is a long list of alternative strategies that will be considered. The long list of biosolids management strategies will be documented in Technical Memo #5 (Long List of Alternatives).

In **Stage 4** of the project, the long list of alternatives documented in Technical Memo #5 will be assessed based on a series of Minimum Performance Threshold criteria to identify a short list of feasible strategies specifically for the Region of Waterloo through a more detailed evaluation. **Section 3.3.1** of this document provides further information on this evaluation step including the draft Minimum Performance Threshold criteria that will be applied. The process of this initial screening of alternatives and information about the resulting short listed alternatives will be the subject of Technical Memo #7 (Short List of Alternatives).

In **Stage 5** of the project, the short list of biosolids strategies will be evaluated using the full list of criteria laid out in **Section 3.3.2** to identify the preferred alternative(s) for managing biosolids in the Region of Waterloo. The evaluation will be based on a

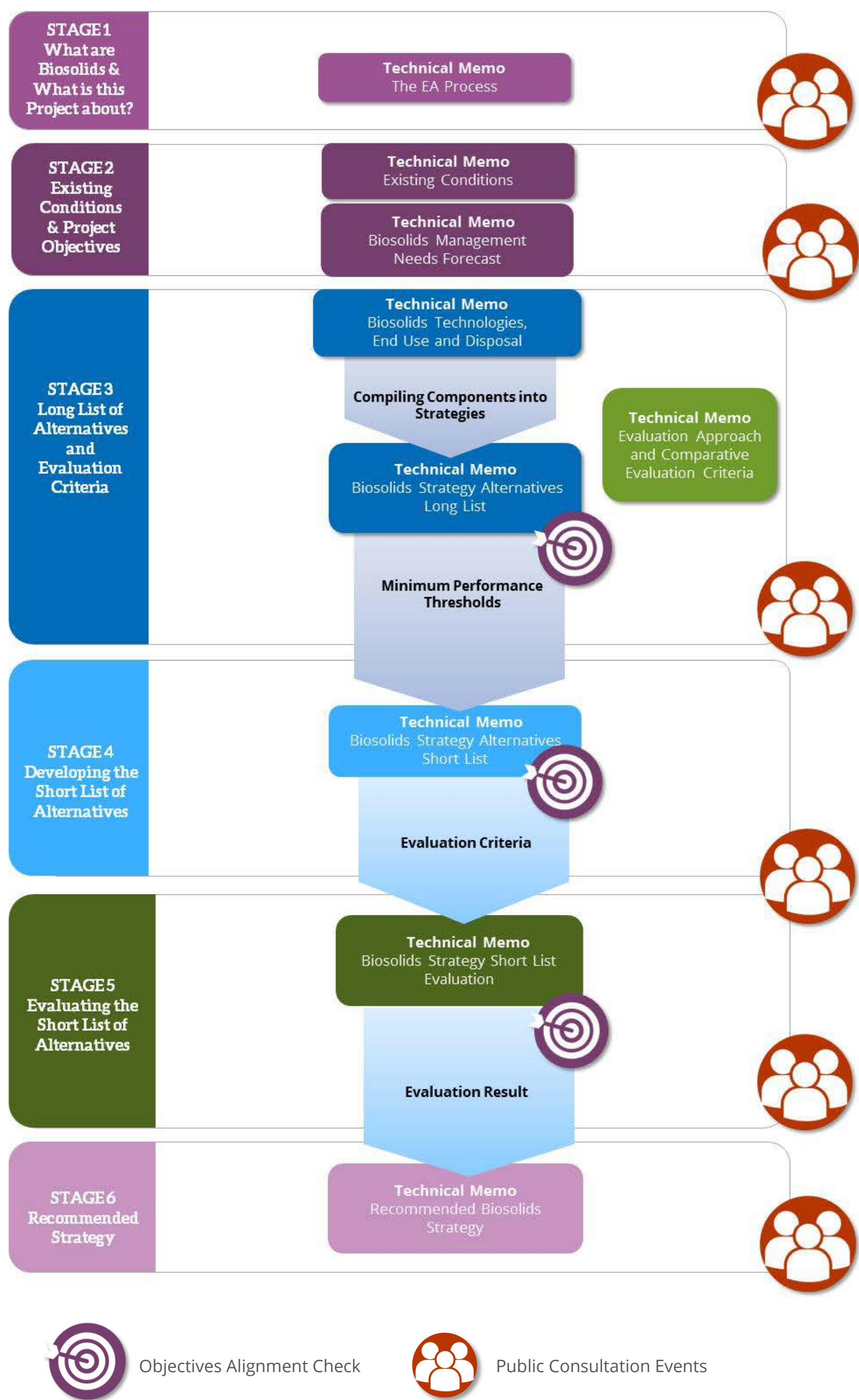
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series of comparative criteria which will assess how well each strategy meets the objectives and will be laid out in Technical Memo #8 (Evaluation of Short Listed Alternatives).

The preferred strategy will be identified during **Stage 6** as an outcome of the evaluation in Technical Memo #9 (The Preferred Strategy).

All of the Technical Memos will ultimately come together to form the Biosolids Master Plan Document. The Biosolids Master Plan Document will clearly outline the preferred strategy to manage biosolids in the Region and how that strategy was selected. It is intended that this document will chart the overall direction for managing biosolids however additional steps will be required to confirm and locate specific infrastructure and facilities. The Biosolids Master Plan Document will be distributed and advertised for the 30 day public review required by the Class EA process.

Figure 3-1 Evaluation Approach



3.3 Evaluation Approach and Criteria

The following section outlines the evaluation approach and criteria that will be used to select the preferred alternative(s). Throughout the evaluation process, the intent is that each alternative will be assessed against the criteria indicators and the alternative(s) that best meet the defined objectives will be confirmed as the preferred strategy for addressing biosolids management in the Region.

Opportunities to mitigate negative impacts will be considered in the development and refinement of the strategies, so that an “optimized” alternative is evaluated. It is recognized none of the alternatives will be fully aligned with all of the objectives and some measure of trade-offs would likely be required, which will be discussed as part of the evaluation results.

3.3.1 Long List Evaluation

The long list of strategies will be screened against minimum performance questions identified for the objectives. Strategies that do not meet the minimum performance will be screened out. The minimum performance questions are intended to screen out alternatives that are not feasible for the Region to consider further. The questions are also tied to the project objectives as laid out in Table 3.

The first objective, ‘Work collaboratively to find solutions’, does not have any Minimum Performance Questions assigned as it is meant to go beyond the minimum requirements and is being met through the study design. This objective will be addressed throughout the development of the strategy.

Table 3-1 Project Objectives and Minimum Performance Questions

Objective	Minimum Performance Question (Yes/No)
Align with existing infrastructure	The Region has significant investment in infrastructure and a strategy that maximizes this investment is preferred. Alternatives will be compared to the following two MPQs • MPQ 1 - Does the alternative build upon the Region's existing wastewater infrastructure? • MPQ 2 - Is it based on commercially proven technology that provides a long term solution?
Protect the natural environment	The preferred strategy should minimize impacts to the environment and surroundings. Alternatives will be compared to the following MPQs: • MPQ 3 - Does it meet current environmental regulations and is it capable of meeting permitting requirements? Legislation to be considered includes: - o Ontario Nutrient Management Act - o Federal Fertilizers Act - o Ontario Compost Quality Standards - o Environmental Assessment Act - o Environmental Protection Act - o Ontario Water Resources Act - o Safe Drinking Water Act - o Clean Water Act • MPQ 4 - Does it align with best environmental practices in the field of biosolids management?

Objective	Minimum Performance Question (Yes/No)
Protect health and safety	The preferred strategy should minimize impacts to the environment and surroundings. Alternatives will be compared to the following MPQs: • MPQ 5 - Does it meet current health and safety regulations? Regulations to be considered include: - o Occupational Health and Safety Act - o Safe Drinking Water Act • MPQ 6 - Does it align with best practices for the protection of public health in the field of biosolids management? - o The alternative should be aligned with current best practices from Canadian Council for Ministers of the Environment (CCME) Guidelines, Water Environment Research Foundation (WERF) and Water and Environment Federation (WEF)
Minimize and manage operational risk	The preferred strategy must allow the Region to provide continual, uninterrupted biosolids management service to the public. Alternatives will be compared to the following MPQs: • MPQ 7 - Can the Region control all necessary elements of implementation? • MPQ 8 - Can the storage requirements be met with a

Objective	Minimum Performance Question (Yes/No)
	facility(s) located in the Region?
Protect quality of life	The existing quality of life for citizens should be maintained when planning for biosolids infrastructure. Alternatives will be compared to the MPQ: • MPQ 9 - Does the alternative protect the quality of life for citizens regardless of where it is built in the Region?
Be cost effective and provide value	The cost of the preferred strategy must be reasonable to the Region, both now and in the future. <i>No specified Minimum Performance Questions applied. It is premature to eliminate an alternative at this stage due to cost considerations. This objective will be addressed through specific criteria for the short-listed strategies.</i>

3.3.2 Short List Evaluation

Once the long list of alternatives has been evaluated against the Minimum Performance Questions, a short list of “eligible” alternatives will be confirmed and evaluated in more detail based on the study objectives. The alternatives will be further optimized prior to being evaluated so that the “best” form of the alternative is evaluated. The following tables provide the evaluation criteria that will be used to provide an assessment of performance of each alternative against the objectives. As noted previously, Objective 1 to ‘Work collaboratively with the community to find

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solutions’ is not included in the evaluation criteria, as it this objective is being assessed as part of the development of the Strategy itself.

Table 3-2 Objective 2: Align with Existing Infrastructure – Criteria

Criteria
How compatible is the alternative with existing Regional wastewater and biosolids processing infrastructure?
How much new supporting municipal infrastructure is required (e.g. roads, power and water services, etc.)?
What is the potential for aligning with other municipal initiatives in the future?
How flexible is the alternative in adapting to changing government regulations, policies and market demands?
Does the alternative allow us to accommodate future population growth?

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Table 3-3 Objective 3: Protect and Enhance the Natural Environment - Criteria

Criteria
What are the environmental effects of the facility?
What are the environmental effects of transport of biosolids, processing materials, and products?
What are the environmental effects of the end uses?
What is the energy balance? Is it possible to recover energy?
Is the alternative adaptable to climate change impacts (e.g. extreme temperatures, weather events [frequency, intensity, duration, and magnitude])?
How much greenhouse gas emissions does the alternative produce? (Note: Greenhouse gases are any gas in the atmosphere that traps heat and contributes to global warming)
How much risk is there that material generated from the process will be landfilled?

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Table 3-4 Objective 4: Minimize and Manage Operational Risk – Criteria

Criteria
How do the end use or disposal options affect the risk of disruption to biosolids management services?
Does the alternative reduce the volume/mass of end product to be managed?
How susceptible is the alternative to disruption in maintenance and labour supply?
How susceptible is the alternative to a process disruption?
How susceptible is the alternative to disruption in end product quality, management or storage?

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Table 3-5 Objective 5: Protect Quality of Life – Criteria

Criteria
How will odour be managed?
How will dust from process or trucking be managed related to nuisance effects?
How will noise be managed?
How will visual effects be managed?
How will effects related to trucking be managed?
What are the potential impacts to source water protection?
Can all components of biosolids management, end uses and/or disposal be managed within Waterloo Region?

EVALUATION APPROACH

Table 3-6 Objective 6: Protect Health and Safety – Criteria

Criteria
What are the relative health risks posed to the public for each alternative?
What are the relative health risks posed to workers for each alternative?
Does the alternative reduce or eliminate undesirable components in the biosolids?
What is the potential nature of an accident or adverse event?

Table 3-7 Objective 7: Be Cost Effective and Provide Value – Criteria

Criteria
What is the relative capital cost?
What is the relative operating cost?
What is the relative life cycle cost including trucking?
How does life cycle cost vary based on implementation timing?
Is there an opportunity to apply for carbon credits? (Note: Carbon credits are given to municipalities by the province for making proven efforts to reduce the gas emissions created.)
What is the local economic benefit?
Is a biosolids end product created that has value? If yes, what is its value?
Would the alternative involve an innovative approach that demonstrates leadership in the area of biosolids management?



APPENDIX D:

**TM#4 – Biosolids Technologies,
End Use and Disposal**

Region of Waterloo Biosolids Strategy

Technical Memo #4:
Biosolids Technologies, End Use,
and Disposal

FINAL DRAFT
December 2017



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Acronyms

ASM	Agricultural Source Material
AS	Activated Sludge
BMP	Biosolids Master Plan
CAS	Conventional Activated Sludge
CCME	Canadian Council of Ministers of the Environment
CFIA	Canadian Food Inspection Agency
CFU	Colony Forming Units
CM	Content of Metals
CP	Content of Pathogens
DAF	Dissolved Air Floatation
ECA	Environmental Compliance Approval
EPA	Environmental Protection Act
HRT	Hydraulic Retention Time
kPa	Kilopascal
MCEA	Municipal Class Environmental Assessment
MLD	Million Litres / Day
MOECC	Ministry of Environment and Climate Change

MPN	Most Probable Number
NASM	Non-Agricultural Source Material
NMA	Ontario Nutrient Management Act, 2002, S.O. 2002, c. 4
OMAFRA	Ontario Ministry of Agriculture, Food and Rural Affairs
PAN	Plant Available Nitrogen
PAP	Plant Available Phosphorus
PS	Primary Sludge
ROW	Region of Waterloo
SRT	Solids Retention Time
TKN	Total Kjeldahl Nitrogen
TM	Technical Memo
TP	Total Phosphorus
TSS	Total Suspended Solids
US EPA	United States Environmental Protection Agency
WAS	Waste Activated Sludge
WEAO	Water Environment Association of Ontario
WWTP	Wastewater Treatment Plant

1.0 Introduction

1.1 Project Purpose and Approach

The Region of Waterloo Biosolids Strategy was initiated in 2015, to develop an approach to manage biosolids in Waterloo Region to the year 2051. The strategy will take a critical look at current practices, and consider available and relevant technologies for processing biosolids. Alternative ways to manage biosolids will be evaluated against a range of criteria to develop a biosolids management strategy for the Region. This project will result with the selection of a preferred strategy that will be implemented in the Region over the next 35 years. The decision making process to select the preferred strategy will be documented in a report and be available for public review. Future projects will further refine the implementation details of the strategy including timing, sizing and location of any facilities.

The strategy is being developed in six stages, which will be outlined in a series of technical memos (TMs). The memos will form the basis for the final study document. The project stages include:

- Stage 1 – What are biosolids and what process is being followed to develop the strategy?
 - o TM: The Environmental Assessment Process
- Stage 2 – What is the current situation related to biosolids in the Region and how will it change as the Region grows?
 - o TM: Existing Conditions
 - o TM: Biosolids Management Needs Forecast
- Stage 3 – What are the project objectives, what technologies and strategies are being considered and how will a decision be made to select the recommended strategy?
 - o TM: Evaluation Approach and Comparative Evaluation Criteria

- o TM: Biosolids Technologies, End Uses, and Disposal
 - o TM: Long List of Biosolids Management Alternatives
- Stage 4 – What alternatives from the long list could work in the Region of Waterloo? How can they be refined based on the project objectives? This stage involves evaluating the alternatives to identify a shorter list that will be evaluated in more detail
 - o TM: Short List of Biosolids Management Alternatives
- Stage 5 – Based on the project objectives and evaluation criteria, what is the recommended strategy? The short listed alternatives are evaluated at this stage and a recommended strategy is brought forward for public input.
 - o TM: Evaluation of Short Listed Alternatives
- Stage 6 – What is the best strategy to meet the project objectives?
 - o TM: Recommended Biosolids Strategy
 - o Biosolids Strategy Document

The Region is committed to public engagement throughout the development of the strategy. The project team will seek to understand the priorities and concerns of community residents across Waterloo Region, as well as technical experts and other stakeholders.

A **sustainable strategy** is one that considers the future growth of the Region and looks to minimize potential landfill disposal requirements of biosolids.

Additional background information regarding the context of biosolids management in the Region of Waterloo is included in **Appendix A**.

1.2 Purpose of this Technical Memo

The purpose of this technical memo is to develop a list of biosolids processing technologies and a list of potential end use and disposal alternatives that will form the building blocks for potential biosolids strategies (presented in Technical Memo #5).

The biosolids technologies considered as part of this technical memo represent an update to those considered in the Biosolids Technology Review (Arcadis, 2015) that was developed for the Region of Waterloo. The technologies presented include those implemented in Ontario as well as other jurisdictions across Canada, the US and Europe.

The biosolids end use and disposal options available in Ontario as well as other jurisdictions across Canada discussed in this memo are based on reports from reputable government and non-government organizations such as the Water Environment Federation or Canadian Council of ministers of the Environment. Published information has been augmented with discussions with relevant municipalities, regulators and stakeholders. End use and disposal options available in the rest of Canada, the U.S. and Europe that may become available over the planning period are presented for comparison and assessment.

1.3 Memo Structure

Technical Memo #4 is organized into five sections:

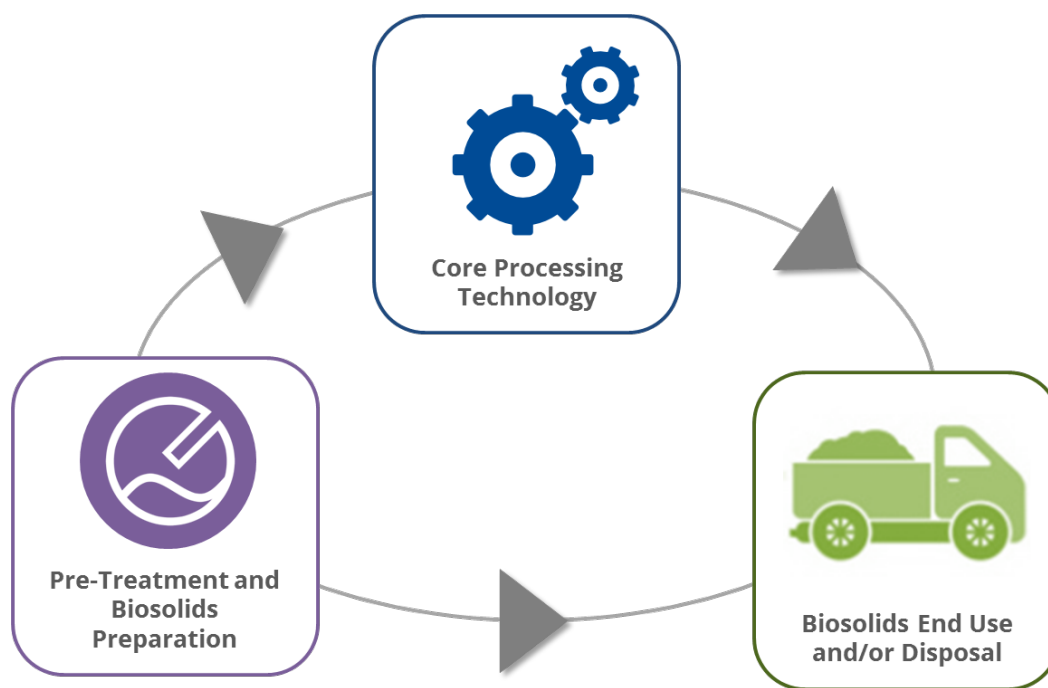
- 1. Chapter 1: Introduction**
- 2. Chapter 2: Introduction to Biosolids Technology**
- 3. Chapter 3: Core Biosolids Processing Technologies**
- 4. Chapter 4: Pre-treatment, Preparation Technologies and Storage**
- 5. Chapter 5: Biosolids End Uses and Disposal**

Appendix A (Study Overview) provides an overview of the study purpose and history of biosolids management in the Region. Chapters 2 through 5 provide technology, end use and disposal options that will form the building blocks of the various Biosolids Strategy alternatives that will be developed as part of Technical Memo #5, and evaluated in line with the project objectives in subsequent technical memos.

2.0 Introduction to Biosolids Technology

This memo provides an overview of technologies, end uses and disposal options considered in the development of the Region's Biosolids Strategy. The technologies and processes associated with biosolids management can be grouped into three stages: core biosolids processing technologies; pre-treatment and biosolids preparation technologies; and biosolids end use and disposal options (**Figure 2-1**).

Figure 2-1 The Three Stages of Biosolids Management



In subsequent sections, for each technology, end use or disposal options that are discussed, a description is provided along with comment on the practicality of the approach. More detailed summaries for each technology, including market maturity and technical attributes are provided in **Appendix B**. For core processing technologies, a table is provided identifying pre and post processing requirements. Pre-treatment and biosolids preparation technologies are presented along with a

table identifying the associated core processing technologies for which they are required. Similarly, end use and disposal approaches are matched to corresponding core processing technologies.

Existing Region treatment facilities at Kitchener, Waterloo, Galt, and Preston employ anaerobic digestion as a core processing technology.

The technologies described in this memo may form part of a process to supplant or enhance digestion as the existing method of biosolids management at these facilities, provide further processing of digested biosolids, or provide a means of onsite processing of managing biosolids at other smaller Region facilities that currently do not have this capability. For the purpose of clarity, it was agreed with the Region that biosolids management prior to and including digestion would be addressed under the Region's ongoing Wastewater Treatment Master Plan. The Biosolids Strategy project thus addresses the biosolids produced after digestion at the Region's plants. The following section describes the potential core biosolids processing technologies that form the anchor for the strategy. Subsequent sections will describe the pre-treatment and post-treatment requirements for each of these core technologies to provide complete biosolids processing.

2.1 Overview of Core Biosolids Processing Technologies



The core processing technology is the main process designed to achieve the stabilization of biosolids. This may include physical transformation of biosolids following the end of the existing processing train at the Region's wastewater treatment plants (WWTPs), or modifications to the existing processes at these plants. Whether the technology is potentially suitable for the local area and compatible with existing infrastructure will be evaluated as part of a subsequent stage of the project.

The core processing technology would be designed to facilitate appropriate use or disposal of the end-product. Several options may be considered for core technologies depending on the intended goal of processing and the envisioned end-use. The adoption of biosolids technologies is based on a number of high-level considerations including:

- Need for prior dewatering or thickening;
- Ability of the process to provide further volume reduction, in addition to other pre-treatment or processing technologies;
- Production of a dry or wet product;
- Production of a biogas by-product;
- Production of thermal energy as a by-product;
- The potential for use of the product; and
- The commercial viability of the technology.

Some core processing technologies feature opportunities for energy recovery, such as enhancements to potential biogas generation through digestion, or opportunities to recover heat as a source of energy.

2.2 Overview of Pre-treatment, Preparation Technologies, and Storage

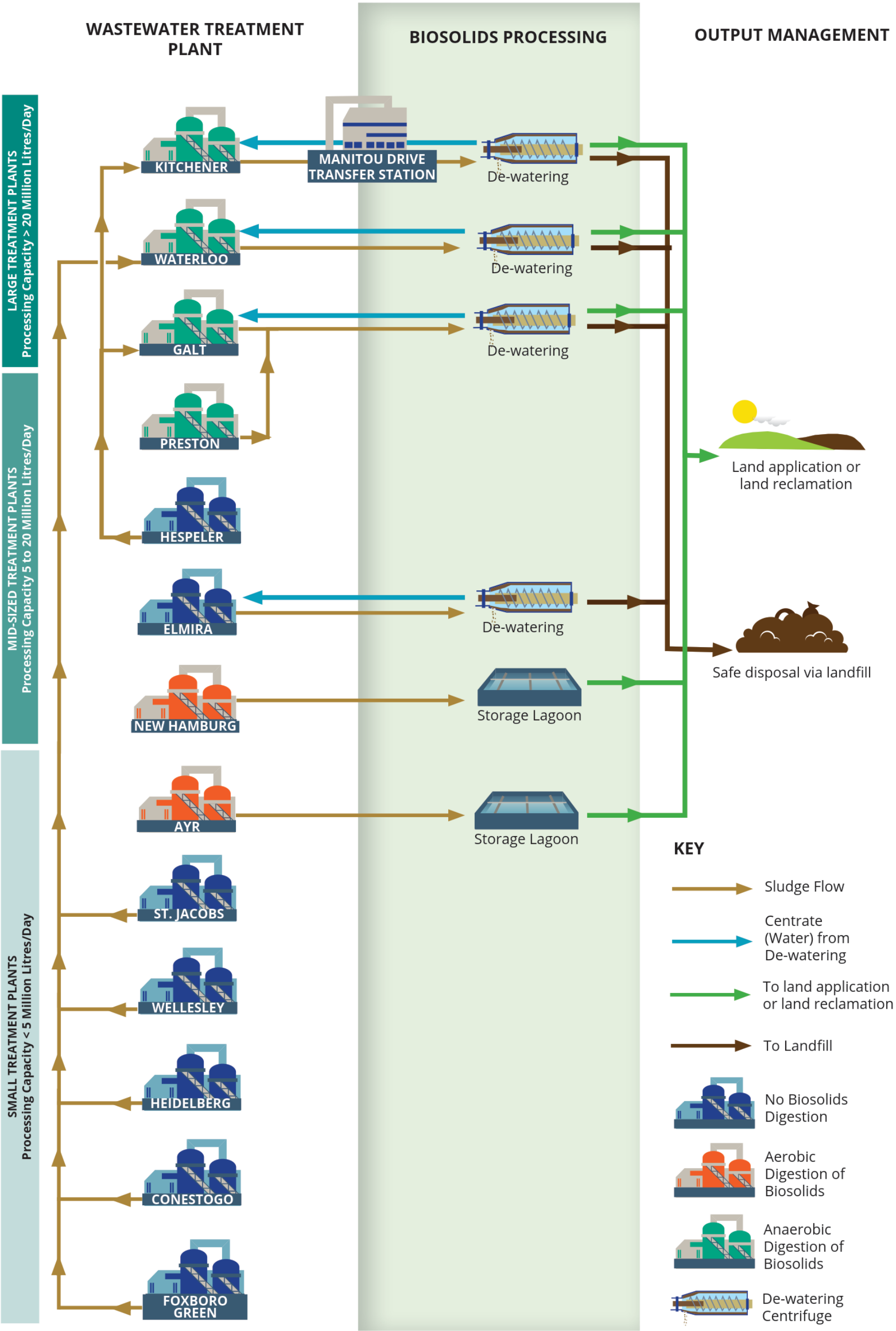


Pre-treatment and other preparation of biosolids may be required to facilitate the operation of many of the core biosolids processing technologies identified in this memo. This section describes the pre-treatment or other preparation technologies that may be required as part of a biosolids processing system.

Pre-treatment and preparation facilitate the interface between biosolids generating processes and downstream biosolids technologies. Technologies and options in this category also include biosolids storage alternatives. Biosolids storage is a critical component of most biosolids processing systems and is

therefore addressed in this section. Existing pre-treatment for biosolids processing ahead of end use (currently, de-watering and storage) is shown in **Figure 2-2**.

Figure 2-2 Mass Flows of Biosolids within the Region



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Pre-treatment may simply consist of physical modifications to biosolids, such as dewatering or thickening. In some cases, more advanced pre-treatment processes may be selected such as thermal hydrolysis. initial biosolids management infrastructure, specifically dewatering, is already implemented at the large WWTPs in the Region. It is anticipated that continuing the process of dewatering, as well as the construction of storage will be a necessary component of the biosolids management strategy in the future.

2.3 Overview of Biosolids End Uses and Disposal



Identifying the preferred end use or disposal option is one of the main goals of the Biosolids Strategy. A core processing technology is required in order to enable use of biosolids:

- for land application as a NASM;
- for land reclamation using an Environmental Compliance Approval (ECA)
- as a Canadian Food Inspection Agency (CFIA) regulated fertilizer;
- as a Compost as defined by the Compost Quality Standards (MOECC, 2012); or
- as a source of fuel / energy value in a manner considered beneficial by CCME.

Core processing technologies considered for use within the Region are presented with potential end use or disposal options in mind.

3.0 Core Biosolids Processing Technologies

Core biosolids processing technologies are considered those that change biosolids to allow additional value to be recovered through beneficial end uses, provide usable by-products such as biogas or heat, or facilitate disposal to landfill. These technologies are considered central to the alternative strategies that will be developed in Technical Memo #5. The core technologies are presented in groups including those focussed on: physical/chemical stabilization, digestion, hydrolysis, dryers, and thermal reduction.

3.1 Stabilization Technologies

Stabilization technologies refer to processes that reduce pathogens and produce a product that may be considered a Non Agricultural Source Material (NASM) or a product meeting the definition of a fertilizer under Canadian Food Inspection Agency (CFIA) guidelines. Additional benefits of stabilization vary depending on the specific approach, but typically include:

- Volume / mass reduction;
- Pathogen reduction; and
- Reduced potential to generate odours.

Stabilization can be achieved using:

- elevated temperature, pH, and / or pressure;
- mechanical means like high shear mixing; or
- other chemical reactions.

3.1.1 Alkaline Stabilization

Alkaline stabilization is a chemical-based treatment process which achieves the stabilization and pathogen inactivation of dewatered biosolids through a combination of elevated pH and temperature for a pre-determined duration. The pH of the biosolids is raised to at least 12 through alkaline addition, and is mixed for an appropriate contact time to create an environment that inactivates or destroys the pathogens and other microorganisms. The reaction of alkaline products with biosolids generates heat which provides additional pathogen reduction. Typical alkaline additives used include hydrated lime ($\text{Ca}(\text{OH})_2$) and quicklime (CaO). Other alternative sources include NaOH, cement kiln dust, potassium hydroxide, and fly ash.

Alkaline stabilization can be used to produce different biosolids qualities by adjusting the contact time the dewatered biosolids cake is exposed to the alkaline material. As the contact time and temperature increases, the pathogen concentration decreases, producing a higher quality biosolids. Additives may be combined with the stabilized material to increase nutrient value of the end product. Alkaline stabilization is a well-established process in Ontario and throughout the wastewater treatment industry.

Process Inputs and Outputs

- Inputs: dewatered biosolids cake, alkaline chemical addition, thermal energy, electricity
- Outputs: Dry biosolids-derived product with consistency like soil meeting fertilizer or NASM standards.

Process Attributes

Table 3.1 Alkaline Stabilization Process Attributes

Process Feature	Description of Process
Infrastructure Requirements	• Building for process equipment • Building or silo for product storage

Process Feature	Description of Process
	• Relatively compact process footprint. Substantial space for final product storage may be required depending on use and required storage time.
Typical Pre-Processing	• Process is typically configured to accommodate dewatered biosolids
Volume Reduction	• Alkaline chemical addition increases the end volume of the stabilized biosolids relative to other processes producing a semi-dry product • Drying may be incorporated into the process to reduce volume (separate process) • Trucking to communal facility (s) likely required
Process Odour Emission Potential	• Typically requires building enclosure and ventilation with odour control primarily for ammonia odour generated through stabilization process.
Product Odour Emission Potential	• Product odour emission potential is low compared with raw sludge, and other biosolids products
Other Air Emissions	• Potential for products of combustion from supporting infrastructure (e.g. boiler for drying component of process)
Noise Considerations	• Truck traffic associated with biosolids delivery for processing and distribution of stabilized product. • Building envelope to mitigate process noise • Enclosures may be required for stationary equipment
Considerations for safe operations	• Engineering controls and safety procedures are required to manage elevated temperature, pressure and pH processes. Potential dust exposure in alkaline blending and drying process. • Full time operations staff required
Biosolids Product	• Biosolids derived fertilizers (per CFIA) facilitates fewer restrictions for storage and handling with limited

Process Feature	Description of Process
	odour emission potential when compared with NASM product
Gas product	• No biogas or syngas typically produced / captured
Thermal / Energy product	• Heat release from alkaline reaction not significant source of energy for recovery. Net energy requirement to operate motorized processing equipment and dryers.
Opportunity for use	• Biosolids derived fertilizer allows use of nutrient value. Loss of some nitrogen content due to production of ammonia during stabilization.
Disposal considerations	• Biosolids derived fertilizer quality and characteristics allows for landfill disposal as a contingency
Anticipated Permitting	• ECA for municipal sewage works (Biosolids processing equipment) • ECA Air and Noise (air emissions from drying and building ventilation)

3.1.2 Thermal Stabilization or Pasteurization

Thermal stabilization or pasteurization is a physical process which provides pathogen reduction through the addition of heat. Heating of biosolids, typically in the form of waste activated sludge (WAS), to a temperature 70°C for at least 30 minutes provides pathogen reduction to meet CFIA fertilizer requirements. This process provides pathogen reduction with limited effect on the total volatile solids. Thermal stabilization and pasteurization processes typically include heat exchangers before and after the pasteurization process and employ heat recovery from treated biomass to pre-heat incoming biosolids. Thermal input for the process may be provided by waste heat generated elsewhere in the biosolids processing system, such as biogas-fuelled combined heat and power (CHP) units.

Thermal stabilization and pasteurization processes are marketed by several established companies internationally but have seen limited use in the Canadian or Ontario markets.

Process Inputs and Outputs

- Inputs: WAS or primary sludge (PS)
- Outputs: Pasteurized/stabilized liquid biosolids

Process Attributes

Table 3.2 Thermal Stabilization and Pasteurization Process Attributes

Process Feature	Description of Process
Infrastructure Requirements	• Building or plant area for process equipment • Thermal energy infrastructure providing required heat input for process • Storage infrastructure for stabilized product
Typical Pre-Processing	• Minimal pre-processing. Installed downstream of sludge collection locations within treatment process
Volume Reduction	• Volume not substantially reduced through process
Process Odour Emission Potential	• Minimal, contained process
Product Odour Emission Potential	• Odour potential consistent with digested sludge
Other Air Emissions	• None
Noise Considerations	• Enclosures may be required for stationary equipment • Truck traffic to transport treated product following processing
Considerations for Safe Operations	• Engineering controls and safety procedures are required to manage elevated temperature, pressure. • Safety considerations associated with combustion of

Process Feature	Description of Process
	- fuel utilized for heating. • Full time operations staff required
Biosolids Product	• Biosolids derived fertilizers (per CFIA) facilitates fewer restrictions for storage and handling with limited odour emission potential when compared with NASM product
Gas Product	• No biogas or syngas produced or captured through pasteurization process. Biogas may be generated through downstream digestion
Thermal / Energy product	• None. Process requires net energy input
Opportunity for use	• Biosolids-derived fertilizer. Form of fertilizer product may vary depending on downstream processing.
Disposal Considerations	• Biosolids derived fertilizer quality and characteristics allows for landfill disposal as a contingency
Anticipated Permitting	• ECA for municipal sewage works (Biosolids processing equipment) • ECA Air and Noise (noise emissions from equipment, air emissions from optional biogas-fired heaters)

3.2 Digestion Technologies

Digestion technologies provide conditions for microbes to convert a portion of volatile solids content to gases, reduce pathogens, and improve the stability of biosolids. Common digestion approaches for biosolids include: anaerobic digestion, aerobic digestion, autothermal thermophilic aerobic digestion, and composting.

3.2.1 Anaerobic Digestion

Anaerobic digestion is one of the most commonly implemented technologies for processing biosolids from municipal treatment systems. In the anaerobic digestion

process, microorganisms consume organic components of biosolids in the absence of oxygen. The primary products generated from anaerobic digestion are biogas (generally 60% methane, and 40% carbon dioxide) and residual organic matter. Anaerobic digestion commonly allows destruction of a portion of the volatile suspended solids (VSS) of biosolids, with typical reductions between 40% and 50% or more depending on operating conditions.

Microorganisms employed by the anaerobic digestion process are sensitive to temperature and perform best within specific temperature ranges. Mesophilic digesters (operating at temperatures around 35°C) and thermophilic digesters (operating between 50°C and 57°C) promote the growth of specific organisms that thrive at this temperature and have different operating characteristics.

Anaerobic digestion is very well established both internationally and in Canada and Ontario. Existing anaerobic digestion processes at Kitchener, Waterloo, Galt and Preston WWTPs presently process the majority of the Region's biosolids. In addition, the Region is currently planning to install cogeneration at the Kitchener, Waterloo and Galt WWTP's to offset their electricity consumption.

Process Inputs and Outputs

- Inputs: Waste Activated Sludge or Primary Sludge
- Outputs: Digested biosolids

Process Attributes

Table 3.3 Anaerobic Digestion Process Attributes

Process Feature	Description of Process
Infrastructure Requirements	• Building for process equipment • Substantial space for final storage may be required depending on use and required storage time
Typical Pre-Processing	• Process is typically configured to accommodate dewatered biosolids • Feed biosolids may be un-thickened at 1% to 2%

Process Feature	Description of Process
	solids, or thickened to 5% to 7%
Volume Reduction	• Volume reduction as anaerobic digestion converts complex organic matter into biogas • Minor volume reduction from conversion of organic material to biogas • Dewatering may be incorporated into the process to further reduce volume
Process Odour Emission Potential	• Odour control for hydrogen sulphide and ammonia
Product Odour Emission Potential	• Product odour emission potential is low compared with raw sludge, or un-stabilized biosolids.
Other Air Emissions	• Potential for products of combustion from supporting infrastructure (e.g. steam boiler)
Noise Considerations	• Truck traffic associated with biosolids delivery for processing and distribution of stabilized product. • Building envelope to mitigate process noise • Enclosures may be required for stationary equipment
Considerations for safe operations	• Engineering controls and safety procedures are required to manage elevated temperature, pressure, and pH processes. • Safety considerations associated with combustion of fuel utilized for heating. • Full time operations staff required
Biosolids Product	• Process can be modified to produce either NASM or CFIA fertilizer products
Gas product	• Methane and carbon dioxide
Thermal / Energy product	• Heat from biogas may be used in boilers for heating digester and building
Opportunity for use	• Land application as NASM or CFIA fertilizer (depending upon process)

Process Feature	Description of Process
Disposal considerations	• Biosolids quality and characteristic allows for landfill disposal and incineration
Anticipated Permitting	• ECA for municipal sewage works (upgrades to biosolids processing equipment) • ECA Air and Noise (air emissions from drying and building ventilation)

3.2.2 Aerobic Digestion

Aerobic digestion involves the digestion of biosolids in the presence of oxygen by microorganisms. Unlike anaerobic digestion, biogas is not produced. Conventional aerobic digestion occurs at temperatures between approximately 4°C and 20°C. As the supply of organic matter within the biosolids depletes and becomes limited, microbial biomass is consumed as a food source for the digestion process. Biosolids processed through aerobic digestion should be relatively low in solids content (3.5% or less) to allow mixing and aeration.

Aerobic digestion may also be employed as a post-aerobic digestion (PAD) process following an anaerobic digestion step. The use of PAD may increase VSS destruction by 20-30% above levels achieved through anaerobic digestion alone and provide ammonia removal through nitrification and denitrification. The most common PAD process is presently licensed to a single technology vendor.

Aerobic digestion is a well-established technology, particularly for relative treatment facilities including Region facilities at Ayr and New Hamburg.

Process Inputs and Outputs

- Inputs: PS and/or WAS. Aerobic digestion is most commonly performed on WAS only, Energy/aeration air for aerobic treatment process
- Outputs: Digested biosolids

Process Attributes

Table 3.4 Aerobic Digestion Process Attributes

Process Feature	Description of Process
	• Outdoor digestion tank • Building for supporting process equipment • Substantial space for final product storage may be required depending on use intended use
Typical Pre-Processing	• Optional thickening if necessary to increase solids concentration and SRT.
	• Some volume reduction through volatile suspended solids destruction
Process Odour Emission Potential	• Potential for odour emissions from process. Odour is typically managed through maintaining sufficient dissolved oxygen in process
	• Reduced odour compared to raw, unprocessed biosolids
Other Air Emissions	• None
	• Truck traffic associated with biosolids delivery for processing and distribution of stabilized product. • Building envelope to mitigate process noise • Enclosures may be required for stationary equipment such as feed pumps and blowers.
Considerations for safe operations	• Minimal additional considerations beyond normal treatment process operating practices • Part time operations staff required
	• Stabilized biosolids product meeting NASM standards
Gas product	• No generation of biogas from aerobic process
	• Minimal heat generation
Opportunity for use	• Land application as NASM
Disposal considerations	• Biosolids derived quality and characteristics allows for

Process Feature	Description of Process
	landfill disposal as contingency
Anticipated Permitting	ECA for municipal sewage works

3.2.3 Autothermal Thermophilic Aerobic Digestion

The Autothermal Thermophilic Aerobic Digestion (ATAD) process is an enclosed, in-vessel aerobic digestion process. Biosolids are pre-thickened to between approximately 4% and 6% solids concentration, which is then mixed and aerated in a covered, insulated tank where the digestion process generates heat to warm the reactor vessel. Energy produced through digestion self-sustains the process at a temperature between approximately 50°C and 70°C, the temperature at which thermophilic bacteria are active and a volatile solids reduction of 30% to 50% is achievable. Some ATAD systems may use high purity oxygen to reduce heat loss through aeration of the tank. The ATAD process may produce a CFIA fertilizer product in a relatively small process footprint.

The ATAD process may operate as a single stage (one-tank) or two stage (two-tank) process. The common configuration of modern ATAD systems involves two reactor tanks in series.

ATAD is less commonly implemented than conventional anaerobic and aerobic digestion, but has been implemented at the commercial scale for more than 30 years, particularly in Europe. A number of operating systems are located within Ontario.

Process Inputs and Outputs

- Inputs: thickened biosolids, oxygen/air
- Outputs: Digested biosolids meeting CFIA fertilizer requirements

Process Attributes

Table 3.5 Autothermal Thermophilic Aerobic Digestion Process Attributes

Process Feature	Description of Process
Infrastructure Requirements	• Building for supporting process equipment • Enclosed ATAD digestion tank • Substantial space for final product storage may be required depending on use and required storage time
Typical Pre-Processing	• Feed biosolids are pre-thickened between 4% and 6% solids
Volume Reduction	• Dewatering may be incorporated into the process to reduce volume • Volatile suspended solids reduction through digestion process
Process Odour Emission Potential	• Potential for substantial odour emissions from process including ammonia – based odours
Product Odour Emission Potential	• Product is odourous and requires odour control
Other Air Emissions	• None
Noise Considerations	• Truck traffic associated with biosolids delivery for processing and distribution of stabilized product • Building envelope to mitigate process noise • Enclosures may be required for stationary equipment
Considerations for safe operations	• Engineering controls and safety procedures are required to manage elevated temperature, pressure, and pH processes. • Full time operations staff required
Biosolids Product	• Digested product eligible for CFIA designation for beneficial reuse as fertilizer
Gas product	• No biogas or syngas typically produced / captured
Thermal / Energy product	• Heat released from digestion self-sustains the liquid

Process Feature	Description of Process
	temperature in the tank
Opportunity for use	• Biosolids quality and characteristic meets CFIA regulations for land application, and may be used as a fertilizer
Disposal considerations	• Biosolids quality and characteristic allows for landfill disposal as a contingency
Anticipated Permitting	• ECA for municipal sewage works (Biosolids processing equipment) • ECA Air and Noise (air emissions from drying and building ventilation)

3.2.4 Composting

Composting is an aerobic process in which biosolids are blended with an amendment or bulking agent such as wood chips and allowed to mature under controlled aerobic conditions for beneficial microorganisms to survive. The type and quantity of bulking agent required is dependent on the composting process type. As organic matter is consumed, microbial growth generates heat and elevates the internal temperature of the compost, which inactivates pathogens. Composting processes consist of several stages including:

- Pre-processing (mixing of dewatered biosolids with bulking agent to increase solids and carbon content);
- High-rate composting (mesophilic and thermophilic microbial activity, generally occurring over 14 to 21 days) under aerobic conditions
- Recovery of bulking agent; and
- Curing for further stabilization and compost cooling (generally lasts for 30 days).

Post-processing may also be required to remove inorganic material to meet quality criteria in the Compost Quality Standards (MOECC, 2012) prior to use. Mature compost that meets the Category A quality standard may be used with few restrictions under the NMA. Several types of composting are commonly used for biosolids and organic waste processing, both in Canada and internationally. Composting is a mature technology although some new high-rate processes employing aerated concrete vessels are less common for biosolids processing in Canada.

Process Inputs and Outputs

- Inputs: bulking agent, pre-processed biosolids, preferably following digestion process
- Outputs: stabilized compost

Process Attributes

Table 3.6 Composting Process Attributes

Process Feature	Description of Process
Infrastructure Requirements	• Building for odour control and process equipment • Substantial space for buffer zone and final product storage/curing required • Substantial building area required if full enclosure of composting operations is required for process odour containment
Typical Pre-Processing	• Some degree of digestion is desirable to reduce potential for odour generation • Bulking agent
Volume Reduction	• Bulking agent increases biosolids volume
Process Odour Emission Potential	• Undigested solids has a greater potential for generating odour compared to digested solids
Product Odour Emission Potential	• Product odour emission potential is low compared with raw sludge, or un-stabilized biosolids.

Process Feature	Description of Process
Other Air Emissions	Minimal support infrastructure generating emissions
Noise Considerations	Truck traffic associated with delivery biosolids for processing and distribution of stabilized product.
Considerations for safe operations	- Potential for generation of dust - Full time operations staff required
Biosolids Product	Stabilized biosolids-derived compost product.
Gas product	No biogas or syngas typically produced / captured
Thermal / Energy product	Heat release from microbial activity not significant source of energy for recovery
Opportunity for use	Biosolids quality and characteristics allows for land application NASM or CFIA fertilizer, land reclamation, landfill day cover
Disposal considerations	Biosolids quality and characteristics allows for landfill disposal as a contingency
Anticipated Permitting	ECA for waste management system (soil conditioner waste management system)

3.3 Hydrolysis Technologies

Hydrolysis technologies use a combination of elevated temperature, pH, and / or pressure as well as mechanical force to break down cell structures, and complex compounds into simpler more easily handled and digested material. Hydrolysis technologies are typically presented as thermal hydrolysis, or using a combination of mechanisms.

3.3.1 Thermal Hydrolysis

Thermal hydrolysis is a process through which the cells of microbes within biomass are disrupted under high temperature and pressure. This process homogenizes the biomass and changes its physical characteristics and also allows the organic content

in biosolids to be more readily available for anaerobic digestion, promoting greater biogas generation and increasing anaerobic digester capacity. The technology may also be used following digestion, or on undigested sludge to improve dewaterability and achieve pathogen reduction for use as a CFIA fertilizer product for end use as a dewatered solid or a liquid. The incoming material must be dewatered to around 15% to 20% solids before being fed to the hydrolysis reactor. Solids dewatered to higher solids content may be diluted using a liquid stream. The process exposes the solids to temperatures between 150°C and 170°C at approximately 827 kilopascal (kPa) for around 30 minutes (WEF MOP 8, 2009). Solids are then rapidly decompressed in a flash tank, completing the process.

Thermal hydrolysis is a well-established technology with a number of international and Canadian reference installations (See **Appendix B** for further details). Thermal hydrolysis is not common in Ontario.

Process Inputs and Outputs

- Inputs: Dewatered sludge to around 15% to 20% solids, heat
- Outputs: Stabilized liquid biosolids product

Process Attributes

Table 3.7 Thermal Hydrolysis Process Attributes

Process Feature	Description of Process
Infrastructure Requirements	• Building for process equipment • Substantial tank volume required for product storage • Stabilized biosolids dewatering equipment (if desired)
Typical Pre-Processing	• Dewatering • Aerobic or anaerobic digestion (optional)
Volume Reduction	• Minimal volume reduction through process. • Enhanced dewaterability through post-processing and VSS destruction through digestion
Process Odour Emission	• Closed process with minimal odour release potential

Process Feature	Description of Process
Potential	
Product Odour Emission Potential	• Reduced final product odours relative to conventional processing
Other Air Emissions	• Potential for products of combustion from supporting infrastructure (e.g. steam boiler)
Noise Considerations	• Noise associated with processing equipment • Truck traffic associated with transport of stabilized product
Considerations for safe operations	• Engineering controls and safety procedures are required to manage elevated temperature and pressure processes. • Full time operations staff required • Safety considerations associated with combustion of fuel utilized for heating.
Biosolids Product	• Stabilized product meeting CFIA fertilizer requirements
Gas product	• No biogas or syngas typically produced / captured
Thermal / Energy product	• Process requires heat and does not generate heat
Opportunity for use	• Biosolids quality and characteristics allows for fertilizer and land reclamation
Disposal considerations	• Biosolids characteristics does not allow for landfill disposal because it is a liquefied product
Anticipated Permitting	• ECA for municipal sewage works (Biosolids processing equipment) • ECA Air and Noise (air emissions from boiler and building ventilation)

3.3.2 Combined Hydrolysis (Chemical/Mechanical/Thermal)

Similar to thermal hydrolysis, the combined hydrolysis process disrupts the cell membranes in biomass to produce a homogenized product with improved handling and digesting properties. In addition to thermal input, the combined hydrolysis process uses a combination of mechanic shear and extreme pH to reduce the amount of energy required to complete hydrolysis. Combined hydrolysis is applied to dewatered biosolids to between approximately 15% and 20% solids before being fed to the hydrolysis reactor. Higher-solids cake may be diluted prior to processing. The temperature, pressure, pH and retention time are typically specific to proprietary technologies.

Combined hydrolysis is more recently developed than thermal hydrolysis, and is less established worldwide but has a presence within the Ontario market.

Process Inputs and Outputs

- Inputs: Dewatered biosolids to around 15% to 20% solids
- Outputs: Stabilized liquid biosolids product

Process Attributes

Table 3.8 Combined Hydrolysis Process Attributes

Process Feature	Description of Process
Infrastructure Requirements	• Building for process equipment • Building or tanks for product storage • Dewatering facilities for processed product (optional).
Typical Pre-Processing	• Process is typically configured to accommodate dewatered biosolids
Volume Reduction	• Minimal volume reduction through process. • Enhanced dewaterability through post-processing and VSS destruction through digestion

Process Feature	Description of Process
Process Odour Emission Potential	• Closed process with minimal odour release potential.
Product Odour Emission Potential	• Potential for ammonia emissions from product. • Closed process with minimal odour release potential
Other Air Emissions	• Potential for products of combustion from supporting infrastructure (e.g. steam boiler)
Noise Considerations	• Truck traffic associated with biosolids delivery for processing and distribution of stabilized product. • Building envelope to mitigate process noise • Enclosures may be required for stationary equipment
Considerations for safe operations	• Engineering controls and safety procedures are required to manage elevated temperature, pressure and pH processes. • Safety considerations associated with combustion of fuel utilized for heating. • Full time operations staff required
Biosolids Product	• Stabilized product meeting CFIA fertilizer requirements
Gas product	• No biogas or syngas typically produced / captured
Thermal / Energy product	• Process requires heat and does not generate heat
Opportunity for use	• Biosolids characteristic and quality allows for land application as fertilizer and land reclamation
Disposal considerations	• Biosolids characteristic does not allow for landfill disposal
Anticipated Permitting	• ECA for municipal sewage works (Biosolids processing equipment)

3.4 Drying Technologies

Drying technologies evaporate water to generate a dried product (typically a powder or pellet) which is stable and suitable for use as fertilizer or fuel.

3.4.1 Direct Drying

As part of the direct drying process, heat transfer media (such as hot gas from combustion) directly contacts the dewatered biosolids or digested biosolids. Biosolids entering the drying process typically are dewatered biosolids with a moisture content of >25% solids and are dried to a final product moisture content of >90% total solids. The most common type of direct dryer is the rotary drum dryer. Rotary drums have a long, cylindrical tank that is rotated on bearings. Feed solids and furnace gases enter the inlet head of the dryer and are conveyed to the discharge end. In traditional drum dryers, the feed biosolids is blended with the dried biosolids to improve the ability of the material to move throughout the drum without sticking.

Direct drying is available at the commercial scale and has historically been implemented for a number of biosolids applications in North America. Presently, indirect biosolids drying technologies are more common than direct drying.

Process Inputs and Outputs

- Inputs: Dewatered biosolids, heat
- Outputs: Dried biosolids, residual heat from drying process

Process Attributes

Table 3.9 Direct Drying Process Attributes

Process Feature	Description of Process
Infrastructure Requirements	• Enclosures for drying process equipment and dried product storage • Fuel and heating source such as natural gas or biogas fired furnace
Typical Pre-Processing	• Biosolids dewatering
Volume Reduction	• Substantial biosolids volume reduction as dry solids content of material is raised.

Process Feature	Description of Process
Process Odour Emission Potential	• Enclosed process with minimal air emission • Possible odour emissions associated with discharge of combustion gasses
Product Odour Emission Potential	• Minimal odour emission from dried product
Other Air Emissions	• Air emission associated with discharge of combustion gases
Noise Considerations	• Noise associated with processing equipment • Truck traffic associated with transport of stabilized product
Considerations for safe operations	• Engineering controls are required to safely manage high temperature processes. • Safety considerations associated with combustion of fuel utilized for heating. • Management of dust from product and potential for combustion may be required depending on process equipment type • Full time operations staff required
Biosolids Product	• Stabilized dry product typically in pellet form, meeting CFIA fertilizer requirements
Gas product	• None
Thermal / Energy product	• Waste heat including heat from process gasses may be collected for reuse.
Opportunity for use	• Land application as fertilizer • Marketing as commercial product
Disposal considerations	• Biosolids product may be disposed of in landfill if necessary
Anticipated Permitting	• ECA for municipal sewage works (Biosolids processing equipment)

3.4.2 Indirect Drying

In indirect drying, heat is transferred from the original generation source before drying occurs. This process may reduce the risk of fires, and maintains separation between waste products from heat generation (such as combustion gasses from furnaces) and the dry biosolids product. **Table 3.10** describes two types of indirect dryers.

Table 3.10 Alternatives for Indirect Drying

Indirect Dryer Options	Description
Paddle and Hollow-Flight Dryers	Paddles or hollow-flight structures convey and agitate solids as they come into contact with the heated surfaces within the dryer.
Thin Film Dryers	A heat transfer media is used to heat the outer walls of a rotating drum. Biosolids are dried as they come in contact with the drum surface.
Fluidized Bed	Fluidized bed dryers operate by heating granules which are suspended within the dryer by upward airflow and provide drying of biosolids. Gas is heated indirectly by a heat transfer media and evenly distributed through a bed of granules, resulting in a higher mass and heat transfer from the gas to the solids than through contact with air alone. This dryer is capable of producing a pellet product. Fluidized bed drying may also be operated as an indirect process, with a heat exchanger transferring energy to media within the drying vessel.

Tray Dryers	Vertical configuration. Biosolids are mixed with granules and fed at the top of the dryer. The dryer contains multiple heated stages (or trays), and the biosolids are moved through the dryer by rotating arms with scrapers. Tray dryers may dry biosolids to approximately 95% solids content.

Indirect drying technologies are the most common form of biosolids drying and are well established internationally and in Canada.

Process Inputs and Outputs

- Inputs: Dewatered biosolids, heat
- Outputs: Dried biosolids, residual heat from drying process

Table 3.11 Indirect Drying Process Attributes

Process Feature	Description of Process
Process Feature	• Description of Process
Infrastructure Requirements	• Enclosures for drying process equipment and dried product storage • Fuel and heating source such as natural gas or biogas fired furnace • Heat exchangers for transfer of heat to media and residual energy recovery
Typical Pre-Processing	• Biosolids dewatering
Volume Reduction	• Substantial biosolids volume reduction as dry solids content of material is raised.
Process Odour Emission Potential	• Enclosed process with minimal air emission • Possible odour emissions associated with discharge of combustion gasses
Product Odour Emission Potential	• Minimal odour emission from dried product

Process Feature	Description of Process
Other Air Emissions	• Air emission associated with discharge of combustion gasses
Noise Considerations	• Noise associated with processing equipment • Truck traffic associated with transport of stabilized product
Considerations for safe operations	• Engineering controls are required to safely manage high temperature processes. • Safety considerations associated with combustion of fuel utilized for heating. • Full time operations staff required
Biosolids Product	• Stabilized dry product typically in pellet form, meeting CFIA fertilizer requirements
Gas product	• None
Thermal / Energy product	• Waste heat including heat from process gasses may be collected for reuse.
Opportunity for use	• Land application as fertilizer • Marketing as commercial product
Disposal considerations	• Biosolids product may be disposed of in landfill if necessary

3.5 Thermal Reduction

Thermal reduction is a biosolids disposal technique in which dewatered biosolids are combusted, producing a reduced-volume residual product, hot gasses and heat. Two main types of thermal reduction processes are described below.

3.5.1 Incineration

Thermal reduction of incineration involves the combustion of biosolids to produce ash, hot gasses (flue gas) and heat. There is typically no recovery of gas as a high-value product. Incinerators may be operated with biosolids as the primary source of fuel, or with the addition of supplementary fuels if necessary to achieve proper combustion. Energy produced from incineration may be collected as heat, or for electricity generation. Incineration may be performed on both un-processed biosolids following dewatering, or on biosolids following digestion. Biosolids contain less energy following digestion, and incineration of digested biosolids is unlikely to provide a source of energy for recovery.

Table 3.12 Alternatives for Thermal Reduction

Incinerator Type	Description
Multiple Hearth Incinerator	Multiple hearth incinerators contain several stacked shelves called hearths around a rotating central shaft. Rabble arms attached to the central shaft rotate above each hearth and use metal blades or teeth to slowly rake the solids towards an opening, which allows them to drop onto the hearth below. The incinerator consists of three zones: drying (top hearths), combustion (central hearths), and cooling (bottom hearths). Multiple hearth incinerators are generally viewed as an out-dated technology with poorer emissions performance than current systems and are commonly replaced in favour of fluidized bed incineration or other biosolids Management processes.

Incinerator Type	Description
Fluidized Bed Incinerator	In a fluidized bed incinerator, dewatered biosolids are injected into a furnace containing a bed of sand maintained in suspension (a fluidized bed) by a continuous upflow of air. The biosolids feed is dewatered to between about 20% and 25% solids prior to incineration. The high temperature of the sand bed, between 760°C and 820°C, allows the incinerator to burn volatile solids and evaporate liquid quickly, thereby creating a high gas-to-solid reaction and an increase in the thermal efficiency. Depending on the dryness and composition of the feed biosolids, supplemental fuel may be required. Combustion gas and ashes are exhausted at the top of the incinerator. The ash from the exhaust is removed by a scrubber. Fluidized bed incineration is a common form of thermal reduction with several operating systems in Ontario.

Process Inputs and Outputs

- Inputs: Dewatered Biosolids, Supplemental Fuel, Combustion/Cooling air.
- Outputs: Waste Heat, Combustion Gasses, Ash

Process Attributes

Table 3.13 Thermal Reduction Process Attributes

Process Feature	Description of Process
Infrastructure Requirements	• Enclosures for incineration process equipment feed biosolids and ash product storage

Process Feature	Description of Process
	• Supplemental fuel servicing (e.g. natural gas) for incineration process (if required) • Cooling system/heat recovery infrastructure
Typical Pre-Processing	• Dewatering of biosolids
Volume Reduction	• Significant volume reduction
Process Odour Emission Potential	• Potential odour emission from combustion gasses
Product Odour Emission Potential	• Minimal odour emission from ash product
Other Air Emissions	• Combustion gasses, minor air pollutant constituents.
Noise Considerations	• Noise associated with processing equipment • Truck traffic associated with transport of dewatered biosolids to the incineration facility (if a new-centralized system is constructed) and removal of ash product
Considerations for safe operations	• Engineering controls are required to safely manage high temperature and high pressure processes • Safety considerations associated with combustion of fuel utilized for heating • Full time operations staff required
Biosolids Product	• Ash product
Gas product	• None
Thermal / Energy product	• Potential for recovery of waste heat from combustion
Opportunity for use	• Ash may be reused in building materials such as cement, or as a fertilizer amendment
Disposal considerations	• Ash may be disposed of in landfill if necessary.
Anticipated Permitting	• ECA waste disposal site (thermal treatment facility) • ECA air and noise • ECA municipal and private sewage works (in the event waste water is generated from cooling or exhaust)

Process Feature	Description of Process
	scrubbing activities)

3.5.2 Pyrolysis and Gasification

Pyrolysis and gasification are closed thermal reduction processes that produce an energy-rich by-product which may be combusted later for energy generation. Pyrolysis decomposes organic matter into a solid, carbon-rich product (referred to as biochar) under high temperatures (approximately 400°C to 700°C) in the absence of oxygen. Gasification produces a biochar which reacts with steam at high temperatures to produce a combustible gas known as syngas.

Pyrolysis and gasification technologies are not well established in the North American market. A commercial scale (80 wet tonnes / day) updraft gasifier was implemented in Sanford FL; however other projects (such as a project in Samford, CT) in the US have not progressed from the pilot to the commercial scale due to capital cost and questions related economic viability. Several gasifier installations are located in British Columbia fuelled by waste wood. Overall, this is considered an emerging technology that has not demonstrated widespread commercial viability.

Process Inputs and Outputs

- Inputs: Dried biosolids, fuel amendment (e.g. wood shavings)
- Outputs: syngas, ash

Process Attributes

Table 3.14 Pyrolysis and Gasification Process Attributes

Process Feature	Description of Process
Infrastructure Requirements	• Enclosures for gasification process equipment feed biosolids and ash product storage • Supplemental fuel servicing (e.g. natural gas) for

Process Feature	Description of Process
	incineration process (if required) • Cooling system/heat recovery infrastructure
Typical Pre-Processing	• Dewatering of biosolids • Homogenization of feed solids • Drying of biosolids (may occur within process using waste heat from combustion)
Volume Reduction	• Volume reduced through thermal oxidation of biosolids
Process Odour Emission Potential	• Closed process with minimal odour emission
Product Odour Emission Potential	• Minimal odour emission from ash product.
Other Air Emissions	• Flue gas from oxidation of syngas
Noise Considerations	• Enclosures for incineration process equipment feed biosolids and ash product storage • Supplemental fuel servicing (e.g. natural gas) for incineration process (if required) • Cooling system/heat recovery infrastructure
Considerations for safe operations	• Engineering controls are required to safely manage high temperature and high pressure processes • Safety considerations associated with combustion of fuel utilized for heating • Full time operations staff required
Biosolids Product	• Ash product
Gas product	• Syngas may be directly oxidized or collected and used to power cogeneration equipment.
Thermal / Energy product	• Thermal energy may be collected if syngas is combusted in the process

Process Feature	Description of Process
Opportunity for use	Ash may be reused in building materials such as cement, or as a fertilizer amendment
Disposal considerations	Ash may be disposed of in landfill if necessary.
Anticipated Permitting	- ECA waste disposal site (thermal treatment facility) - ECA air and noise - ECA municipal and private sewage works (in the event waste water is generated from cooling or exhaust scrubbing activities)

3.6 Summary of Core Processing Technologies

Table 3.15 provides a summary of the key attributes of core processing technologies presented here. Further details of each technology are provided in **Appendix B**.

4.0 Pre-treatment, Preparation Technologies and Storage

In order to implement core technologies as part of a biosolids strategy, in many cases there are modifications required to the existing WWTPs, or supporting infrastructure requirements. This section presents some of these supporting processes including: thickening, dewatering and storage. Some technologies presented as “core” treatment technologies such as thermal hydrolysis may also be used as pre-treatment ahead of anaerobic digestion. The processes presented in this section are well established although some are more commonly implemented than others.

4.1 Thickening

Thickening is the process of removing liquid portions of the biosolids to increase the solid content of the end product. By doing so there is a volume reduction that is beneficial for processes such as digestion, dewatering, drying and combustion. Thickening typically increases solids content to between 2% and 6%, and generates a liquid slurry and filtrate that needs to be stored and re-processed through the liquid treatment train.

4.1.1 Gravity

Gravity thickeners are historically a common and effective method for thickening primary sludge or diluted biosolids. Typically, sludge is fed into a tank similar in configuration to a circular primary clarifier with a center feed well where sludge is allowed to settle and compact. Thickened biosolids are withdrawn from the bottom of the tank for further processing. Dilution water may be added to the thickener to maintain aerobic conditions, and to increase the removal of soluble inorganic and organic compounds.

Process Inputs and Outputs

- Inputs: primary sludge or waste activated sludge
- Outputs: thickened biosolids, liquid supernatant

Process Attributes

Table 4.1 Gravity Thickening Process Attributes

Technology Type	Core Treatment Process	Potential to Utilize Gravity Thickening
Stabilization Technologies	Alkaline Stabilization	
	Thermal Stabilization	
Digestion Technologies	Anaerobic Digestion	✓
	Aerobic Digestion	✓
	Autothermal Thermophilic Aerobic Digestion	✓
Composting	Composting	✓
Hydrolysis Technologies	Thermal Hydrolysis	✓
	Combined Hydrolysis	✓
Drying Technologies	Direct Drying	✓
	Indirect Drying	✓
Thermal	Multiple Hearth Incineration	✓

Technology Type	Core Treatment Process	Potential to Utilize Gravity Thickening
Reduction/ Incineration Technologies	Fluidized Bed Incineration	✓
	Pyrolysis and Gasification	✓

Gravity thickening is best suited to processing primary sludge but may also be used to thicken waste activated sludge to a solid concentration of 2% to 5%. Odour generation is a common concern with the gravity thickening process.

4.1.2 Gravity Belt

In gravity belt thickening, polymer is added to biosolids to enhance the separation of solids from water and the mixture is distributed evenly across the width of a moving belt. As biosolids moves along the belt it encounters a series of plow blades which enhance release of liquid from the material. Once the thickened biosolids is removed from the belt, the belt travels through a wash cycle before receiving more biosolids.

Gravity belts are less common than other belt thickening processes as they are prone to odour release, require the addition of a polymer, and are sensitive to biosolids composition. They are still preferred in some applications due to relatively low capital and operating costs. Gravity belts are capable of thickening biosolids to around 4% to 6% solids content.

Process Inputs and Outputs

- Inputs: raw biosolids (e.g. waste activated sludge), polymer
- Outputs: thickened biosolids, liquid filtrate

Process Attributes

Table 4.2 Gravity Belt Process Attributes

Technology Type	Core Treatment Process	Potential to Utilize Gravity Belt
Stabilization Technologies	Alkaline Stabilization	✓
	Thermal Stabilization	
Digestion Technologies	Anaerobic Digestion	✓
	Aerobic Digestion	✓
	Autothermal Thermophilic Aerobic Digestion	✓
Composting	Composting	✓
Hydrolysis Technologies	Thermal Hydrolysis	✓
	Combined Hydrolysis	✓
Drying Technologies	Direct Drying	✓
	Indirect Drying	✓
Thermal Reduction/ Incineration Technologies	Multiple Hearth Incineration	✓
	Fluidized Bed Incineration	✓
	Pyrolysis and Gasification	✓

4.1.3 Rotary Drum

Rotary drum thickeners are a common technology for thickening biosolids. Diluted sludge is mixed with a polymer prior to entering a rotating screen drum where flocculated solids are separated from liquid sludge. Solids exit the rotating drum while liquid passes through the screens. Rotary drum thickening commonly produces good results when used with waste-activated sludge but requires a large quantity of polymer to be added during the conditioning phase. They are a very well established technology both in Ontario and internationally. Rotary drums are able to thicken biosolids to around 4% to 6% solids content.

Process Inputs and Outputs

- Inputs: waste activated sludge or primary sludge, polymer
- Outputs: thickened biosolids, filtrate

Process Attributes

Table 4.3 Rotary Drum Process Attributes

Technology Type	Core Treatment Process	Potential to Utilize Rotary Drum
Stabilization Technologies	Alkaline Stabilization	✓
	Thermal Stabilization	
Digestion Technologies	Anaerobic Digestion	✓
	Aerobic Digestion	✓
	Autothermal Thermophilic Aerobic Digestion	✓

Technology Type	Core Treatment Process	Potential to Utilize Rotary Drum
Composting	Composting	✓
Hydrolysis Technologies	Thermal Hydrolysis	✓
	Combined Hydrolysis	✓
Drying Technologies	Direct Drying	✓
	Indirect Drying	✓
Thermal Reduction/ Incineration Technologies	Multiple Hearth Incineration	✓
	Fluidized Bed Incineration	✓
	Pyrolysis and Gasification	✓

4.1.1 Dissolved Air

Dissolved air floatation (DAF) is a method for thickening biosolids using floatation to separate solids from clarified liquid. Air and water are combined and held at an elevated pressure which causes the air to dissolve. This solution is then released into the liquid where fine bubbles form and carry the solid components to the top of the tank where they are removed. Dissolved air thickening is very effective when used for waste activated sludge treatment, but is less commonly used for primary sludge thickening as gravity settling may be more economical for these types of solids. This is a common technology, both internationally and in Ontario, but is less commonly used for municipal biosolids thickening.

Process Inputs and Outputs

- Inputs: waste activate sludge or primary sludge, polymer (optional)
- Outputs: thickened biosolids, clarified liquid.

Process Attributes

Table 4.4 Dissolved Air Process Attributes

Technology Type	Core Treatment Process	Potential to Utilize Dissolved Air
Stabilization Technologies	Alkaline Stabilization	
	Thermal Stabilization	
Digestion Technologies	Anaerobic Digestion	✓
	Aerobic Digestion	✓
	Autothermal Thermophilic Aerobic Digestion	✓
Composting	Composting	✓
Hydrolysis Technologies	Thermal Hydrolysis	✓
	Combined Hydrolysis	✓
Drying Technologies	Direct Drying	✓
	Indirect Drying	✓
Thermal	Multiple Hearth Incineration	✓

Technology Type	Core Treatment Process	Potential to Utilize Dissolved Air
Reduction/ Incineration Technologies	Fluidized Bed Incineration	✓
	Pyrolysis and Gasification	✓

4.2 Dewatering

Dewatering also serves to remove water from biosolids, increasing solids content to between 20% and 30%, and generating a biosolids cake and centrate.

4.2.1 Centrifuge

Centrifuges can be used both for thickening and dewatering of biosolids. Biosolids entering the centrifuge process are thickened as solids settle and are compacted by centrifugal forces within the centrifuge bowl. Biosolids continuously enters the solid-bowl while a helical mixer (scroll) moves material towards the tapered end of the unit.

Centrifuges are a common technology as the process is clean, achieves good dewatered cake concentrations, contains odours well, and requires moderate polymer dosage depending on a number of sludge characteristics including the conditions in upstream digestion units, ratio between mono- and divalent cations, and protein content. Centrifuges are also used for thickening of biosolids with low starting solids content at a number of facilities. The use of centrifuges as a biosolids processing technology is a very well established technology both in Ontario and internationally.

Process Inputs and Outputs

- Inputs: Raw waste activated sludge or primary sludge, polymer

- Outputs: Dewatered biosolids cake, liquid centrate

Process Attributes

Table 4.5 Centrifuge Process Attributes

Technology Type	Core Treatment Process	Potential to Utilize Centrifugation
Stabilization Technologies	Alkaline Stabilization	✓
	Thermal Stabilization	
Digestion Technologies	Anaerobic Digestion	
	Aerobic Digestion	
	Autothermal Thermophilic Aerobic Digestion	✓
Composting	Composting	✓
Hydrolysis Technologies	Thermal Hydrolysis	✓
	Combined Hydrolysis	✓
Drying Technologies	Direct Drying	✓
	Indirect Drying	✓
Thermal Reduction/ Incineration Technologies	Multiple Hearth Incineration	✓
	Fluidized Bed Incineration	✓
	Pyrolysis and Gasification	✓

4.2.2 Recuperative thickening

Recuperative thickening is a thickening technique associated with anaerobic or aerobic digestion processes (see **Section 3.2.1**) in which biosolids are removed from the digestion process, thickened, and then reintroduced to the digester (WEF, 2012). The objective of the recuperative thickening process is to increase solids retention time (SRT) relative to hydraulic retention time (HRT) to enhance stabilization and biogas production without increasing the size of the digestion vessels. Recuperative thickening can be combined with the technologies described above (except for DAF, which may only be used if biogas is used for floatation). Systems for use with anaerobic digesters are typically implemented by vendors familiar with the challenges associated with digester gas that may evolve from digestate and could be released during the thickening process.

Process Inputs and Outputs

- Inputs: Partially digested biosolids, polymer
- Outputs: Dewatered biosolids, centrate to liquid treatment process

Process Attributes

Table 4.6 Recuperative Thickening Process Attributes

Technology Type	Core Treatment Process	Potential to Utilize Recuperative Thickening
Stabilization Technologies	Alkaline Stabilization	
	Thermal Stabilization	
Digestion Technologies	Anaerobic Digestion	✓
	Aerobic Digestion	✓

Technology Type	Core Treatment Process	Potential to Utilize Recuperative Thickening
	Autothermal Thermophilic Aerobic Digestion	
Composting	Composting	
Hydrolysis Technologies	Thermal Hydrolysis	
	Combined Hydrolysis	
Drying Technologies	Direct Drying	
	Indirect Drying	
Thermal Reduction/ Incineration Technologies	Multiple Hearth Incineration	
	Fluidized Bed Incineration	
	Pyrolysis and Gasification	

Recuperative thickening is a less common technology not well established in Ontario.

4.3 Biosolids Storage

Storage may be provided as part of a biosolids management strategy prior to or following the core processing technology. Storage may serve different purposes including:

- **Emergency Storage:** Emergency storage within the biosolids processing system provides capacity to allow upstream or downstream equipment operation to continue in the event of an equipment failure or short term loss of access to end use / disposal. It is intended to be short-term in nature and may be relatively small in size.
- **Operational Storage:** Operational storage is an integral part of a biosolids management strategy and enables more flexible management of biosolids processing technology, and end use options. This may include:
 - o Storage of pre-treated biosolids prior to the next management step, such as trucked transport to another facility for further processing; and
 - o Storage of treated biosolids-derived products such as, compost, fertilizer, or NASM for land application during appropriate times.

Historically, large facilities in Ontario such as the Halton Region Biosolids Management Centre were designed with capacity to accommodate eight months of biosolids generation following MOECC design guidelines to facilitate agricultural land application, however there are challenges siting these large storage facilities. The purpose of the storage (emergency or operational) may influence the size required, as outlined in below.

Table 4.7 Alternatives for Biosolids Storage

Storage Facility Description	Capacity	Objective
Small Storage System	3 – 30 Days of Storage	Short-term flexibility and emergency storage for short term disruptions to typical management system (Primarily Emergency Storage).
Medium Storage System	30 – 90 days of Storage	Short term flexibility and contingency for short term disruptions to typical

Storage Facility Description	Capacity	Objective
		management system Ability to accumulate some inventory to provide enhanced capacity to adjust to markets for biosolids use and avoid disposal (Emergency Storage or short-term Operational Storage).
Large Storage System	240 days of Storage	Allow accumulation of biosolids for up to 8 months; primarily relevant for facilitating agricultural land application (Primarily long-term Operational Storage).

4.3.1 Liquid Storage

Biosolids generated at individual wastewater treatment sites may be stored in liquid form at low solids content (e.g. 1-3%) in tanks prior to disposal or further processing. Liquid storage allows for the management of biosolids in a state that is suitable for easy handling but requires large storage volumes. Liquid storage has the potential to require large site areas. This approach has been implemented by Halton Region. A substantial amount of truck traffic would be generated by the transport of biosolids to and from the storage facility.

4.3.2 Dewatered Cake Storage

Biosolids may be stored in the form of dewatered cake following processing. Dewatered cake (with increased solids content relative to liquid sludge, 20 to 30%) requires less volume for storage than liquid storage and may be contained in less

costly building structures or open air stockpiles. Open air stockpiling of biosolids may present odour concerns depending on the level of stabilization and pre-processing, and may generate runoff which would require collection and appropriate management. Furthermore, the quality of dewatered biosolids stockpiled over time may change, potentially altering its value for use. This approach was common in Ontario; however it has become increasingly difficult to permit large dewatered cake storage facilities, especially open air stockpiling facilities.

4.3.3 Storage of Other End Products

Storage of other end products may be considered depending on the preferred biosolids processing technology. Solid end products may include biosolids in dried, pelletized, alkaline stabilized or composted form, or thermal reduction by-products such as ash. Storage of these end products requires less volume than liquid biosolids or dewatered biosolids cake due to reduced water content, and may also reduce odour emission concerns because the products are more stable. Additionally, there are fewer requirements for the storage of dried biosolids products (e.g. biosolids derived fertilizers) and compost products than NASM quality dewatered biosolids cake. There are a number of issues related to the storage of thermally stabilized material in silos that need to be dealt with appropriately.

4.4 Summary of Pre-Treatment, Preparation Technologies and Storage

Table 4.8 identifies pre-treatment processes that may be applied to each of the core processing technologies identified in Chapter 3. Core processing technologies requiring dewatered biosolids may also employ one of several thickening technologies ahead of the dewatering stage.

Table 4.8 Pre-Treatment and Biosolids Preparation Summary

	Core Processing Technology											
	Stabilization Technologies		Digestion Technologies			Hydrolysis Technologies		Drying Technologies		Thermal Reduction/Incineration Technologies		
Pre-treatment Process	Alkaline Stabilization	Thermal Stabilization and Pasteurization	Anaerobic Digestion	Aerobic Digestion	Autothermal Thermophilic Aerobic Digestion	Thermal Hydrolysis	Combined Hydrolysis	Direct Drying	Indirect Drying	Multiple Hearth Incineration	Fluidized Bed Incineration	Pyrolysis and Gasification
Centrifuge	✓				✓	✓	✓	✓	✓	✓	✓	✓
Drum Thickener	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dissolved Air Floatation			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Gravity Thickening			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Gravity Belt Thickening	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Belt Press			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Recuperative Thickening			✓	✓								

5.0 Biosolids End Uses and Disposal

This section provides the end uses and disposal options. The market maturity, feasibility, and long-term sustainability of each alternative are considered. A description of each alternative presents the typical approach, and subsections provide specifics within each group. The final subsection presents a summary table of the end use and disposal alternatives considered.

5.1 Use of Biosolids Nutrients

Agricultural application of municipal biosolids has been a common practice in Canada for several decades. As agricultural soil becomes depleted in nutrients and organic matter, the application of biosolids has been proven to replenish some of the soil nutrients which can increase crop yield. A number of agricultural and non-agricultural uses of biosolids nutrients are described below. Additional applications may be available and can be evaluated on a case-by-case basis.

5.1.1 Biosolids Used as Non-Agricultural Source Material

The Ontario Nutrient Management Act, 2002, S.O. 2002, c. 4 (NMA) provides the framework for biosolids use as a Non-Agricultural Source Material (NASM) in agriculture. Digested and dewatered biosolids are considered a Category 3 NASM unless they meet the quality criteria for Fertilizers or Compost. Nutrients, metals and pathogen content are key aspects of biosolids quality that restrict use in agriculture. Nutrients measured as part of required testing are used to determine application rates in a NASM Plan. The person preparing the plan must have a NASM Plan Development Certificate, and is required to ensure the biosolids application rate is based upon site specific conditions and the biosolids quality. The concentration of regulated metals must remain below maximum concentrations in the regulation, and the maximum application rate for Category 3 NASMs is 22 dry tonnes per hectare per five year period (NMA, 2013). There are a number of criteria that may reduce the application rate below the maximum including:

- Crop nutrient requirements, mainly plant available nitrogen (PAN) and plant available phosphate (PAP); and
- Metals content.

In most cases phosphate limits the five year application rate for municipal biosolids.

The available area for application is reduced by setbacks required for wells, surface waters and odour receptors.

A restriction as part of the NMA for biosolids is that these materials shall not be applied to land during the restricted period, December 1st to March 31st, or when the ground is frozen or snow covered. The restricted period generates the need for substantial storage or alternate management over winter. In terms of storage at the site of application, the maximum duration allowed for dewatered biosolids is 10 days.

Methods used to apply biosolids vary based on the land type and the consistency of the biosolids. Liquid biosolids require special equipment which injects the biosolids into the soil while dewatered biosolids can be applied and mixed into soil with conventional agricultural equipment (US EPA, 2000).

Land application of biosolids is often a cost effective alternative for biosolids management. Public acceptance of land application is a potential challenge, related to environmental and quality of life concerns as well as emerging contaminants of concern. These issues are further addressed in Technical Memo #3. The seasonal limits to land application periods may require large storage capacities, or diversion of material to alternate use or disposal during winter.

Applicability of Management Approach

Table 5.1 Applicability of NASM Management Approach

Core Treatment Process	Ability to Use Biosolids as NASM
Alkaline Stabilization	
Thermal Stabilization	
Anaerobic Digestion	✓
Aerobic Digestion	✓
Autothermal Thermophilic Aerobic Digestion	✓
Composting	
Thermal Hydrolysis	
Combined Hydrolysis	

Core Treatment Process	Ability to Use Biosolids as NASM
Direct Drying	✓
Indirect Drying	✓
Multiple Hearth Incineration	
Fluidized Bed Incineration	
Pyrolysis and Gasification	

5.1.2 Biosolids Derived Fertilizers

There are technologies presented in Section 4 that generate a product that meets the requirements of the Federal Fertilizers Regulation as administered by the CFIA for biosolids derived fertilizers. Alkaline stabilization, combined hydrolysis, and thermal dryers are examples of technologies that have been used in Ontario to generate and market a fertilizer product. In order to sell any product as a fertilizer in Canada, it must meet the labelling and safety requirements of the regulation.

Biosolids derived fertilizers are generally lower risk to human health than NASM quality biosolids products. This enhanced quality of biosolids-derived fertilizer provides benefits in terms of operational flexibility such as:

- Fewer restrictions on agricultural use as part of the NMA;
- Potential to access additional markets such as commercial landscaping;
- Greater potential for use at Landfills as daily cover; and
- More flexible storage options.

Application rates are limited by the nutrient content, and recommendations provided by the fertilizer producer in order to meet labelling requirements.

Applicability of Management Approach

Table 5.2 Applicability of Biosolids Derived Fertilizer Approach

Core Treatment Process	Applicability to Use of Biosolids Derived Fertilizer
Alkaline Stabilization	✓
Thermal Stabilization	✓
Anaerobic Digestion	✓
Aerobic Digestion	✓
Autothermal Thermophilic Aerobic Digestion	✓
Composting	✓
Thermal Hydrolysis	✓
Combined Hydrolysis	✓
Direct Drying	✓
Indirect Drying	✓
Multiple Hearth Incineration	
Fluidized Bed Incineration	
Pyrolysis and Gasification	

5.1.3 Land Reclamation

Land reclamation is a form of application of biosolids meeting at least NASM quality requirements to areas that lack soil fertility, or have soil with poor physical properties. The application of biosolids aids in the rejuvenation process by increasing the soil quality and, thereby, increasing biodiversity (CCME, 2012a).

Biosolids have high organic content, which helps soils retain water, and has been shown to improve crop yield. Soils with land-applied biosolids show better aeration and root penetration, and have a reduced erosion risk. Benefits to ecosystem health include habitat creation through increased vegetative cover (CCME, 2012a). Biosolids supply essential plant micronutrients which are not found in conventional fertilizers, and are slow-release fertilizers, releasing nutrients at equal rates to plant uptake, leading to less nutrient leaching (Lu, He, & Stoffella, 2012).

Applicability of Management Approach

Table 5.3 Applicability of Land Reclamation

Core Treatment Process	Applicability to Use of Biosolids for Land Reclamation
Alkaline Stabilization	✓
Thermal Stabilization	✓
Anaerobic Digestion	✓
Aerobic Digestion	✓
Autothermal Thermophilic Aerobic Digestion	✓
Composting	✓

Core Treatment Process	Applicability to Use of Biosolids for Land Reclamation
Thermal Hydrolysis	✓
Combined Hydrolysis	✓
Direct Drying	✓
Indirect Drying	✓
Multiple Hearth Incineration	
Fluidized Bed Incineration	
Pyrolysis and Gasification	

5.1.4 Mine and Tailings Pond Reclamation

Surface mines typically stockpile the organic topsoil and reapply it to the mine during the reclamation process. However, due to decomposition through the stockpiling period, concentrations of organic matter and nutrients may diminish. Biosolids may be added as an amendment to the soil through a single high rate application or through periodic application events. The use of biosolids has the additional benefit of suppressing dust generation and improving slope stability. Additionally, the use of lime-stabilized biosolids may have the added benefit of reducing the generation of acid mine drainage by increasing the pH of the soil (BC MOE, 2015).

Mine tailings ponds are another area of mine sites where mostly inorganic material is accumulated after the valuable portion of ore has been recovered. In Ontario there is an ongoing project to use NASM quality biosolids to enhance soil quality at closed

portions of mine tailings ponds in order to increase vegetation growth. The objective of reclamation is to re-vegetate closed areas of the mine tailings ponds to limit erosion, and the potential for impacted water quality run-off such as acid mine drainage.

In addition to use in surface mines, biosolids may also be applied to rehabilitate stone and gravel quarry sites.

Application rates are defined in ECAs specific to the reclamation sites and regulated by the MOECC.

Applicability of Management Approach

Table 5.4 Applicability of Mine and Tailings Pond Reclamation

Core Treatment Process	Applicability to Use of Biosolids for Mine and Tailings Pond Reclamation
Alkaline Stabilization	✓
Thermal Stabilization	
Anaerobic Digestion	✓
Aerobic Digestion	✓
Autothermal Thermophilic Aerobic Digestion	✓
Composting	✓
Thermal Hydrolysis	
Combined Hydrolysis	

Core Treatment Process	Applicability to Use of Biosolids for Mine and Tailings Pond Reclamation
Direct Drying	
Indirect Drying	
Multiple Hearth Incineration	
Fluidized Bed Incineration	
Pyrolysis and Gasification	

5.1.5 Forestry

The application of biosolids in forested areas can enhance tree growth, understory vegetation and wildlife habitats. Biosolids can also be applied to commercial woody biomass crops that are produced for fibre and wood products (i.e. pulp and paper industry) to increase the crop yield (CCME, 2012a).

For example, in British Columbia, biosolids are used to fertilize short-rotation intensive culture of fast growing trees such as hybrid poplar and Christmas trees. The biosolids act as a slow-release fertilizer and can increase the timber production by up to 75% (BC MOE, 2015).

Applicability of Management Approach

Table 5.5 Applicability of Forestry Approach

Core Treatment Process	Applicability to Use of Biosolids for Forestry
Alkaline Stabilization	✓
Thermal Stabilization	✓
Anaerobic Digestion	✓
Aerobic Digestion	✓
Autothermal Thermophilic Aerobic Digestion	✓
Composting	✓
Thermal Hydrolysis	
Combined Hydrolysis	
Direct Drying	✓
Indirect Drying	✓
Multiple Hearth Incineration	
Fluidized Bed Incineration	
Pyrolysis and Gasification	

NASM quality biosolids are most likely to be used in forestry applications. Biosolids derived fertilizers could also be used in forestry applications; however it is likely that this would be a secondary end use when agricultural use is not available.

5.2 Landfill Operational Use

Biosolids meeting appropriate quality requirements, such as those satisfying Ontario NASM guidelines and meeting leachate generation guidelines under Ontario Regulation 347 may be used at landfills as daily cover. Biosolids use provides an alternative to other materials such as soil or wood chips commonly used for this purpose.

Biosolids that meet the NASM criteria can be used for landfill daily cover; however, concerns over odour emission potentially limit this approach in practice. Products with enhanced stability such as biosolids derived fertilizers or compost have lower odour emission potential, and are more likely candidates for use as landfill daily cover.

Applicability of Management Approach

Table 5.6 Applicability of Landfill Operational Use Approach

Core Treatment Process	Applicability to Use of Biosolids for Landfill Operational Purposes
Alkaline Stabilization	✓
Thermal Stabilization	✓
Anaerobic Digestion	✓
Aerobic Digestion	✓
Autothermal Thermophilic Aerobic Digestion	✓
Composting	✓
Thermal Hydrolysis	✓

Core Treatment Process	Applicability to Use of Biosolids for Landfill Operational Purposes
Combined Hydrolysis	✓
Direct Drying	✓
Indirect Drying	✓
Multiple Hearth Incineration	
Fluidized Bed Incineration	
Pyrolysis and Gasification	

5.3 Industrial Use of Ash (Disposal per CCME document)

For thermal reduction technologies that produce an ash product, the material must be disposed to landfill, or used as an industrial input. The most commonly referenced approach is the use of ash as a substitute for lime in cement production. Examples of implementation of this approach were not identified in Ontario, but there are a few examples in the United States (e.g. Philadelphia)

Applicability of Management Approach

Table 5.7 Applicability of Industrial Use of Ash

Core Treatment Process	Applicability to Industrial Use of Ash
Alkaline Stabilization	

Core Treatment Process	Applicability to Industrial Use of Ash
Thermal Stabilization	
Anaerobic Digestion	
Aerobic Digestion	
Autothermal Thermophilic Aerobic Digestion	
Composting	
Thermal Hydrolysis	
Combined Hydrolysis	
Direct Drying	
Indirect Drying	
Multiple Hearth Incineration	
Fluidized Bed Incineration	✓
Pyrolysis and Gasification	✓

5.4 Energy Recovery

Energy recovery alternatives are those that produce fuel, electricity, or useable heat with a net positive energy balance. Primary sludge has the highest energy content (23,000 – 29,000 kJ/kg total solids), while secondary sludge, or waste activate

activated sludge is slightly lower (20,000 – 23,000 kJ/kg total solids). Once anaerobically digested, volatile solids are converted to biogas with a lower energy content of 9,000 – 14,000. Biosolids can typically be processed with net positive energy when the total solids content is 30 – 35% (CCME, 2012b). Biosolids combustion is considered a beneficial use by the CCME and biosolids may be included in the definition of renewable biomass fuel in Ontario. Beneficial use of biosolids as a fuel for specific industries may be evaluated on a case-by-case basis.

5.4.1 Biogas

Anaerobic digestion technologies generate biogas with the potential for energy recovery.

Pre-treatment technologies such as thickening, or combining core technologies such as hydrolysis with anaerobic digesters as well as co-digestion can be used to enhance production of biogas and the reduction of volatile solids in the biosolids product. The use of co-digestion as an enhancement of existing digester operation within Region treatment facilities is covered in the Region's ongoing Wastewater Treatment Master Plan.

In order to use biogas, it can be combusted to produce useful heat, and / or electricity in stationary applications, or compressed for use as a vehicle fuel. Use of biogas for applications such as vehicle fuel requires more complex pre-treatment processing to meet quality requirements.

The Region is in the process of implementing combined heat and power projects at its Kitchener, Waterloo and Galt WWTPs to utilize the current biogas produced for electricity/heat production for use before the meter for electricity generation. This is addressed in the Region's ongoing Wastewater Treatment Master Plan.

There are no large scale examples identified in Ontario where biogas is compressed for vehicle fuel. There are a number of ongoing biogas projects including a facility in

the City of Surrey, BC, the Rural Green Energy Project in Southwest Ontario and the Hamilton Renewable Natural Gas project for re-injection of biogas into the natural gas distribution system.

Applicability of Management Approach

Table 5.8 Applicability for Biogas Use

Core Treatment Process	Applicability to Use of Biosolids for Biogas
Alkaline Stabilization	
Thermal Stabilization	
Anaerobic Digestion	✓
Aerobic Digestion	
Autothermal Thermophilic Aerobic Digestion	
Composting	
Thermal Hydrolysis	
Combined Hydrolysis	
Direct Drying	
Indirect Drying	
Multiple Hearth Incineration	
Fluidized Bed Incineration	

Core Treatment Process	Applicability to Use of Biosolids for Biogas
Pyrolysis and Gasification	✓

5.4.2 Renewable Natural Gas

Renewable natural gas (RNG) is generated by upgrading biogas such that it is interchangeable with pipeline quality natural gas. RNG projects from wastewater treatment plants in Ontario were not identified. Incentives to develop RNG projects are anticipated to grow over the planning period in order to displace a portion of the fossil fuel natural gas in distribution pipelines.

5.4.3 Electricity Generation

Electricity generated from biogas or direct combustion of biosolids is eligible for a preferred rate for the electricity distributed to the grid as part of programs administered by Ontario's Independent Electricity System Operators (IESO). Biogas projects where a grid connection is available with capacity less than 500 kW are eligible for a feed-in-tariff rate, and projects greater than 500 kW have previously been eligible under the large renewable procurement (LRP) program (although the future of this program is uncertain at this time).

Applicability of Management Approach

Table 5.9 Applicability for Electricity Generation

Core Treatment Process	Applicability to Use of Biosolids for Electricity Generation
Alkaline Stabilization	

Core Treatment Process	Applicability to Use of Biosolids for Electricity Generation
Thermal Stabilization	
Anaerobic Digestion	✓
Aerobic Digestion	
Autothermal Thermophilic Aerobic Digestion	
Composting	
Thermal Hydrolysis	✓
Combined Hydrolysis	✓
Direct Drying	
Indirect Drying	
Multiple Hearth Incineration	✓
Fluidized Bed Incineration	✓
Pyrolysis and Gasification	✓

5.4.4 Combined Heat and Power

Combined heat and power projects generate electricity and heat for use. An example would be the planned reciprocating engine cogeneration projects planned at Kitchener, Waterloo and Galt WWTPs where electricity will be generated and used for

processes like aeration in the liquid treatment train, and heat will be recovered for use at the anaerobic digesters.

5.4.5 Industrial Energy Recovery

Industrial energy recovery projects are those that use biosolids as a fuel source. The most commonly referenced example is the cement industry, where waste heat from cement production is used to dry biosolids, which are then blended with raw materials. Volatile solids are combusted in the cement kiln displacing fossil fuels for heating, and the ash content is incorporated into the cement product. This approach has been piloted in North America; however no examples of ongoing implementation were identified in Ontario. There is an operating facility in Philadelphia, which in basic terms brings dried biosolids for combustion to a cement kiln.

5.5 Disposal Options

Disposal options are those that do not take advantage of nutrient value or energy content of biosolids. The most common disposal method is landfilling, with thermal reduction also in use in Ontario.

5.5.1 Landfill

Disposal of biosolids in a landfill is expensive due to the significant tipping fees charged at most landfill sites. In addition, landfilling often requires biosolids to be dewatered to at least 18-20% solids to prevent the creation of excess leachate, adding additional cost to the disposal process. The biosolids needs to pass the “slump test” to be accepted to landfill disposal. In some instances, landfilling has been viewed as a more publically acceptable alternative as it may be less likely to create public concern than incineration or end uses such as land application (UN-HABITAT, 2008).

Landfilling is the most likely disposal route for residuals produced through incineration and may be considered as an alternative for other core processing technologies in the event end use alternatives are unavailable.

Several countries in Europe have legally banned the disposal of biosolids in landfills (UN HABITAT, 2008). In Canada, Nova Scotia and Prince Edward Island introduced additional restrictions and taxes to discourage this form of biosolids disposal (UN-HABITAT, 2008). Land application is the primary method of biosolids management in these jurisdictions.

Applicability of Management Approach

Table 5.10 Applicability for Landfill

Core Treatment Process	Applicability to Dispose of Biosolids via Landfill
Alkaline Stabilization	✓
Thermal Stabilization	✓
Anaerobic Digestion	✓
Aerobic Digestion	✓
Autothermal Thermophilic Aerobic Digestion	✓
Composting	✓
Thermal Hydrolysis	
Combined Hydrolysis	
Direct Drying	✓

Core Treatment Process	Applicability to Dispose of Biosolids via Landfill
Indirect Drying	✓
Multiple Hearth Incineration	✓
Fluidized Bed Incineration	✓
Pyrolysis and Gasification	✓

5.5.2 Thermal Reduction (Incineration)

Combustion of biosolids to an ash product without energy recovery is not considered a biosolids use and is considered a disposal approach. The ash residual from the combustion process could be used as a soil conditioner and source of phosphorus, as raw materials for industrial processes like cement production, or disposed in landfill.

Applicability of Management Approach

Table 5.11 Applicability for Thermal Reduction (Incineration)

Core Treatment Process	Applicability to Dispose of Biosolids via Thermal Reduction (Incineration)
Alkaline Stabilization	
Thermal Stabilization	

Core Treatment Process	Applicability to Dispose of Biosolids via Thermal Reduction (Incineration)
Anaerobic Digestion	
Aerobic Digestion	
Autothermal Thermophilic Aerobic Digestion	
Composting	
Thermal Hydrolysis	
Combined Hydrolysis	
Direct Drying	
Indirect Drying	
Multiple Hearth Incineration	✓
Fluidized Bed Incineration	✓
Pyrolysis and Gasification	

5.6 Summary of End Uses and Disposal

Table 5.12 provides a summary of end use and disposal technologies which may be considered for each of the core processing technologies identified in Chapter 4 of this technical memo.

Table 5.12 Biosolids End Use Summary

	End Use									Disposal		
Core Processing Technology	Agricultural Use		Land Reclamation		Forestry	Landfill Use	Energy Recovery			Disposal Options		
	NASM application	Biosolids-Derived Fertilizer	Mine Reclamation	Stone and Gravel Site Reclamation	Forestry Use	Landfill Day Cover	Electricity Generation	Heat	Fuel	Landfilling of Residual	Landfill Disposal of Biosolids	Thermal Reduction
Alkaline Stabilization		✓	✓	✓	✓	✓					✓	
Pasteurized		✓	✓	✓	✓	✓					✓	
Anaerobic Digestion	✓	✓	✓	✓	✓				✓		✓	
Aerobic Digestion	✓	✓	✓	✓	✓	✓					✓	
Autothermal Aerobic Digestion	✓	✓	✓	✓	✓	✓					✓	
Composting		✓	✓	✓	✓	✓					✓	
Thermal Hydrolysis		✓	✓	✓	✓							
Combined Hydrolysis		✓	✓	✓	✓							
Direct Drying	✓	✓	✓	✓	✓	✓			✓	✓	✓	
Indirect Drying	✓	✓	✓	✓	✓	✓			✓	✓	✓	
Multiple Hearth Incineration							✓	✓		✓		✓
Fluidized Bed Incineration							✓	✓		✓		✓
Pyrolysis and Gasification									✓	✓		

6.0 References

- British Columbia Ministry of Environment (BC-MOE). 2015. Biosolids FAQ and Case Studies. Available Online:
http://www2.gov.bc.ca/assets/gov/environment/waste-management/recycling/organics/biosolids_faq_and_case_studies.pdf. Last Accessed: August 11, 2016.
- Canadian Council for Ministers of the Environment (CCME). 2010. A Review of the Current Canadian Legislative Framework for Wastewater Biosolids. PN 1446. Available Online:
http://www.ccme.ca/files/Resources/waste/biosolids/pn_1446_biosolids_leg_review_eng.pdf. Last Accessed: August 11, 2016.
- Canadian Council for Ministers of the Environment (CCME). 2012a. Guidance Document For The Beneficial Use Of Municipal Biosolids, Municipal Sludge And Treated Septage. PN 1473. Available Online:
http://www.ccme.ca/files/Resources/waste/biosolids/pn_1473_biosolids_guidance_eng_1.0.pdf. Last Accessed: March 22, 2016.
- Canadian Council for Ministers of the Environment (CCME). 2012b. Guidance Document For The Beneficial Use Of Municipal Biosolids, Municipal Sludge And Treated Septage. PN 1473. Available Online:
http://www.ccme.ca/files/Resources/waste/biosolids/pn_1473_biosolids_guidance_eng_1.0.pdf. Last Accessed: March 22, 2016.
- Canadian Water and Wastewater Association (CWWA). 2007. Beneficial Uses of Municipal Wastewater Residuals - Biosolids. Available Online:
[http://www.cwwa.ca/cbp-pcb/pdf%20files/BENEFICIAL%20USES%20OF%20MUNICIPAL%20WASTEWATER%20RESIDUALS%20\(BIOSOLIDS\)%20-%20FINAL%20REPORT.pdf](http://www.cwwa.ca/cbp-pcb/pdf%20files/BENEFICIAL%20USES%20OF%20MUNICIPAL%20WASTEWATER%20RESIDUALS%20(BIOSOLIDS)%20-%20FINAL%20REPORT.pdf). Last Accessed: August 11, 2016.
- Metcalf & Eddy, Inc., George Tchobanoglous, Franklin Burton, H. David Stensel. 2002. Wastewater Engineering: Treatment and Reuse. (2002) (4th ed.).
- Ontario Ministry of the Environment and Climate Change (MOECC). 2012. Ontario Compost Quality Standards. PIBS 8412. Queen's Printer Ontario.

- United Nations Human Settlements Programme (UN-HABITAT). 2008. Global Atlas of Excreta. Available online: <http://unhabitat.org/books/global-atlas-of-excreta-wastewater-sludge-and-biosolids-management/>. Last Accessed: March 24, 2016.
- United States Environmental Protection Agency (EPA). 2000. Biosolids Technology Fact Sheet - Land Application Of Biosolids. EPA 832-F-064. Available Online: https://www3.epa.gov/npdes/pubs/land_application.pdf. Last Accessed: August 11, 2016.
- Water Environment Federation (WEF). 2009. Design of Municipal Wastewater Treatment Plants. McGraw Hill, New York.
- Water Environment Federation (WEF). 2012. Solids Process Design and Management. McGraw Hill, New York.

Appendix A

Biosolids Processing Technology Summaries

Alkaline Stabilization

Principle of Operation

Alkaline stabilization is a chemical-based treatment process which achieves the stabilization and pathogen inactivation of biosolids through a combination of elevated pH and temperature, (at least 70 C) for a pre-determined duration. The pH of the biosolids is raised to at least 12 through alkaline addition, and is mixed for an appropriate contact time to create an environment that inactivates or destroys the pathogens and other microorganisms. The reaction of alkaline products with sludge generates heat which provides additional pathogen reduction. Typical alkaline additions used are hydrated lime (Ca(OH)_2) and quicklime (CaO). Other alternative sources include NaOH, cement kiln dust, potassium hydroxide, and fly ash. The alkaline addition may occur before dewatering (pre-treatment) or after dewatering (post-treatment). For post dewatering applications alkaline material is added to dewatered cake with a solids concentration between 18% and 25% (National Manual of Good Practice for Biosolids, 2005).

End Uses and Disposal Options

Biosolids-derived fertilizer, site reclamation, forestry reuse, landfill day cover

General Operational & Maintenance Considerations

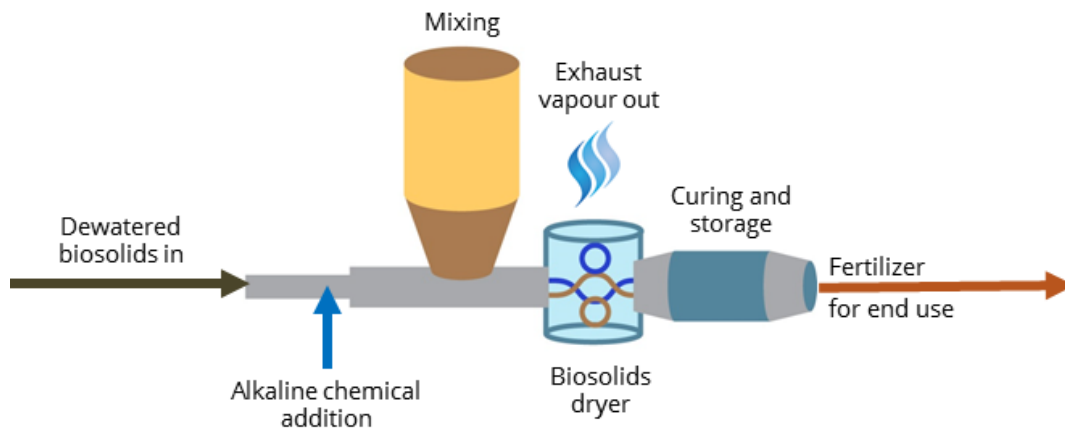
- Uncomplicated system that does not involve specialized operation skills
- The degree of mixing is important to maintain a homogenous product

Limitations of Technology

- Potential for pathogen regrowth if pH drops below 9.5 while material is being stored
- Odours from ammonia gas are produced and should be treated before it is exhausted. Odours may be associated with the treatment process (indoor) and to a lesser degree with the treated product.
- Alkaline stabilized biosolids are most appropriate for low pH soils, availability of land area with appropriate soil type may limit use
- Increased transportation management and cost due to volume increases of biosolids from alkaline chemical addition (increases by approximately 15% to 50% (US EPA, 2000))

- Nutrient content in alkaline stabilized biosolids is lower than other stabilization methods. Nitrogen may be converted to ammonia and lost through volatilization as part of the process (US EPA, 2000)

Typical Schematic



Common Vendors

N-Viro Systems, BioFIX, Schwing Bioset, RDP Technologies

Example Installations

N-Viro systems have seven Canadian installations including:

- Banff, Alberta
- Halifax, Nova Scotia
- Summerside, Prince Edward Island
- Leamington, Sarnia, Niagara, and Sudbury Ontario

Schwing Bioset operates a system in London, Ontario. Additional vendors have a number of installations in North America and overseas.

Thermal Stabilization or Pasteurization

Principle of Operation

Thermal stabilization or pasteurization raises the temperature of the biosolids, typically liquid waste activated sludge (WAS) prior to digestion or other processing, above 70°C for at least 30 minutes. This process provides pathogen reduction with limited effect on the total volatile solids. Depending on the vendor specific process it may also provide some benefit for biogas recovery. It can be implemented before or after digestion, or after dewatering depending on the configuration of the specific vendor process. Thermal stabilization typically includes heat exchangers to heat incoming biosolids, with heat recycle to capture energy from treated biosolids. It can be configured to use the heat energy from a combined heat and power boiler system or biogas energy recovery system. Equipment handling raw biosolids with the potential for biogas generation should have appropriate explosion classification ratings.

End Uses and Disposal Options

Biosolids derived fertilizer, landfill day cover, land reclamation, landfill disposal

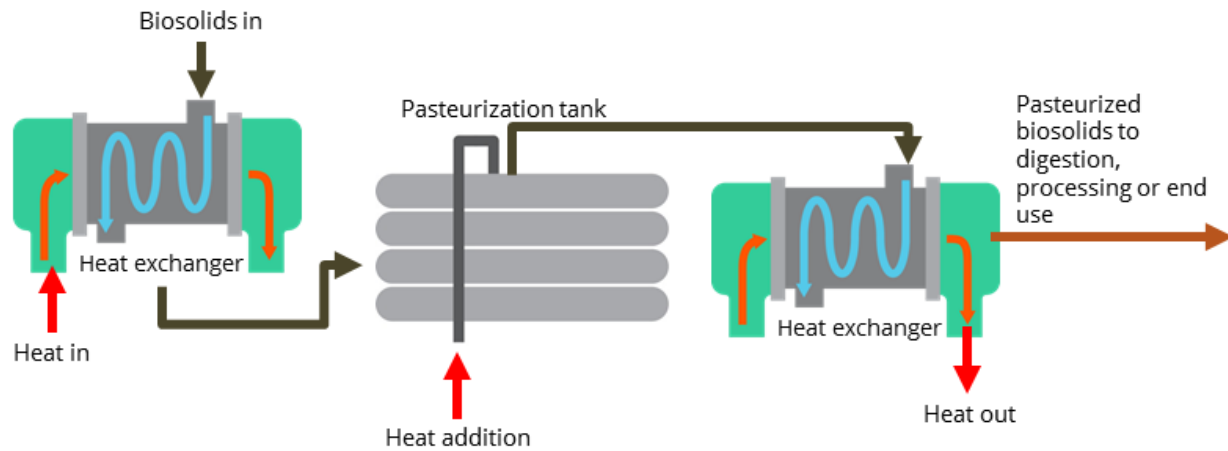
General Operational & Maintenance Considerations

- Mixing must be carefully controlled to ensure all biosolids is treated, and to maintain uniform heating
- Batch process is used to prevent the biosolids being from being re-contaminated

Limitations of Technology

- Standard pasteurization procedure does not destroy bacteria endospores (Arthurson, 2008)
- Potential regrowth of pathogens and odours during storage

Typical Schematic



Common Vendors

GE offers a thermal pasteurization system not combined with chemical addition, Kruger BioPasteur, Ashbrook Eco-Therm

Example Installations

GE Installation: Rexburg, Idaho

Anaerobic Digestion

Principle of Operation

Anaerobic digestion has been the most commonly implemented technology used to process biosolids. It is similar to aerobic digestion, with the exception that the microorganisms decompose the biomass in the absence of oxygen. The primary products generated from anaerobic digestion are biogas (generally 60% CH₄, and 40% CO₂, with other trace components) and residual organic matter. Volatile suspended solids reduction between 40% and 50% can be achieved.

The microorganisms that decompose the organic content of the biomass prefer to live within specific temperature ranges where mesophilic digesters operate at temperatures around 35°C, and thermophilic digesters operate between 50°C to 57°C.

Feed may be un-thickened sludge from primary and secondary clarifiers with between 1% and 2% solids, or thickened to approximately 5% to 7% (WEF MOP 8, 2010). Some pre-treatment options such as hydrolysis are being implemented to enhance biogas production, and allow adequate mixing during the digestion process with solids concentrations at approximately 10%.

Several different types of anaerobic digestion processes are commercially available. Several main technologies available are summarized below.

Process Options	Description
Single-Stage High-Rate	The sludge is heated and fed at a uniform or timed cycle rate to achieve optimum digestion rates. Multiple digester feed points are used to reduce shock loading to the microorganisms. It is important that digested biosolids are drawn out before adding new, undigested sludge. Single stage digesters may be operated under mesophilic conditions (temperature around 35°C), or thermophilic conditions (temperature between 50°C to 57°C).

Process Options	Description
Two-Stage	Two tanks are arranged in series, such that each performs a different function. The two-staged options are explained below. Mesophilic Digestion The first and second stages are heated and mixed to allow for anaerobic digestion. The first phase provides conditions to break complex organic compounds to simple compounds, mainly volatile organic acids at a pH less than 6 with a relatively short retention time (typical 1 – 2 days). The second stage provides conditions for methogenesis (production of biogas) and requires a higher pH and longer retention time. There is also the option of using the second stage as a solids-liquid separator. Temperature-Phased Anaerobic Digestion The first stage is operated under thermophilic conditions (around 55°C), and the second stage is operated under mesophilic conditions (around 35°C). This configuration utilizes thermophilic temperatures to enhance reaction rate and organics destruction and mesophilic conditions to reduce digested biosolids odour and enhance dewatering characteristics.
High Solids	The digester is designed to process feed sludge with increased solids concentrations of up to 20%. High solids anaerobic digestion is relatively uncommon but is being pursued in some North American applications for treatment of organic solid waste.
Anaerobic Co-Digestion	Organic rich feedstocks (such as fats, oils, grease, and food waste) are added to anaerobic digesters in addition to wastewater biosolids. Anaerobic co-digestion may be considered to provide a beneficial alternative to divert organic wastes from landfills, enhance biogas production by providing additional readily available organic feedstock or allow excess digester capacity to be used.

End Uses and Disposal Options

- Land application as NASM or CFIA fertilizer (if digestion technologies producing CFIA stabilized biosolids are implemented), land reclamation, landfill disposal, incineration

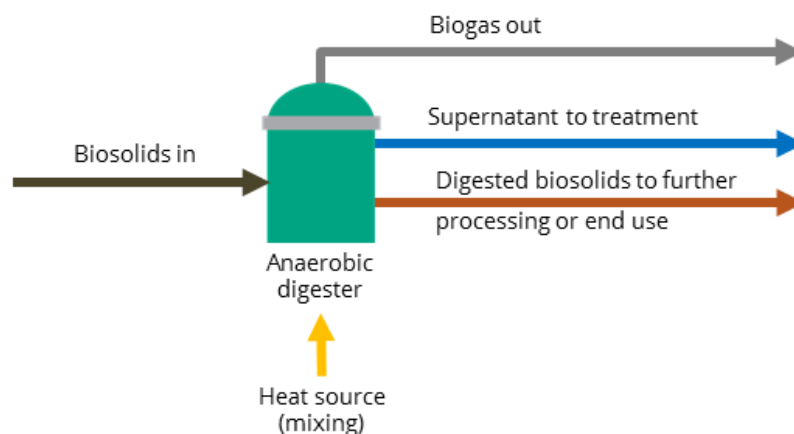
General Operational & Maintenance Considerations

- Maintaining the operating temperature at a stable temperature is important as temperature significantly affects the performance and stability of digestion
- pH range between 6.8 and 7.2 is the optimum pH condition for producing methane (WEF MOP 8, 2010)
- Excessive foaming may form
- Minimum HRT of 15 days should be maintained (MOECC, 2008)

Limitations of Technology

- Generation of potential explosive and corrosive gases
- Acquiring additional feedstock for co-digestion such as the organic fraction of municipal solid waste may substantially increase the mass of biosolids that requires management
- Explosion classification areas are required surrounding digesters and biogas infrastructure increasing the cost and complexity of electrical equipment.

Typical Schematic



Common Vendors

Conventional wet anaerobic digestion has been implemented for many years as part of the biosolids management train at wastewater treatment plants and is considered a very mature technology / treatment approach. Innovation including phased digestion, high solids approaches, and co-digestion are relatively less common and represent newer entries to the market although these technologies are gaining a presence in Canada.

Example Installations

Anaerobic digestion is currently implemented at the Region's wastewater treatment plants in Kitchener, Waterloo, Galt, and Preston. It is well established at a number of other Ontario treatment facilities.

Aerobic Digestion

Principle of Operation

Aerobic digestion involves the breakdown and digestion of organic components of biosolids in the presence of oxygen. Conventional aerobic digestion occurs at temperatures between approximately 4°C to 20°C and may be performed in open tanks. Aerobic digestion does not typically produce a product suitable for beneficial use as fertilizer, but products may meet NASM quality guidelines.

End Uses and Disposal Options

Land application as NASM, land reclamation, landfill disposal

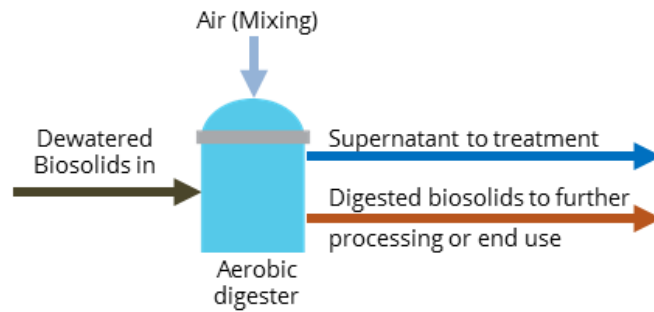
General Operational & Maintenance Considerations

- Reduced efficiency during cold weather
- High operating cost for aeration
- System has tendency to drop to a pH around 5.5, and should be frequently monitored to prevent filamentous bacteria growth. Other primary process indicators include temperature, DO, odour, and settling characteristics
- Maintain DO at 1 mg/L to 2 mg/L
- Intermittent aeration (settle, decant, denitrify)
- Minimum SRT of 45 days (including upstream activated sludge process)

Limitations of Technology

- Pathogen reduction rate is lower than anaerobic digestion, therefore the necessary retention times for stabilization may be longer
- Diffuser plugging and surface fouling on porous diffusers are a potential issue (WEF MOP 8, 2010)
- Performance is sensitive to temperature, location, tank geometry and material, mixing and aeration type, concentration of feed solids
- Typically used for waste-activated sludge only. Aerobic digestion has been used to digest primary sludge; however, the process requires significantly more oxygen demand and a higher retention time (WEF MOP 8, 2010)

Typical Schematic



Common Vendors

Aerobic digestion has been implemented for many years as part of the solids train at wastewater treatment plants and is considered a very mature technology / treatment approach.

Example Installations

Aerobic digestion is currently implemented at the Region's wastewater treatment plants in Hespeler, New Hamburg, Ayr, and Heidelberg.

Autothermal Aerobic Digestion (ATAD)

Principle Operation

ATAD uses concepts from both the conventional and high-purity oxygen aerobic digestion techniques. Waste sludge is pre-thickened to around 4% and 6% solids concentration, then is mixed and aerated in a covered, insulated tank. Aeration may use high purity oxygen to reduce heat stripping from aeration air. The exothermic energy produced during the microbial oxidation process self-sustains the process temperature, and is maintained between approximately 50°C and 70°C (MOE Sewage Guidelines, 2008), which is the temperature thermophilic bacteria are active. Volatile solids reduction of 30% to 50% is achievable.

A single stage or multi-stage approach may be used; however, the single stage arrangement does not reduce pathogens to the same extent as the multi-stage configuration.

End Uses and Disposal Options

Land application NASM or fertilizer, land reclamation, landfill disposal

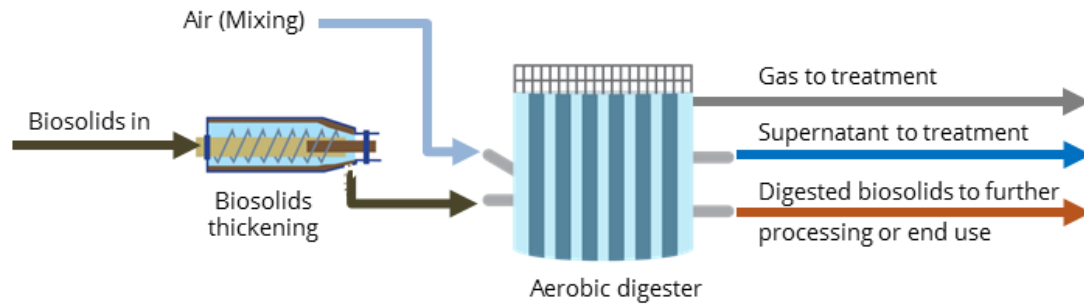
General Operational & Maintenance Considerations

- Simple operation
- Temperature control and solids monitoring are important
- Foam control is important because it can inhibit oxygen transfer
- The minimum VSS concentration can range from 2.5% to 5%
- Typical total HRT of 10 days
- Ammonia odours released, potentially requiring treatment process for off-gas collected from the covered ATAD process tanks.

Limitations of Technology

- Effect of heat and corrosion on longevity of the ATAD tank
- Tank environment inhibits nitrification because of the high temperature
- Poor dewaterability characteristics
- Sidestream contain high concentrations of nutrients that require additional treatment

Typical Schematic



Common Vendors

Fuchs, Thermal Process Systems

Example Installations

Thermal Process Systems has installed 6 systems in Ontario including facilities in Morrisburg, Penetanguishene and Amherstview

Composting

Principle of Operation

As part of the composting process, dewatered biosolids with a solids content of 13% to 40% solids is blended with a bulking agent (such as wood chips, sawdust) to produce the solids content required for the specific composting process selected (WEF MOP 8, 2010). Final composted biosolids solids content may be approximately 60%. Microorganisms within the compost mixture reduce the organic content of biosolids and decrease pathogen content through heat generation. A number of composting technologies are available including: aerated static-pile, turned windrow, and in-vessel. All technologies involve aerating the compost pile, typically in a batch processing configuration for the specified number of days (3 to 15) required for a technology in order to stabilize the pile.

End Uses and Disposal Options

Land application NASM or fertilizer, land reclamation, landfill day cover, landfill disposal

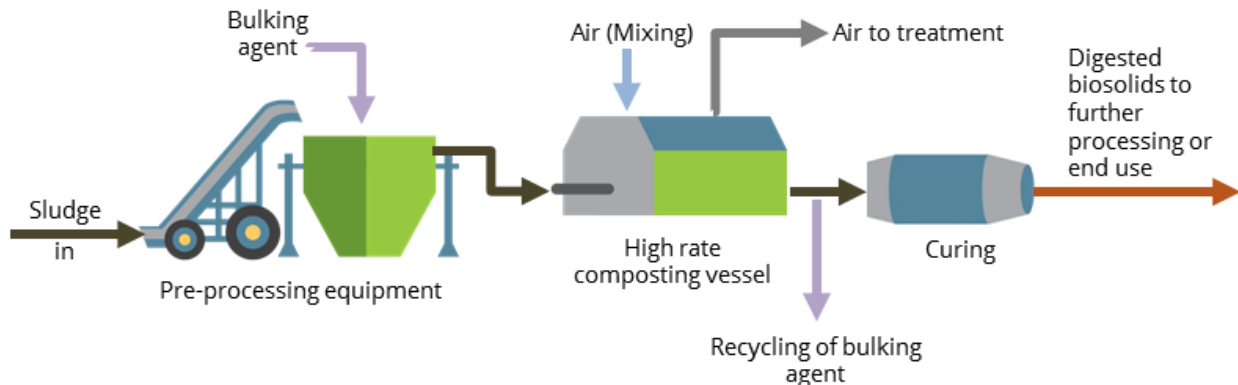
General Operational & Maintenance Considerations

- Control aeration based on oxygen demand, temperature, and moisture removal
- Monitor and record compost pile temperature, moisture content, and measures of stability as required by the Compost Quality Standards (MOECC, 2012)
- Labour intensive (bulking agents must be added and removed, storage piles must be maintained for curing, mechanical equipment required to move compost throughout the composting process)
- Additional O&M for leachate produced from the composting process
- Odour management for receiving, pre-processing, composting, and curing is required to mitigate the risk of nuisance impacts

Limitations of Technology

- Inconsistent biosolids quality (Metals concentration affects Quality Category)
- Open windrow composting is likely to face challenges meeting environmental permitting requirements for odour management
- Land requirements for processing operation

Typical Schematic



Common Vendors

A number of vendors offer equipment for turned windrow composting and aerated static pile systems. More complex in-vessel composting technologies are offered by vendors including Christiaens and Adverio.

Example Installations

- Banff and Fort McMurray, Alberta
- Prince Albert, Saskatchewan

Thermal Hydrolysis

Principle of Operation

Thermal hydrolysis may be used as a pre-treatment step prior to anaerobic digestion or as a stand-alone process to homogenize sludge and reduce pathogen content. As part of the hydrolysis process cells within the biosolids are ruptured under high temperature and pressure, typically through addition of steam. Biosolids are dewatered to around 15% to 20% solids before being fed to the hydrolysis reactor. The material is exposed to temperatures between 150°C and 170°C at approximately 827 kPa for around 30 minutes (WEF MOP 8, 2010). The biosolids are then rapidly decompressed in a flash tank, producing a liquefied product.

End Uses and Disposal Options

Land application as fertilizer, land reclamation

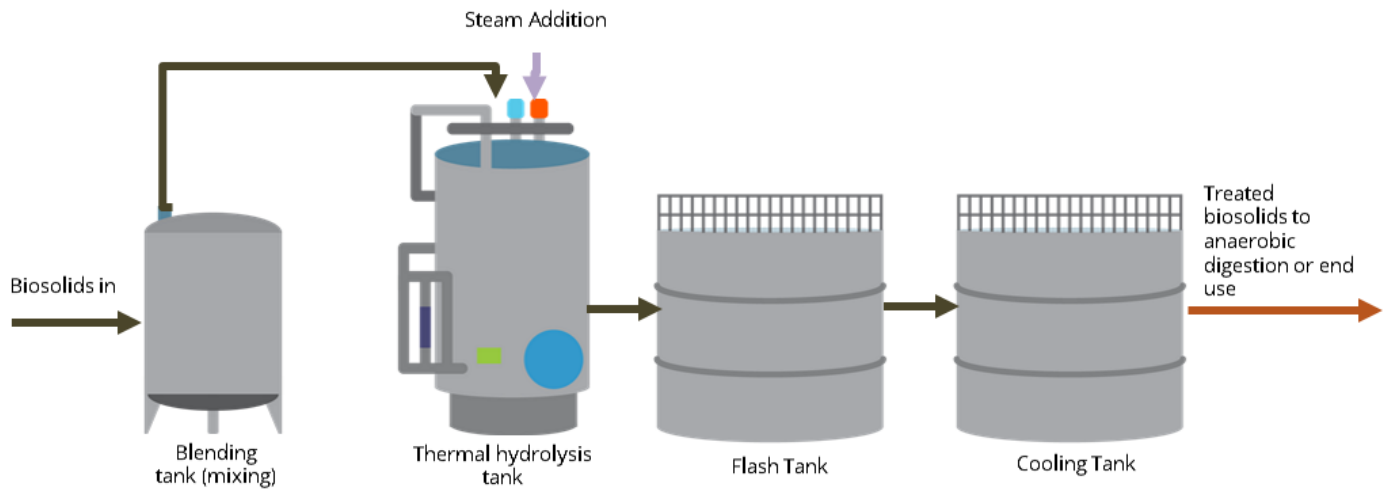
General Operational & Maintenance Requirements

- Complex operation and rigorous maintenance program
- Biosolids require storage tank for cooling, if the process is included in wastewater treatment and treated biosolids would be recycled to anaerobic digestion (biosolids must be cooled from approximately 165°C to about 40°C for mesophilic anaerobic digestion)
- Operates under batch or continuous condition (dependent on proprietary process used)

Risks to Consider

- Formation of salt crystallization resulting in maintenance issues and deterioration of dewaterability (Barber, 2016)

Typical Schematic



Common Vendors

Cambi Systems, Veolia/Kruger, Sustec, SH&E Group

Example Installations

- Washington DC (Blue Plains)
- Several pending North American installations including City of Calgary

Combined Hydrolysis (Chemical/Mechanical/Thermal)

Principle of Operation

Combined hydrolysis has the objectives as thermal hydrolysis; however a combination of mechanic shear and extreme pH are used to reduce the amount of energy required to elevate the temperature and pressure. Similar to thermal hydrolysis, it involves the process of making the organic content in biosolids more readily available for anaerobic digestion by rupturing cell walls under high temperature and pressure. Combined hydrolysis is applied to dewatered biosolids to around 15% to 20% solids before being fed to the hydrolysis reactor. The temperature (70-75°C), pressure, pH (9.5-10) and retention time are typically specific to proprietary technologies.

End Uses and Disposal Options

Land application as fertilizer, land reclamation

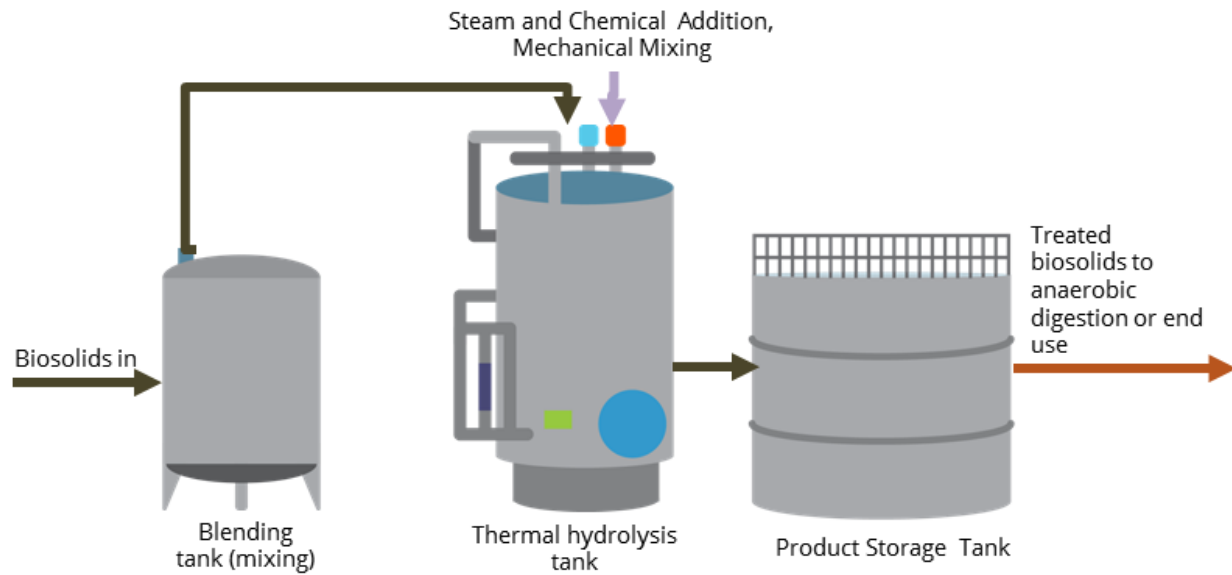
General Operational & Maintenance Considerations

- Product may be stored for long period of time without regrowth of pathogens
- Product can be pumped and transported through closed pipes
- Modes of operation are continuous, semi-continuous and pure batch

Limitations of Technology

- Mixer has a high energy requirement
- Liquid storage required for product
- End use limited to land application as fertilizer.

Typical Schematic



Common Vendors

Lystek

Example Installations

Lystek has 5 installations in Ontario including the City of Guelph, Town of St. Marys and City of Perborough.

Direct Drying

Principle of Operation

Heat is used to reduce the moisture content in the biosolids to produce a thermally dried product (referred to as pellets or granules). The heat transfer media (commonly 80°C or more) in direct dryers comes into contact with the dewatered sludge or digested biosolids. Moisture content of the feed material is typically reduced to the limit of dewatering >25% solids. Dried product moisture content is typically >90% total solids.

Direct Dryer Options	Description
Rotary Drum	Rotary drums have a long, cylindrical tank that is rotated on bearings. Feed solids and furnace gases enter the inlet head of the dryer and are conveyed to the discharge end. The feed biosolids is blended with the dried biosolids to form a blended mixture with a moisture content around 65%. This improves the ability of the blended biosolids to move throughout the drum without sticking.

End Uses and Disposal Options

Land application as NASM or fertilizer, land reclamation, landfill day cover, landfill disposal, incineration / thermal energy production

General Operational & Maintenance Considerations

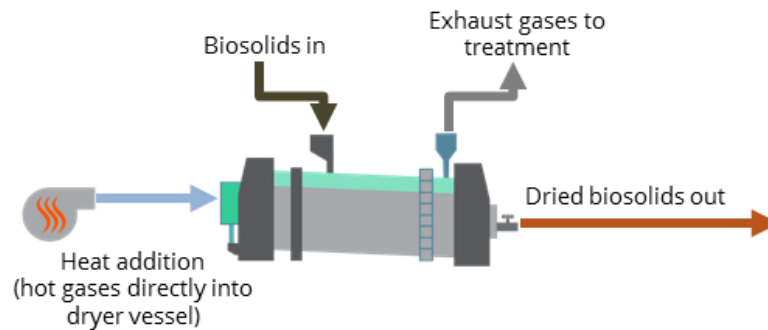
- Air/fuel ratio must be checked and tested before starting up the furnace
- Uniform feeding to maintain effective drying
- Vapours from biosolids are released and must be separated and treated from the biosolids

Limitations of Technology

- Fine particles and dryness creates a deflagration hazard
- Capital construction and utility costs, particularly utility costs may be substantial relative to other solids processing options (WEF Residuals & Biosolids Committee, 2014)

- Potential for fires in the dryer and storage silos
- Abrasive-resistant materials are required due to continuous contact with dried biosolids material

Typical Schematic



Common Vendors

Andritz, Haarslev, Synagro, Veolia

Example Installations

Large scale implementation in the US in cities including Philadelphia and Honolulu,. Several other smaller scale US installations. Canadian references not presently identified.

Indirect Drying

Principle of Operation

Heat is transferred from the heat-transfer media to the biosolids through a material (the heat-transfer media does not come in direct contact with the biosolids).

Options	
Tray Dryers	Vertical configuration. Biosolids are mixed with granules and fed at the top of the dryer. The dryer contains multiple heated stages (or trays), and the biosolids are moved through the dryer by rotating arms with scrapers.

End Uses and Disposal Options

Land application as NASM or fertilizer, land reclamation, landfill day cover, landfill disposal, incineration of dried biosolids product, with recovery of residual energy.

General Operational & Maintenance Considerations

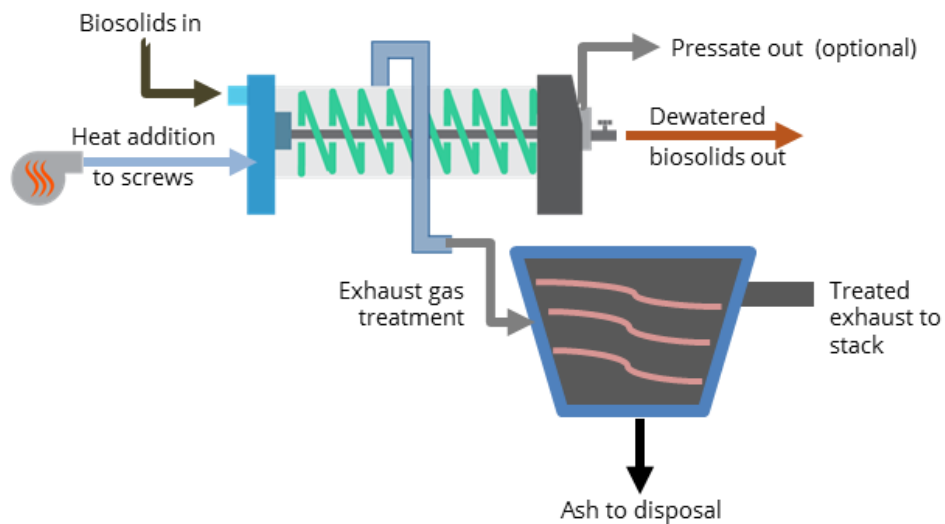
- Air/fuel ratio must be checked and tested before starting up the furnace
- Uniform feeding to maintain effective drying

Limitations of Technology

- Capital construction and utility costs, particularly utility costs may be substantial relative to other solids processing options (WEF Residuals & Biosolids Committee, 2014)
- Potential for fires in the dryer and storage silos

- Thermal efficiency decreases when product is dried to around 90% (drying time must increase, or dried biosolids must be recycled) (National Biosolids Partnership, 2005)

Typical Schematic



Common Vendors

Veolia, Keppel Seghers, Vomm

Example Installations

- Ashbridges Bay Wastewater Treatment Plant, Toronto
- Stickney Water Reclamation Plant, Chicago
- Black River Wastewater Treatment Plant, Ohio
- Vomm: City of Montreal (under construction)

Advanced Thermal Oxidation

Multiple Hearth Incineration

Principle of Operation

Multiple hearth incinerators are used to incinerate dewatered biosolids. The incinerator contains several stacked shelves (or hearths). A typical multiple hearth incinerator has 5 to 12 hearths (EPA, 2003). In the centre of the hearths, a rotating shaft has rabble arms that are attached above each hearth. Each rabble arm contains metal blades (or rabble teeth) to slowly rake the solids towards the middle of the hearth, where it drops to the edges of the hearth below. The rabble teeth also chop the solids in. There are three zones within the incinerator: drying (top hearths), combustion (central hearths), and cooling (bottom hearths). Thermal oxidation in a multiple hearth incinerator typically occurs at a maximum of 870°C, with cooler temperatures common in upper hearths which may result in less complete combustion (WEF, 2014)

Air is introduced at the lowest hearth to cool the ashes before disposal. As the air moves concurrent to the solids in the incinerator, the heat released from the solids in the combustion stage heats the air. This hot air cools down at the top hearths because it releases heat to dry the incoming biosolids.

The ashes are collected at the bottom of the incinerator and fall into an ash hopper. Feed solids are dewatered to at least 15% solids.

End Uses and Disposal Options

Landfill

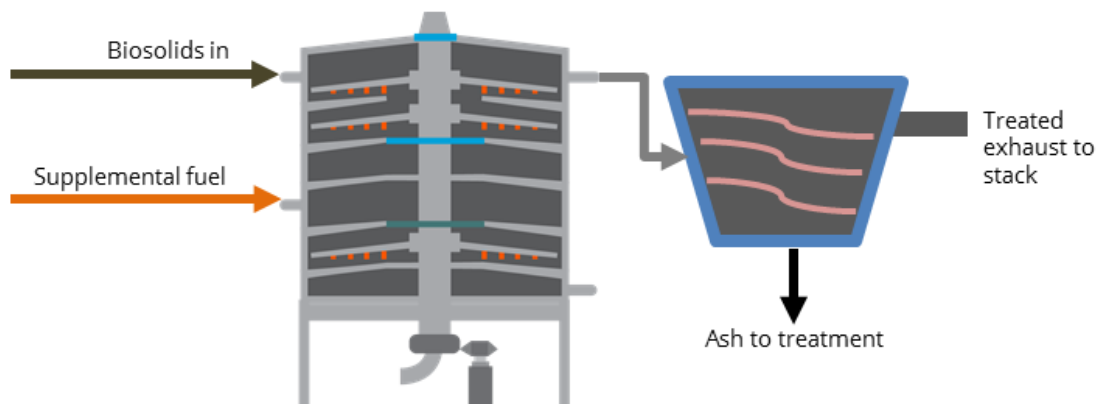
General Operational & Maintenance Considerations

- Air pollution and odour control issues
- Incinerator is sensitive to changes in feed characteristics, such as flow rate and moisture (Dangtran et al., 2000)
- Requires specially trained operators
- Operates at high levels of excess air to prevent creating areas that are deficient in oxygen
- Biosolids stabilization is unnecessary because it reduces the volatile content and energy content

Limitations of Technology

- Low excess air levels increases emissions of CO, soot, and hydrocarbons (A.J. Chandler & Associates, 2006)
- Operation is not as efficient as the fluidized bed reactor (such as emitting a higher concentration of contaminants, and has a higher operating cost)

Typical Schematic



Common Vendors

Wyse

Example Installations

- Technology is considered out-dated and is currently not commonly used. Existing multiple hearth facilities are generally being replaced with fluidized-bed systems.

Fluidized Bed Incineration

Principle of Operation

The fluidized bed is a sand bed that is kept in fluid condition by an upflow of combustion air. The temperature of sand bed is maintained between 760°C and 820°C to burn the volatile fraction of the solids and evaporate the liquid, which creates a high gas-to-solid reaction that increase the thermal efficiency. Combustion gas and ashes are exhausted at the top of the incinerator. The ash from the exhaust is removed by a scrubber.

End Uses and Disposal Options

Landfill

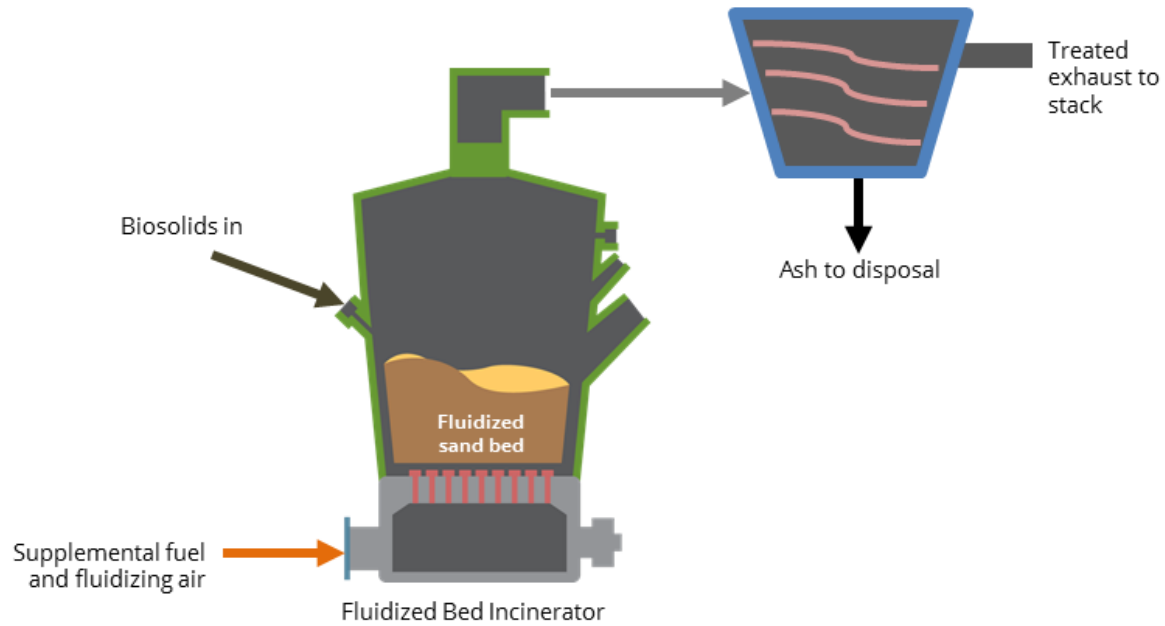
General Operational & Maintenance Considerations

- Combustion controlled by modifying the air flow and dewatered biosolids flowrate
- Daily start-up and shutdown is possible

Limitations of Technology

- Potential build-up of residual matter that requires cleaning
- Formation of eutectic mixtures that fuse to the furnace
- Bed degradation

Typical Schematic



Common Vendors

Degremont, Waterleau

Example Installations

- GE Booth (Lakeview) Wastewater Treatment Plant, Mississauga
- Greenway Pollution Control Plant, London
- Duffin Creek Water Pollution Control Plant, Pickering

Pyrolysis and Gasification

Principle of Operation

Pyrolysis decomposes organic matter into a solid, carbon-rich product (referred to as biochar, or a similar product used for carbon sequestrations, soil amendment, and/or use as fuel) under high temperatures (approximately 400° C to 700°C) in the absence of oxygen. In the gasification phase, the biochar reacts with steam (temperatures of approximately 850°C to 1,200°C) to produce a gas (referred to as syngas). Syngas is a low energy content gas (typically contains 100 to 130 BTU/Ft³ compared to 950 BTU/ft³ for natural gas) that is primarily consists of CO, H₂, and N₂. This process occurs after the biosolids has been dried to around 85% to 93% solids.

There are different configurations of gasifiers that may be used for municipal application:

- Fixed Bed (Updraft and Downdraft)
 - Updraft suitable for small scale application, whereas downdraft is suitable for medium scale application
- Fluidized Bed
 - The media (sand) is kept in suspension by air or oxygen and steam
 - Suitable for large scale applications

End Uses and Disposal Options

Landfill

General Operational & Maintenance Considerations

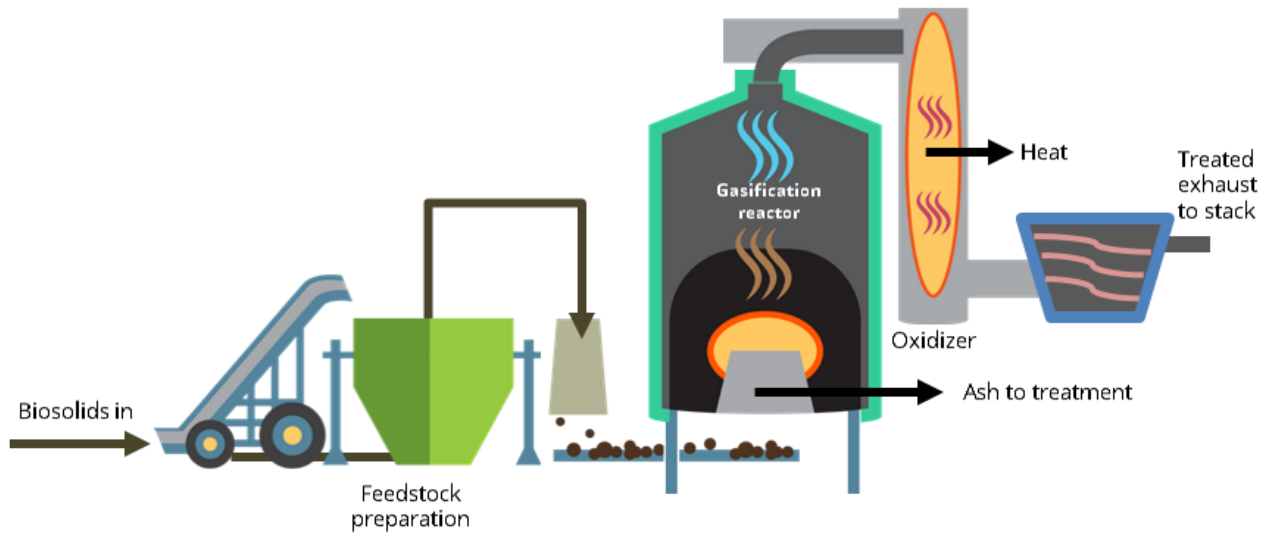
- Expensive process as biosolids have comparatively low caloric content to other feedstocks and must be dried before gasification representing a substantial energy input and decrease in net energy generation (MOP 8, 2010)
- Oxygen levels need to be maintained at less than 15% in the dryer
- Undigested biosolids preferred to be used as the feed material
- Considered an emerging technology with limited installations operating using biosolids worldwide

Limitations of Technology

- Requires specialized operator experience
- High capital and operating costs

- Potential for explosion
- Syngas cleaning is required for direct firing in internal combustion or gas engines (Pytlar, T. et al, 2010)

Typical Schematic



Common Vendors

Nexterra, Primenergy

Example Installations

- Two wastewater treatment plants in Germany
- Tokyo Bureau of Sewerage, Japan
- Nexterra: 4 gasification process installations in British Columbia

References

- A.J. Chandler & Associates Ltd. 2006. Review of Dioxins and Furans from Incineration In Support of a Canada-wide Standard Review.
- Arthurson, V. 2008. Proper sanitation of sewage sludge: A critical issue for a sustainable society. *Applied Environmental Microbiology*, 74(17), 5267-5275.
- Barber, W. 2016. Thermal hydrolysis for sewage treatment: A critical review. *Water Research*, 104, 53-71
- British Columbia Ministry of Environment (BC-MOE). 2015. Biosolids FAQ and Case Studies. Available Online:
http://www2.gov.bc.ca/assets/gov/environment/waste-management/recycling/organics/biosolids_faq_and_case_studies.pdf . Last Accessed: August 11, 2016.
- Canadian Council for Ministers of the Environment (CCME). 2010. A Review of the Current Canadian Legislative Framework for Wastewater Biosolids. PN 1446. Available Online:
http://www.ccme.ca/files/Resources/waste/biosolids/pn_1446_biosolids_leg_review_eng.pdf. Last Accessed: August 11, 2016.
- Canadian Council for Ministers of the Environment (CCME). 2012a. Guidance Document For The Beneficial Use Of Municipal Biosolids, Municipal Sludge And Treated Septage. PN 1473. Available Online:
http://www.ccme.ca/files/Resources/waste/biosolids/pn_1473_biosolids_guidance_eng_1.0.pdf. Last Accessed: March 22, 2016.
- Canadian Water and Wastewater Association (CWWA). 2007. Beneficial Uses of Municipal Wastewater Residuals - Biosolids. Available Online:
<http://www.cwwa.ca/cbp-pcb/pdf%20files/BENEFICIAL%20USES%20OF%20MUNICIPAL%20WASTEWATER>

[%20RESIDUALS%20\(BIOSOLIDS\)%20-%20FINAL%20REPORT.pdf](#). Last Accessed: August 11, 2016.

Dang, T., Mullen, J., and Mayrose, D. 2000. *A comparison of fluid bed and multiple hearth biosolids incineration*. Paper presented at the Annual Residuals & Sludge Management Conference, Boston, MA. Retrieved from http://www.degremont-technologies.com/cms_medias/pdf/tech_infilco_biosolids.pdf

Metcalf & Eddy, Inc., George Tchobanoglous, Franklin Burton, H. David Stensel. 2002. *Wastewater Engineering: Treatment and Reuse* (4th ed.).

Ontario Ministry of the Environment – Waste Management Policy Branch. 2012. Ontario Compost Quality Standards. Available online: <https://www.ontario.ca/page/ontario-compost-quality-standards>. Last Accessed: July 20, 2016.

Pytlar, S. 2010. *Status of existing biomass gasification and pyrolysis facilities in North America*. Paper presented at the Annual North American Waste-to-Energy Conference, Orlando, FL.

Roy, M., Dutta, A., Corscadden, K., Havard, P., & Dickie, L. 2011. Review of biosolids management options and co-incineration of a biosolid-derived fuel. *Waste Management*, 31(11), 2228-2235. Available online: <http://dx.doi.org/10.1016/j.wasman.2011.06.008>. Last Accessed: August 11, 2016.

United Nations Human Settlements Programme (UN-HABITAT). 2008. *Global Atlas of Excreta*. Available online: <http://unhabitat.org/books/global-atlas-of-excreta-wastewater-sludge-and-biosolids-management/>. Last Accessed: March 24, 2016.

United States Environmental Protection Agency (EPA). 2000. *Biosolids Technology Fact Sheet – Alkaline Stabilization of Biosolids* – Alkaline Stabilization of

Biosolids. EPA 832-F-00-052. Available Online:

<https://nepis.epa.gov/Exe/ZyPDF.cgi/901U0R00.PDF?Dockey=901U0R00.PDF>.

Last Accessed: July 7, 2016.

United States EPA. 2006. Biosolids Technology Fact Sheet – Heat Drying. EPA 832-F-06-029. Available Online:

<https://nepis.epa.gov/Exe/ZyPDF.cgi/P10053EN.PDF?Dockey=P10053EN.PDF> .

Last Accessed: August 22, 2016.

United States EPA. 2000. Biosolids Technology Fact Sheet - Land Application Of Biosolids. EPA 832-F-064. Available Online:

https://www3.epa.gov/nepdes/pubs/land_application.pdf. Last Accessed:

August 11, 2016.

United States EPA. 2002. Biosolids Technology Fact Sheet – Use of Composting for Biosolids Management. EPA 832-F-02-024. Available Online:

https://www.epa.gov/sites/production/files/2015-06/documents/use_of_composting_for_biosolids_management.pdf. Last

Accessed: July 11, 2016.

United States EPA. 2003. Biosolids Technology Fact Sheet – Use of Incineration for Biosolids Management. EPA 832-F-03-013. Available Online:

<https://nepis.epa.gov/Exe/ZyPDF.cgi/P10053DX.PDF?Dockey=P10053DX.PDF>.

Last Accessed: July 28, 2016.

Water Environment Federation. 2012. Solids Process Design and Management. McGraw Hill, New York.

Water Environment Federation National Biosolids Partnership. 2005. National Manual of Good Practice for Biosolids.

Water Environment Federation National Biosolids Partnership. 2014. Drying of wastewater solids fact sheet. Available Online:

http://www.wrrfdata.org/NBP/DryerFS/Drying_of_Wastewater_Solids_Fact_Sheet_January2014.pdf. Last Accessed: August 22, 2016.

Water Environment Federation National Biosolids Partnership. 2014. Thermal oxidation fact sheet. Available Online:
http://www.wrrfdata.org/ThermalOxidationFS/Thermal_Oxidation_Fact_Sheet_May2014.pdf. Last Accessed: December 15, 2017.



APPENDIX E:

TM#5 – Long List of Alternatives

Region of Waterloo Biosolids Strategy

Technical Memo #5:
Long List of Biosolids Management
Alternatives

DRAFT
April 2017



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Glossary of Terms

ATAD	Autothermal Thermophilic Aerobic Digestion
AS	Activated Sludge
BMP	Biosolids Master Plan
CCME	Canadian Council of Ministers of the Environment
CFIA	Canadian Food Inspection Agency
C:N	Carbon to Nitrogen
ECA	Environmental Compliance Approval
EFW	Energy from Waste
EPA	Environmental Protection Act
MCEA	Municipal Class Environmental Assessment
MOECC	Ministry of Environment and Climate Change
NASM	Non-Agricultural Source Material
NC	Not Compatible
NMA	Ontario Nutrient Management Act, 2002, S.O. 2002, c. 4
ROW	Region of Waterloo
US EPA	United States Environmental Protection Agency
WWTP	Wastewater Treatment Plant

Executive Summary

This technical memorandum presents the Biosolids Strategy alternatives that will be evaluated in subsequent technical memoranda. It builds upon the information describing core technologies, end uses, and disposal options presented in Technical Memorandum #4. A discussion of the core technology compatibility with each other and existing infrastructure is presented ahead of the alternatives. A description of features and considerations used to develop alternatives is also presented. The alternatives developed organize the core technologies, end uses, and disposal options into potential Biosolids Strategy alternatives relevant to the Region.

The long list of biosolids strategy alternatives is:

- Alternative #1 – Current Approach with Expanded Capacity;
- Alternative #2 – Enhanced Anaerobic Digestion;
- Alternative #3 – Enhanced Anaerobic Digestion with Stabilization;
- Alternative #4 – Stabilize Dewatered Biosolids Cake to Make Fertilizer;
- Alternative #5 – Composting Digested Dewatered Biosolids (To Category A or B Quality);
- Alternative #6 – Reduce Volume and Stabilize Dewatered Biosolids Cake to Make Fertilizer;
- Alternative #7 – Thermal Reduction; and
- Alternative #8 – Thermal Reduction with Energy Recovery.

These alternatives will be developed in further detail and evaluated to generate a short list of alternatives in the next phase of the project. Input from public consultation and other stakeholder engagement will allow adjustment of the alternatives to suit the needs of the Region. Additional details will be added to each alternative in the next stage of the process to allow screening of the short list of alternatives.

1.0 Introduction

1.1 Project Purpose and Approach

The Region of Waterloo Biosolids Strategy was initiated in 2015, to develop an approach to manage biosolids in Waterloo Region to the year 2051. The strategy will take a critical look at current practices, and consider available and relevant technologies for processing biosolids. Alternative ways to manage biosolids will be evaluated against a range of criteria to develop a biosolids management strategy for the Region. This project will result with the selection of a preferred strategy that will be implemented in the Region over the next 35 years. The decision making process to select the preferred strategy will be documented in a report and be available for public review. Future projects will further refine the implementation details of the strategy including timing, sizing and location of any facilities.

The strategy is being developed in six stages, which will be outlined in a series of technical memos (TMs). The memos will form the basis for the final study document. The project stages include:

- Stage 1 – What are biosolids and what process is being followed to develop the strategy?
 - o TM: The Environmental Assessment Process
- Stage 2 – What is the current situation related to biosolids in the Region and how will it change as the Region grows?
 - o TM: Existing Conditions
 - o TM: Biosolids Management Needs Forecast
- Stage 3 – What are the project objectives, what technologies and strategies are being considered and how will a decision be made to select the recommended strategy?
 - o TM: Evaluation Approach and Comparative Evaluation Criteria
 - o TM: Biosolids Technologies, End Uses, and Disposal

- o TM: Long List of Biosolids Management Alternatives
- Stage 4 – What alternatives from the long list could work in the Region of Waterloo? How can they be refined based on the project objectives? This stage involves evaluating the alternatives to identify a shorter list that will be evaluated in more detail
 - o TM: Short List of Biosolids Management Alternatives
- Stage 5 – Based on the project objectives and evaluation criteria, what is the recommended strategy? The short listed alternatives are evaluated at this stage and a recommended strategy is brought forward for public input.
 - o TM: Evaluation of Short Listed Alternatives
- Stage 6 – What is the best strategy to meet the project objectives?
 - o TM: Recommended Biosolids Strategy
 - o Biosolids Strategy Document

The Region is committed to public engagement throughout the development of the strategy. The project team will seek to understand the priorities and concerns of community residents across Waterloo Region, as well as technical experts and other stakeholders.

A **sustainable strategy** is one that considers the future growth of the Region and looks to minimize potential landfill disposal requirements of biosolids.

Additional background information regarding the context of biosolids management in the Region of Waterloo is included in **TM1**.

1.2 Purpose of this Technical Memorandum

This technical memorandum presents the Biosolids Strategy alternatives that will be evaluated in subsequent technical memoranda. The technical memo builds upon the information describing core technologies, end uses, and disposal options presented in Technical Memorandum #4. A discussion of the core technology compatibility with each other and existing infrastructure is presented ahead of the alternatives. A

description of features and considerations used to develop alternatives is also presented. The alternatives developed organize the core technologies, end uses, and disposal options into potential Biosolids Strategy alternatives relevant to the Region.

1.3 Report Structure

Technical Memorandum #5 is organized into six sections:

- 1. Chapter 1: Introduction**
- 2. Chapter 2: Preliminary Technology Assessment**
- 3. Chapter 3: Features of Biosolids Strategy Alternatives**
- 4. Chapter 4: Strategy Alternatives**
- 5. Chapter 5: Summary**

TM1 provides an overview of the study purpose and history of biosolids management in the Region. Chapters 2 through 4 examine how various technologies fit with the infrastructure currently available in the Region and how these technologies could fit together to make up Biosolids Strategy alternatives for consideration. Chapter 5 provides a summary of the memo and findings.

2.0 Preliminary Technology Assessment

Technical Memorandum #4 identified core biosolids processing technologies that change biosolids to provide value in terms of management of the final biosolids product to be recovered through end uses, or to facilitate disposal. Value may include:

- Straight forward handling (e.g. more reliable material handling, fewer health and safety considerations)
- Reduced potential for nuisance (e.g. lower potential for odour);
- Reduced quantity of product; and / or
- Improved quality of product or greater value in markets.

The core technologies are presented in groups including:

- Stabilization;
- Digestion;
- Hydrolysis;
- Drying; and
- Thermal reduction.

In order to generate the long list of potential Biosolids Alternatives relevant for the Region of Waterloo context, additional assessment of these core processing technologies is presented in this section based on compatibility:

- With the existing system including;
 - o With existing infrastructure;
 - o With biosolids production rates;
- Between core processing technologies; and
- With biosolids end uses and disposal options under consideration.

2.1 Compatibility with Existing System

Compatibility, integration and alignment with existing wastewater treatment and biosolids management are considered in terms of the potential adjustments that would be required to accommodate each technology.

2.1.1 Compatibility with Existing Infrastructure

The compatibility with the existing infrastructure is intended to consider whether core technologies tend to enhance existing investments in infrastructure. New technology can be implemented to improve performance / efficiency of existing infrastructure and / or provide value in terms of the management of the final biosolids product. **Table 2-1** categorizes each technology as:

- Does not align with existing infrastructure;
- Does not enhance existing infrastructure;
- Requires substantial adjustment to existing infrastructure;
- Requires some adjustment of existing infrastructure; and
- Supplements existing infrastructure effectively.

Configurations that do not align or enhance existing infrastructure alternatives were not developed further.

2.1.2 Compatibility with Production Rates

Technologies can also be matched with facility level production or the production of biosolids for the entire Region. **Table 2-1** also shows compatibility with:

- Small Region Facilities (<100 dt/year);
- Medium Region Facilities(100 - 1000 dt/year);
- Large Region Facilities (1000 - 10000 dt/year);
- Region-wide production (>10,000 dt/year);

There were no technologies identified in the table where the:

- Minimum size of new facility is too large for the anticipated production rates;
and
- Maximum size of new facility is too small for appropriate implementation.

Table 2-1: Technology Compatibility with Existing Infrastructure

Technology Group	Technology	Capacity Matches Small Facility Generations Rates (<100 dt/year)	Capacity Matches Medium Facility Generation Rates (100 - 1000 dt/year)	Capacity Matches Large Facility Generation Rates (1000 - 10000 dt/year)	Capacity Matches entire Region generation Rate (>10,000 dt/year)	Compatible with Existing Infrastructure
Stabilization	Alkaline Stabilization	N	Y	Y	Y	Supplements for medium facilities and larger
Stabilization	Thermal / Pasteurization	N	N	Y	Y	Supplements large and Region wide infrastructure
Digestion	Mesophilic Anaerobic Digestion	N	N	Y	Y	Not applicable for small / medium facilities, and does not enhance and large facility infrastructure
Digestion	Thermophilic Anaerobic Digestion	N	N	Y	Y	Not applicable for small / medium facilities, and would require Substantial Adjustment for large facilities
Digestion	Two-Phase Anaerobic Digestion	N	N	Y	Y	Not applicable for small / medium facilities, and would require Substantial Adjustment for large facilities
Digestion	Aerobic Digestion	Y	Y	N	N	Supplements small and medium facilities Does not enhance larger facilities with anaerobic digestion
Digestion	Autothermal Aerobic Digestion (ATAD)	N	Y	N	N	Supplements Hespeler or a combination of all small and medium facilities Does not align with large facilities or the Region-wide scale
Stabilization	Composting	Y	Y	Y	Y	Supplements
Hydrolysis	Thermal Hydrolysis	N	N	Y	N	Not applicable for small / medium facilities, and would require Substantial Adjustment for large facilities

Technology Group	Technology	Capacity Matches Small Facility Generations Rates (<100 dt/year)	Capacity Matches Medium Facility Generation Rates (100 - 1000 dt/year)	Capacity Matches Large Facility Generation Rates (1000 - 10000 dt/year)	Capacity Matches entire Region generation Rate (>10,000 dt/year)	Compatible with Existing Infrastructure
Hydrolysis	Combined Hydrolysis	N	Y	Y	Y	Not applicable for small facilities, and would require Substantial Adjustment for large facilities
Drying	Direct Drying	N	N	Y	Y	Not applicable for small / medium facilities, and Supplements large facilities or the Region-wide scale
Drying	Indirect Drying	N	N	Y	Y	Not applicable for small / medium facilities, and Supplements large facilities or the Region-wide scale
Thermal Reduction	Multiple Hearth Incineration	N	N	N	Y	Supplements, and likely implemented at the Region-wide scale
Thermal Reduction	Fluidized Bed Incineration	N	N	Y	Y	Supplements, and likely implemented at the Region-wide scale

The technology compatibility review presented in **Table 2-1** offers a high-level assessment of the potential to use technologies in various applications. In addition to capacity, an assessment is presented that considers whether the technology supplements existing infrastructure by accepting the current solids or biosolids product, or would require substantial process adjustment.

The configuration of anaerobic digestion is being considered as part of the Wastewater Treatment Master Plan currently being undertaken by the Region, because of the required interaction with the liquid train processes at wastewater treatment plants (WWTPs). For the purposes of the Biosolids Alternatives, it is assumed that WWTPs with anaerobic digestion will maintain this process and expand the existing approach to provide the necessary capacity for solids processing. Alternatives that include changes to the type of anaerobic digestion and dewatering are not presented for the Waterloo, Kitchener, Galt and Preston WWTPs.

Alternatives that include thermal reduction (combustion) consider the existing dewatered biosolids cake as the feedstock. Abandoning anaerobic digesters to provide raw sludge with higher energy content for combustion does not align with existing infrastructure, and is not presented as an alternative.

2.2 Compatibility Between Technologies

Technologies are assessed in terms of their compatibility with each other, which is presented in **Table 2-2** using the following:

-  Compatible technologies that complement each other, or can be used in series as part of a management strategy;
-  **Parallel:** Technologies that have the potential to complement each other as parallel processes in a diversified approach; or
- Technologies are not considered compatible for the following reasons:
 - o **NC1 – Too Similar:** Not compatible because objective of technologies is too similar, where combining in series does not provide value,

combining in parallel does not provide a diversified approach. For example, two stabilization technologies that can achieve the same level of stabilization do not provide value in series, and do not provide access to different markets where applied in parallel.

- o **NC2 – Inefficient:** Not Compatible for reasons of capacity or efficiency. For example, thermal reduction (incineration) technologies typically require large capacity to be economically viable, and benefit from increasing scale, and therefore do not benefit from a diversified approach where multiple technologies are implemented.
- o **NC3:** Application of one technology reduces the efficiency or increases the cost of a follow-up technology/parallel technology such as digestion followed by thermal reduction.

As the Alternatives presented are developed into Strategies in future memos, there is potential that the Region could select a single preferred technology, or multiple technologies that are viable at the scale of the large WWTPs for implementation in parallel as part of a diversified approach to biosolids management.

Table 2-2: Compatibility Between Technologies

Technology	Thickening	Dewatering	Enhanced Stabilization	Anaerobic Digestion	Aerobic Digestion	Composting	Drying	Thermal Reduction
Thickening		✓	✓	✓	✓	✓	✓	✓
Dewatering			✓	✓	✓	✓	✓	✓
Enhanced Stabilization (Alkaline Stabilization, Hydrolysis, ATAD)				✓	NC2 Inefficient	Parallel	Parallel	NC2 Inefficient
Anaerobic Digestion					NC1 Too Similar	✓	✓	✓
Aerobic Digestion						✓	✓	NC2 Inefficient
Composting							✓ Parallel	NC2 Inefficient
Drying								✓
Thermal Reduction								

2.3 Technology Compatibility with End Uses and / or Disposal

Biosolids end uses are those management practices that use the nutrients, organic matter and / or energy associated with solids collected at the WWTPs. The end use approaches developed must align with the Canadian Council of Ministers of the Environment (CCME, 2012) management principles and definitions for use.

Biosolids disposal options are practices that protect the environment and public health, but do not use biosolids. Burial in landfill and combustion without energy capture are the two most common methods of disposal that are currently available in Ontario.

The core processing technologies, end use and disposal options developed as part of Technical Memorandum #4 will be combined to develop the Biosolids Alternatives. Not all end uses and disposal options align with each core processing technology option and therefore the total number of alternatives is limited by identifying compatible combinations.

To take advantage of nutrient and/or soil conditioning qualities, biosolids can be processed to generate a NASM-quality product or a biosolids derived fertilizer for use in agriculture, forestry, or land reclamation such as mine tailings pond or sand and gravel site rehabilitation. Biosolids derived fertilizers must be sold, and are typically used primarily for agricultural or landscaping activities, although they can also be used in forestry and land reclamation.

To capture energy content, volatile solids collected at the wastewater treatment plants can either be converted to biogas in anaerobic digesters, or combusted. The Region is planning to implement cogeneration facilities at Waterloo, Kitchener and Galt WWTPs to use biogas to generate electricity and displace natural gas used to heat anaerobic digesters. In order to align with plans and investments already in place, renewable natural gas, and other biogas use alternatives have not been

included in the alternatives developed. Alternative biogas uses are considered in Wasterwater Treatment Master Plan update.

Table 2-3 presents appropriate combinations of core technologies, end use and disposal methods. The table shows:

- Preferred end use that is anticipated to capture the full value of the biosolids for the Region and the user;
- Acceptable end uses may capture less value for the Region, or be considered positive but not the preferred end user; and
- Contingency management approaches are those that would not typically be used, but represent responsible options when preferred and acceptable approaches are not available.

For example, biosolids derived fertilizers may not be purchased at the agricultural market price when used for mine tailing reclamation projects, but reclamation projects use the nutrients effectively. Landfilling a biosolids derived fertilizer is unlikely, but does represent responsible contingency for disposal if uses are not available.

Table 2-3: Technology Compatibility with End Uses

Technology	Agricultural Use			Use for Land Reclamation (Mines, Stone, Sand and Gravel sites)	Landfill Use as Daily Cover (Outside the Region ²)	Forestry	Energy Recovery (Electricity Generation)	Industrial Energy or resource Recovery (e.g. Cement Kiln)	Energy Recovery (Produce Fuel)	Landfill Disposal (Outside the Region ²)	Thermal Disposal (Incineration)
	NASM	Fertilizer	Compost								
Alkaline Stabilization		Preferred		Acceptable	Acceptable	Acceptable				Contingency	Contingency
Thermal / Pasteurization		Preferred		Acceptable	Acceptable	Acceptable				Requires dewatering	Requires dewatering
Mesophilic Anaerobic Digestion	Preferred			Acceptable ¹	Acceptable but, not typical due to risk of odour emissions	Acceptable ¹	Preferred from biogas	Requires dewatering	Preferred (Renewable natural gas from biogas)	Requires dewatering	Requires dewatering
Thermophilic Anaerobic Digestion	Preferred			Acceptable ¹	Acceptable but, not typical due to risk of odour emissions	Acceptable ¹	Preferred from biogas	Requires dewatering	Preferred (Renewable natural gas from biogas)	Requires dewatering	Requires dewatering
Two-Phase Anaerobic Digestion	Preferred			Acceptable ¹	Acceptable but, not typical due to risk of odour emissions	Acceptable ¹	Preferred from biogas	Requires dewatering	Preferred (Renewable natural gas from biogas)	Requires dewatering	Requires dewatering
Aerobic Digestion	Preferred			Acceptable ¹	Acceptable but, not typical due to risk of odour emissions	Acceptable ¹				Requires dewatering	Requires dewatering
Autothermal Aerobic Digestion (ATAD)		Preferred		Acceptable	Requires dewatering	Acceptable				Contingency	Contingency
Composting			Preferred	Acceptable	Acceptable	Acceptable				Contingency	Contingency
Thermal Hydrolysis		Preferred		Acceptable	Requires dewatering	Acceptable				Requires dewatering	Requires dewatering
Combined		Preferred		Acceptable	Requires	Acceptable				Requires	Requires

Technology	Agricultural Use			Use for Land Reclamation (Mines, Stone, Sand and Gravel sites)	Landfill Use as Daily Cover (Outside the Region ²)	Forestry	Energy Recovery (Electricity Generation)	Industrial Energy or resource Recovery (e.g. Cement Kiln)	Energy Recovery (Produce Fuel)	Landfill Disposal (Outside the Region ²)	Thermal Disposal (Incineration)
	NASM	Fertilizer	Compost								
Hydrolysis					dewatering					dewatering	dewatering
Direct Drying		Preferred		Acceptable	Acceptable	Acceptable	Preferred	Preferred	Preferred	Contingency	Contingency
Indirect Drying		Preferred		Acceptable	Acceptable	Acceptable	Preferred	Preferred	Preferred	Contingency	Contingency
Multiple Hearth Incineration							Preferred	Preferred for use of ash		Contingency for biosolids Acceptable for Ash	Acceptable
Fluidized Bed Incineration							Preferred	Preferred for use of ash		Contingency for biosolids Acceptable for Ash	Acceptable

1 The location of reclamation projects may be considered when determining if the project represents a preferred or acceptable alternative. The shortest transportation distance for equal end use value would be considered preferred.

2 – The Region of Waterloo landfills do not currently accept biosolids.

3.0 Features of Biosolids Alternatives

Section 2.0 provided an initial assessment of core processing technologies, including how they might integrate with existing infrastructure; the possible combinations between technologies; and possible core processing technology combinations with end use and disposal options. The alternatives are developed to satisfy a technical or operational objective. The elements of each strategy or management approach described in Section 3.0 have features that have been presented consistently for each alternative and may include:

- **Mass and volume reduction:** to maintain or reduce the current amount of biosolids requiring transportation, end use or disposal;
- **Enhanced stability, or product quality:** of biosolids products allowing additional end uses, and / or additional operational flexibility;
- **End use and disposal** features present more diverse and or reliable management of biosolids within an alternative;
- **Energy Recovery** is a component of the management approach which generates fuel or electricity;
- Flexible **centralized or decentralized** implementation to facilitate future site selection and configuration; and
- **Region of Waterloo control** of the alternative to facilitate reliable operations over the planning period.

3.1 Biosolids Quantity

The quantity of biosolids requiring management can be reduced by removing water, or converting volatile solids to dissolved solids or gases. Dissolved solids are typically returned to the WWTP and must be considered in terms of WWTP capacity and effluent quality.

Digesters and thermal reduction processes can be used to reduce volatile solids and therefore the total dry solids requiring management.

Pre-treatment and preparation technologies as well as dryers can be used to remove water associated with solids requiring management.

The anticipated quantity of biosolids requiring management relative to the existing per capita quantity is presented for each alternative in section 5.

3.2 Enhanced Stabilization and Product Quality

Stabilization processes enhance biosolids product quality because they reduce pathogens, and/or volatile solids content in the solids. Processes such as pasteurization, hydrolysis, alkaline stabilization, advanced digestion (ATAD) and drying reduce pathogens such that the biosolids can be managed as a fertilizer, which generates additional opportunities for end uses. Composting also provides additional stabilization value, and increased flexibility of end uses compared with NASM where the end product meets the requirements of the Compost Quality Standards for Category A compost (MOECC, 2012).

The current NASM product generated by the Region meets all regulatory requirements for responsible use of the nutrients and organic content in biosolids. Compost and biosolids derived fertilizers, provide additional flexibility in terms of handling and storage because they have further reduced pathogen content, and lower nuisance potential which is mainly lower odour emission potential.

3.3 Energy Recovery

The potential to recover the energy content collected with solids at the wastewater treatment plant is also a feature associated with a number of core technologies. Production of biogas through the existing approach to anaerobic digestion is anticipated to continue for each alternative. Biogas use in a combined heat power process is planned for Kitchener Waterloo and Galt WWTPs, which is included in each

alternative presented as planned infrastructure. Alternatives that enhance biogas production, or generate other fuels and electricity are considered features of some alternatives. Energy products may take a number of forms including, biogas, renewable natural gas, syngas, and solid fuels such as pellets.

3.4 Use and Disposal

The existing management approach provides two alternatives for biosolids use (agricultural use as NASM, or mine tailings pond reclamation), and disposal to approved landfills. Facilitating increased use of biosolids and therefore avoiding disposal is considered a feature of alternatives. Although use is prioritized, reliable disposal options are considered a feature as well. Allowing for multiple end use and disposal options is considered a feature as it mitigates the risk associated with the reliability of any one use or disposal option included as part of the alternative.

3.5 Centralized or Decentralized Infrastructure

The approach to biosolids management can consist of a single centralized facility or decentralized infrastructure. A centralized process may be considered on an existing WWTP site, or at new site where biosolids would be transferred to a single new process implemented for a core technology.

In a decentralized approach, technology for biosolids processing is located either at the WWTPs, or at dedicated facilities serving one or more WWTPs similar to the Manitou Drive dewatering facility that serves the Kitchener WWTP.

There are technical and operational advantages that must be considered as detail is added in subsequent technical memos. The alternatives are presented with the relative potential to allow centralized or decentralized approach, but do not identify the approach at this level of alternative development.

3.6 Region Control

Currently, many aspects of wastewater and biosolids management are contracted out by the Region. The level of control retained by the Region affects the level of financial and operational risk associated with biosolids management alternatives.

There are vendors that provide biosolids management services using their own facilities. In this way, the Region could choose to procure the services of a contractor to haul the current biosolids cake to an existing or new private facility for additional treatment, end use or disposal. This approach exposes the Region to a financial and operational risk by limiting the ability to ensure the contractor manages biosolids responsibly as agreed upon through the procurement contract. It also exposes the Region to an operational risk in the event that a contractor goes out of business or operations are otherwise disrupted by business decisions. These risks are not considered acceptable, and therefore the Region is pursuing alternatives where dedicated facilities would be constructed for the Region as necessary to support each alternative. The delivery method for new infrastructure would remain open at this stage of planning including the potential for alternative procurement methods such as public-private-partnerships, alternative project delivery with full Regional operation, or traditional design-bid-build with contracted operations.

Another alternative is a partnership where an industrial facility would use the current dewatered cake as an industrial input directly. An example is incorporating biosolids into cement production, where volatile solids provide fuel, and the ash is incorporated into the cement product. This approach relies directly on a partner facility with similar risks as described above, and therefore is not considered as a primary management approach as part of the alternatives described below. It is a strategy that could be incorporated as a management practice in parallel with the main alternatives described below.

4.0 Alternatives

As a result of the assessment in Section 3.0, and building on previous master planning, eight biosolids alternatives have been developed and are described in detail in this section:

- Alternative #1 – Current Approach with Expanded Capacity;
- Alternative #2 – Current Approach with Solids Preparation Before Digestion;
- Alternative #3 – Produce Fertilizer from Biosolids;
- Alternative #4 – Produce Compost from Biosolids;
- Alternative #5 – Produce Dry Fertilizer Pellets from Biosolids;
- Alternative #6 – Thermal Reduction of Biosolids to Ash (No Energy Recovery);
- Alternative #7 – Thermal Reduction with Energy Recovery; and
- Alternative #8 – Landfill all Biosolids

Each alternative is presented in terms of the following components:

1. **Pre-Treatment, Preparation and Storage** which includes enhancements to existing infrastructure (e.g., digester and dewatering capacity)
2. **Core Biosolids Processing Technologies** which are primarily focused on:
 - a. Reducing volume / mass of biosolids requiring management
 - b. Enhancing quality to allow access to new end use and disposal options
3. **End uses and disposal options**

Figure 4-1 presents the components of the alternatives as an info-graphic.

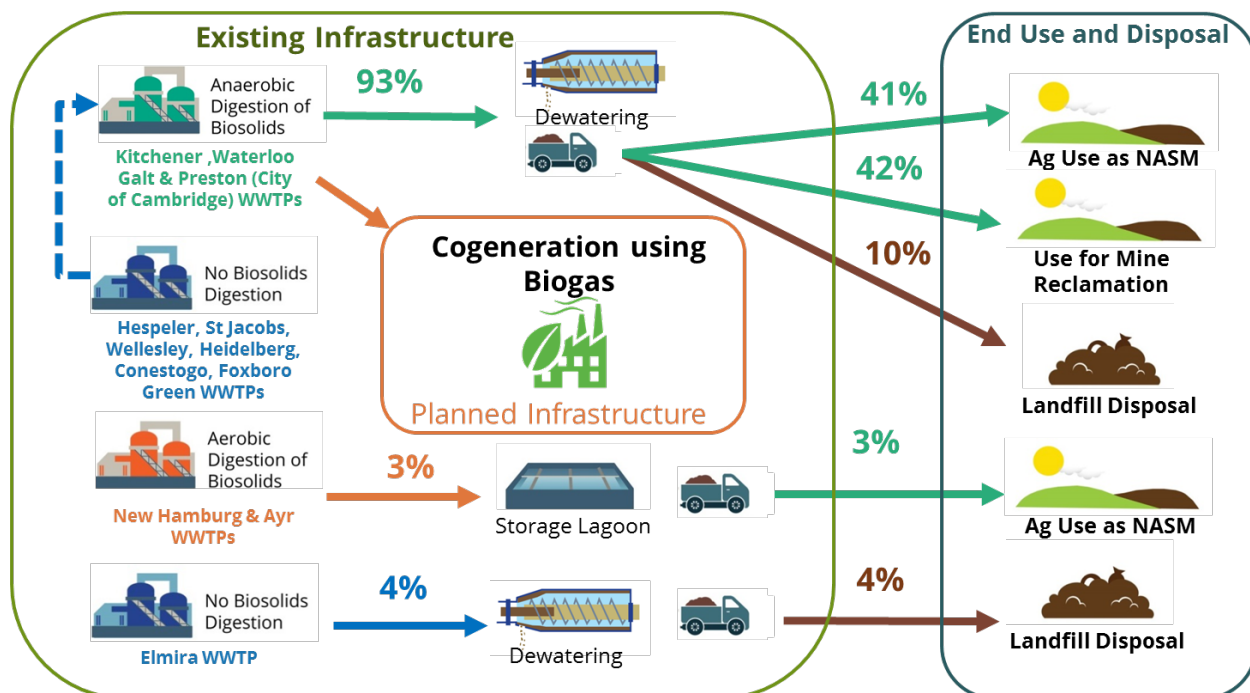


Figure 4-1: Components of Biosolids Management Alternatives

The alternatives presented in this section each include the following information:

- Name of the alternative;
- Description of the approach;
- Block flow diagrams to describe:
 - o Existing infrastructure, and planned projects,
 - o Required pre-treatment, preparation and storage
 - o New core processing technologies
 - o Storage, End use and / or disposal;
- Summary of key infrastructure and logistical needs; and
- Summary of the maturity of the technology and considerations relevant to the long term viability of the alternative.

The Biosolids Strategy for the Region of Waterloo is intended to build upon its past investments in wastewater treatment and biosolids handling infrastructure as well as aligning with other planning decisions. The figure below presents a simplified process flow of the current operations.



Note: Percentage values shown represent data from 2016 operations

Figure 4-2: Block Flow Diagram – Current Biosolids Management Operations

The completed strategy must consider all of the WWTPs that are generating solids for management; however the focus of these high level alternatives is the four largest facilities with anaerobic digestion and dewatering including: Kitchener, Waterloo, Galt and Preston. Facilities that currently have limited or no solids processing on site including: Hespeler, St. Jacobs, Wellesley, Heidelberg, Conestogo, and Foxboro Green WWTPs are envisioned to continue to be managed through the facilities with digestion and dewatering. These facilities along with New Hamburg and Ayr, that have aerobic digestion in place with on-site storage to accommodate management of biosolids as a NASM, will be incorporated as details are added during the assessment process to align with alternative objectives. Adjustments or additions to the digestion approach at these facilities as well as the Elmira WWTP may be considered as part of the wastewater treatment master plan. Projections of the amount of solids requiring management, or information developed as part of the wastewater treatment master plan may require refinement of the alternatives presented below, but are not anticipated to generate new alternatives.

4.1 Alternative #1 – Current Approach with Expanded Capacity

The current approach provides stable biosolids management that complies with applicable regulations. The majority of biosolids are anaerobically digested and dewatered, and all biosolids used or disposed using one of three options:

- Agricultural use as NASM;
- Mine tailings pond reclamation; or
- Landfill disposal.

Figure 4-2 presents the block flow diagram for the current approach to biosolids management. For this alternative digestion and dewatering would be expanded only as necessary to accommodate the population growth and the associated increase in solids generated at the wastewater treatment plants. Storage would be added to

limit operational risk related to the existing just in time trucking approach, and facilitate additional use to limit disposal. Operational risk can be mitigated with new storage capacity (approximately 10 days of biosolids generation), while facilitating additional uses would require larger storage capacity (30 days or greater).

4.1.1 What are the Features?

The main features of this alternative include:

- Limited investment in new infrastructure; and
- Proven approach to biosolids management given existing regulations.

4.1.2 What is the end use or disposal method?

The quality of biosolids would remain the same and continue to be managed as a NASM. The end use and disposal methods would remain the same as those available now, including:

- Agricultural use as NASM;
- Mine tailings pond reclamation; or
- Landfill disposal.

4.1.3 What do we need to implement it?

This approach does not require a substantial amount of new infrastructure. Expansions or enhancements to digestion and dewatering if required are anticipated to be required for all the alternatives presented. Additional storage is required to enhance the existing level of Regional control. The quantity of biosolids generated per capita would remain the same as it is now, and the number of trucks would increase with the mass of biosolids produced. The increase in mass of biosolids and trucks required are presented in TM6 – Biosolids Forecast.

4.1.4 Has it been done before and what are the considerations for the future?

The current approach is demonstrated to deliver appropriate biosolids management given current conditions, and the regulatory framework in Ontario. However, it should be recognized that the mass of biosolids requiring management will increase in the future. The current approach relies on end uses outside the Region and on the Provincial policy regarding biosolids related regulations.

4.2 Alternative #2 – Current Approach with Solids Preparation before Digestion

This alternative would implement pre-treatment and preparation to accommodate the existing digestion approach for future solids production rates. Candidate technologies for thickening prior to digestion and dewatering include:

- o Gravity;
- o Gravity belt;
- o Rotary drum;
- o Dissolved air; and
- o Recuperative thickening.

The approach has the potential to increase the conversion of volatile solids to biogas, and decrease the mass of biosolids requiring end use or disposal. However, the approach could also be used to expand the capacity of digestion with very similar rates of volatile solids conversion, and therefore similar biosolids quantity per person. This alternative has many more considerations that affect operations of the digesters and liquid train that must be considered as part of the wastewater treatment master plan. The focus of the information presented here are impacts on biosolids management. It would affect the majority of biosolids (93%) produced in the Region that are anaerobically digested and dewatered, and the quality of digestate is anticipated to remain NASM quality.

Figure 4-3 presents the block flow diagram showing that solids thickening infrastructure would be required ahead of anaerobic digestion.

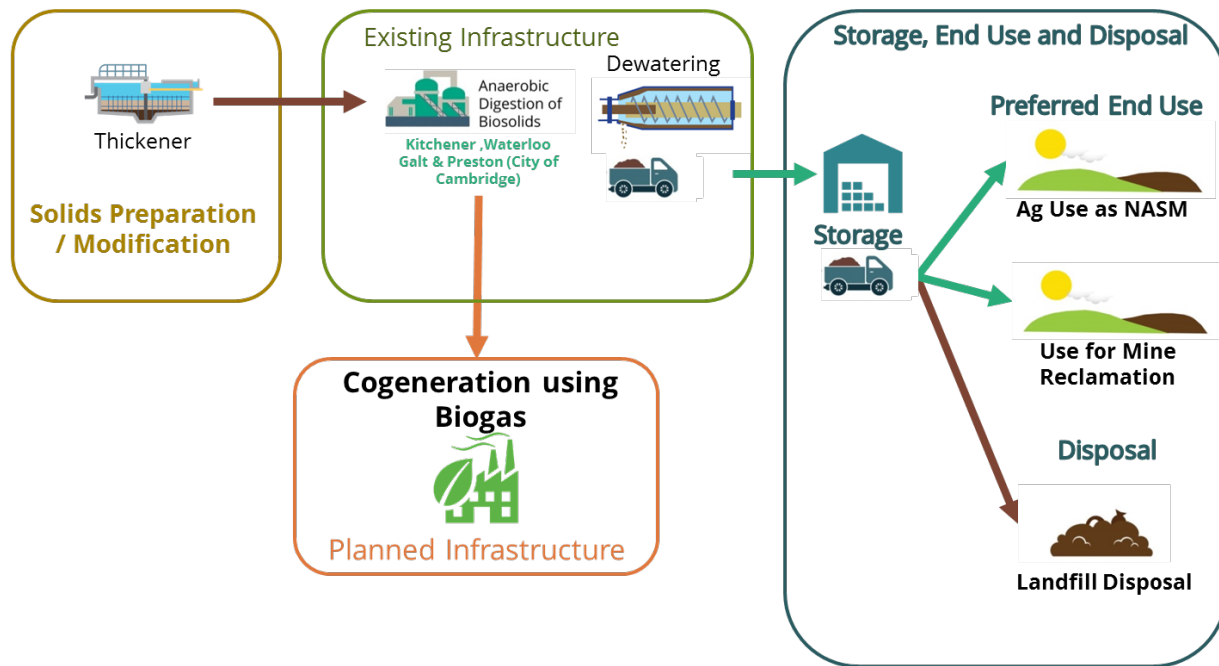


Figure 4-3: Block Flow Diagram – Current Approach with Solids Preparation Before Digestion

This alternative could be used to manage the footprint of new infrastructure to increase the capacity of digestion to accommodate future increases in solids generated at the wastewater treatment plants.

4.2.1 What are the features?

The main features of selecting this alternative include:

- Investment in mature thickening technologies may marginally increase biogas production, and reduce the quantity of biosolids produced per capita;
- Limited investment in new infrastructure related to digestion; and
- Continues existing proven approach to biosolids end use and disposal.

4.2.2 What is the end use or disposal method?

The quality of biosolids would remain the same and continue to be managed as a NASM. The end use and disposal methods would remain the same as those available now, including:

- Agricultural use as NASM;
- Mine tailings pond reclamation; or
- Landfill disposal.

4.2.3 What do we need to implement it?

New thickening infrastructure would be required at WWTPs ahead of anaerobic digestion.

The number of trucks would be similar per capita, as compared with the current management approach, and trucking would be anticipated to increase with time and the corresponding increase in mass of biosolids produced.

4.2.4 Has it been done before and what are the considerations for the future?

Thickening technologies are well established, and digestion at higher solids content is also a mature approach. Increasing the solids content for the digesters requires an assessment of the impact on operations such as:

- Mixing within digesters;
- Biogas production rate; and
- Impacts on dewatering.

This approach provides an option to manage footprint of new infrastructure and process performance where thickening is used with existing digester vessels to manage additional solids. The approach is anticipated to deliver similar biosolids quality. Concerns would remain including that increasing mass of biosolids requiring

management in the future will place pressure on the system, requiring more trucks and more land area.

4.3 Alternative #3 – Produce Fertilizer from Biosolids

This alternative would implement a core stabilization technology before or after anaerobic digestion to generate a biosolids derived fertilizer product. Candidate technologies proposed in this category would produce biosolids derived fertilizer including:

- Thermal hydrolysis;
- Combined hydrolysis;
- Thermal stabilization (pasteurization); and
- Alkaline stabilization.

The quantity of biosolids generated is dependent on technology selected. Technologies implemented ahead of digestion can enhance conversion of volatile solids to biogas reducing the quantity of dry solids requiring management. These technologies affect the liquid train at WWTPs substantially and would be considered by the WWTMP. Technologies implemented after digestion would use the existing dewatering capacity with a new core technology to generate a biosolids derived fertilizer. The fertilizers generated can range in moisture content from 15 – 55% solids depending on technology implemented. Therefore the quantity of biosolids per capita would range from about 2/3 more than the current amount to about 1/3 less, given that the existing dewatered cake is typically about 25% solids.

Technologies considered would generate a product that would meet the US EPA definition of Class A biosolids. Processes in the proposed configuration have been demonstrated to meet the requirements of a fertilizer under the Fertilizers Act as administered by CFIA. Based upon the enhanced stability of the dewatered cake, additional biosolids storage options are available.

Figure 4-4 presents the block flow diagram showing the new core technology and storage required after anaerobic digestion.

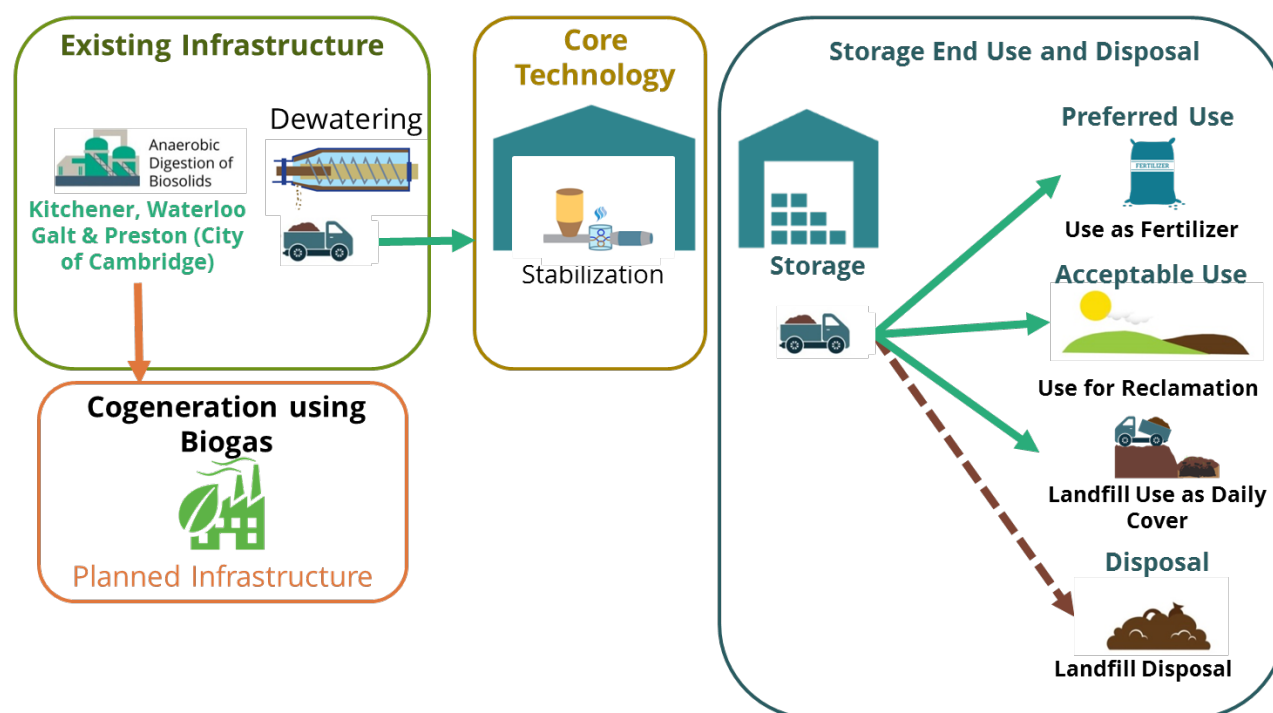


Figure 4-4: Block Flow Diagram – Produce Fertilizer from Biosolids

4.3.1 What are the features?

The main feature of selecting this alternative is enhanced biosolids quality (produce fertilizer) to add end use options (Agricultural use as fertilizer and landfill use as daily cover), which provide operational flexibility. The fertilizer products also facilitate storage and reduce odour emission potential as compared with the current NASM product.

The sale of the fertilizer product would generate revenue to offset costs associated with biosolids management.

4.3.2 What is the end use or disposal method?

Technologies considered for this alternative would produce a fertilizer that meets the regulatory requirements under the Fertilizers Act administered by the Canadian Food

Inspection Agency (CFIA). This alternative would provide the following end use or disposal options:

- Agricultural use as fertilizer;
- Non-agricultural soil amendment;
- Landfill use; or
- Landfill disposal.

A fertilizer product provides equal or greater opportunity for use in agriculture. Non-agricultural soil amendment options such as the existing mine tailings pond reclamation remains available, with additional bulk fertilizer uses available (e.g. landscaping / golf courses). Adding more flexibility to end uses is considered a valuable feature as it mitigates risk if any one end use or disposal method is unavailable in the short or long-term.

4.3.3 What do we need to implement it?

A new process would be required at WWTPs, at a number of new sites to serve WWTPs, or in a centralized facility. A building would be required to protect equipment, as well as controlling emissions such as odour and noise.

The quantity of biosolids generated per capita and the number of trucks required is dependent on the technology selected, and could increase by 2/3, or decrease by 1/3, as compared with the existing quantity per capita.

A storage building is envisioned to protect the product from weather, and control emission potential (e.g., particulate and odours) while facilitating multiple end uses. Allowing for inventory of the biosolids derived fertilizer provides flexibility to match seasonal demand from different users.

4.3.4 Has it been done before and what are the considerations for the future?

Stabilization after digestion has been implemented in Ontario at WWTPs, and at centralized facilities.

This approach would deliver a fertilizer product for sale. Agricultural use as the preferred end use of a biosolids derived fertilizer product means similar risks related to the land area required, and the distance of trucking; however more options are available, and storage to align with the markets mitigates some risk when compared with the existing approach.

4.4 Alternative #4 – Produce Compost from Biosolids (To Category A or B Quality)

This alternative would implement composting for stabilization that integrates with the current dewatering infrastructure that follows anaerobic digestion. There are two categories of compost available, Category A where biosolids are co-composted with other biomass (e.g. source separated organics, leaf and yard waste, purchased amendment like wood chips) in a mixture up to 25% biosolids, minimum 75% other biomass, and Category B where biosolids can be composted with amendment (typically woodchips) selected to maintain key properties for composting such as carbon to nitrogen ratio (C:N). The two different categories lead to different end uses and are discussed separately below. The Compost Quality Standard (2012) requires compost to be maintained at 40% moisture content (60% solids) during curing; therefore the quantity of biosolids per capita would be less than half the current amount, given that the existing dewatered cake is typically about 25% solids. Other sources of organic material added as feedstock to the biosolids may increase the total quantity of finished compost.

4.4.1 Composting Digested Dewatered Biosolids to Category A Quality

Figure 4-5 presents the block flow diagram showing the new core technology and storage required to produce Category A compost.

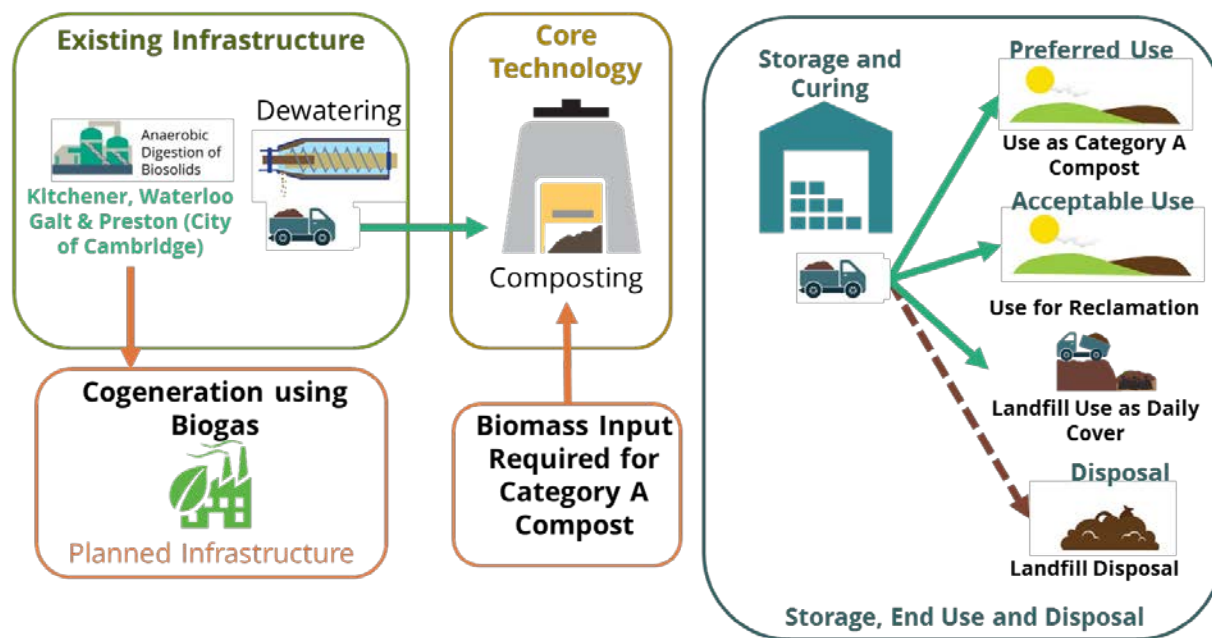


Figure 4-5: Block Flow Diagram – Composting Digested Dewatered Biosolids – Category A

4.4.1.1 What are the features?

The main features of selecting this alternative are:

- Stabilization mitigates the odour emission potential of the final product compared with the existing NASM product, and facilitates storage;
- Compost that meets Compost Quality Standards for Category A is subject to fewer restrictions for use than NASM containing biosolids;
- Adding two new end use options (agricultural and non-agricultural use as compost and landfill use as daily cover), which provide operational flexibility; and

- The compost product is acceptable for sale, and has potential to generate revenue to offset costs associated with biosolids management.

4.4.1.2 What is the end use or disposal method?

This alternative would provide the following end use or disposal options:

- Agricultural and Non-Agricultural use as compost;
- Non-Agricultural Soil Amendment such as mine tailings pond reclamation;
- Landfill use; or
- Landfill disposal.

Adding more end uses is considered a feature as it mitigates risk where any one end use or disposal method is unavailable in the short or long-term. The stabilized product is anticipated to be more straightforward to handle, store and use.

4.4.1.3 What do we need to implement it?

A new composting processing facility would be required either at a number of distributed sites or in a centralized facility. The number and type of sites could be determined based upon supporting WWTP operations, limiting trucking distances, and limiting overall impact on communities with new infrastructure. It is not likely that a composting facility could be constructed in the space available at existing WWTPs. A building would be required to protect equipment, as well as controlling emissions such as odour and noise.

Local trucking to transfer dewatered cake to the composting site or sites would be required, and the number of trucks at WWTPs would be similar to the current approach. Composting to Category A quality would require transportation of additional biomass to the composting site. Depending on the current amount of trucking required for the biomass used in co-composting, the total amount of trucking related to the biomass may be equal or higher than it is currently. The number of trucks leaving the compost facility to deliver the Compost to end use or

disposal would be lower per capita for the biosolids compared with the current approach.

A storage facility is required to protect compost from weather during storage and curing, as well as to control emission potential (e.g. particulate and odours) while facilitating multiple end uses. Allowing for inventory of the compost provides flexibility to match seasonal demand from different users.

4.4.1.4 Has it been done before and what are the considerations for the future?

Composting biosolids and other anaerobic digestate has been demonstrated in many jurisdictions. There were no facilities identified in Ontario that are permitted to compost biosolids to meet Category A standards. Halton Region has completed a pilot project with promising results, and a feasibility study to further develop the project is under way. Meeting the Compost Quality Standards (MOECC, 2012) for Category A compost is considered likely achievable, but has not been completed in Ontario at the commercial scale.

This approach is anticipated to deliver a compost product that is acceptable for sale. The Category A compost feedstock is limited to a maximum 25% biosolids (dry weight basis), which may generate more finished compost to manage when compared with other stabilization alternatives. The biomass that makes up 75% of the compost generated could be composted to Category AA quality if biosolids were not added, and therefore the broader organics management strategy must be considered before directing additional biomass to co-composting with biosolids.

4.4.2 Composting Digested Dewatered Biosolids to Category B Quality

Figure 4-6 presents the block flow diagram showing the new core technology and storage required for Category B compost.

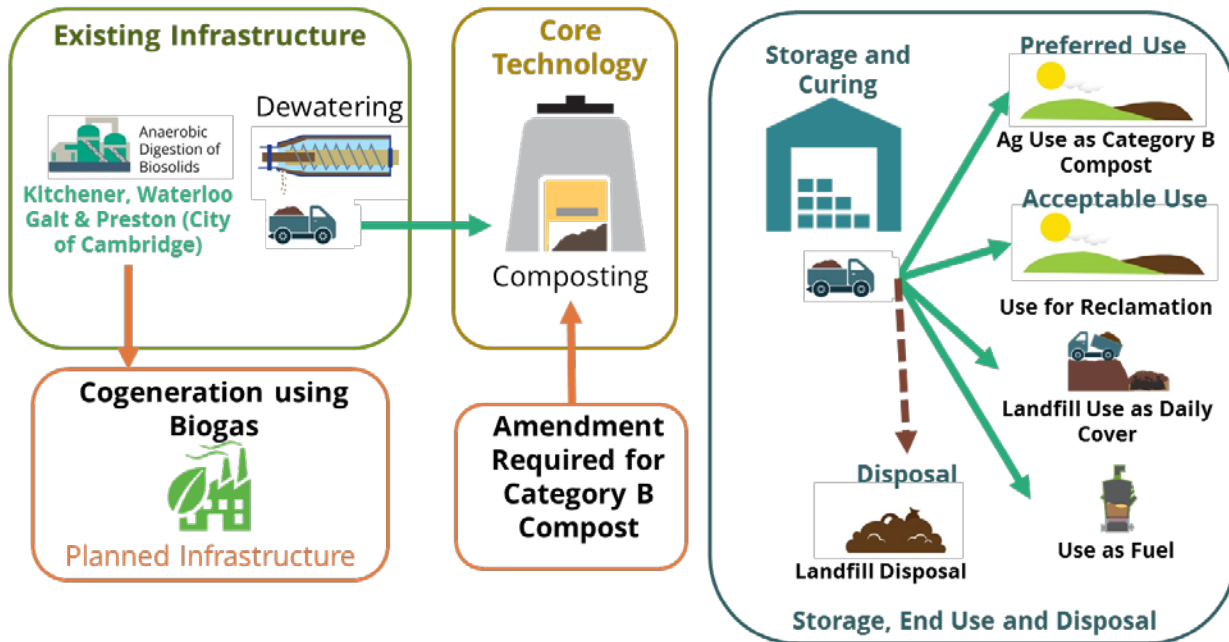


Figure 4-6: Block Flow Diagram – Composting Digested Dewatered Biosolids – Category B

4.4.2.1 What are the features?

The main features of selecting this alternative are:

- Stabilization mitigates the odour emission potential of the final product compared with the existing NASM product, and facilitates storage; Category B compost is acceptable for agricultural use and must meet the requirements of the NMA for a Category 3 NASM the same as the existing product;
- Reducing the volume / mass of biosolids that require transportation, end use or disposal by up to 60% compared with the existing biosolids product; and
- Adding two new end use options (Landfill use as daily cover, and use as fuel), which provide operational flexibility;

4.4.2.2 What is the end use or disposal method?

This alternative would provide the following end use or disposal options:

- Agricultural Use as NASM;

- Non-agricultural soil conditioners such as mine tailings pond reclamation;
- Landfill use;
- Use as fuel; or
- Landfill disposal.

Category B compost would be considered renewable biomass under the Green Energy Act, and is anticipated to provide net energy for combustion; however this is considered an acceptable end use that has low probability of implementation. Adding more end uses is considered a feature as it mitigates risk where any one end use or disposal method is unavailable in the short or long-term.

4.4.2.3 What do we need to implement it?

A new composting facility would be required either at a number of distributed sites or in a centralized facility. The number and type of sites would be determined based upon supporting WWTP operations, limiting trucking distances, and limiting overall impact on communities with new infrastructure. It is not likely that a composting facility could be constructed in the space available at existing WWTPs. A building would be required to protect equipment, as well as controlling emissions such as odour and noise.

Local trucking to transfer dewatered cake to the composting site or sites would be required, and the number of trucks at WWTPs would be similar to the current approach. Composting to Category B quality would require transportation of amendment to the composting site. The number of trucks leaving the compost facility to deliver the Compost to end use or disposal would be lower per capita than for the biosolids alone.

A storage facility is required to protect compost from weather during storage and curing, as well as to control emission potential (e.g. particulate and odours) while facilitating multiple end uses. Allowing for inventory of the compost provides flexibility to match demand from different users.

4.4.2.4 Has it been done before and what are the considerations for the future?

Composting biosolids and other anaerobic digestate has been demonstrated in many jurisdictions. There were no facilities identified in Ontario that are permitted to compost biosolids to meet Category B standards. Meeting the Compost Quality Standards (MOECC, 2012) for Category B compost is considered likely achievable, but has not been completed in Ontario at the commercial scale.

The Category B compost is considered a waste and must be managed as a waste using an ECA; unless it is used as a NASM in accordance with the NMA. The new opportunities to use nutrients from the biosolids beyond those available for the existing NASM product are limited for Category B compost.

4.5 Alternative #5 – Produce Dry Fertilizer Pellets from Biosolids

This alternative would implement a dryer technology after anaerobic digestion and dewatering to reduce the volume of dewatered cake and generate a biosolids derived fertilizer product.

The technologies proposed in this category would produce a substantially lower quantity of biosolids derived fertilizer per capita compared with the current approach (up to 75% less).

The product would meet the US EPA definition of Class A biosolids, and stabilization processes in this configuration have been demonstrated to meet the regulatory requirements of a fertilizer under the Fertilizers Act as administered by CFIA. Based upon the enhanced stability of the dry product, additional biosolids storage is considered feasible.

Figure 4-7 presents the block flow diagram showing the new core technology required for this alternative.

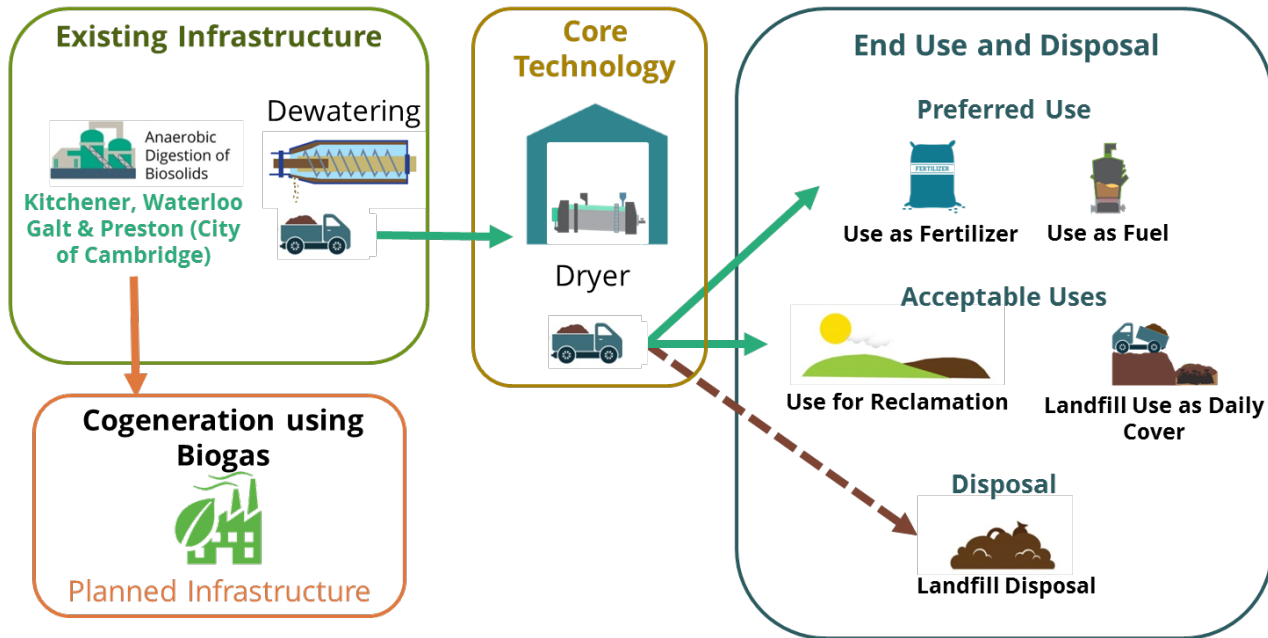


Figure 4-7: Block Flow Diagram - Produce Dry Fertilizer Pellets from Biosolids

4.5.1 What are the features?

The main features of selecting this alternative are:

- Adding three new end use options (Agricultural Use as Fertilizer, Landfill use as daily cover, and use as fuel), which provide operational flexibility; and
- Reducing the volume / mass of biosolids that require transportation, end use or disposal.

4.5.2 What is the end use or disposal method?

This alternative would provide the following end use or disposal options:

- Agricultural use as fertilizer;
- Non-Agricultural Soil Amendment such as mine tailings pond reclamation;
- Landfill use as daily cover;
- Use as a renewable fuel in combustion; or
- Landfill disposal.

Adding more end uses is considered a feature as it mitigates risk where any one end use or disposal method is unavailable in the short or long-term. The pelletized product generated from this alternative has been used as a fuel in other jurisdictions, and presents an end use that does not rely on use as a soil amendment or fertilizer in agricultural or non-agricultural applications. The pellets can be used directly as fuel in combustion processes that generate useful heat (steam) and electricity, or provide energy to an industrial process such as cement production. The pellets are also anticipated to be appropriate feedstock for emerging pyrolysis processes being developed to use dry organic feedstock.

4.5.3 What do we need to implement it?

A new process would be required either at WWTPs, or in a centralized facility. A building would be required to protect equipment, as well as controlling emissions such as odour and noise.

For a central facility, there would be a similar number of trucks required to transport dewatered cake from WWTPs to the central facility when compared with the current amount of truck traffic at WWTPs. The number of trucks required to handle the dry product for delivery to end use or disposal would be substantially the lower per capita (up to 75% less) than the existing approach.

A storage system is required for the dry product; however the substantially lower quantity of material requires a much smaller footprint than alternatives 1 – 4. Engineering controls to mitigate the risk of fires during storage is required for this dry product. Allowing for inventory of the biosolids derived fertilizer would provide flexibility to match demand from different users.

4.5.4 Has it been done before and what are the considerations for the future?

Stabilization with volume reduction using dryer technology has been implemented in Ontario at a number of facilities. All pelletized biosolids in Ontario are currently used

as agricultural fertilizers. Additional end uses for this product such as use as a fuel further mitigates the risk of losing access to any one end use or disposal option. The amount of land required would be similar to the existing approach when targeting agricultural use of a biosolids derived fertilizer product.

4.6 Alternative #6 – Thermal Reduction

This alternative would implement a core technology after anaerobic digestion and dewatering to reduce the volume of dewatered cake to ash for use as an industrial input, or disposal in landfill. Energy recovered from the process would be used to preheat or dry dewatered biosolids cake to limit the amount of supplementary fuel required. The most promising technology is a fluidized bed incinerator. The technologies proposed in this category would produce the lowest mass and volume of end product.

Figure 4-8 presents the block flow diagram showing the new thermal reduction process after digestion and dewatering.

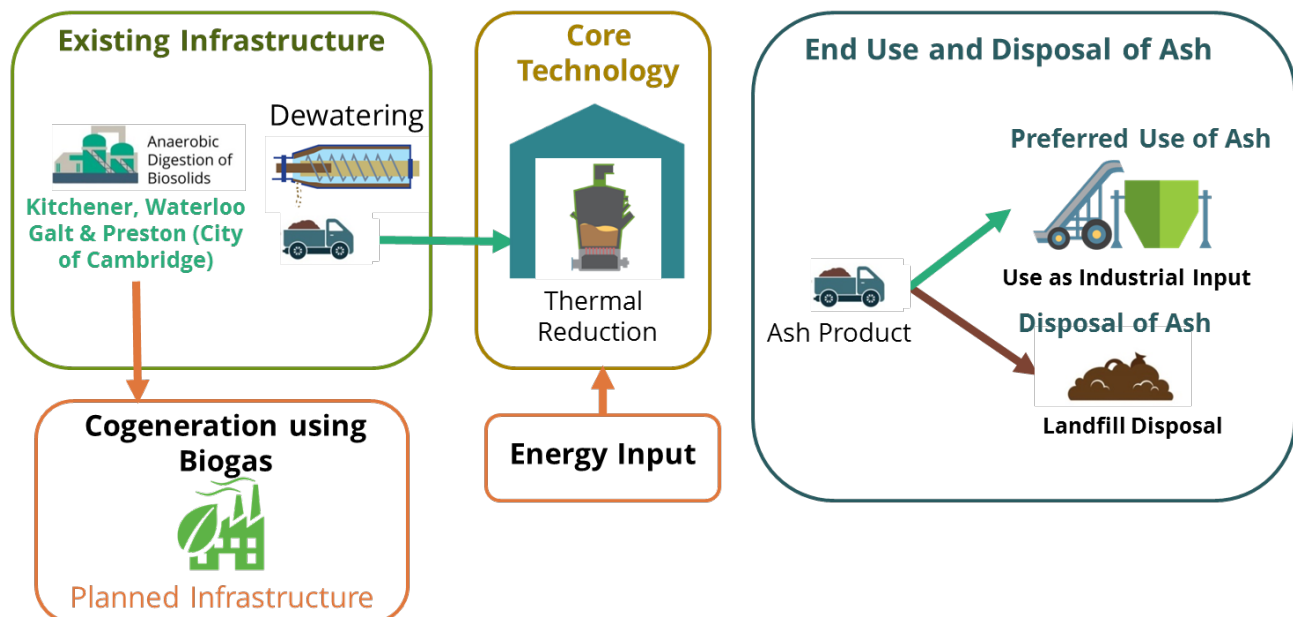


Figure 4-8: Block Flow Diagram – Thermal Reduction to Ash

4.6.1 What are the features?

The main features of selecting this alternative are:

- The largest reduction in quantity of product that requires management of all of the alternatives;
- Relies on industrial use of ash, or landfill disposal of a low volume product with no organic matter; and
- The ash product is anticipated to be straightforward to handle, store and use.

4.6.2 What is the end use or disposal method?

This alternative would provide the following end use or disposal options:

- Use as an industrial input; or
- Landfill disposal.

This alternative does not take advantage of the nutrient value of biosolids. The energy content of biosolids is used in combustion, but supplementary fuel such as natural gas is also required to maintain combustion temperatures given the moisture and volatile solids content of the current biosolids product.

4.6.3 What do we need to implement it?

A new thermal reduction process would be required most likely as a centralized facility. A building would be required to protect equipment, as well as controlling emissions to air such as criteria air contaminants, odour and noise.

There would be a similar number of trucks required to transport dewatered cake from WWTPs to the central facility when compared with the current approach. The number of trucks required to handle the ash product would be the lowest of any alternative, up to 90% less than the existing approach per capita. Depending on the final destination for ash the vehicle kilometers travelled to truck the ash is likely to be the lowest per capita of all the alternatives. A storage system is required for the ash

product; however the substantially lower quantity of material requires a much smaller footprint than other alternatives.

4.6.4 Has it been done before and what are the considerations for the future?

Thermal reduction has been implemented in Ontario at a number of facilities, mainly in larger centres such as London and Toronto. This alternative is not sensitive to potential markets for biosolids products that take advantage of nutrients. It must comply with air quality restrictions for the combustion, and it must generate a product that can be landfilled.

4.7 Alternative #7 – Thermal Reduction with Energy Recovery

This alternative would implement a core technology to reduce the volume of dewatered cake to ash for use as an industrial input, or disposal in landfill. Energy recovered from the process would be used to generate renewable electricity. In order to align with existing infrastructure, anaerobic digestion, and dewatering would be retained for this alternative which limits energy available for recovery through this alternative. It is anticipated that a supplementary energy source would be required either to reduce the moisture content of the dewatered cake prior to combustion, or co-combust with the current biosolids cake product. Renewable biomass such as low value by-products from the lumber industry would facilitate co-combustion as part of a renewable biomass to energy facility. The most promising technology for this application is a fluidized bed incinerator. The technologies proposed in this category would produce the lowest mass and volume of end product.

Figure 4-9 presents the block flow diagram showing the new thermal reduction process after digestion and dewatering.

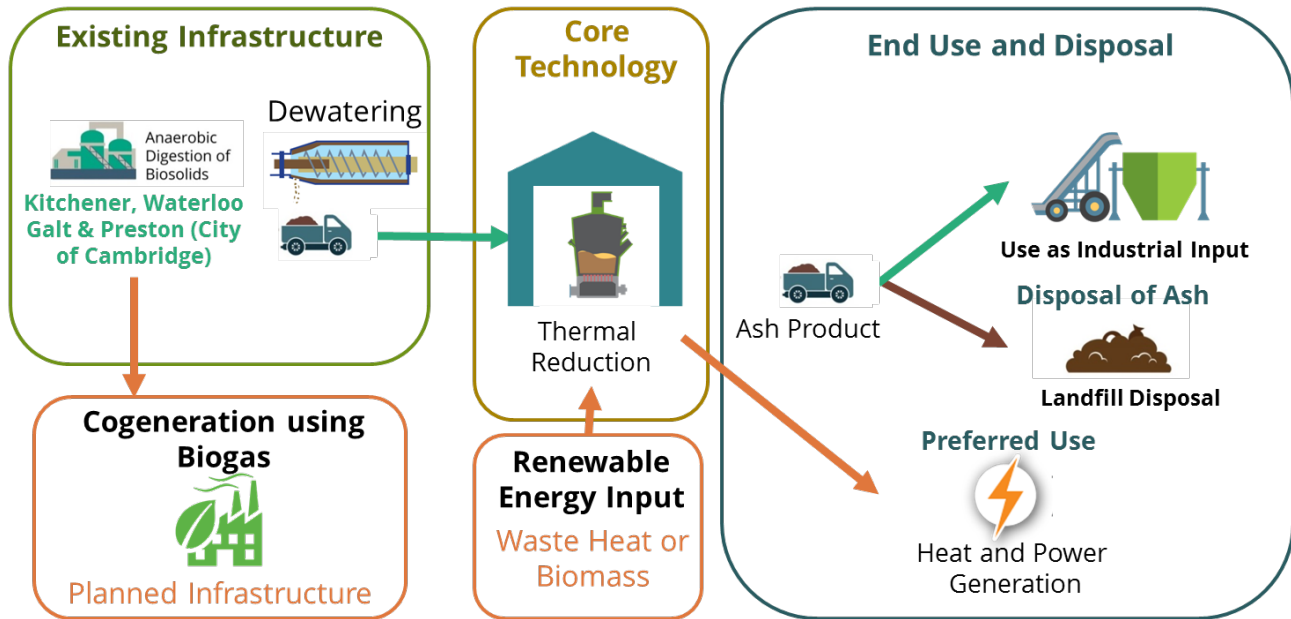


Figure 4-9: Block Flow Diagram – Thermal Reduction with Energy Recovery

4.7.1 What are the features?

The main features of selecting this alternative are:

- The largest reduction in quantity of product that requires management of all alternatives;
- Relies on industrial use of ash, or landfill disposal of a low volume product with no organic matter;
- The ash product is anticipated to be straightforward to handle, store and use; and
- It contributes to renewable energy generation.

4.7.2 What is the end use or disposal method?

This alternative would provide the following end use or disposal options for ash:

- Use as an industrial input; or
- Landfill disposal.

In the event that there is net energy from the combustion of biosolids, renewable electricity, or heat recovery typically as steam are the main products. This alternative does not take advantage of the nutrient value of biosolids, and although energy content of biosolids is used to reduce the use of supplementary fuel, it would not export energy unless enhanced dewatering or drying of the biosolids was implemented ahead of the thermal process. The CCME guideline for use of the energy content of biosolids requires greater than 25% of the ash to be used (CCME, 2012).

4.7.3 What do we need to implement it?

A new thermal reduction process would be required most likely as a centralized facility. A building would be required to protect equipment, as well as controlling emissions to air such as criteria air contaminants, odour and noise. A source of supplement renewable energy input (waste heat or biomass) is likely required to dry the current biosolids product to allow meaningful amounts of net energy to be recovered from combustion. A partner industrial facility willing to use ash is also required.

There would be a similar number of trucks required to transport dewatered cake from WWTPs to the central facility when compared with the current approach. The number of trucks required to handle the ash product would be the lowest of any alternative, up to 90% less than the existing approach per capita. . Depending on the final destination for ash the vehicle kilometers travelled to truck the ash is likely to be the lowest per capita of all the alternatives.

A storage system is required for the ash product; however the substantially lower quantity of material requires a much smaller footprint than other alternatives.

4.7.4 Has it been done before and what are the considerations for the future?

Thermal reduction has been implemented in Ontario at a number of facilities mainly in larger centres such as London and Toronto. There are also facilities operating in Ontario that generate electricity from municipal solids waste such as the Emerald Energy from Waste (EFW) facility; however it is not clear that there are any facilities in Ontario that are permitted to accept biosolids to generate renewable electricity under the Green Energy Act.

This alternative is not sensitive to potential markets for biosolids products that take advantage of nutrients. It must comply with air quality restrictions for the combustion, and it must generate a product that can be landfilled.

4.8 Alternative #8 – Landfill All Biosolids

This alternative would send all biosolids for disposal in regulated landfills. For this alternative digestion and dewatering would be expanded only as necessary to accommodate the population growth and the associated increase in solids generated at the wastewater treatment plants. Storage would be added to limit operational risk related to the existing just in time trucking approach. Operational risk can be mitigated with a relatively small amount of new storage capacity at each WWTP. Facilities without dewatering would be required to transfer solids to WWTPs with dewatering capacity. This would continue the existing transfer approach with the exception of Ayr and New Hamburg which would add a new source of solids for transfer, or would require new dewatering equipment.

Figure 4-10 presents the block flow diagram showing the process for landfilling.

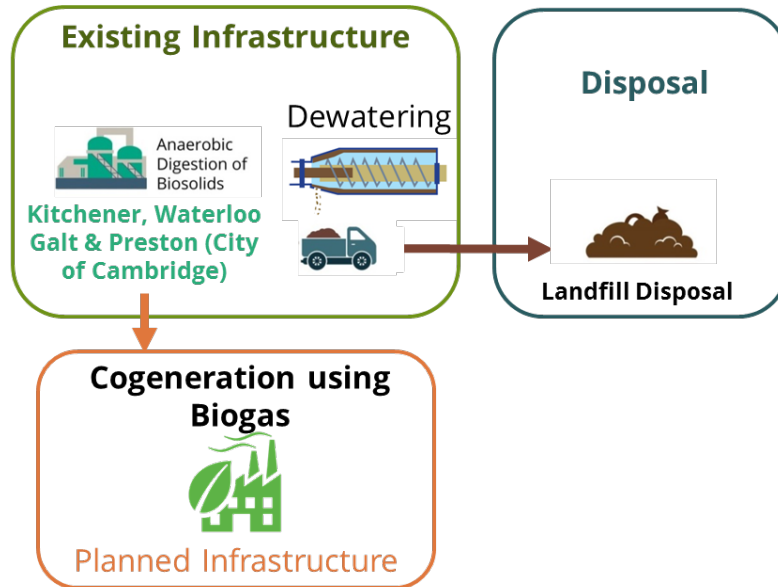


Figure 4-10: Block Flow Diagram - Landfill Disposal

4.8.1 What are the features?

The main feature of selecting this alternative is that it does not rely on a market for a biosolids product, and provides disposal that complies with regulations for all biosolids generated in the Region.

4.8.2 What is the end use or disposal method?

This alternative would send all biosolids generated in the Region to Landfill disposal outside the Region.

4.8.3 What do we need to implement it?

Operational storage systems to protect dewatered biosolids from weather, and control emission potential (e.g., particulate and odours) would be required to mitigate the risk of disruptions to trucking.

The number of trucks would be similar per capita, as compared with the current management approach, and trucking would be anticipated to increase with time and the corresponding increase in mass of biosolids produced.

Permitted landfills capable, and willing to accept the full quantity of biosolids generated by the Region would be required.

4.8.4 Has it been done before and what are the considerations for the future?

Many municipalities in Ontario use landfill disposal for a portion of their biosolids; however, no examples of municipalities in Ontario of similar scale to the Region of Waterloo were identified that rely solely on landfill disposal.

This alternative is not sensitive to potential markets for biosolids products that take advantage of nutrients, organic matter or energy value. However, a single end use or disposal method presents a risk, and landfill capacity may not be available or allocated to organic material like biosolids for the quantity required in the future.

5.0 Summary

The long list of biosolids strategy alternatives is:

- Alternative #1 – Current Approach with Expanded Capacity;
- Alternative #2 – Enhanced Anaerobic Digestion;
- Alternative #3 – Enhanced Anaerobic Digestion with Stabilization;
- Alternative #4 – Stabilize Dewatered Biosolids Cake to Make Fertilizer;
- Alternative #5 – Composting Digested Dewatered Biosolids (To Category A or B Quality);
- Alternative #6 – Reduce Volume and Stabilize Dewatered Biosolids Cake to Make Fertilizer;
- Alternative #7 – Thermal Reduction; and
- Alternative #8 – Thermal Reduction with Energy Recovery.

Figure 5 – 1 provides an info-graphic summary of the long list of alternatives. These alternatives will be developed in further detail and evaluated to generate a short list of alternatives in the next phase of the project. Input from public consultation and other stakeholder engagement will allow adjustment of the alternatives to suit the needs of the Region. Additional details will be added to each alternative in the next stage of the process to allow screening of the short list of alternatives.

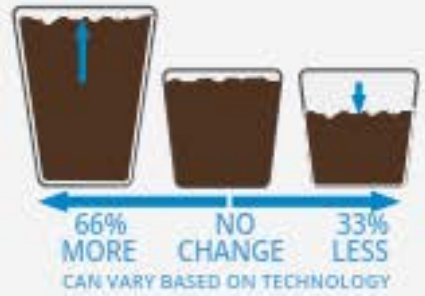
	 SOLIDS PREPARATION/ MODIFICATION	 BIOSOLIDS PROCESSING	 NEW STORAGE FACILITY SIZE	 OUTPUT VOLUME (COMPARED TO CURRENT APPROACH)	 END USES & DISPOSAL
Alternative #1 Current Approach with Expanded Capacity The current approach provides stable biosolids management. Biosolids are spread on fields or used for land reclamation, or landfilled when these options are not available.	CURRENT DEWATERING (EXPANSION WITH POPULATION GROWTH)	CURRENT DIGESTION (EXPANSION WITH POPULATION GROWTH)		 NO CHANGE	 AGRICULTURAL SOIL AMENDMENT  NON-AGRICULTURAL SOIL AMENDMENT  LANDFILL
Alternative #2 Current Approach with Solids Preparation Before Digestion This alternative can reduce the total solids by generating more biogas, and reduce the amount of liquid in the dewatered biosolids, with a similar end product.	THICKENING (NEW INFRASTRUCTURE)	CURRENT DIGESTION (LESS EXPANSION WITH POPULATION GROWTH)		 NO CHANGE	 AGRICULTURAL SOIL AMENDMENT  NON-AGRICULTURAL SOIL AMENDMENT  LANDFILL
Alternative #3 Produce Fertilizer from Biosolids This alternative would make a fertilizer product that could be sold. Different technologies can produce fertilizer products with slightly varying volumes.	CURRENT DEWATERING (EXPANSION WITH POPULATION GROWTH)	STABILIZATION OR HYDROLYSIS TECHNOLOGIES (NEW INFRASTRUCTURE)		 66% MORE NO CHANGE 33% LESS CAN VARY BASED ON TECHNOLOGY	 AGRICULTURAL SOIL AMENDMENT  NON-AGRICULTURAL SOIL AMENDMENT  LANDFILL
Alternative #4 Produce Compost from Biosolids This alternative would add composting to the current process.	CURRENT DEWATERING (EXPANSION WITH POPULATION GROWTH)	COMPOSTING TECHNOLOGY + ASSOCIATED BUILDINGS (NEW INFRASTRUCTURE)		 60% LESS	 AGRICULTURAL SOIL AMENDMENT  NON-AGRICULTURAL SOIL AMENDMENT  LANDFILL



Figure 5-1: Info Graphic Summary of Biosolids Alternatives

6.0 References

- Ministry of the Environment and Climate Change (MOECC). 2015. Draft Strategy for a Waste Free Ontario: Building The Circular Economy. Available Online: http://www.downloads.ene.gov.on.ca/envision/env_reg/er/documents/2015/012-5834_DraftStrategy.pdf. Last Accessed: August 25, 2016.
- Canadian Council for Ministers of the Environment (CCME). 2012a. Canada-wide Approach for the Management of Wastewater Biosolids. PN 1477. Available Online: <http://www.ccme.ca/en/resources/waste/biosolids.html>. Last Accessed: March 22, 2016.
- Canadian Council for Ministers of the Environment (CCME). 2012b. Guidance Document For The Beneficial Use Of Municipal Biosolids, Municipal Sludge And Treated Septage. PN 1473. Available Online: http://www.ccme.ca/files/Resources/waste/biosolids/pn_1473_biosolids_guidance_eng_1.0.pdf. Last Accessed: March 22, 2016.
- Metcalf & Eddy, Inc., George Tchobanoglous, Franklin Burton, H. David Stensel. 2002. Wastewater Engineering: Treatment and Reuse. (2002) (4th ed.).
- Ontario Ministry of the Environment and Climate Change (MOECC). 2012. Ontario Compost Quality Standards. PIBS 8412. Queen's Printer Ontario.



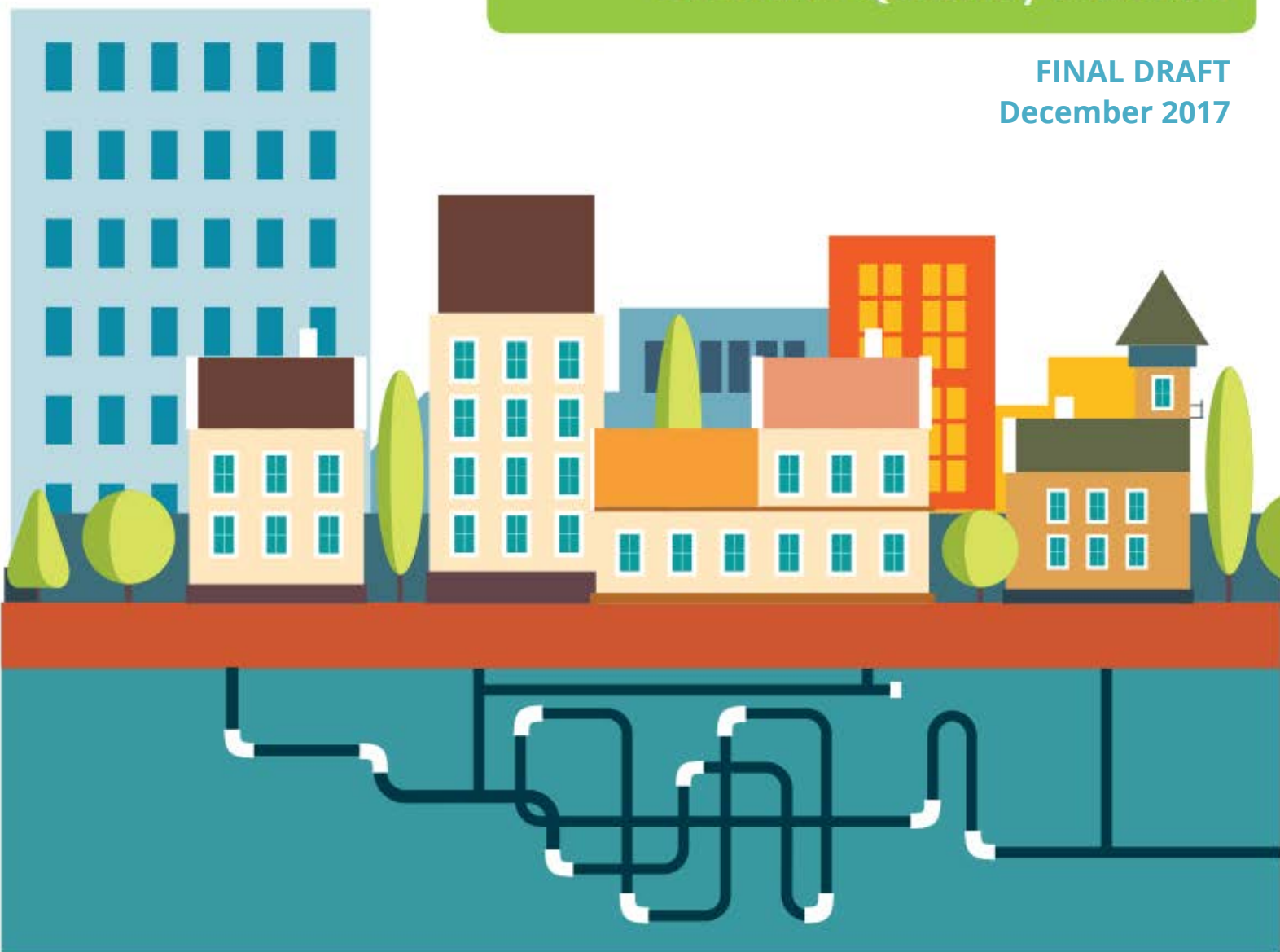
APPENDIX F:

TM#6 – Biosolids Forecast

Region of Waterloo Biosolids Strategy

Technical Memo #6 Biosolids Quantity Forecast

FINAL DRAFT
December 2017



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Acronyms

AAGR	Annual Average Growth Rates
AS	Activated Sludge
BMP	Biosolids Master Plan
BOD₅	5-day Biochemical Oxygen Demand
MCEA	Municipal Class Environmental Assessment
MOF	Ministry of Finance
ROW	Region of Waterloo
TM	Technical Memo
TSS	Total Suspended Solids
US EPA	United States Environmental Protection Agency
WAS	Waste Activated Sludge
WEAO	Water Environment Association of Ontario
WWTMP	Wastewater Treatment Master Plan
WWTP	Wastewater Treatment Plant

Introduction

1.1 Project Purpose and Approach

The Region of Waterloo Biosolids Strategy was initiated in 2015, to develop an approach to manage biosolids in Waterloo Region to the year 2051. The strategy will take a critical look at current practices, and consider available and relevant technologies for processing biosolids. Alternative ways to manage biosolids will be evaluated against a range of criteria to develop a biosolids management strategy for the Region. This project will result with the selection of a preferred strategy that will be implemented in the Region over the next 35 years. The decision making process to select the preferred strategy will be documented in a report and be available for public review. Future projects will further refine the implementation details of the strategy including timing, sizing and location of any facilities.

The strategy is being developed in six stages, which will be outlined in a series of technical memos (TMs). The memos will form the basis for the final study document. The project stages include:

- Stage 1 – What are biosolids and what process is being followed to develop the strategy?
 - o TM: The Environmental Assessment Process
- Stage 2 – What is the current situation related to biosolids in the Region and how will it change as the Region grows?
 - o TM: Existing Conditions
 - o TM: Biosolids Management Needs Forecast
- Stage 3 – What are the project objectives, what technologies and strategies are being considered and how will a decision be made to select the recommended strategy?
 - o TM: Evaluation Approach and Comparative Evaluation Criteria

- o TM: Biosolids Technologies, End Uses, and Disposal
 - o TM: Long List of Biosolids Management Alternatives
- Stage 4 – What alternatives from the long list could work in the Region of Waterloo? How can they be refined based on the project objectives? This stage involves evaluating the alternatives to identify a shorter list that will be evaluated in more detail
 - o TM: Short List of Biosolids Management Alternatives
- Stage 5 – Based on the project objectives and evaluation criteria, what is the recommended strategy? The short listed alternatives are evaluated at this stage and a recommended strategy is brought forward for public input.
 - o TM: Evaluation of Short Listed Alternatives
- Stage 6 – What is the best strategy to meet the project objectives?
 - o TM: Recommended Biosolids Strategy
 - o Biosolids Strategy Document

The Region is committed to public engagement throughout the development of the strategy. The project team will seek to understand the priorities and concerns of community residents across Waterloo Region, as well as technical experts and other stakeholders.

A **sustainable strategy** is one that considers the future growth of the Region and looks to minimize potential landfill disposal requirements of biosolids.

Additional background information regarding the context of biosolids management in the Region of Waterloo is included in **TM1**.

1.2 Purpose of this Technical Memo

The Biosolids Quantity Forecast memorandum (TM 6) documents the projection of biosolids quantities to the end of the planning period (2051). The biosolids quantity projections are broken down by individual Region WWTP facility. A biosolids quantity forecast that aligns with the current wastewater treatment master plan (WWTMP)

forecast is presented along with a sensitivity analysis that outlines a range of potential solids quantities anticipated in the future based low and high growth scenarios. These low and high estimates provide a range of biosolids quantities for consideration around the moderate and preferred forecast presented as part of the WWTMP. This forecast will be used to support the analysis of alternatives and strategies in the subsequent phases of the project.

1.3 Memo Structure

Technical Memo #4 is organized into five sections:

- 1. Chapter 1: Introduction**
- 2. Chapter 2: Population Forecast**
- 3. Chapter 3: Wastewater Flow Projections**
- 4. Chapter 4: Biosolids Forecast**
- 5. Chapter 5: Conclusion**

Chapters 2 through 4 present the main factors that are used to support projections, and the quantities of biosolids projected over the planning period. The fifth and final chapter presents the conclusions and next steps.

Population Forecast

The quantity of biosolids that will require management in the future is a direct function of the number and type of users (residential and industrial) discharging to the Region's WWTPs as well as the wastewater treatment and biosolids management infrastructure in place. Establishing a population forecast is the first step of biosolids quantity forecasting. The forecast presented in this memo for the Biosolids Strategy is aligned with the information used as the basis for the Wastewater Treatment Master Plan (WWTMP) currently being completed. This section discusses the population projections available for the Region and the projections that inform the sensitivity analysis and the forecast quantities.

1.4 Region of Waterloo Growth Scenarios

The Region is a vibrant community that is projected to experience continued population and employment growth over the next 35 years. Depending on the source accessed, the amount and timing of this growth varies. Since projected population directly impacts biosolids forecasts and therefore potential alternatives, it is important to understand the range and differences in these projections.

In order to identify the rate of growth that is forecast for the Region, a number of background documents were considered. The Province of Ontario's Places to Grow: Growth Plan for the Greater Golden Horseshoe (including Amendment 2) provides growth forecasts for municipalities within the Greater Golden Horseshoe, including the Region of Waterloo to 2041. However, the Region has experienced lower observed growth and the Growth Plan projections are now considered aggressive. As a result, the Region's Planning, Development & Legislative Services Department developed growth projections based on the more moderate observed growth within the Region to enable the development of realistic infrastructure needs and capital budgets. This moderate growth forecast was used to prepare the Region's

Wastewater Treatment Master Plan (WWTMP) (CIMA, 2016). In addition, the Ontario Ministry of Finance provides population projections for each upper tier municipality based on historic Statistics Canada rates of growth. For the purposes of this study, these three key sources of population projections were considered for the Region of Waterloo.

1.4.1 Growth Plan Forecasts

The 2005 Growth Plan formed the basis of the 2007 WWTMP, which included population projections to a 2031 growth horizon for upper- and single-tier municipalities within the Greater Golden Horseshoe including the Region of Waterloo. Amended in June 2013, the Growth Plan provides revised growth projections for 2031 and 2041. The population projections included in the 2005 and 2013 Growth Plan are based on analysis completed by Hemson Consulting Ltd (Hemson, June 2013)).¹ **Table 1** presents the reference scenario population projections for the Region of Waterloo from the June 2013 Technical Report Addendum developed by Hemson. The Growth Plan forecasts do not account for student or seasonal population.

Table 1: Growth Plan Technical Report - Region of Waterloo Population Projections

Year	2011	2016	2021	2026	2031	2036	2041
Region of Waterloo Population	528,000	573,000	624,000	681,000	742,000	789,000	835,000

Source: Greater Golden Horseshoe Growth Forecasts to 2041, Technical Report (November 2012), Addendum, Hemson Consulting Ltd., Table 1, pg. 62 (June 2013).

¹ **Note:** The 2016 Proposed Growth Plan for the Greater Golden Horseshoe includes population projections that are the same as those reported in 2013.

The population projections from the Growth Plan for the Region of Waterloo are considerably higher than observed based on census information and are considered aggressive for the Region. As a result, the Region's Planning, Development & Legislative Services (Planning) Department developed growth projections based on the more moderate observed growth within the Region to enable the development of realistic infrastructure needs and capital budgets.

1.4.2 Region of Waterloo Planning Population Estimates

The Region of Waterloo is proceeding with a Wastewater Treatment Master Plan Update, and the future forecast population and solids generation rate to be used for the Biosolids Strategy must align with this effort. The future population projections used in the WWTMP were developed by the Region to the year 2051 (CIMA+, 2016). Wastewater flow projections to the year 2051 for each of the WWTPs were subsequently developed by the WWTMP team (CIMA+, 2016) based on these population projections. The subtotal serviced and unserviced population projections used within this assessment are shown in **Table 2**. The projections are based on a 2015 existing population identified from the Region's 2016 Water and Wastewater Monitoring Report (ROW, 2016). According to this source, the total population serviced by WWTPs for the Region in 2015 was 540,510. .

Table 2: Wastewater Treatment Master Plan Update – Population Projections (2016 to 2051)

Service Area	Existing Population (ROW, 2016)	Projected Population ²							
	2015 ¹	2016	2021	2026	2031	2036	2041	2046	2051
Subtotal: Serviced Population	540,510	556,399	591,859	627,276	662,380	697,668	732,525	765,062	793,441
Unserviced Population		30,548	31,951	32,887	33,410	34,250	35,263	37,558	42,780
Total Population	575,000³	586,947	623,810	660,163	695,790	731,918	767,788	802,620	836,221
<i>Source: Table 1 and Table 14 WWTMP – Technical Memo No. 1 – Population and Flow (CIMA+, 2016).</i>									

1 – Does not include the population of Alt Heidelberg, Foxboro Green, Conestogo, or East Side Lands population

2 – Projected Serviced Population includes Alt Heidelberg, Foxboro Green, Conestogo, and East Side Lands population estimates

3 – 2016 Region of Waterloo Planning, Development, and Legislative Services Council Report (PDL-CPL-16-18, 2016)

Future projected populations for the WWTMP includes unserved populations which are not included in the populations served by WWTPs and therefore do not contribute to flow rates used in this forecast. According to the 2016 Region of Waterloo Planning, Development, and Legislative Services Council Report (PDL-CPL-16-18, 2016), the total year-end 2015 population in the Region was 575,000 people. This estimate includes a temporary student population which accounts for 30,160 students living in student residences or other accommodations, and 7,780 students who leave the Region to attend school elsewhere.

With the recent release of population information from the 2016 Census, it is possible to compare the baseline data and the first projection year (2016). The 2016 Statistics Canada Census reports a Region population of 535,154 or 556,560 people assuming 4% undercoverage.² If one also accounts for the estimated 22,270 students noted in 2015, the total potential 2016 population in the region was 578,000, which is aligned with the Region's planning estimate of 575,000.

The long-term horizon year of 2051 reflects a projected population of 836,221 people. The projections in the WWTMP are reported to reflect a moderate growth scenario. For the 25 year period from 2016 to 2041, the compounding annual average growth rate (AAGR) is 1.1%. The projections identified in **Table 2** were based on information provided by the Region and reflect a moderate growth scenario.

² Statistics Canada provides undercoverage estimates for each Census. Accounting for undercoverage is intended to account for both people who may have been missed in the Census or others who should not have been included or were counted twice. An undercoverage amount has not yet been reported for the 2016 Census. In the Growth Plan projections, 4% undercoverage was applied.

1.4.3 Ministry of Finance

In the spring of 2016, the Ministry of Finance (MFO) released the Ontario Population Projections Update. This report provides population projections for all of the census subdivisions in Ontario including the Region of Waterloo. These projections are based on both the 2011 Census and 2015 post-censal population estimates released by Statistics Canada. The MFO completes a reference, high-growth, and low-growth scenario for the entire province. Several reference scenario projections are then provided for each of the 49 Census Divisions in the province.

Table 3 presents the reference scenario population projections for the Region according to the analysis conducted by the Ministry of Finance. Overall, the projected population in the Region according to the MFO is lower than the other two population projections presented above. For example, the 2041 forecast population is 135,600 higher in the Growth Plan and approximately 67,000 higher in the WWTMP projections when compared to the MFO forecast (Hemson, 2013; CIMA+, 2016). Based on the MFO projections, for the 25-year period from 2016 to 2041, the compounding annual average growth rate for the Region is 1.0%. This is the lowest of the three identified compounding annual average growth rates (AAGR). The MOF reference scenario is considered a reasonable low growth scenario for biosolids projections.

Table 3: Ministry of Finance - Region of Waterloo Population Projections

Year	2011	2015	2016	2021	2026	2031	2036	2041
Region of Waterloo Population	523,800	542,500	548,000	579,600	611,000	641,900	671,300	699,400

Source: Ontario Population Projections Update 2015 to 2014, Ontario Ministry of Finance, Table4, pg. 40 (Spring 2016).

1.5 Discussion

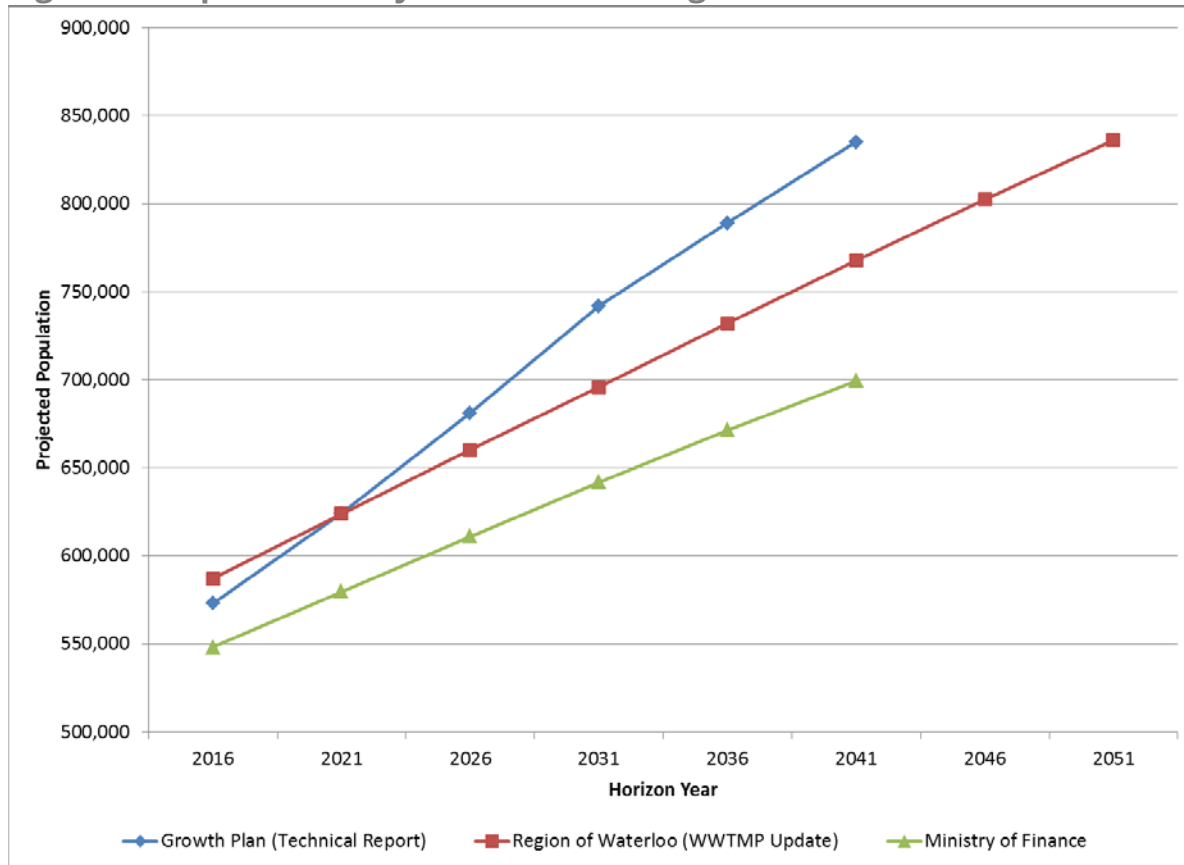
A summary of the projected population from 2016 to 2041 and compounding AAGR for each of three identified sources of population projections for the Region of Waterloo is shown in **Table 4**. Comparatively, the identified compounding AAGR reflect high (Growth Plan), moderate (WWTMP), and low (Ministry of Finance reference) growth scenarios. This is consistent with the projected population identified in absolute numbers presented in **Table 5** and **Figure 1**.

Table 4: Compounding Growth Rates

Projection Source	2016 Projected Population	2041 Projected Population	Compounding Average Annual Growth Rate (2016 to 2041)
Growth Plan (Technical Report) (High)	573,000	835,000	1.5%
Region of Waterloo WWTMP Update (Moderate)	586,947	767,788	1.1%
Ministry of Finance (Low)	548,000	699,400	1.0%

Table 5: Region of Waterloo Population Projections

Year	2016	2021	2026	2031	2036	2041	2046	2051
Growth Plan (Technical Report, 2013)	573,000	624,000	681,000	742,000	789,000	835,000		
Region of Waterloo WWTP (CIMA+, 2016)	586,947	623,810	660,163	695,790	731,918	767,788	802,620	836,221
Ministry of Finance (2016)	548,000	579,600	611,000	641,900	671,300	699,400		

Figure 1: Population Projections for the Region of Waterloo

The Region of Waterloo's growth projection that was used to inform the ongoing Wastewater Treatment Master Plan reflects a moderate growth scenario in comparison to the Growth Plan and MFO projections. Based on the available horizon years, the percent difference between the Region's WWTMP projections, the low-growth (MFO) and high-growth (Growth Plan) scenarios, there is a range of approximately $\pm 7\%$ in 2031, and $\pm 9\%$ by the 2041 planning year. This increasing divergence reflects the impact of compounding population growth rates. It also suggests that a reasonable population uncertainty band would be $\pm 10\%$ of the Region's moderate projection at the end of the planning period in 2051.

Based on this analysis, Region's WWTMP population projections will be used for the detailed biosolids forecast with a sensitivity analysis of $\pm 10\%$ of future biosolids production to account for the uncertainty in the estimates that are used.

Wastewater Flow Projections

The total serviced population projections developed by the Region for the 2016 WWTMP are broken down by Wastewater Treatment Plant service area. The Region's thirteen WWTPs are shown in **Figure 2**. Each treatment plant has a treatment capacity based upon existing infrastructure, and uncommitted hydraulic reserve capacity remaining. In addition to the 13 treatment plants an additional planning area representing the East Side Lands is included to project wastewater flow from this development area.

Table 6 shows both the projected serviced population by wastewater treatment plant in the Region as well as the identified full build-out population that can be serviced at each location. Build-out populations and the population projections were based on the data provided by the Region's Planning Department. As shown in the table, build-out populations were not provided for Waterloo, Wellesley, and St. Jacobs. This is because "the anticipated 2051 population projection is already very close to the build-out projection" (pg. 3, CIMA+, 2016). For Wellesley and St. Jacobs, the population projections were higher than the "Townships have land to accommodate within the settlement areas" (pg. 3, CIMA+, 2016).

Based on these population projections, wastewater flow projections were developed. The wastewater flow projections were calculated based on the population and the observed average per capita flows (CIMA+, 2016). The resulting projected wastewater flows by Wastewater Treatment Plant are presented in **Table 7**.

Figure 2: Wastewater Treatment Plants in the Region of Waterloo

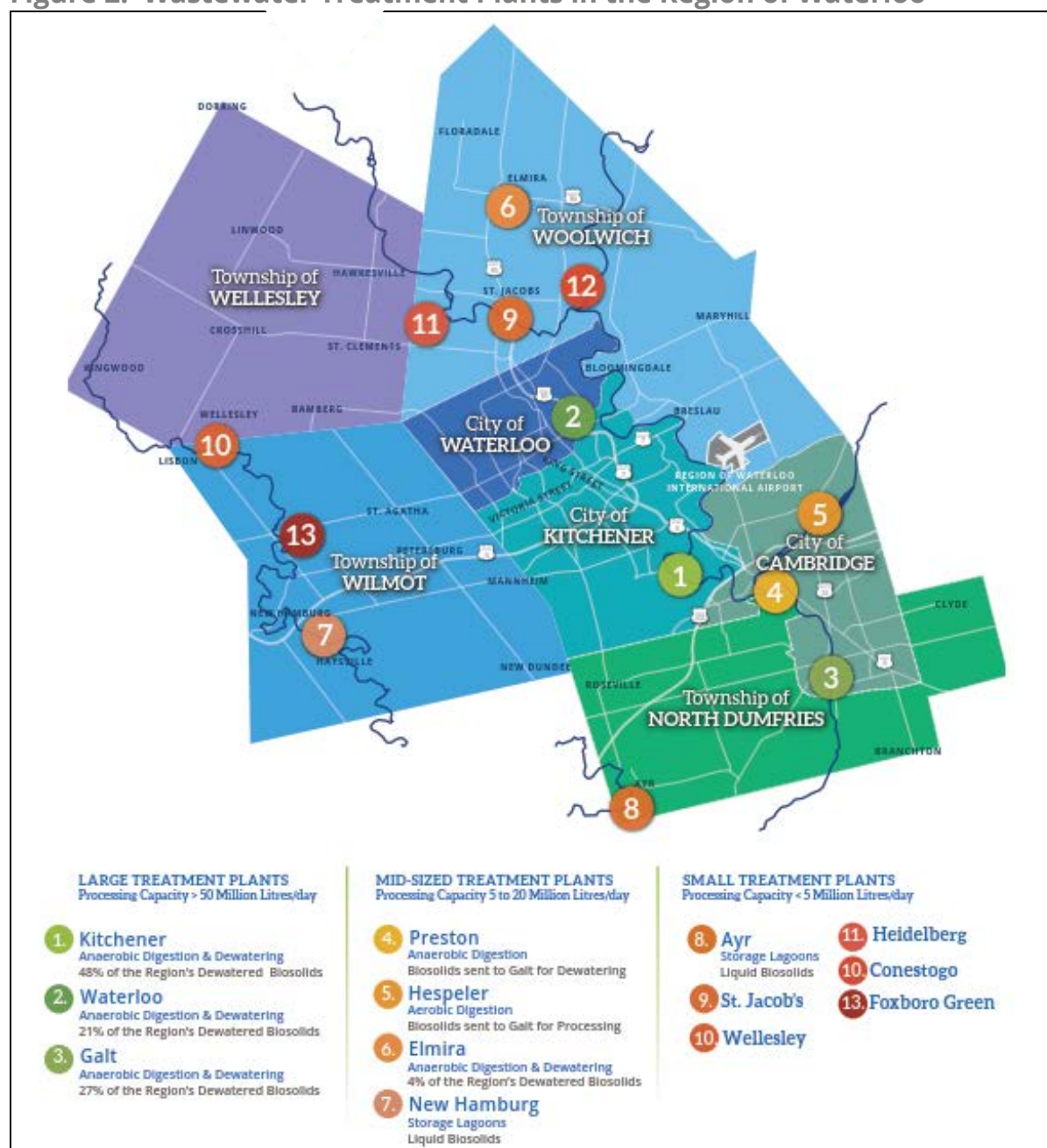


Table 6: Population Projections by Wastewater Treatment Plant Service Area

Service Area	Projected Population								Build-out Pop.
	2016	2021	2026	2031	2036	2041	2046	2051	
Kitchener	242,626	257,162	273,850	291,211	308,186	323,356	337,207	348,358	378,154
Waterloo	139,527	148,197	155,182	161,469	167,384	172,235	177,011	181,219	-
Galt	89,236	93,974	98,536	103,249	108,251	113,307	117,543	120,984	143,346
Preston	21,961	23,319	24,349	25,056	25,692	26,306	26,905	27,477	29,275
Hespeler	25,722	26,336	26,665	27,077	28,523	31,333	33,188	35,984	42,670
Ayr	5,198	6,351	7,520	8,271	8,640	9,058	9,617	10,064	12,623
Baden/New Hamburg	14,574	15,541	16,045	16,537	17,832	19,986	21,512	23,475	28,425
Wellesley	3,508	3,565	3,631	3,878	4,386	4,732	5,077	5,411	-
St. Jacobs	1,993	2,329	2,518	2,674	2,799	2,897	2,991	3,078	-
Elmira	10,484	11,487	13,461	16,268	17,623	19,125	20,872	22,132	29,861
Alt-Heidelberg	268	268	268	269	269	270	270	270	279
Foxboro Green	409	406	404	404	405	415	420	424	416
Conestogo	265	263	263	264	265	266	267	268	264
East Side Lands	628	2,661	4,584	5,753	7,413	9,239	12,182	14,297	45,733
Projected Serviced Population	556,399	591,859	627,276	662,380	697,668	732,525	765,062	793,441	-
Projected Unserviced Population	30,548	31,951	32,887	33,410	34,250	35,263	37,558	42,780	-

WASTEWATER FLOW PROJECTIONS

Service Area	Projected Population								Build-out Pop.
	2016	2021	2026	2031	2036	2041	2046	2051	
Total Projected Population	586,947	623,810	660,163	695,790	731,918	767,788	802,620	836,221	-
<i>Source: Table 14 WWTMP – Technical Memo No. 1 – Population and Flow (CIMA+, 2016).</i>									

Table 7: Future Wastewater Flow Projections to Wastewater Treatment Plants

Service Area	Average Day Flow (m³/d)									
	2016	2021	2026	2031	2036	2041	2046	2051	Ultimate Flow	Ultimate Rated Capacity
Kitchener	71,842	76,146	81,087	86,228	91,254	95,746	99,847	103,149	111,971	122,745
Waterloo	46,602	49,498	51,831	53,931	55,906	57,526	59,122	60,527	-	57,500
Galt	36,150	38,069	39,917	41,826	43,852	45,901	47,617	49,011	58,069	56,800
Preston	9,503	10,090	10,536	10,842	11,117	11,383	11,642	11,889	12,667	16,860
Hespeler	7,079	7,248	7,338	7,452	7,850	8,623	9,133	9,903	11,743	9,320
Ayr	1,425	1,741	2,062	2,268	2,369	2,484	2,637	2,760	3,461	3,000
New Hamburg	4,264	4,547	4,695	4,839	5,218	5,848	6,294	6,869	8,317	6,900
Wellesley	818	831	847	904	1,023	1,104	1,184	1,262	-	1,100
St. Jacobs	960	1,128	1,222	1,301	1,363	1,423	1,484	1,545	-	1,450
Elmira	4,479	4,907	5,751	6,950	7,529	8,170	8,917	9,455	12,757	7,800
East Side Lands	363	1,540	2,652	3,329	4,289	5,346	7,049	8,272	26,461	-
Unserviced Areas	8,682	9,081	9,347	9,496	9,734	10,022	10,675	12,159	-	-
Total	192,167	204,826	217,285	229,366	241,504	253,576	265,601	276,801	245,446	283,475
Source: Table 15 WWTMP – Technical Memo No. 1 – Population and Flow (CIMA+, 2016).										

Biosolids Forecast

The quantity of biosolids that requires management is a function of the load treated at the WWTPs, and the infrastructure available to treat the solids collected. The estimated quantity of dry solids that requires management now, and for future years, is a function of the loading to WWTPs based primarily on:

- Population;
- Per capita wastewater flow rate; and
- Concentration of TSS and BOD₅ in the wastewater

The loading was characterized for the moderate population scenario presented in the WWMP, and quantity of biosolids requiring management was estimated for the WWTMP based upon:

- Solids collected at WWTPs;
- BOD₅ converted to solids collected as waste activated sludge (WAS); and
- Volatile solids removal in the WWTPs solids processing.

The biosolids quantities estimated for the WWTMP are presented in terms of dry solids requiring management in Table 8 below. These estimates considered the most appropriate for planning. As alternatives for biosolids management are developed in additional detail the quantity of biosolids will be used to size unit processes.

Table 8: Biosolids Quantity Projections (CIMA, 2016)

WWTP	Parameter	Production at Current Flow (2012-2014) (kg/d)		2016 Production (kg/d)		2021 Production (kg/d)		2026 Production (kg/d)		2031 Production (kg/d)		2036 Production (kg/d)		2041 Production (kg/d)		2046 Production (kg/d)		2051 Production (kg/d)	
		Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month
Kitchener	Raw Sludge		16,720	12,090	16,930	12,810	17,940	13,640	19,100	14,510	20,310	15,350	21,500	16,110	22,560	16,800	23,520	17,350	24,300
		11,940																	
	WAS	8,300	11,620	8,400	11,760	8,910	12,470	9,480	13,280	10,080	14,120	10,670	14,940	11,200	15,680	11,680	16,350	12,060	16,890
	Sludge to Digesters		28,340	20,490	28,690	21,720	30,410	23,130	32,380	24,590	34,430	26,020	36,440	27,310	38,230	28,480	39,870	29,420	41,190
		20,240																	
	Total Biosolids Produced		17,990	13,290	18,610	13,790	19,300	14,680	20,550	15,980	22,370	16,520	23,130	17,340	24,270	18,080	25,310	19,130	26,780
		12,850																	
Waterloo	Raw Sludge	7,350	10,290	7,340	10,280	7,800	10,920	8,170	11,440	8,500	11,900	8,810	12,330	9,070	12,690	9,320	13,040	9,540	13,350
	WAS	6,000	8,400	6,000	8,390	6,370	8,910	4,382	6,135	6,940	9,710	7,190	10,070	7,400	10,360	7,610	10,650	7,790	10,900
	Sludge to Digesters		18,690	13,340	18,670	14,170	19,840	9,750	13,650	15,440	21,610	16,000	22,400	16,470	23,050	16,920	23,690	17,320	24,250
		13,350																	
	Total Biosolids Produced	8,350	11,690	8,340	11,680	8,860	12,410	6,098	8,537	9,660	13,520	10,010	14,010	10,300	14,420	10,580	14,820	10,840	15,170
Galt	Raw Sludge (1)	7,440	9,670	7,630	9,920	8,040	10,450	8,430	10,960	8,830	11,480	9,260	12,040	9,690	12,600	10,060	13,070	10,350	13,450
	WAS	3,980	5,170	4,080	5,310	4,300	5,590	4,510	5,860	4,730	6,140	4,950	6,440	5,190	6,740	5,380	6,990	5,540	7,190
	Sludge to Digesters		14,850	11,720	15,240	12,340	16,050	12,940	16,830	13,560	17,630	14,210	18,480	14,880	19,350	15,440	20,070	15,890	20,660
		11,420																	
	Total Biosolids Produced	7,140	9,280	7,330	9,520	7,720	10,030	8,090	10,510	8,480	11,020	8,890	11,550	9,300	12,090	9,650	12,540	9,930	12,910
Preston	Raw Sludge	1,030	1,440	1,090	1,520	1,150	1,610	1,210	1,690	1,240	1,730	1,270	1,780	1,300	1,820	1,330	1,860	1,360	1,900
	WAS	1,080	1,510	1,140	1,590	1,210	1,690	1,260	1,770	1,300	1,820	1,330	1,870	1,370	1,910	1,400	1,950	1,430	1,990
	Sludge to Digesters	2,110	2,950	2,230	3,110	2,370	3,310	2,470	3,450	2,540	3,550	2,610	3,640	2,670	3,730	2,730	3,820	2,790	3,900
	Total Biosolids Produced	1,320	1,850	1,390	1,950	1,480	2,070	1,550	2,170	1,590	2,230	1,630	2,290	1,670	2,340	1,710	2,390	1,740	2,440
Hespeler	WAS	-	-	930	1,300	950	1,330	960	1,340	980	1,360	1,030	1,440	1,130	1,580	1,200	1,670	1,300	1,810
	Sludge to Digesters	-	-	930	1,300	950	1,330	960	1,340	980	1,360	1,030	1,440	1,130	1,580	1,200	1,670	1,300	1,810
	Total Biosolids Produced	-	-	660	930	680	950	690	960	700	980	740	1,030	810	1,130	860	1,200	930	1,300

WWTP	Parameter	Production at Current Flow (2012-2014) (kg/d)		2016 Production (kg/d)		2021 Production (kg/d)		2026 Production (kg/d)		2031 Production (kg/d)		2036 Production (kg/d)		2041 Production (kg/d)		2046 Production (kg/d)		2051 Production (kg/d)	
		Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month
Ayr	WAS	210	320	230	350	280	430	330	340	370	560	380	580	400	610	430	650	450	680
	Sludge to Digesters	210	320	230	350	280	430	330	340	370	560	380	580	400	610	430	650	450	680
	Total Biosolids Produced	170	260	190	290	230	350	270	270	300	450	310	470	320	500	340	530	360	550
Baden / New Hamburg	WAS	510	770	590	890	630	950	650	980	670	1,010	720	1,090	810	1,220	870	1,310	950	1,430
	Sludge to Digesters	510	770	590	890	630	950	650	980	670	1,010	720	1,090	810	1,220	870	1,310	950	1,430
	Total Biosolids Produced	430	650	500	750	530	800	550	820	560	850	610	920	680	1,030	730	1,110	800	1,210
Wellesley	Total Sludge Produced	120	200	110	190	110	190	120	190	120	210	140	240	150	250	160	270	170	290
St. Jacobs	Total Sludge Produced	90	140	100	150	110	180	120	190	130	200	140	210	140	220	150	230	150	230
Elmira	Raw Sludge	630	950	640	960	700	1,060	820	1,240	990	1,500	1,080	1,620	1,170	1,760	1,270	1,920	1,350	2,040
	WAS	590	890	600	900	660	990	770	1,160	930	1,400	1,010	1,520	1,090	1,650	1,190	1,800	1,260	1,910
	Total Sludge Produced	1,220	1,830	1,240	1,860	1,360	2,040	1,590	2,390	1,920	2,880	2,080	3,120	2,260	3,390	2,470	3,700	2,620	3,920
Alt - Heidelberg	Total Sludge Produced	11	15	12	16	12	16	12	16	12	16	12	16	12	16	12	16	12	16
Foxboro Green	Raw Sludge	6	9	6	9	6	9	6	9	6	9	6	9	6	9	6	9	6	10
	WAS	9	14	9	14	9	14	9	14	9	14	9	14	9	14	9	15	9	15
	Total Sludge Produced	14	23	15	23	14	23	14	23	14	23	15	23	15	24	15	24	15	24
Conestogo	Total Sludge Produced	6	9	7	10	7	10	7	10	7	10	7	10	7	10	7	10	7	10
	Total Sludge/Total Biosolids Produced	31,721	43,937	32,904	45,579	34,903	48,369	33,791	46,636	39,103	54,249	41,104	57,019	43,004	59,690	44,764	62,150	46,254	64,220

The quantity forecast is sensitive to the factors presented above, and the estimates will vary linearly with changes to each parameter. The overall solids load influent to WWTPs in the future is considered most sensitive to the population forecast. The detailed evaluation of population projections presented demonstrates that a range of +/- 10 % would be prudent to consider particularly where the feasibility of an alternative is close to a size threshold.

Water conservation by individuals such as water efficient appliances, and low flow fixtures (e.g. faucets, toilets, showers) is likely to continue to reduce per capita wastewater flow rates; however it is considered less likely to impact loading at WWTPs. It is considered likely wastewater total solids concentrations will increase to offset per capita flow reductions, and therefore loading at WWTPs is likely to increase with population growth as presented.

The quantity of solids collected is anticipated to be relatively stable as a percentage of the influent load. Effluent water quality criteria are considered likely to remain the same or become more stringent and therefore an equal or higher percentage to the load influent to WWTPs must be removed from the liquid stream. More stringent effluent quality criteria will tend to increase the rate of biosolids production per capita; however current requirements are relatively stringent, and changes are not anticipated to generate more than a 10% increase in biosolids production.

The quantity of biosolids to be managed is also dependant on the amount of volatile solids removed during solids processing, primarily conversion to gas during digestion. Energy recovery as biogas is likely to incentivize volatile solids reduction, and reduce the per capita quantity requiring management in the future. Optimizing operations of the existing digestion infrastructure is considered unlikely to generate more than a 10% reduction in quantity. New technologies that substantially affect volatile solids reduction will be considered separately from the sensitivity analysis.

The biosolids quantity projected is sensitive to a number of factors related to the load influent, as well as solids collection and processing to the WWTPs. The

parameters considered are unlikely to all act to increase quantity, or all act to decrease quantity. For example, effluent quality criteria may tend to increase solids collected, while optimization of biogas generation will tend to decrease the amount of biosolids requiring management. Therefore the uncertainty band identified for population growth of +/- 10% is considered the appropriate range to consider for future projections. The total biosolids produced for the Region of Waterloo for the moderate population projection in the WWTMP was an average of 46,300 and a peak of 64,200 kg dry solids / day. Using 10% uncertainty, the range biosolids production projected for the year 2051 is 42,000 – 51,000 kg dry solids / day on average, and 58,000 – 71,000 kg dry solids / day for a peak month.

1.6 Wastewater Treatment Plants

The projected biosolids generation rates stated in equivalent dry solids provides a useful basis to compare between facilities. These estimates can be extended to the actual amount of material that will require management in the future by incorporating plant specific processing. The solids content of the material produced at each facility is used to estimate the future volume of material and associated trucking requirements.

1.6.1 Kitchener, Waterloo, Galt, Preston

The Kitchener, Waterloo, Galt and Preston facilities have existing anaerobic digesters, and centrifuges for dewatering. The projected quantity of biosolids requiring management from each is dependent on the solids content of the dewatered cake. The Kitchener WWTP biosolids quantities are presented in **Table 9**. The Waterloo WWTP biosolids quantities are presented in **Table 10**. Solids collected at the Preston WWTP are digested on site and transferred to Galt for dewatering. Preston biosolids quantities are summarized in **Table 11**. The quantity of biosolids for Preston is shown at 2.5% solids, which is the average after digestion, when the material is transferred to Galt using local trucking, and 25%, which represents the quantity of

cake contributed currently to the Galt WWTP. Galt and Preston biosolids Product are presented in **Table 12**.

Table 9: Kitchener Summary of Solids

Parameter	Production at		2016		2021		2026		2031		2036		2041		2046		2051	
	Current Flow		Production (kg/d)		Production (kg/d)		Production (kg/d)		Production (kg/d)		Production (kg/d)		Production (kg/d)		Production (kg/d)		Production (kg/d)	
	Average	Peak	Average	Peak	Average	Peak	Average	Peak	Average	Peak	Average	Peak	Average	Peak	Average	Peak	Average	Peak
	Month	Month	Month	Month	Month	Month	Month	Month	Month	Month	Month	Month	Month	Month	Month	Month	Month	Month
Raw Sludge (Dry kg / day)	11,940	16,720	12,090	16,930	12,810	17,940	13,640	19,100	14,510	20,310	15,350	21,500	16,110	22,560	16,800	23,520	17,350	24,300
WAS (Dry kg /day)	8,300	11,620	8,400	11,760	8,910	12,470	9,480	13,280	10,080	14,120	10,670	14,940	11,200	15,680	11,680	16,350	12,060	16,890
Sludge to Digesters (Dry kg/day)	20,240	28,340	20,490	28,690	21,720	30,410	23,130	32,380	24,590	34,430	26,020	36,440	27,310	38,230	28,480	39,870	29,420	41,190
Total Biosolids Produced (Dry Kg /day)	12,850	17,990	13,290	18,610	13,790	19,300	14,680	20,550	15,610	21,860	16,520	23,130	17,340	24,270	18,080	25,310	18,680	26,150
Total Biosolids Cake Produced (Wet kg / day) ¹	49,400	69,200	51,100	71,600	53,000	74,200	56,500	79,000	61,500	86,000	63,500	89,000	66,700	93,300	69,500	97,300	73,600	103,000
Equivalent Number of Trucks	2	3	3	4	3	4	3	4	3	4	3	4	3	5	3	5	4	5

1 – Total biosolids (Wet kg / day) based upon 2013 – 2015 data and 26% average solids content in dewatered cake at the Manitou Drive Facility that serves the Kitchener WWTP

Table 10: Waterloo Summary of Solids

Parameter	Production at Current Flow (2012-2014) (kg/d)		2016 Production (kg/d)		2021 Production (kg/d)		2026 Production (kg/d)		2031 Production (kg/d)		2036 Production (kg/d)		2041 Production (kg/d)		2046 Production (kg/d)		2051 Production (kg/d)	
	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month
Raw Sludge (Dry kg / day)	7,350	10,290	7,340	10,280	7,800	10,920	8,170	11,440	8,500	11,900	8,810	12,330	9,070	12,690	9,320	13,040	9,540	13,350
WAS (Dry kg /day)	6,000	8,400	6,000	8,390	6,370	8,910	4,382	6,135	6,940	9,710	7,190	10,070	7,400	10,360	7,610	10,650	7,790	10,900
Sludge to Digesters (Dry kg/day)	13,350	18,690	13,340	18,670	14,170	19,840	9,750	13,650	15,440	21,610	16,000	22,400	16,470	23,050	16,920	23,690	17,320	24,250
Total Biosolids Produced (Dry Kg /day)	8,350	11,690	8,340	11,680	8,860	12,410	6,098	8,537	9,660	13,520	10,010	14,010	10,300	14,420	10,580	14,820	10,840	15,170
Total Biosolids Cake Produced (Wet kg / day) ¹	27,800	39,000	27,800	38,900	29,500	41,400	20,300	28,500	32,200	45,100	33,400	46,700	34,300	48,100	35,300	49,400	36,100	50,600
Equivalent Number of Trucks	1	2	1	2	1	2	1	1	2	2	2	2	2	2	2	2	2	3

1 – Total biosolids (Wet kg / day) based upon data from May 2014 to September 2015 and 30% average solids content in dewatered cake at the Waterloo Facility

Table 11: Galt Summary of Solids

Parameter	Production at Current Flow (2012-2014) (kg/d)		2016 Production (kg/d)		2021 Production (kg/d)		2026 Production (kg/d)		2031 Production (kg/d)		2036 Production (kg/d)		2041 Production (kg/d)		2046 Production (kg/d)		2051 Production (kg/d)	
	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month
Raw Sludge (Dry kg / day)	7,440	9,670	7,630	9,920	8,040	10,450	8,430	10,960	8,830	11,480	9,260	12,040	9,690	12,600	10,060	13,070	10,350	13,450
WAS (Dry kg /day)	3,980	5,170	4,080	5,310	4,300	5,590	4,510	5,860	4,730	6,140	4,950	6,440	5,190	6,740	5,380	6,990	5,540	7,190
Sludge to Digesters (Dry kg/day)	11,420	14,850	11,720	15,240	12,340	16,050	12,940	16,830	13,560	17,630	14,210	18,480	14,880	19,350	15,440	20,070	15,890	20,660
Total Biosolids Produced (Dry Kg /day)	7,140	9,280	7,330	9,520	7,720	10,030	8,090	10,510	8,480	11,020	8,890	11,550	9,300	12,090	9,650	12,540	9,930	12,910
Total Biosolids Cake Produced (Wet kg / day) ¹	28,600	37,100	29,300	38,100	30,900	40,100	32,400	42,000	33,900	44,100	35,600	46,200	37,200	48,400	38,600	50,200	39,700	51,600
Equivalent Trucks	1	2	1	2	2	2	2	2	2	2	2	2	2	2	2	3	2	3

1 – Total biosolids (Wet kg / day) based upon data from 2012 to 2015 and 25% average solids content in dewatered cake at the Galt Facility

Table 12: Preston Summary of Solids

Parameter				Production at Current Flow (2012-2014) (kg/d)		2016 Production (kg/d)		2021 Production (kg/d)		2026 Production (kg/d)		2031 Production (kg/d)		2036 Production (kg/d)		2041 Production (kg/d)		2046 Production (kg/d)		2051 Production (kg/d)	
				Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month
Raw Sludge (Dry kg / day)				1,030	1,440	1,090	1,520	1,150	1,610	1,210	1,690	1,240	1,730	1,270	1,780	1,300	1,820	1,330	1,860	1,360	1,900
WAS (Dry kg /day)				1,080	1,510	1,140	1,590	1,210	1,690	1,260	1,770	1,300	1,820	1,330	1,870	1,370	1,910	1,400	1,950	1,430	1,990
Sludge to Digesters (Dry kg/day)				2,110	2,950	2,230	3,110	2,370	3,310	2,470	3,450	2,540	3,550	2,610	3,640	2,670	3,730	2,730	3,820	2,790	3,900
Total Biosolids Produced (Dry Kg /day)				1,320	1,850	1,390	1,950	1,480	2,070	1,550	2,170	1,590	2,230	1,630	2,290	1,670	2,340	1,710	2,390	1,740	2,440
Total Biosolids Produced and Transferred to Galt (Wet kg / day) ¹				52,800	74,000	55,600	78,000	59,200	82,800	62,000	86,800	63,600	89,200	65,200	91,600	66,800	93,600	68,400	95,600	69,600	97,600
Average Local Trucks Required for Transfers to Galt				3	4	3	4	3	4	3	4	3	4	3	5	3	5	3	5	3	5
Total Biosolids Cake Produced (Wet kg / day) ²				5,300	7,400	5,600	7,800	5,900	8,300	6,200	8,700	6,400	8,900	6,500	9,200	6,700	9,400	6,800	9,600	7,000	9,800
Approximate Number of Truck Required				0.3	0.4	0.3	0.4	0.3	0.4	0.3	0.4	0.3	0.4	0.3	0.5	0.3	0.5	0.3	0.5	0.4	0.5

1 – Total biosolids (Wet kg / day) based upon data from 2012 - 2015 and 2.5% average solids content in digested biosolids transferred to the Galt Facility

2 – Total biosolids (Wet kg / day) based upon data from 2012 to 2015 and 25% average solids content in dewatered cake at the Galt Facility

1.6.2 Hespeler WWTP

The quantity of biosolids generated at the Hespeler Facility is presented in Table 13. Currently solids at the Hespeler WWTP are collected in aerated storage until they are transferred as a 0.8% solids slurry to the Galt and Kitchener WWTPs for digestion and dewatering. The solids quantity of material currently transferred between plants using local transportation is presented as well as the contribution to the quantity of dewatered cake. A relatively low volatile solids reduction, 40%, is assumed for the aerated storage, and additional reduction through the digesters at Galt and Preston are not accounted in the solids projections. Changes to digestion at Hespeler are anticipated to reduce the quantity of biosolids requiring management by reducing volatile solids at the Hespeler facility, and enhancing thickening such that substantially less material would require transfer.

Table 13: Hespeler Summary of Solids

Parameter				Production at Current Flow (2012-2014) (kg/d)		2016 Production (kg/d)		2021 Production (kg/d)		2026 Production (kg/d)		2031 Production (kg/d)		2036 Production (kg/d)		2041 Production (kg/d)		2046 Production (kg/d)		2051 Production (kg/d)	
				Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month
WAS (Dry kg /day)				-	-	930	1,300	950	1,330	960	1,340	980	1,360	1,030	1,440	1,130	1,580	1,200	1,670	1,300	1,810
Sludge to Digesters (Dry kg/day)				-	-	930	1,300	950	1,330	960	1,340	980	1,360	1,030	1,440	1,130	1,580	1,200	1,670	1,300	1,810
Total Biosolids Produced (Dry Kg /day)				-	-	660	930	680	950	690	960	700	980	740	1,030	810	1,130	860	1,200	930	1,300
Total Biosolids Produced and Transferred to Galt (Wet kg / day) ¹				-	-	82,500	116,250	85,000	118,750	86,250	120,000	87,500	122,500	92,500	128,750	101,250	141,250	107,500	150,000	116,250	162,500
Average Local Trucks Required for Transfers to Galt				-	-	4	6	4	6	4	6	4	6	5	6	5	7	5	8	6	8
Total Biosolids Cake Produced (Wet kg / day) ²				-	-	2,600	3,700	2,700	3,800	2,800	3,800	2,800	3,900	3,000	4,100	3,200	4,500	3,400	4,800	3,700	5,200
Approximate Number of Truck Required				-	-	0.1	0.2	0.1	0.2	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3

1 – Total biosolids (Wet kg / day) based upon data from 2012 - 2015 and 0.8% average solids content in digested biosolids currently transferred to the Kitchener and Galt Facilities

2 – Total biosolids (Wet kg / day) based upon data from 2012 to 2015 and 25% average solids content in dewatered cake at the Galt Facility

1.6.3 Elmira

The quantity of biosolids generated at the Elmira Facility is presented in Table 14. Currently solids at the Elmira WWTP are collected in aerated storage until they are dewatered on site, and transferred to landfill for disposal.

Table 14: Elmira Summary of Solids

Parameter			Production at Current Flow (2012-2014) (kg/d)		2016 Production (kg/d)		2021 Production (kg/d)		2026 Production (kg/d)		2031 Production (kg/d)		2036 Production (kg/d)		2041 Production (kg/d)		2046 Production (kg/d)		2051 Production (kg/d)	
			Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month
WAS (Dry kg /day)			630	950	640	960	700	1,060	820	1,240	990	1,500	1,080	1,620	1,170	1,760	1,270	1,920	1,350	2,040
Sludge to Digesters (Dry kg/day)			590	890	600	900	660	990	770	1,160	930	1,400	1,010	1,520	1,090	1,650	1,190	1,800	1,260	1,910
Total Biosolids Produced (Dry Kg /day)			1,220	1,830	1,240	1,860	1,360	2,040	1,590	2,390	1,920	2,880	2,080	3,120	2,260	3,390	2,470	3,700	2,620	3,920
Total Biosolids Cake Produced (Wet kg / day) ¹			4,900	7,300	5,000	7,400	5,400	8,200	6,400	9,600	7,700	11,500	8,300	12,500	9,000	13,600	9,900	14,800	10,500	15,700
Equivalent Trucks			0.2	0.4	0.3	0.4	0.3	0.4	0.3	0.5	0.4	0.6	0.4	0.6	0.5	0.7	0.5	0.7	0.5	0.8

1 – Total biosolids (Wet kg / day) based upon assumed 25% average solids content in dewatered cake at the Elmira Facility

1.6.4 Ayr and New Hamburg

The Ayr and New Hamburg facilities both aerobic digestion and storage lagoons to accumulate solids until they can be managed as liquid biosolids. The quantity of biosolids generated at the Ayr facility is presented in Table 15 and the New Hamburg facility is presented in Table 16.

Table 15: Ayr Summary of Solids

Parameter	Production at Current Flow (2012-2014) (kg/d)		2016 Production (kg/d)		2021 Production (kg/d)		2026 Production (kg/d)		2031 Production (kg/d)		2036 Production (kg/d)		2041 Production (kg/d)		2046 Production (kg/d)		2051 Production (kg/d)	
	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month
WAS (Dry kg /day)	210	320	230	350	280	430	330	340	370	560	380	580	400	610	430	650	450	680
Sludge to Digesters (Dry kg/day)	210	320	230	350	280	430	330	340	370	560	380	580	400	610	430	650	450	680
Total Biosolids Produced (Dry Kg /day)	170	260	190	290	230	350	270	270	300	450	310	470	320	500	340	530	360	550
Total Biosolids Produced (Wet kg / day) ¹	3,617	5,532	4,043	6,170	4,894	7,447	5,745	5,745	6,383	9,574	6,596	10,000	6,809	10,638	7,234	11,277	7,660	11,702
Average Trucks Required	0.2	0.3	0.2	0.3	0.2	0.4	0.3	0.3	0.3	0.5	0.3	0.5	0.3	0.5	0.4	0.6	0.4	0.6

1 – Total biosolids (Wet kg / day) based upon data from 2013 - 2015 and 4.7% average solids content in digested biosolids transferred out of the Ayr storage lagoon

Table 16: New Hamburg Summary of Solids

Parameter	Production at Current Flow (2012-2014) (kg/d)		2016 Production (kg/d)		2021 Production (kg/d)		2026 Production (kg/d)		2031 Production (kg/d)		2036 Production (kg/d)		2041 Production (kg/d)		2046 Production (kg/d)		2051 Production (kg/d)	
	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month
WAS (Dry kg /day)	510	770	590	890	630	950	650	980	670	1,010	720	1,090	810	1,220	870	1,310	950	1,430
Sludge to Digesters (Dry kg/day)	510	770	590	890	630	950	650	980	670	1,010	720	1,090	810	1,220	870	1,310	950	1,430
Total Biosolids Produced (Dry Kg /day)	430	650	500	750	530	800	550	820	560	850	610	920	680	1,030	730	1,110	800	1,210
Total Biosolids Produced (Wet kg / day) ¹	23,889	36,111	27,778	41,667	29,444	44,444	30,556	45,556	31,111	47,222	33,889	51,111	37,778	57,222	40,556	61,667	44,444	67,222
Average Trucks Required	1.2	1.8	1.4	2.1	1.5	2.2	1.5	2.3	1.6	2.4	1.7	2.6	1.9	2.9	2.0	3.1	2.2	3.4

1 – Total biosolids (Wet kg / day) based upon data from 2013 - 2015 and 1.8% average solids content in digested biosolids transferred out of the New Hamburg storage lagoon

1.6.5 Small Facilities – Alt-Heidelberg, Conestogo, St. Jacobs, Foxboro Green, and Wellesley WWTPs

The small facilities providing wastewater treatment in the Region generate limited quantities of solids that require management. Table 16 presents the quantities anticipated from Alt-Heidelberg, Conestogo, St. Jacobs, Foxboro Green, and Wellesley WWTPs.

Table 17: Alt-Heidelberg, Conestogo, St. Jacobs, Foxboro Green, and Wellesley WWTP Summary of Solids

Parameter	Production at Current Flow (2012-2014) (kg/d)		2016 Production (kg/d)		2021 Production (kg/d)		2026 Production (kg/d)		2031 Production (kg/d)		2036 Production (kg/d)		2041 Production (kg/d)		2046 Production (kg/d)		2051 Production (kg/d)	
	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month	Average Month	Peak Month
Total Sludge Produced (Dry kg / day) at Wellesley	120	200	110	190	110	190	120	190	120	210	140	240	150	250	160	270	170	290
Total Sludge Produced (Dry kg / day) at St. Jacobs	90	140	100	150	110	180	120	190	130	200	140	210	140	220	150	230	150	230
Total Sludge Produced (Dry kg / day) at Alt - Heidelberg	11	15	12	16	12	16	12	16	12	16	12	16	12	16	12	16	12	16
Raw Sludge (Dry kg / day) at Foxboro Green	6	9	6	9	6	9	6	9	6	9	6	9	6	9	6	9	6	10
WAS (Dry kg / day) at Foxboro Green	9	14	9	14	9	14	9	14	9	14	9	14	9	14	9	15	9	15
Total Sludge Produced (Dry kg / day) at Foxboro Green	14	23	15	23	14	23	14	23	14	23	15	23	15	24	15	24	15	24
Total Sludge Produced (Dry kg / day) at Conestogo	6	9	7	10	7	10	7	10	7	10	7	10	7	10	7	10	7	10
Total Sludge produced for by Small Facilities (Dry kg / day)	241	387	244	389	253	419	273	429	283	459	314	499	324	520	344	550	354	570
Total Sludge produced for by Small Facilities (Wet kg / day) ¹	12050	19350	12200	19450	12650	20950	13650	21450	14150	22950	15700	24950	16200	26000	17200	27500	17700	28500
Approximate Number of Truck Required	0.6	1.0	0.6	1.0	0.6	1.0	0.7	1.1	0.7	1.1	0.8	1.2	0.8	1.3	0.9	1.4	0.9	1.4

1 – Total biosolids (Wet kg / day) based upon assumed 2% average solids content in solids collected at small WWTPs

Conclusion

The quantity of biosolids that require management is a function of the wastewater load treated at the WWTPs, and the infrastructure available to treat the solids collected. The estimated quantity of dry solids that requires management now, and for future years is a function of the loading to WWTPs based primarily on:

- Forecasted population growth;
- Per-capita wastewater flow rate; and
- Concentration of TSS and BOD₅ in the wastewater.

The loading was characterized for the moderate population scenario presented in the WWMP, and quantity of biosolids requiring management was estimated for the WWTMP based upon:

- Solids collected at WWTPs;
- BOD₅ converted to solids collected as waste activated sludge (WAS); and
- Volatile solids removal in the WWTPs solids processing.

The biosolids quantity projected is sensitive to a number of factors related to the load influent, as well as solids collection and processing to the WWTPs. The parameters considered are unlikely to all act to increase quantity, or all act to decrease quantity. For example, effluent quality criteria may tend to increase solids collected, while optimization of biogas generation will tend to decrease the amount of biosolids requiring management. Therefore the uncertainty band identified for population growth of +/- 10% is considered the appropriate range to consider for future projections. The total biosolids produced for the Region of Waterloo for the moderate population projection in the WWTMP was an average of 46,300 and a peak of 64,200 kg dry solids / day. Using 10% uncertainty, the range biosolids production

projected for the year 2051 is 42,000 – 51,000 kg dry solids / day on average, and 58,000 – 71,000 kg dry solids / day for a peak month.



APPENDIX G:

TM#7 – Short List of Alternatives

Region of Waterloo Biosolids Strategy

Technical Memo #7 Biosolids Alternatives Short List

Final Draft
December 2017



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Acronyms

AS	Activated Sludge
BMP	Biosolids Master Plan
CCME	Canadian Council of Ministers of the Environment
CFIA	Canadian Food Inspection Agency
CHP	Combined Heat and Power
EPA	Environmental Protection Act
GHG	Greenhouse Gas
MLD	Million Litres / Day
MOECC	Ministry of Environment and Climate Change
MPQ	Minimum Performance Questions
NASM	Non-Agricultural Source Material
NMA	Ontario Nutrient Management Act, 2002, S.O. 2002, c. 4
OH&S	Ontario Health and Safety
TM	Technical Memo
US EPA	United States Environmental Protection Agency
WAS	Waste Activated Sludge
WWTP	Wastewater Treatment Plant

1.0 Introduction

1.1 Project Purpose and Approach

The Region of Waterloo Biosolids Strategy was initiated in 2015, to develop an approach to manage biosolids in Waterloo Region to the year 2051. The strategy will take a critical look at current practices, and consider available and relevant technologies for processing biosolids. Alternative ways to manage biosolids will be evaluated against a range of criteria to develop a biosolids management strategy for the Region. This project will result with the selection of a preferred strategy that will be implemented in the Region over the next 35 years. The decision making process to select the preferred strategy will be documented in a report and be available for public review. Future projects will further refine the implementation details of the strategy including timing, sizing and location of any facilities.

The strategy is being developed in six stages, which will be outlined in a series of technical memos (TMs). The memos will form the basis for the final study document. The project stages include:

- Stage 1 – What are biosolids and what process is being followed to develop the strategy?
 - o TM: The Environmental Assessment Process
- Stage 2 – What is the current situation related to biosolids in the Region and how will it change as the Region grows?
 - o TM: Existing Conditions
 - o TM: Biosolids Management Needs Forecast
- Stage 3: What are the project objectives, what technologies and strategies are being considered and how will a decision be made to select the recommended strategy?
 - o TM: Evaluation Approach and Comparative Evaluation Criteria

- o TM: Biosolids Technologies, End Uses, and Disposal
 - o TM: Biosolids Alternatives - Long List
- Stage 4 – What alternatives from the long list could work in the Region of Waterloo? How can they be refined based on the project objectives? This stage involves evaluating the alternatives to identify a shorter list that will be evaluated in more detail
 - o TM: Biosolids Alternatives Short List
- Stage 5 – Based on the project objectives and evaluation criteria, what is the recommended strategy? The short listed alternatives are evaluated at this stage and a recommended strategy is brought forward for public input.
 - o TM: Biosolids Alternative Short List Evaluation
- Stage 6 – What is the best strategy to meet the project objectives?
 - o TM: Recommended Biosolids Strategy
 - o Biosolids Strategy Document

The Region is committed to public engagement throughout the development of the strategy. The project team will seek to understand the priorities and concerns of community residents across Waterloo Region, as well as technical experts and other stakeholders.

Additional background information regarding the context of biosolids management in the Region of Waterloo is included in **Appendix A**.

A **sustainable strategy** is one that considers the future growth of the Region and looks to minimize potential landfill disposal requirements of biosolids.

1.2 Purpose of this Technical Memo

The Biosolids Alternatives Short List memorandum (TM7) provides a high-level assessment of the alternatives presented in TM5 based on the minimum performance questions (MPQ) developed as an initial evaluation tool. Alternatives that are deemed unacceptable at this stage will be removed from further

consideration and the short-list of alternatives identified will be carried forward for further review in the next stages of the Master Plan. This memorandum presents additional detail specific to every WWTP in the Region for each alternative to support the evaluation process. Specific design details for short listed technologies, or a strategy for implementation (e.g. at specific WWTPs, at new centralized or new decentralized facilities), will be addressed in the next stage of the Master Plan process. The main purpose of this evaluation of the long list of alternatives is to eliminate from further consideration alternatives that are not viable to address the biosolids management needs of the Region of Waterloo.

1.3 Memo Structure

Technical Memo # 7 is organized into five sections:

- 1. Chapter 1: Introduction**
- 2. Chapter 2: Evaluation Approach**
- 3. Chapter 3: Review of Facilities and Management Alternatives**
- 4. Chapter 4: MPQ Evaluation Summary**
- 5. Chapter 5: Conclusions**

Chapter 1 provides an introduction to the memo, including the purpose and structure. Chapters 2 through 4 present the outcomes of the evaluation exercise conducted in this memo. The fifth and final chapter presents conclusions, short-listed alternatives that will be evaluated further and next steps.

2.0 Evaluation Approach

An objectives-based evaluation approach is being used to select the preferred Biosolids Strategy. This is a multi-disciplinary approach to completing the evaluation. It reflects a desire to achieve an outcome for the strategy by evaluating the alternatives against environment, social and economic objectives.

The objectives were developed based on initial consultation with key stakeholders (the “issues that matter”) and members of the community, alignment with the Region’s Strategic Plan, and input from the project’s technical team. The seven objectives that mattered the most were identified and evaluation criteria were developed for subsequent detailed evaluation of short-listed alternatives as part of Technical Memo #3. Minimum Performance Questions (MPQ) were developed for the long-list of alternatives evaluation in order to present “yes” or “no” decision points to reduce the long list of eight alternatives to a short list for biosolids management.

2.1 Review of Selection Criteria

The seven objectives for the project are identified below. Where applicable, the MPQ’s associated with each objective is also listed:

- **Work collaboratively to find solutions:** Provide multiple opportunities for public engagement and input in the decision making process. This objective is meant to go beyond the minimum requirements and is being met through the study design. *No specified Minimum Performance Question was applied for this objective. This objective will be addressed throughout the development of the strategy.*
- **Build upon Existing Infrastructure:** The Region has significant investment in infrastructure and a strategy that maximizes this investment is preferred. Alternatives will be compared to the following two MPQs

- o MPQ 1 - Does the alternative build upon the Region's existing wastewater infrastructure?
 - o MPQ 2 - Is it based on commercially proven technology that provides a long term solution?
- **Protect the Natural Environment:** The preferred strategy should minimize impacts to the environment and surroundings. Alternatives will be compared to the following MPQs:
 - o MPQ 3 - Does it meet current environmental regulations and is it capable of meeting permitting requirements?
 - o MPQ 4 - Does it align with best environmental management practices in the field of biosolids?
- **Protect Health and Safety:** The preferred strategy should minimize impacts to the environment and surroundings. Alternatives will be compared to the following MPQs:
 - o MPQ 5 - Does it meet current health and safety regulations?
 - o MPQ 6 - Does it align with best practices for the protection of public health in the field of biosolids management?
- **Minimize and Manage Operational Risk:** The preferred strategy must allow the Region to provide continual, uninterrupted biosolids management service to the public. Alternatives will be compared to the following MPQs:
 - o MPQ 7 - Can the Region control all necessary elements of implementation?
 - o MPQ 8 - Can the storage requirements be met with a facility(s) located in the Region?

- **Protect Quality of Life:** The existing quality of life for citizens should be maintained when planning for biosolids infrastructure. Alternatives will be compared to the MPQ:
 - o MPQ 9 - Does the alternative protect the quality of life for citizens regardless of where it is built in the Region?
- **Be Cost Effective and Provide Value:** The cost of the preferred strategy must be reasonable to the Region, both now and in the future. *No specified Minimum Performance Question was applied. It is premature to eliminate an alternative at this stage due to cost considerations. This objective will be addressed through specific criteria for the short-listed strategies.*

The minimum performance questions will be applied to each of the eight long-listed biosolids management approaches. Additional details of the evaluation approach are presented in the subsections below.

2.1.1 Build upon Existing Infrastructure

MPQ 1 - Is it compatible with the Region's existing wastewater treatment infrastructure?

The Region of Waterloo biosolids planning and infrastructure implementation to date has focused on digestion of solids and quantity reduction to generate biosolids products that facilitates use of nutrients as a non-agricultural source material (NASM) under the Nutrient Management Act (NMA). Meeting the quality requirements for NASM means that the current product can also be used for mine tailings reclamation, and is acceptable for landfill disposal.

Based upon the Region's 2011 Master Plan recommendations, the Region has also developed projects to implement combined heat and power projects to use additional biogas at Kitchener, Waterloo and Galt WWTPs.

Alternatives that build upon the infrastructure and planning decisions to date are those that maintain or enhance the quality of biosolids products generated (e.g. NASM compost or fertilizer), further reduce quantity (i.e. – minimize quantity), or enhance energy recovery as biogas.

Alternatives that would require ending the use of existing anaerobic digesters, reduce biogas recovery for planned combined heat and power (CHP) projects, or ending the use of existing dewatering infrastructure are not considered compatible and will not pass the minimum performance questions.

For facilities that do not currently have dedicated anaerobic digesters and dewatering, the technologies considered will align with the objectives of the alternatives and / or improve integration with digestion and dewatering at other WWTPs.

MPQ 2 - Is it based on commercially proven technology that provides a long term solution?

Commercially proven technologies are ones with multiple installations implemented in North America, preferably in Ontario that have been operating for a number of years. For the purpose of this minimum performance question, alternatives will only be eliminated if there are no candidate technologies that can be demonstrated to achieve the objectives of the overall biosolids alternative. Individual technologies may be eliminated using this criterion to refine alternatives.

2.1.2 Protect the Natural Environment

MPQ 3 - Does it meet current environmental regulations and is it capable of meeting permitting requirements?

The alternative biosolids management strategies developed must comply with the Ontario regulatory framework. Additions and adjustments to the Region's existing

biosolids management must be aligned with the requirements and restrictions of legislation that apply in Ontario including:

- Ontario Nutrient Management Act
- Federal Fertilizers Act
- Ontario Compost Quality Standards
- Environmental Assessment Act
- Environmental Protection Act
- Ontario Water Resources Act
- Safe Drinking Water Act
- Clean Water Act

Alternatives would be eliminated if they present an unacceptable risk related to the environmental permitting or planning process, which may include experience with challenges during the environmental assessment, design or construction phase of implementation.

Technologies or alternatives would only be eliminated using this criteria, if there are no examples of implementation in Ontario, and there is evidence that the technology or alternative conflicts with requirements of environmental regulations.

MPQ 4 - Does it align with best environmental management practices in the field of biosolids?

The Canada-Wide approach for the Management of Wastewater Biosolids (2012) represents a key resource in terms of defining best practices. The CCME policy statement in the document promotes use of biosolids as a resource for nutrients, organic matter, and / or energy. Sound management principles include:

1. Consideration of the utility and resource value;
2. Strategies to minimize potential risks to the environment and human health;
3. Strategies to minimize GHG emissions; and

4. Adherence to federal, provincial, territorial, and municipal standards, requirements or guidelines.

Using these principles the fourth minimum performance question will be answered based upon the following:

1. An alternative will be considered to have achieved the Minimum Performance level if it has end uses in addition to disposal. An alternative that relies on disposal exclusively will not pass the minimum performance question. Disposal of biosolids does not align with CCME best practices as this approach does not use the nutrients, organic matter or energy content of the biosolids product generated. Disposal does not align with the first principle, and should be considered the lowest priority option for end use and disposal, or should be used as a contingency only.
2. Each alternative is considered to achieve the minimum performance level of environmental and human health risk mitigation if it complies with applicable regulations.
3. Greenhouse gas (GHG) objectives are considered better aligned with the detailed evaluation of short list alternatives where the relative level of GHG emissions can be evaluated to support the selection of an alternative.
4. Provincial and municipal standards are considered to be met based upon compliance with regulations and by-laws. Alignment with the Region of Waterloo strategic plan is considered a relevant municipal guideline. In particular, the Region of Waterloo presents strategic objectives that specifically reference biosolids:
 - Strategic Objective 3.1 Increase the amount of waste diverted from landfill, and 3.1.3 Evaluate alternative waste (solids waste, biosolids, and any other) disposal technologies (energy from waste).

Therefore to meet the minimum performance acceptable for MPQ 4, the alternative must comply with federal, provincial and municipal regulations; additionally, consideration of the resource value or utility of biosolids is required.

2.1.3 Protect Health and Safety

MPQ 5 - Does it meet current health and safety regulations?

The main legislation related to safety is the Occupational Health and Safety Act. The intent is to ensure that alternatives can be developed to protect worker health and safety. One of the ways that this will be evaluated is through facilities operating in North America and particularly Ontario. Unless there is information to the contrary, existing facilities operating in Ontario are assumed to be operating in compliance with the Ontario Health and Safety (OH&S) Act and other relevant safety guidelines. Facilities operating in North America are considered likely to be capable of being designed and operated in compliance with the OH&S Act and other relevant safety guidelines. For the purpose of this minimum performance question, alternatives will only be eliminated if there are no candidate technologies that can be demonstrated to meet requirements in Ontario.

MPQ 6 - Does it align with best practices for the protection of the environment and human health in the field of biosolids management?

The minimum performance acceptable is compliance with requirements of federal, provincial and municipal regulations for the protection of the environment and human health. The Environmental Protection Act (EPA), and the Nutrient Management Act (NMA) maintain concentration based standards, and operational practices that provide many of the protections that are in place currently and would continue as part of the biosolids strategy in the future. Compliance with regulations is the minimum performance acceptable.

Consideration of protection of human health and the environment beyond regulatory compliance are priority considerations; however, these aspects go beyond minimum performance and will be evaluated on a relative basis during the detailed short list evaluation.

2.1.4 Minimize and Manage Operational Risk

MPQ 7 - Can the Region maintain control all the necessary elements of implementation?

The level of control retained by the Region affects the level of financial and operational risk associated with biosolids management strategy alternatives.

There are a number of models available for new biosolids management assets where the Region could:

- Finance, own and operate new assets
- Finance and own the assets but contract operations
- Finance a design build, operate contract for new assets;
- Select a proponent to design, build, finance, operate and maintain new assets.

The delivery method and procurement strategy for new infrastructure or services to support the Biosolids Strategy remains open at this stage of planning. Alternatives that have aspects that are not within the control of the Region to select a planning, permitting and / or procurement approach may be eliminated based upon this minimum performance question.

MPQ 8 - Can the storage requirements be met with a facility(s) located in the Region?

A new storage facility or facilities developed to reduce operational risk, or provide additional control for the Region is considered a key aspect of the Biosolids Strategy. Storage must be implemented with mitigation of nuisances as a central aspect of

design such as control of odour and noise emissions. The appropriate facility is likely to be a fully enclosed building including receiving, material handling and storage with a ventilation system that includes odour control.

The MOECC Design Guidelines for Sewage Works (2008) recommends a minimum of 240 days of storage for biosolids management strategies that rely exclusively on agricultural land. An outcome of the 2003 Wastewater Treatment Master Plan was a recommendation for a central storage facility for all of the Region's biosolids. Given the Region's experience with challenges of siting this type of facility within the Region, a single centralized large scale NASM quality biosolids storage facility for 240 days storage of biosolids is not recommended as part of the alternatives developed. These large scale storage facilities for NASM quality biosolids have not commonly been implemented in Ontario in the recent past, and previously permitted facilities of this nature have been closed.

The Region's strategic plan makes biosolids diversion from landfill a priority, and although landfill should remain a contingency option, the preferred strategy must include infrastructure to decrease the likelihood of biosolids disposal in landfill. The current biosolids management strategy also uses biosolids for mine tailings reclamation. This mine application allows use of biosolids during periods when agricultural land is not available, and avoids disposal to landfill. The amount of biosolids transferred to landfill since the mine application has become available was: 3,045 wet tonnes in 2016 and 14,216 wet tonnes in 2015. These masses represented 40 and 172 days biosolids production respectively that would have required storage until agricultural, or use for mine tailings reclamation became available. Disposal of biosolids to landfill was practiced more often in 2015 during a transitional period in the Region's biosolids management program, and not because the total capacity for agricultural or mine tailings reclamation uses were exhausted for the year. A facility(s) that can store approximately 10-30 days of dewatered biosolids cake is considered appropriate for the Region's current operational processes.

Alternatives that require more than 4 months of storage will not meet the minimum performance level for this question. Storage of products such as compost, fertilizer or ash must be considered an acceptable component of proposed new infrastructure to satisfy this minimum performance question.

2.1.5 Protect Quality of Life

MPQ 9 - Does it protect quality of life for citizens regardless of where it is built?

Implementation of new infrastructure must be completed to comply with regulations protecting citizens from adverse effects including health and nuisance impacts. New facilities must be constructed in alignment with best practices for odour and noise mitigation such as enclosing receiving, biosolids handling and processing within buildings that include mitigation measures such as fast closing truck doors and ventilation with odour control. Technologies or aspects of strategies that cannot be implemented to mitigate nuisance impacts do not meet the minimum performance of this question.

Aesthetic appeal of infrastructure, and trucking requirements are priority considerations to protect quality of life however these is no minimum performance identified and these aspects will be evaluated on a relative basis during the detailed short list evaluation.

3.0 Review of Facilities and Management Alternatives

The following chapter presents a high level facility-based review of biosolids management approaches.

The quantity of sludge produced at each facility is considered in relation to the potential need for storage to achieve operational and strategic management objectives. Individual facilities are evaluated for compatibility with each of the eight long-listed technologies based upon potential site area available for new process equipment.

A more detailed review of each long-list biosolids management alternative is provided, considering individual facility compatibility, and compatibility with MPQs.

3.1 Biosolids Generation

A preliminary estimate of the current and future sludge and biosolids production was completed as a component of the Region's Wastewater Treatment Master Plan (WWTMP) (CIMA, 2017). **Table 3-1** on the next page summarizes the average mass of solids (waste activated sludge) or biosolids (aerobically or anaerobically digested biosolids) estimated to be produced at each WWTP under current and future conditions.

Table 3-1: Biosolids Generation Summary

WWTP	Parameter	Average Biosolids Sludge Produced (kg dry solids / day)		
		2016	2031	2051
Kitchener	Biosolids	13,010	15,610	18,680
Waterloo	Biosolids	8,340	9,660	10,840
Galt	Biosolids	7,330	8,480	9,930
Preston	Biosolids	1,390	1,590	1,740
Hespeler	Biosolids	660	700	930
Ayr	Biosolids	190	300	360
New Hamburg	Biosolids	500	560	800
Wellesley	Sludge	110	120	170
St. Jacobs	Sludge	100	130	150
Elmira	Sludge	1,240	1,920	2,620
Heidelberg	Sludge	12	12	12
Conestogo	Sludge	7	7	7
Foxboro Green	Sludge	15	14	15

3.2 Storage Requirements

Storage of both pre-processed material and end product(s) is paramount to the successful application of the biosolids management alternatives. An in-depth review of storage needs for each of the alternatives is pertinent at this stage to order to confirm the feasibility and constructability of the necessary facility(s). Biosolids storage is required to satisfy a short term operational need, or facilitate the long term strategic management of biosolids end use in order to avoid landfill disposal. Adding storage to the existing system is a priority for the Region to address operational risks related to just in time production of biosolids. Most of the biosolids facilities in the Region have sufficient capacity to store biosolids to allow trucking during normal business hours (i.e. 3 days storage to accommodate a long weekend, with no excess). Three categories of new storage approaches considered are summarized below:

Short-Medium Term Storage (~10-30 days): Short term storage is needed to reduce the risk of operational disruptions to individual treatment facilities due to unforeseen temporary disruptions in removal of biosolids for processing, or collection of processed biosolids for use or long term storage. Storage volume of approximately 10 days would be considered the minimum capacity needed to satisfy short-term needs. Medium term storage of approximately 30 days would be considered to provide additional process flexibility, or the ability to manage biosolids inventory to adjust to variations in demand for end uses and minimize likelihood of biosolids landfill disposal. This could be located at individual treatment facilities, or following processing biosolids at distributed or centralized facility(s).

Long Term Storage (Minimum 4 months – Maximum 8 months): Storage located following biosolids processing, providing the capability to accumulate biosolids for extended periods, primarily to facilitate use on agricultural land during allowable / preferred application periods. The quantity of product, and quality aspects such as

odour emission potential, are considered key aspects of the potential to site a storage facility of this size. Alternatives that provide for minimal processing of biosolids material and therefore have more rigid land application requirements would require upwards of 8 months of long term storage. A minimum long term storage capacity of 4 months would be suitable for alternatives that generate a processed end product intended for land application with less rigid application requirements and restrictions.

Storage Strategies

- **Cake storage pads/bunkers**

Cake storage facilities are envisioned to consist of a concrete foundation to support biosolids and vehicle traffic within bunker walls, and a tensioned fabric roof or other enclosure for weather protection to avoid precipitation (rainfall) and respective runoff, and mitigate odour emissions. The specific design of the facility is dependent on its location and the required capacity.

- **Warehouse/bunker for pellets**

Warehouses for dried, stabilized biosolids products are anticipated to be co-located with processing facilities. Key considerations include weather protection, odour and dust containment, and vehicle access for offloading/transport of product. These structures are suited for medium/long term storage of product.

- **Tank for WAS or aerobic sludge**

Aerobically digested sludge, or WAS generated at facilities may be stored as liquid within tanks or lagoons (such as in Ayr and New Hamburg). Aeration and mixing may be required to maintain product quality and large scale liquid storage tanks are not considered practical for long term storage prior to further processing (e.g. digestion or dewatering).

A preliminary assessment was completed to determine if areas for storage and biosolids processing are available at each of the Region's existing WWTPs, based on the solids content currently generated (**Table 3.2**). Actual available site area that can be dedicated to storage at WWTPs, considering future wastewater process improvements must be determined as alternatives are refined and in conjunction with the Region's Wastewater Treatment Master Plan.

Table 3-2: Storage Requirements Summary – Based on Plant Processing Volume

Wastewater Treatment Plant	Likely Technology	10 days		4 months	
		Approximate Footprint ²		Approximate Footprint ¹	
		(m ²)		(m ²)	
		2016	2051	2016	2051
Kitchener	Bunker	170	240	4,020	5,770
Waterloo	Bunker	100	125	2,295	2,980
Galt	Bunker	100	135	2,385	3,230
Preston					
Hespeler	Tank	85	100	N/A (storing undigested thin sludge for this duration, does not align with investments in dewatering to decommission former lagoon storage)	
Elmira	Bunker	20	35	400	840
New Hamburg	Tank			N/A (Storage lagoon already available on site)	
Ayr	Tank			N/A (Storage lagoon already available on site)	
St. Jacobs	Tank	10	15	N/A (more practical to transfer to WWTPs with existing storage or dewatering)	
Wellesley	Tank	15	15	N/A (more practical to transfer to WWTPs with existing storage or dewatering)	
Heidelberg	Tank	5	5	N/A (more practical to transfer to WWTPs with existing storage or dewatering)	
Conestogo	Tank	5	5	N/A (more practical to transfer to WWTPs with existing storage or dewatering)	
Foxboro Green	Tank	5	5	N/A (more practical to transfer to WWTPs with existing storage or dewatering)	

¹ Footprint for bunker storage estimated at a conceptual scale for an average cake pile height of 3 m. Area must be added to the value presented to account for material handling, roadways and parking as required for the new facilities. This does not take into account any buffers or working area that may be required.

² Tank footprint was estimated assuming a 1:1 ratio for the diameter and height. A vendor sizing chart was consulted to confirm a tank of the proposed diameter and volume could be constructed.

3.3 Biosolids Management Alternative Compatibility

Biosolids production, and the availability of site area to accommodate new biosolids management infrastructure was considered at a high-level for each facility. This assessment considers the likely availability of area at WWTPs (or adjacent to) only, based on a preliminary sizing of required storage and processes. Offsite storage (not at or near the existing facilities) must be considered if site area at WWTP's is not available. The justification is summarized in **Table 3-2** and documented in greater detail in subsequent sections dedicated to each alternative.

Table 3-3: Facility Compatibility with Existing Site Area

Wastewater Treatment Plant	Status Quo With Expanded Capacity	Status Quo with Solids Preparation	Produce Fertilizer	Produce Dry Low Volume Fertilizer	Produce Compost	Thermal Reduction with Energy Recovery	Thermal Reduction	Landfill All Biosolids
Kitchener	✓	✓	Off Site	On Site	Off Site	✓	✓	Off Site
Waterloo	✓	✓	Off Site	On Site	Off Site	Off Site	Off Site	Off Site
Galt	✓	✓	Off Site	On Site	Off Site	Off Site	Off Site	Off Site
Preston	Off Site	Off Site	Off Site	Off Site	Off Site	Off Site	Off Site	Off Site
Hespeler	✓	✓	✓	✓	Off Site	Off Site	Off Site	Off Site
Elmira	✓	✓	✓	✓	✓	Off Site	Off Site	Off Site
New Hamburg	✓	✓	✓	✓	Off Site	Off Site	Off Site	Off Site
Ayr	✓	✓	✓	✓	Off Site	Off Site	Off Site	Off Site
St. Jacobs	✓	✓	✓	✓	Off Site	Off Site	Off Site	Off Site
Wellesley	✓	✓	✓	✓	Off Site	Off Site	Off Site	Off Site
Heidelberg	✓	✓	✓	✓	Off Site	Off Site	Off Site	Off Site
Conestogo	✓	✓	✓	✓	Off Site	Off Site	Off Site	Off Site
Foxboro Green	✓	✓	Off Site	Off Site	Off Site	Off Site	Off Site	Off Site

✓ = Area may be allocated at WWTPs

Off Site = Implementation at a new location will be required

3.4 Review of Selection Criteria

Each long-list alternative was reviewed in terms of overall alignment of the alternative with the objectives-based MPQ evaluation. The outcomes of this evaluation are documented in the sections below. Facilities were grouped into the following three categories for the purposes of reviewing compatibility:

- Facilities with anaerobic digestion processes (Waterloo, Kitchener, Galt and Preston)
- Facilities with aerobic digestion processes (New Hamburg and Ayr, Hespeler in the short-term)
- Facilities without solids digestion processes (Elmira, Heidelberg, St. Jacobs, Wellesley, Conestogo, Foxboro Green)

For the purposes of this memo, Heidelberg was listed as facility without biosolids digestion processes. Although these facilities have aerobic digestion processes, the product generated may require additional processing to meet biosolids end use criteria and therefore digester basins are considered aerated storage tanks.

The groups are intended to capture facilities with similar onsite biosolids management infrastructure that may allow for similar, or possibly centralized, approaches to implementing new technology, equipment and strategies.

3.4.1 Current Approach with Expanded Capacity

3.4.1.1 Overview

This alternative would include the construction of additional capacity to manage biosolids within the existing management system, with additional capacity constructed only as required to meet anticipated growth. In addition to the potential expansion of existing processing facilities, operational storage is required to limit the quantity of material disposed to landfill when use options are not available.

Siting and Area Considerations

This alternative is suited to processing of biosolids at decentralized facilities (existing Region treatment plants). Site area associated with additional digestion and dewatering equipment will be addressed as part of the WWTMP; however, area is anticipated to be available or obtainable at or in close proximity to existing facilities. Additional area requirements for storage of biosolids at individual treatment facilities, prior to use or disposal are identified in Table 3-2. It is assumed that four to eight months of storage would be needed for this alternative to address land application restrictions.

3.4.1.2 Review of Facility Compatibility

The compatibility of individual treatment facilities with this alternative are summarized below in **Table 3-4**.

Table 3-4: Review of Facility Compatibility – Current Approach with Expanded Capacity

Facility Category by Biosolids Digestion Process		Facility Name	Considerations	Area Available On- site for Extended Capacity?	Technology Acceptable On- site?
Anaerobic Facilities	Digestion	Kitchener	Expand existing digester and dewatering capacity	Yes	Yes
			Provide 4 Month Storage	Unlikely – separate site required	
		Waterloo	Expand existing digester and dewatering capacity	Yes	Yes
			Provide 4 Month Storage	Unlikely – separate site required	
		Galt	Expand existing digester and dewatering capacity	Yes	Yes
			Provide 4 Month Storage	Unlikely – separate site required	
		Preston	Expand existing digester capacity	No	Yes
			Provide 4 Month Storage	Unlikely – separate site required	

REVIEW OF FACILITIES AND MANAGEMENT ALTERNATIVES

Facility Category by Biosolids Digestion Process	Facility Name	Considerations	Area Available On-site for Extended Capacity?	Technology Acceptable On-site?
Aerobic Digestion Facilities	Ayr	Expand existing digester capacity	Yes	Yes
	New Hamburg	Expand existing digester capacity	Yes	Yes
Facilities Without Biosolids Digestion	Elmira	Provide operational storage on-site	Yes	Yes
	Hespeler	Expand existing digester capacity	Yes	Yes
	Heidelberg	Expand existing digester capacity	Yes	Yes
	St. Jacobs	Provide operational storage on-site	Yes	Yes
	Wellesley	Provide operational storage on-site	Likely	Yes
	Conestogo	Provide operational storage on-site	Likely	Yes
	Foxboro Green	Provide operational storage on-site	Likely	Yes

The Preston WWTP is constrained for space and no additional area is anticipated to be allocated to solids processing or storage. Digested biosolids will continue to require dewatering at Galt or another WWTP in the future, and no storage can be added at this site.

3.4.1.3 MPQ Compatibility

The compatibility of each management technology with individual MPQs is summarized below in **Table 3-5**. The “yes” or “no” assessment is accompanied by a narrative description of the considerations for each MPQ.

Table 3-5: Review of MPQ Compatibility – Current Approach with Expanded Capacity"

	MPQ	Compatibility Considerations	Acceptable? (Yes/No)
1.	Build upon Existing Infrastructure: Does the alternative build upon the Region's existing wastewater infrastructure?	Technologies compatible since existing technologies will be expanded.	Yes
2.	Build upon Existing Infrastructure: Is it based on commercially proven technology that provides a long term solution?	Existing infrastructure will be expanded.	Yes
3.	Protect the Natural Environment: Does it meet current environmental regulations and is it capable of meeting permitting requirements?	Expanding capacities of technologies are capable of receiving required permitting.	Yes
4.	Protect the Natural Environment: Does it align with best environmental management practices in the field of biosolids?	Current approach is aligned with CCME best management, but could be improved to increase use, and limit disposal.	Yes
5.	Protect Health and Safety: Does it meet current health and safety regulations?	Existing approach complies with regulations.	Yes

REVIEW OF FACILITIES AND MANAGEMENT ALTERNATIVES

MPQ	Compatibility Considerations	Acceptable? (Yes/No)
6. Protect Health and Safety: Does it align with best practices in the field of biosolids management?	Existing approach complies with regulations.	Yes
7. Minimize and Manage Operational Risk: Can the Region control all necessary elements of implementation?	Adding storage to the existing approach mitigates the risk associated with just in time trucking to Landfill or end use.	Yes
8. Minimize and Manage Operational Risk: Can the storage requirements be met with a facility(s) located in the Region?	- Challenging due to limited area available at WWTPs, - Permitting challenges for associated or stand-alone storage based on storing up to 8 months of NASM quality product which is likely to generate odour. - Potential challenges with identifying an appropriate site for required storage capacity.	Siting storage presents a substantial risk
9. Protect Quality of Life: Does the alternative protect the quality of life for citizens regardless of where it is built in the Region?	Proper handling and storage of solids and biosolids are expected to mitigate impacts on citizens at the current level.	Yes

3.4.1.4 Summary

This alternative is compatible with all facilities, but there is a risk that it will not satisfy the MPQ to minimize and mitigate operational risk over the planning period, as the necessary storage will likely be challenging to site for NASM quality biosolids. This alternative may be considered the most appropriate alternative if combined with another biosolids management alternative to be implemented later in the planning period. It is not recommended that the existing approach be considered as a stand-alone alternative for the entire planning period due to the issues associated with storage of the product; it could be considered for the short-term until the need for other alternative is identified.

3.4.2 Current Approach with Solids Preparation before Digestion

3.4.2.1 Overview

This alternative would implement pre-treatment and preparation to accommodate the existing digestion approach as necessary for future solids production rates. The approach has the potential to increase the conversion of volatile solids to biogas, and decrease the mass of biosolids requiring end use or disposal. However, the approach could also be used to expand the capacity of digestion with very similar rates of volatile solids conversion, and therefore similar biosolids quantity per capita. The quality of digestate is anticipated to remain NASM quality. In addition to the potential expansion of existing processing facilities, operational storage is required to limit the quantity of material disposed to landfill when use options are not available.

Siting and Area Considerations

This alternative is suited to processing of biosolids at decentralized facilities (existing Region treatment plants). Site area associated with additional solids preparation, digestion and dewatering equipment requirements will be addressed as part of the WWTMP; however site area is anticipated to be available on existing facilities. Similar to the first Alternative, 8 months of biosolids storage would be required. Additional area requirements for storage of biosolids at individual treatment facilities, prior to use or disposal are identified in **Table 3-2**.

3.4.2.2 Review of Facility Compatibility

The compatibility of individual treatment facilities with this alternative are summarized below in **Table 3-6**.

Table 3-6: Review of Facility Compatibility – Current Approach with Solids Preparation before Digestion

Facility Category by Biosolids Digestion Process	Facility Name	Considerations	Area Available On-site for Extended Capacity?	Technology Acceptable On-site?
Anaerobic Digestion Facilities	Kitchener	Expand existing digester and dewatering capacity with solids preparation.	Yes	Yes
	Waterloo	Expand existing digester and dewatering capacity with solids preparation.	Yes	Yes
	Galt	Expand existing digester and dewatering capacity with solids preparation.	Yes	Yes
	Preston	Expand existing digester capacity with solids preparation.	No	Yes
Aerobic Digestion Facilities	Ayr	Expand existing digester capacity. Thickening through RDT or membranes?	Yes	Yes
	New Hamburg	Expand existing digester capacity. Thickening through RDT and membranes?	Yes	Yes

REVIEW OF FACILITIES AND MANAGEMENT ALTERNATIVES

Facility Category by Biosolids Digestion Process	Facility Name	Considerations	Area Available On-site for Extended Capacity?	Technology Acceptable On-site?
Facilities Without Biosolids Digestion	Elmira	Provide operational storage on-site to reduce frequency of trucking for off-site processing.	Yes	Yes
Facilities Without Biosolids Digestion	Hespeler	Expand existing digester capacity. Thickening with RDT or membranes?	Yes	Yes
	Heidelberg	Provide operational storage on-site to reduce frequency of trucking.	Yes	Yes
	St. Jacobs	Provide operational storage on-site to reduce frequency of trucking.	Yes	
	Wellesley	Provide operational storage on-site to reduce frequency of trucking.	Likely	Yes

REVIEW OF FACILITIES AND MANAGEMENT ALTERNATIVES

Facility Category by Biosolids Digestion Process	Facility Name	Considerations	Area Available On- site for Extended Capacity?	Technology Acceptable On-site?
	Conestogo	Provide operational storage on-site to reduce frequency of trucking.	Likely	Yes
	Foxboro Green	Provide operational storage on-site to reduce frequency of trucking.	Likely	Yes

3.4.2.3 Review of MPQ Compatibility

The compatibility of each management technology with individual MPQs is summarized below in **Table 3-7**. The “yes” or “no” assessment is accompanied by a narrative description of the considerations for each MPQ.

Table 3-7: Review of MPQ Compatibility – Current Approach with Solids Preparation before Digestion

MPQ	Compatibility Considerations	Acceptable? (Yes/No)
1. Build upon Existing Infrastructure: Does the alternative build upon the Regions existing wastewater infrastructure?	Technologies compatible since existing technologies will be expanded, with solids preparation as required.	Yes
2. Build upon Existing Infrastructure: Is it based on commercially proven technology that provides a long term solution?	Existing infrastructure will be expanded, with established solids preparation technologies added as required.	Yes
3. Protect the Natural Environment: Does it meet current environmental regulations and is it capable of meeting permitting requirements?	Expanding capacities of technologies are capable of receiving required permitting.	Yes
4. Protect the Natural Environment: Does it align with best environmental management practices in the field of biosolids?	Current approach is aligned with CCME best management, but could be improved to increase use, and limit disposal.	Yes
5. Protect Health and Safety: Does it meet current health and safety regulations?	Existing approach complies with regulations.	Yes

REVIEW OF FACILITIES AND MANAGEMENT ALTERNATIVES

MPQ	Compatibility Considerations	Acceptable? (Yes/No)
6. Protect Health and Safety: Does it align with best practices in the field of biosolids management?	Existing approach complies with regulations.	Yes
7. Minimize and Manage Operational Risk: Can the Region control all necessary elements of implementation?	Adding storage to the existing approach mitigates the risk associated with just in time trucking to Landfill or end use. Co-digestion, if included, will increase truck traffic to plants and eventually cause odour emissions to increase at materials receiving facility.	Yes
8. Minimize and Manage Operational Risk: Can the storage requirements be sited in the Region?	Challenging due to limited area available at WWTPs, Storing NASM quality product more likely to generate odour than other products as 8 months storage required Potential challenges with identifying an appropriate site for required storage capacity.	Siting storage presents a substantial risk
9. Protect Quality of Life: Does the alternative protect the quality of life for citizens regardless of where it is built in the Region?	Proper handling and storage of solids and biosolids are expected to mitigate impacts on citizens at the current level.	Yes

3.4.2.4 Summary

This alternative is compatible with all facilities, but there is a risk that it will not satisfy the MPQ to minimize and mitigate operational risk over the planning period, as the necessary storage may be challenging to site for NASM quality biosolids. This alternative may be considered the most appropriate alternative for part of the planning period, and combined with another biosolids management alternative to be implemented later in the planning period. It is not recommended that the existing approach with solids preparation be considered as a stand-alone alternative for the entire planning period.

3.4.3 Produce Fertilizer from Biosolids

3.4.3.1 Overview

This alternative may consider a variety of technologies capable of producing a biosolids derived fertilizer that meets the requirements of the Fertilizer Act administered by the CFIA. The technologies capable of achieving the CFIA designation may follow a variety of operating principles and produce solid or liquid products typically with 15 – 40 % solids*. Space requirements and operating capacities for individual technologies vary and implementation may be considered in centralized locations, distributed among individual WWTPs, or distributed at a number of new sites.

*For the Region's anaerobic facilities which handle a large portion of the overall volume of biosolids, 25-30% solids content is currently being achieved.

Siting and Area Considerations

Based on RFI submissions from vendors of stabilization technologies, footprints for technologies producing a fertilizer product range from 80m² to 2500m² with varying throughput capacities. There is potential for processes considered to be accommodated on most facilities that have area for additional biosolids processing development. Based on industry standards it is assumed that 4 months storage of the fertilizer product will be required for long term storage.

3.4.3.2 Review of Facility Compatibility

Table 3-8 summarizes facility-specific considerations for implementation of a biosolids management approach producing fertilizer. Overall acceptability is noted as well as facility-specific considerations that may influence the type of technology selected or its location.

The compatibility of three groups of candidate technologies capable of producing a fertilizer was considered for the WWTPs including:

- Pasteurization
- Thermal or Combined Hydrolysis
- Alkaline Stabilization
- Autothermal Aerobic Digestion (ATAD)

These technologies are presented to demonstrate that a distributed approach at WWTPs or centralized may be considered. A process may not be implemented at each facility shown to align with a technology below. The estimated number of trucks in this section is based the quantity of finished product requiring transportation. For local trucking of existing products from WWTPs to a centralized facility the estimated number of trucks in **Table 3-5** is representative

Table 3-8: Review of Facility Compatibility – Produce Fertilizer from Biosolids

Facility Category by Biosolids Digestion Process	Facility Name	Compatible Technology / Options	Area Available On-site?	Technology Acceptable On-site?
Anaerobic Digestion Facilities	Kitchener	• Applicable with existing infrastructure; • Pasteurization (product is typically 25 % solids dependent on dewatering strategy; typically located at WWTPs); • Hydrolysis (product is 15% - 40 % solids dependent on dewatering strategy; typically located at WWTPs); side stream treatment for centrate required • Hydrolysis (product <25% solids);or • Alkaline Stabilization (40% solids; flexible location)	Yes	Yes
	Waterloo	• Applicable with existing infrastructure; • Pasteurization (product is typically 25 % solids dependent on dewatering strategy; typically located at WWTPs); • Hydrolysis (product is 15% - 40 % solids dependent on dewatering strategy; typically located at WWTPs); side stream treatment	Yes	Yes

REVIEW OF FACILITIES AND MANAGEMENT ALTERNATIVES

Facility Category by Biosolids Digestion Process	Facility Name	Compatible Technology / Options	Area Available On-site?	Technology Acceptable On-site?
Anaerobic Digestion Facilities		for centrate required; or Alkaline Stabilization (40% solids; flexible location).		
	Galt	- Applicable with existing infrastructure; - Pasteurization (product is typically 25 % solids dependent on dewatering strategy; typically located at WWTPs); - Hydrolysis (product is 15% - 40 % solids dependent on dewatering strategy; typically located at WWTPs); side stream treatment for centrate required; or - Alkaline Stabilization (40% solids; flexible location).	Yes	Yes
	Preston	- Applicable with existing infrastructure; - Current approach to transfer anaerobic digestate off site likely to continue.	No	No

REVIEW OF FACILITIES AND MANAGEMENT ALTERNATIVES

Facility Category by Biosolids Digestion Process	Facility Name	Compatible Technology / Options	Area Available On-site?	Technology Acceptable On-site?
Aerobic Digestion Facilities	Ayr	• Applicable with existing infrastructure; • ATAD (product is typically 5% solids unless dewatering is added after digestion); or • Transfer of existing biosolids to other WWTP or central facility may be considered.	Yes	Yes
	New Hamburg	• ATAD (product is typically 5% solids unless dewatering is added after digestion); • Transfer of existing biosolids to other WWTP or central facility may be considered.	Yes	Yes
Facilities Without Biosolids Digestion	Elmira	• Continue current approach •	Yes	Yes
	Hespeler	• Transfer of existing biosolids to other WWTP or central facility may be considered.	Yes	Yes
	Heidelberg	• Transfer of existing solids product to other WWTP (Waterloo) or central facility likely to be considered.	Potentially	Yes

REVIEW OF FACILITIES AND MANAGEMENT ALTERNATIVES

Facility Category by Biosolids Digestion Process	Facility Name	Compatible Technology / Options	Area Available On-site?	Technology Acceptable On-site?
Facilities Without Biosolids Digestion	St. Jacobs	Transfer of existing solids product to other WWTP (Waterloo) or central facility likely to be considered.	Yes	Yes
	Wellesley	Transfer of existing solids product to other WWTP (Waterloo) or central facility likely to be considered.	Potentially	Yes
	Conestogo	Transfer of existing solids product to other WWTP (Waterloo) or central facility likely to be considered.	Potentially	Yes
	Foxboro Green	Transfer of existing solids product to other WWTP (Waterloo) or central facility likely to be considered.	No	No

3.4.3.3 Review of MPQ Compatibility

The compatibility of each management approach or technology implementation with individual MPQs is summarized below in **Table 3-9**. The “yes” or “no” assessment is accompanied by a narrative description of the considerations for each MPQ.

Table 3-9: Review of MPQ Compatibility – Produce Fertilizer from Biosolids

[illegible]

REVIEW OF FACILITIES AND MANAGEMENT ALTERNATIVES

MPQ	Compatibility Considerations	Acceptable? (Yes/No)
5. Protect Health and Safety: Does it meet current health and safety regulations?	Several well-established candidate technologies producing fertilizer from biosolids are available, including facilities permitted and operating in Ontario.	Yes
6. Protect Health and Safety: Does it align with best practices in the field of biosolids management?	Meets CFIA fertilizer requirements for pathogen reduction, representing a quality improvement compared with existing NASM product.	Yes
7. Minimize and Manage Operational Risk: Can the Region control all necessary elements of implementation?	Several well-established candidate technologies producing fertilizer from biosolids have been procured by municipalities in Ontario.	Yes

MPQ	Compatibility Considerations	Acceptable? (Yes/No)
8. Minimize and Manage Operational Risk: Can the storage requirements be sited in the Region?	- Operational product storage required for implementation is expected to be acceptable if volume is maintained or decreased as part of new processing facilities, and fertilizer product quality is lower risk of nuisance impacts than existing NASM quality product - Requirements for storage of fertilizer products are more flexible than existing NASM product and it is expected that a storage facility for 4 months of fertilizer product could be sited with the facility.	Yes
9. Protect Quality of Life: Does the alternative protect the quality of life for citizens regardless of where it is built in the Region?	New receiving, material handling, process equipment and storage will be implemented in buildings with engineering controls to mitigate nuisance impacts on citizens near new infrastructure.	Yes

3.4.3.4 Summary

This alternative is compatible with individual facilities and passes all MPQ, except for technologies that increase the unit volume from the current management practices. The manner of implementation of this alternative (distributed among several individual treatment plant sites or centralized in one location) will be refined based on technologies available, local biosolids production and trucking considerations, and storage needs developed in further detail in the next stage of the planning process.

3.4.4 Produce Compost

3.4.4.1 Overview

This alternative encompasses a variety of technologies capable of enhancing biosolids quality through a composting process to produce a product meeting Category A criteria as defined by the Compost Quality Standards (2012). Composting of biosolids, with the addition of amendment materials may be considered for dewatered biosolids cake at a minimum solids content of 18%. This is aligned with the current dewatered cake which is typically greater than 25% solids. Transfer to existing WWTPs, or new dewatering equipment would be required for WWTPs that do not currently have that capacity. Space requirements and operating capacities for individual composting technologies vary and implementation may be considered in centralized locations, or partially distributed among number of sites either at WWTPs with larger site areas available for development, or new sites.

Siting and Area Considerations

This alternative is best suited to processing of biosolids at a centralized facility, or a few selected WWTPs due to the relatively large area requirements typically associated with composting processes. Based on RFI submissions from vendors of stabilization technologies, footprints for technologies producing compost product range from 12,000m² to 140,000m² with varying throughput capacities. In-vessel

processes may be constructed with smaller footprint requirements. It is unlikely that a composting facility accommodating a large fraction of the Region's biosolids could be constructed at an existing WWTPs site. Based on industry practices it is assumed that 4 months of long-term storage will need to be sited with the processing facility.

3.4.4.2 Review of Facility Compatibility

Table 3-10 below summarizes facility-specific considerations for implementation of a biosolids management approach producing fertilizer. Overall acceptability is noted as well as facility-specific considerations that may influence the type of technology selected or its location. The estimated number of trucks in this section is based the quantity of finished product requiring transportation. For local trucking of existing products from WWTPs to a centralized facility the estimated number of trucks in **Table 3-5** is representative.

Table 3-10: Review of Facility Compatibility – Compost from Biosolids

Facility Category by Biosolids Digestion Process	Facility Name	Compatible Technology/Options	Area Available On-site?	Technology Acceptable On- site?
Anaerobic Digestion Facilities	Kitchener	Applicable with existing infrastructure. Dewatering available on-site.	No	Yes
	Waterloo	Applicable with existing infrastructure. Dewatering available on-site.	No	Yes
	Galt	Applicable with existing infrastructure. Dewatering available on-site.	No	Yes
	Preston	Current approach to transfer anaerobic digestate off site likely to continue	No	No, biosolids must be processed off-site

REVIEW OF FACILITIES AND MANAGEMENT ALTERNATIVES

Facility Category by Biosolids Digestion Process		Facility Name	Compatible Technology/Options	Area Available On-site?	Technology Acceptable On- site?
Aerobic Facilities	Digestion	Ayr	- Dewatering not available on-site. Biosolids to be trucked for off-site processing; or - Add dewatering only on site – composting to be done off-site	Yes, for dewatering requirements	Yes, for dewatering
		New Hamburg	- Dewatering not available on-site. Biosolids to be trucked for off-site processing; or - Add dewatering and composting on-site.	Yes, for dewatering	Yes, for dewatering
Facilities Biosolids	Without Digestion	Elmira	- Continue current approach; or - Transfer of existing dewatered cake to other WWTP or central facility may be considered.	Yes, for dewatering	Yes, for dewatering

Facility Category by Biosolids Digestion Process	Facility Name	Compatible Technology/Options	Area Available On-site?	Technology Acceptable On- site?
Facilities Without Biosolids Digestion	Hespeler	- Dewatering not available on-site. Biosolids to be trucked for off-site processing; or - Add dewatering and composting? On-site. Why not off-site?	Not Applicable (to be processed off- site)	No, biosolids must be processed off- site
	Heidelberg	Transfer of existing solids product to other WWTP (Waterloo)	Not Applicable (to be processed off- site)	No, biosolids must be processed off- site
	St. Jacobs	Transfer of existing solids product to other WWTP (Waterloo).	Not Applicable (to be processed off- site)	No, sludge must be processed off-site
	Wellesley	Transfer of existing solids product to other WWTP (Waterloo).	Not Applicable (to be processed off- site)	No, sludge must be processed off-site

Facility Category by Biosolids Digestion Process	Facility Name	Compatible Technology/Options	Area Available On-site?	Technology Acceptable On- site?
	Conestogo	Transfer of existing solids product to other WWTP (Waterloo).	Not Applicable (to be processed off- site)	No, sludge must be processed off-site
	Foxboro Green	Transfer of existing solids product to other WWTP (Waterloo).	Not Applicable (to be processed off- site)	No, sludge must be processed off-site

3.4.4.3 Review of MPQ Compatibility

The compatibility of each management technology with individual MPQs is summarized below in **Table 3-11**. The “yes” or “no” assessment is accompanied by a narrative description of the considerations for each MPQ.

Table 3-11: Review of MPQ Compatibility – Produce Compost from Biosolids

MPQ	Compatibility Considerations	Acceptable? (Yes/No)
1. Build upon Existing Infrastructure: Does the alternative build upon the Region's existing wastewater infrastructure?	Technologies producing compost require dewatered biosolids as feedstock which is compatible with, or builds upon the facilities already present at Region facilities.	Yes
2. Build upon Existing Infrastructure: Is it based on commercially proven technology that provides a long term solution?	Several well-established candidate technologies producing compost from biosolids are available, including other Ontario facilities (City of Ottawa uses compost as the primary use of biosolids).	Yes
3. Protect the Natural Environment: Does it meet current environmental regulations and is it capable of meeting permitting requirements?	• Receiving, material handling, process technologies producing compost, and storage of product may be contained within buildings that are capable of receiving required permitting.	Yes
	• Those not contained in buildings • Several well-established candidate technologies producing compost are available, including facilities permitted and operating in Ontario.	No
4. Protect the Natural Environment: Does it align with best environmental management practices in the field of	• Use of compost products produced from biosolids is aligned with CCME best practices, and products meet or exceed environmental	Yes

MPQ	Compatibility Considerations	Acceptable? (Yes/No)
biosolids?	regulations.	
5. Protect Health and Safety: Does it meet current health and safety regulations?	Several well-established candidate technologies producing compost are available, including facilities permitted and operating in Ontario.	Yes
6. Protect Health and Safety: Does it align with best practices in the field of biosolids management?	Compost Quality Standard (2012) requirements for pathogen reduction represent the same or better quality compared with existing NASM product.	Yes
7. Minimize and Manage Operational Risk: Can the Region control all necessary elements of implementation?	Several well-established candidate technologies producing compost have been procured by municipalities in Ontario.	Yes
8. Minimize and Manage Operational Risk: Can the storage requirements be sited in the Region?	- Operational compost storage required for implementation is expected to be acceptable as part of new processing facilities, and compost product quality is lower risk of nuisance impacts than existing NASM quality product. - Requirements for storage of compost are more flexible than existing NASM product as 4 months of long terms storage is assumed to be required.	Yes

[illegible]

3.4.4.4 Summary

This alternative is compatible with existing processes at individual facilities and meets all MPQs, as long as the facility can be sufficiently enclosed to prevent nuisances to the public. The manner of implementation of this alternative (localized at a few select treatment facility sites, or at a central processing facility) may be refined based on the specific technologies selected, local biosolids production, trucking considerations and storage needs.

3.4.5 Produce Dry, Low Volume Fertilizer from Biosolids

3.4.5.1 Overview

This alternative considers technologies capable of producing dry fertilizer pellets. Processes achieving thermal pathogen reduction while producing dry pellets meeting the requirements of the Fertilizers Act administered by the CFIA may follow a variety of operating principles and have varying operating and space requirements.

Siting and Area Considerations

A variety of implementation scenarios may be considered, although thermal energy requirements and economic considerations are likely to favour construction of a centralized facility or installation of this process at a few selected treatment facilities. Locating at or adjacent to a partner facility with excess heat energy should be considered for this alternative. Construction of this facility could be considered at one treatment facility with sufficient onsite area or at a new dedicated facility. It is assumed that 4 months of long-term storage will be required at the facility

3.4.5.2 Review of Facility Compatibility

Table 3-12 below summarizes facility-specific considerations for implementation of a biosolids management approach producing fertilizer. Overall acceptability is noted

as well as facility-specific considerations that may influence the type of technology selected or its location.

Table 3-12: Review of Facility Compatibility – Produce Dry, Low-Volume Fertilizer from Biosolids

Facility Category by Biosolids Digestion Process	Facility Name	Compatible Technology/Options	Area Available On- site?	Technology Acceptable On- site?
Anaerobic Digestion Facilities	Kitchener	Applicable with existing infrastructure. Dewatering available on-site.	No (would need to be at adjacent/nearby site)	Yes
	Waterloo	Applicable with existing infrastructure. Dewatering available on-site.	Potentially (if constructed on-site, area available may be limited for future facility expansions)	yes
	Galt	Applicable with existing infrastructure. Dewatering available on-site.	No (would need to be at adjacent/nearby site))	Yes
	Preston	Current approach to transfer anaerobic digestate off site likely to continue.	No (biosolids to be processed off-site)	No, biosolids must be processed off-site

REVIEW OF FACILITIES AND MANAGEMENT ALTERNATIVES

Facility Category by Biosolids Digestion Process	Facility Name	Compatible Technology/Options	Area Available On- site?	Technology Acceptable On- site?
Aerobic Digestion Facilities	Ayr	- Dewatering not available on-site. Biosolids to be trucked for off-site processing; or - Add dewatering on-site prior to transfer.	Not Applicable (biosolids to be processed off-site)	No, biosolids must be processed off- site
	New Hamburg	- Dewatering not available on-site. Biosolids to be trucked for off-site processing; or - Add dewatering on-site prior to transfer.	Not Applicable (biosolids to be processed off-site)	No, biosolids must be processed off- site
Facilities Without Biosolids Digestion	Elmira	- Continue current approach; or	Not Applicable (dewatered cake to be processed off- site)	No, sludge must be processed off- site
	Hespeler	- Dewatering not available on-site. Biosolids to be trucked for off-site processing; or - Add dewatering on-site	Not Applicable (biosolids to be processed off-site)	No, biosolids must be processed off- site

REVIEW OF FACILITIES AND MANAGEMENT ALTERNATIVES

Facility Category by Biosolids Digestion Process	Facility Name	Compatible Technology/Options	Area Available On-site?	Technology Acceptable On-site?
Facilities Without Biosolids Digestion	Heidelberg	Transfer of existing solids product to other WWTP (Waterloo).	Not Applicable (biosolids to be processed off-site)	No, biosolids must be processed off-site
	St. Jacobs	Transfer of existing solids product to other WWTP (Waterloo).	Not Applicable (sludge to be processed off-site)	No, sludge must be processed off-site
	Wellesley	Transfer of existing solids product to other WWTP (Waterloo).	Not Applicable (sludge to be processed off-site)	No, sludge must be processed off-site
	Conestogo	Transfer of existing solids product to other WWTP (Waterloo).	Not Applicable (sludge to be processed off-site)	No, sludge must be processed off-site
	Foxboro Green	Transfer of existing solids product to other WWTP (Waterloo).	Not Applicable (sludge to be processed off-site)	No, sludge must be processed off-site

3.4.5.3 Review of MPQ Compatibility

The compatibility of each management technology with individual MPQs is summarized below in **Table 3-13**. The “yes” or “no” assessment is accompanied by a narrative description of the considerations for each MPQ.

Table 3-13: Review of MPQ Compatibility – Produce Dry Fertilizer Pellets from Biosolids

MPQ	Compatibility Considerations	Acceptable? (Yes/No)
1. Build upon Existing Infrastructure: Does the alternative build upon the Regions existing wastewater infrastructure?	Technologies producing dry fertilizer pellets can use dewatered cake as feedstock and are compatible with the wastewater treatment infrastructure already present at Region facilities. But not really compatible with facilities that process solids with aerobic digestion.	Yes
2. Build upon Existing Infrastructure: Is it based on commercially proven technology that provides a long term solution?	Technologies producing dry fertilizer pellets are operating in Ontario with a growing track record of performance.	Yes
3. Protect the Natural Environment: Does it meet current environmental regulations and is it capable of meeting permitting requirements?	Well-established candidate technologies producing dry fertilizer pellets from biosolids are available, including facilities permitted and operating in Ontario.	Yes
4. Protect the Natural Environment: Does it align with best environmental management practices in the field of biosolids?	Use of dry fertilizer pellet products produced from biosolids for nutrients, or renewable energy is aligned with CCME best practices, and products meet or exceed environmental regulations.	Yes
5. Protect Health and Safety: Does it meet current health and safety regulations?	Well-established candidate technologies producing dry fertilizer pellets from biosolids are available, including facilities permitted and operating in Ontario with a growing track	Yes

MPQ	Compatibility Considerations	Acceptable? (Yes/No)
	record of performance.	
6. Protect Health and Safety: Does it align with best practices in the field of biosolids management?	Meets CFIA fertilizer requirements for pathogen reduction, representing a quality improvement compared with existing NASM product.	Yes
7. Minimize and Manage Operational Risk: Can the Region control all necessary elements of implementation?	Well-established candidate technologies producing fertilizer from biosolids have been procured by municipalities in Ontario.	Yes
8. Minimize and Manage Operational Risk: Can the storage requirements be sited in the Region?	- Operational product storage required for implementation is expected to be acceptable as part of new processing facilities, and dry fertilizer pellets require a smaller storage system; - Product quality is lower risk of nuisance impacts than existing NASM quality product; - Requirements for storage of fertilizer products are more flexible than existing NASM product. 4 months of long -term storage will be required	Yes
Protect Quality of Life: Does the alternative protect the quality of life for citizens regardless of where it is built in the Region?	New receiving, material handling, process equipment and storage will be implemented in buildings with engineering controls to mitigate nuisance impacts on citizens near new infrastructure.	Yes

3.4.5.4 Summary

This alternative is not likely to be sited at most existing WWTPs but passes all MPQs. The manner of implementation of this alternative (located at a new centralized facility or a selected existing WWTP site) will be refined based on local biosolids production and trucking considerations, and storage needs. Likely not applicable for aerobically digested biosolids produced at smaller plants, but this represents only xyz% of the total biosolids produced at the Region. Other technologies might be more suitable for aerobically digested biosolids than thermal drying.

3.4.6 Thermal Reduction to Ash (Without Energy Recovery)

3.4.6.1 Overview

This alternative considers thermal reduction of biosolids to ash, primarily through fluidized bed incineration. Thermal energy released through combustion of biosolids would be used to maintain process temperature. The process may be energy neutral, or require supplemental fuel to sustain operation. Factors including reduced energy content in biosolids due to prior digestion and biogas release, or energy demand required to combust biosolids at the current dewatered moisture content are anticipated to limit the opportunity for net energy capture. Ash produced through the thermal reduction process may be used as an industrial input primarily in the cement industry.

Siting and Area Considerations

This alternative is best suited to the processing of biosolids at a centralized facility accepting most or all of the Region's biosolids production. Based on RFI submissions from vendors of thermal reduction technologies, facility footprints of 1,800m² to 2,200m² are reported with varying throughput capacities (not including supporting infrastructure or buffers). It is possible that a thermal reduction system could be co-located at a single existing treatment facility site, or located at a dedicated offsite location. It is assumed that 4 months of long-term storage will be required at the facility.

3.4.6.2 Review of Facility Compatibility

Table 3-14 below summarizes facility-specific considerations for implementation of a biosolids management approach reducing the end product to ash. Overall acceptability is noted as well as facility-specific considerations that may influence the type of technology selected or its location.

Table 3-14: Review of Facility Compatibility - Thermal Reduction to Ash (Without Energy Recovery)

Facility Category by Biosolids Digestion Process	Facility Name	Compatible Technology/Options	Area Available On- site?	Technology Acceptable On-site?
Anaerobic Digestion Facilities	Kitchener	- Applicable with existing infrastructure. Dewatering available on-site. - Only Facility anticipated to produce a large enough quantity of biosolids to make an on-site incinerator economical	Not applicable (biosolids to be processed off-site)	No, biosolids must be processed off-site
	Waterloo	Applicable with existing infrastructure. Dewatering available on-site.	Not applicable (biosolids to be processed off-site)	No, biosolids must be processed off-site
	Galt	Applicable with existing infrastructure. Dewatering available on-site.	Not applicable (biosolids to be processed off-site)	No, biosolids must be processed off-site
	Preston	Current approach to transfer anaerobic digestate off site likely to continue	No	No, biosolids must be processed off-site

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Facility Category by Biosolids Digestion Process		Facility Name	Compatible Technology/Options	Area Available On- site?	Technology Acceptable On-site?
Aerobic Facilities	Digestion	Ayr	- Dewatering not available on-site. Biosolids to be trucked for off-site processing; or - Add dewatering on-site prior to transfer.	Not Applicable (biosolids to be processed off-site)	No, biosolids must be processed off-site
		New Hamburg	- Dewatering not available on-site. Biosolids to be trucked for off-site processing; or - Add dewatering on-site prior to transfer.	Not Applicable (biosolids to be processed off-site)	No, biosolids must be processed off-site
Facilities Biosolids Digestion	Without	Elmira	Transfer of existing dewatered cake to central facility	Not Applicable (sludge to be processed off-site)	No, sludge must be processed off-site

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Facility Category by Biosolids Digestion Process	Facility Name	Compatible Technology/Options	Area Available On- site?	Technology Acceptable On-site?
Facilities Without Biosolids Digestion	Hespeler	- Dewatering not available on-site. Biosolids to be trucked for off-site processing; or - Add dewatering on-site.	Not Applicable (sludge to be processed off-site)	No, sludge must be processed off-site
	Heidelberg	Transfer of existing solids product to other WWTP (Waterloo).	Not Applicable (sludge to be processed off-site)	No, sludge must be processed off-site
	St. Jacobs	Transfer of existing solids product to other WWTP (Waterloo).	Not Applicable (to be processed off-site)	No, sludge must be processed off-site
	Wellesley	Transfer of existing solids product to other WWTP (Waterloo).	Not Applicable (to be processed off-site)	No, sludge must be processed off-site
	Conestogo	Transfer of existing solids product to other WWTP (Waterloo).	Not Applicable (to be processed off-site)	No, sludge must be processed off-site
	Foxboro Green	Transfer of existing solids product to other WWTP (Waterloo).	Not Applicable (to be processed off-site)	No, sludge must be processed off-site

3.4.6.3 Review of MPQ Compatibility

The compatibility of the thermal reduction technology with individual MPQs is summarized below in **Table 3-15**. The “yes” or “no” assessment is accompanied by a narrative description of the considerations for each MPQ.

Table 3-15: Review of MPQ Compatibility - Thermal Reduction to Ash (Without Energy Recovery)

MPQ	Compatibility Considerations	Acceptable? (Yes/No)
1. Build upon Existing Infrastructure: Does the alternative build upon the Region's existing wastewater infrastructure?	- Compatible with existing facilities producing dewatered biosolids cake which may serve as a feedstock for the thermal reduction process. - Facilities not currently dewatering require transfer to existing facilities, or new equipment. Facilities that generate aerobically digested biosolids (20% solids at the most) may not achieve the optimal solids (the drier the better) content for incineration and might not be economically attractive.	Yes
2. Build upon Existing Infrastructure: Is it based on commercially proven technology that provides a long term solution?	Thermal reduction technologies, particularly fluidized bed incineration for biosolids are operating in Ontario.	Yes
3. Protect the Natural Environment: Does it meet current environmental regulations and is it capable of meeting permitting requirements?	Thermal reduction technologies producing ash may be contained within process buildings and are expected to be capable of receiving appropriate permits. Fluidized bed incinerators in particular are equipped with air emission and environmental controls to meet environmental regulations.	Yes
4. Protect the Natural Environment: Does it align with best environmental	Energy recovery as biogas followed by thermal reduction to ash combined with use of the ash	Yes

MPQ	Compatibility Considerations	Acceptable? (Yes/No)
management practices in the field of biosolids?	product as an industrial input (e.g. cement production) is aligned with CCME guidelines.	
5. Protect Health and Safety: Does it meet current health and safety regulations?	Well-established candidate technologies reducing biosolids to ash are available, including facilities permitted and operating in Ontario.	Yes
6. Protect Health and Safety: Does it align with best practices in the field of biosolids management?	- Well-established candidate technologies reducing biosolids to ash are available, including facilities permitted and operating in Ontario. - Landfilling of ash provides an acceptable safe disposal approach.	Yes
7. Minimize and Manage Operational Risk: Can the Region control all necessary elements of implementation?	Well-established candidate technologies for incineration of biosolids have been procured by municipalities in Ontario.	Yes
8. Minimize and Manage Operational Risk: Can the storage requirements be sited in the Region?	- Minimum operational storage of feedstock is anticipated. - A storage system for ash product as part of new processing facilities is not required as material would be directed to landfill	Yes

MPQ	Compatibility Considerations	Acceptable? (Yes/No)
9. Protect Quality of Life: Does the alternative protect the quality of life for citizens regardless of where it is built in the Region?	• New receiving, material handling, process equipment and storage will be implemented in buildings with engineering controls to mitigate nuisance impacts on citizens near new infrastructure, and control air emissions from the facility.	Yes

3.4.6.4 Summary

This alternative is not compatible with siting at most facilities but meets all MPQs, provided an appropriate use for ash is identified. The manner of implementation of this alternative to be located at a new centralized location or within a WWTP site may be refined based on the specific thermal reduction technology selected.

3.4.7 Thermal Reduction with Energy Recovery

3.4.7.1 Overview

This alternative considers thermal reduction of biosolids to ash, primarily through fluidized bed incineration. Thermal energy released through combustion of biosolids would be used to maintain process temperature. The inclusion of heat recovery and energy recovery (primarily in the form of cogeneration from waste heat) provides an additional product from processed biosolids. The practicality of thermal energy recovery is dependent on a number of factors, including the residual energy content of biosolids feedstock following upstream processes such as digestion, as well as the dry solids content of biosolids. A minimum of 25% of the ash produced through thermal reduction must also be used to align with CCME best practice guidelines.

Siting and Area Considerations

This alternative is suited to processing of biosolids at a centralized facility, at either at an existing treatment facility site or at a new centralized facility. Space considerations have been considered equivalent to thermal reduction without energy recovery. Based on RFI submissions from vendors of thermal reduction technologies, footprints of 1,800m² to 2,200m² are reported with varying throughput capacities. It is assumed that 4 months of long-term storage of the ash product will be required at the site.

3.4.7.2 Review of Facility Compatibility

Table 3-16 below summarizes facility-specific considerations for implementation of a biosolids management approach producing fertilizer. Overall acceptability is noted as well as facility-specific considerations that may influence the type of technology selected or its location.

Table 3-16: Review of Facility Compatibility – Thermal Reduction with Energy Recovery

Facility Category by Biosolids Digestion Process	Facility Name	Compatible Technology/Options	Area Available On-site?	Technology Acceptable On-site?
Anaerobic Digestion Facilities	Kitchener	- Applicable with existing infrastructure. Dewatering available on-site. - Only Facility anticipated to produce a large enough quantity of biosolids to make an on-site incinerator economical.	Potentially	Yes Facility may also be considered as a location for a centralized unit
	Waterloo	Applicable with existing infrastructure. Dewatering available on-site.	Not applicable (biosolids to be processed off-site)	No, biosolids must be processed off-site
	Galt	Applicable with existing infrastructure. Dewatering available on-site.	Not applicable (biosolids to be processed off-site)	No, biosolids must be processed off-site
	Preston	Current approach to transfer anaerobic digestate off site likely to continue.	No	No, biosolids must be processed off-site

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Facility Category by Biosolids Digestion Process		Facility Name	Compatible Technology/Options	Area Available On- site?	Technology Acceptable On- site?
Aerobic Facilities	Digestion	Ayr	- Dewatering not available on-site. Biosolids to be trucked for off-site processing; or - Add dewatering on-site prior to transfer.	Not Applicable (biosolids to be processed off-site)	No, biosolids must be processed off-site
		New Hamburg	- Dewatering not available on-site. Biosolids to be trucked for off-site processing; or - Add dewatering on-site prior to transfer.	Not Applicable (biosolids to be processed off-site)	No, biosolids must be processed off-site
Facilities Without Biosolids Digestion	Without	Elmira	- Continue current approach; or - Transfer of existing dewatered cake to other WWTP or central facility may be considered.	Not Applicable (sludge to be processed off-site)	No, sludge must be processed off-site
		Hespeler	- Dewatering not available on-site. Biosolids to be trucked for off-site processing; or - Add dewatering on-site.	Not Applicable (sludge to be processed off-site)	No, sludge must be processed off-site

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Facility Category by Biosolids Digestion Process		Facility Name	Compatible Technology/Options	Area Available On- site?	Technology Acceptable On- site?
Facilities Without Biosolids Digestion		Heidelberg	Transfer of existing solids product to other WWTP (Waterloo).	Not Applicable (sludge to be processed off-site)	No, sludge must be processed off-site
		St. Jacobs	Transfer of existing solids product to other WWTP (Waterloo).	Not Applicable (to be processed off-site)	No, sludge must be processed off-site
		Wellesley	Transfer of existing solids product to other WWTP (Waterloo).	Not Applicable (to be processed off-site)	No, sludge must be processed off-site
		Conestogo	Transfer of existing solids product to other WWTP (Waterloo).	Not Applicable (to be processed off-site)	No, sludge must be processed off-site
		Foxboro Green	Transfer of existing solids product to other WWTP (Waterloo).	Not Applicable (to be processed off-site)	No, sludge must be processed off-site

3.4.7.3 Review of MPQ Compatibility

The compatibility of thermal reduction with energy recovery with individual MPQs is summarized below in **Table 3-17**. The “yes” or “no” assessment is accompanied by a narrative description of the considerations for each MPQ.

Table 3-17: Review of MPQ Compatibility – Thermal Reduction with Energy Recovery

MPQ	Compatibility Considerations	Acceptable? (Yes/No)
1. Build upon Existing Infrastructure: Does the alternative build upon the Regions existing wastewater infrastructure?	Net energy recovery from the current digested and dewatered cake product will be minimal in the thermal reduction unit. Existing infrastructure will facilitate energy recovery through the planned combined heat and power process.	No
2. Build upon Existing Infrastructure: Is it based on commercially proven technology that provides a long term solution?	Thermal reduction technologies, particularly fluidized bed incineration are operating in Ontario.	Yes
3. Protect the Natural Environment: Does it meet current environmental regulations and is it capable of meeting permitting requirements?	Thermal reduction technologies producing ash may be contained within process buildings and are expected to be capable of receiving appropriate permits. Fluidized bed incineration in particular may be equipped with air emission and environmental controls to meet environmental regulations.	Yes
4. Protect the Natural Environment: Does it align with best environmental management practices in the field of biosolids?	Energy recovery as biogas followed by thermal reduction to ash combined with use of the ash product as an industrial input (e.g. cement production) is aligned with CCME guidelines.	Yes
5. Protect Health and Safety: Does it meet current health and safety	Well-established candidate technologies reducing biosolids to ash are available,	Yes

MPQ	Compatibility Considerations	Acceptable? (Yes/No)
regulations?	including facilities permitted and operating in Ontario.	
6. Protect Health and Safety: Does it align with best practices in the field of biosolids management?	- Well-established candidate technologies reducing biosolids to ash are available, including facilities permitted and operating in Ontario. - Landfilling of ash provides an acceptable safe disposal approach.	Yes
7. Minimize and Manage Operational Risk: Can the Region control all necessary elements of implementation?	Well-established candidate technologies producing fertilizer from biosolids have been procured by municipalities in Ontario.	Yes
8. Minimize and Manage Operational Risk: Can the storage requirements be sited in the Region?	- Small capacity operational storage of feedstock is anticipated to relatively straight forward to site for this alternative. - A storage system for 4 months of the ash product as part of new processing facilities is anticipated to be acceptable to accumulate inventory to facilitate use.	Yes
Protect Quality of Life: Does the alternative protect the quality of life for citizens regardless of where it is built in the Region?	New receiving, material handling, process equipment and storage will be implemented in buildings with engineering controls to mitigate nuisance impacts on citizens near new infrastructure, and control air emissions from the facility.	Yes

3.4.7.4 Summary

This alternative does not pass the MPQ for compatibility with existing infrastructure. Anaerobic digestion and biogas collection upstream of biosolids processing is anticipated to remove energy content in biosolids required to allow the thermal reduction process to operate with net energy recovery.

3.4.8 Landfill All Biosolids

3.4.8.1 Overview

This alternative consists of the construction of biosolids storage infrastructure for temporary management of material prior to landfiling as dewatered cake. No additional processing equipment would be provided.

In addition, a landfill with a permit that allows biosolids to be disposed would be required.

Siting and Area Considerations

This alternative requires minimal site footprint and could be implemented at existing treatment facilities. Additional operational storage to manage transfer of material prior to landfiling may be considered at existing WWTPs. IT is not anticipated that long-term storage would be required as landfills can accept waste material year-round.

3.4.8.2 Review of Facility Compatibility

Table 3-18 below summarizes facility-specific considerations for implementation of a biosolids management approach through landfiling. Overall acceptability is noted as well as facility-specific considerations that may influence implementation.

Table 3-18: Review of Facility Compatibility – Landfill All Biosolids

Facility Category by Biosolids Digestion Process	Facility Name	Compatible Technology/Option	Anticipated Technology Footprint Area Available On- site?	Technology/Option Acceptable On- site?
Anaerobic Digestion Facilities	Kitchener	Add short term operational storage to facilitate trucking.	Yes	Yes
	Waterloo	Add short term operational storage to facilitate trucking.	Yes	Yes
	Galt	Add short term operational storage to facilitate trucking.	Yes	Yes
	Preston	Current approach to transfer anaerobic digestate off site likely to continue.	Does not require additional area	Yes
Aerobic Digestion Facilities	Ayr	- Dewatering not available on-site. Biosolids to be trucked for off-site processing; or - Add dewatering on-site prior to transfer.	Does not require additional area	Yes, biosolids can be dewatered off-site
	New Hamburg	- Dewatering not available on-site. Biosolids to be trucked for off-site processing; or - Add dewatering on-site prior to transfer.	Does not require additional area	Yes, biosolids can be dewatered off-site

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Facility Category by Biosolids Digestion Process		Facility Name	Compatible Technology/Option	Anticipated Technology Footprint Area Available On-site?	Technology/Option Acceptable On-site?
Facilities Without Biosolids Digestion		Elmira	Continue current approach;	Does not require additional area	Yes
		Hespeler	- Dewatering not available on-site. Biosolids to be trucked for off-site processing; or - Add dewatering on-site.	Does not require additional area	Yes, sludge can be dewatered off-site
		Heidelberg	Transfer of existing solids product to other WWTP (Waterloo).	Does not require additional area	Yes, sludge can be dewatered off-site
		St. Jacobs	Transfer of existing solids product to other WWTP (Waterloo).	Does not require additional area	Yes, sludge can be dewatered off-site
		Wellesley	Transfer of existing solids product to other WWTP (Waterloo).	Does not require additional area	Yes, sludge can be dewatered off-site
		Conestogo	Transfer of existing solids product to other WWTP (Waterloo).	Does not require additional area	Yes, sludge can be dewatered off-site
		Foxboro Green	Transfer of existing solids product to other WWTP (Waterloo).	Does not require additional area	Yes, sludge can be dewatered off-site

3.4.8.3 Review of MPQ Compatibility

The compatibility of this management approach with individual MPQs is summarized below in **Table 3-19**. The “yes” or “no” assessment is accompanied by a narrative description of the considerations for each MPQ.

Table 3-19: Review of MPQ Compatibility – Landfill All Biosolids

MPQ	Compatibility Considerations	Acceptable ? (Yes/No)
1. Build upon Existing Infrastructure: Does the alternative build upon the Regions existing wastewater infrastructure?	- Compatible with existing facilities producing dewatered biosolids cake which may be directed to landfill. - Facilities not currently dewatering require transfer to existing facilities, or new equipment.	Yes
2. Build upon Existing Infrastructure: Is it based on commercially proven technology that provides a long term solution?	Landfilling is a common biosolids management alternative; however, there were no other examples of municipalities of the scale of the Region identified that are currently landfilling 100% of biosolids.	Yes
3. Protect the Natural Environment: Does it meet current environmental regulations and is it capable of meeting permitting requirements?	Capable of complying with regulations and receiving required permitting.	Yes
4. Protect the Natural Environment: Does it align with best environmental management practices in the field of biosolids?	Landfilling biosolids does not consider the nutrient, organic matter or energy content, and therefore does not align with CCME guidelines.	No
5. Protect Health and Safety: Does it meet current health and safety regulations?	Landfilling a portion of biosolids is a well-established management practice that complies with regulations.	Yes

MPQ	Compatibility Considerations	Acceptable ? (Yes/No)
6. Protect Health and Safety: Does it align with best practices in the field of biosolids management?	Landfilling a portion of biosolids is a well-established management practice that protects public health.	Yes
7. Minimize and Manage Operational Risk: Can the Region control all necessary elements of implementation?	- There are landfills outside the Region that are permitted to accept municipal biosolids, and would willingly accept the quantity of biosolids generated over the planning period; - Reliance on single disposal method presents a substantial risk over planning period, particularly given the potential for landfills to limit acceptance of organic material.	Yes, but presents a substantial risk
8. Minimize and Manage Operational Risk: Can the storage requirements be sited in the Region?	Small capacity operational storage of dewatered cake is anticipated to be relatively straight forward to site for this alternative.	Yes
9. Protect Quality of Life: Does the alternative protect the quality of life for citizens regardless of where it is built in the Region?	Proper handling, storage and odour control of biosolids and sludge prior to landfilling are expected to mitigate impacts on citizens.	Yes

3.4.8.4 Summary

This alternative is simple and compatible with existing processes at all treatment facilities; however, it does not meet the MPQ for best-practices in terms of using the nutrients, organic matter, or energy content. Landfill disposal is an important contingency for the other alternatives, but is not recommended as the primary approach for biosolids management.

4.0 MPQ Summary

4.1 Summary Table

Table 4-1 summarizes the evaluation of each alternative with respect to MPQ criteria conducted in previous sections. Alternatives to be carried forward to the shortlist for further examination are identified.

Table 4-1: MPQ Summary

MPQ	Current Approach with Expanded Capacity	Current Approach with Solids Preparation Before Digestion	Produce Fertilizer	Produce Compost	Produce Dry, Low Volume Fertilizer	Thermal reduction to Ash (No Energy Recovery)	Thermal Reduction With Energy Recovery	Landfill All Biosolids
1. Build upon Existing Infrastructure: Does the alternative build upon the Regions existing wastewater infrastructure?	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2. Build upon Existing Infrastructure: Is it based on commercially proven technology that provides a long term solution?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3. Protect the Natural Environment: Does it meet current environmental regulations and is it capable of meeting permitting requirements?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4. Protect the Natural Environment: Does it align with best environmental management practices in the field of biosolids?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
5. Protect Health and Safety: Does it meet current health and safety regulations?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6. Protect Health and Safety: Does it align with best practices in the field of biosolids management?	Yes	Yes	Yes	Yes	Yes	Yes,	Yes	Yes
7. Minimize and Manage Operational Risk: Can the Region control all necessary elements of implementation?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8. Minimize and Manage Operational Risk: Can the storage requirements be met with a facility(s) located in the Region?	No	No	Yes	Yes	Yes	Yes	Yes	Yes
9. Protect Quality of Life: Does the alternative protect the quality of life for citizens regardless of where it is built in the Region?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Carry forward to shortlist?	Consider carrying forward as component of strategy	Consider carry forward as component of strategy	Yes	Yes	Yes	Yes	No	No

4.2 Discussion for Removal of Alternatives

Following a review of the facility and MPQ compatibility, Thermal Reduction with Energy Recovery and Landfill All Biosolids are proposed to be removed from further consideration. The Status Quo and Status Quo with Solid Preparation are also proposed to be removed from further consideration as stand-alone alternatives for implementation but may be combined with another alternative, or as part of the phased implementation of a biosolids management strategy. Discussion for removing these alternatives is provided below.

4.2.1.1 Discussion for Removal of Current Approach with Expanded Capacity Alternative

The MOECC Design Guidelines for Sewage Works (2008) recommends a minimum of 240 days (8 months) of storage for biosolids management strategies that rely exclusively on land application. Given the Region's experience attempting to site this type of facility within the Region, this type of facility is not recommended. These large scale storage facilities for NASM have not commonly been sited in Ontario in the recent past, and previously permitted facilities of this nature have been closed since the last Master Plan.

The Region's Strategic Plan makes biosolids diversion from landfill a priority, and although landfill should remain a contingency option, the preferred strategy must include infrastructure to decrease the likelihood of biosolids disposal in landfill. The current biosolids management strategy also uses biosolids for mine tailings reclamation. This mine application allows use during periods when agricultural land is not available, and allows diversion from landfill. Therefore the 240 day storage facility is not necessarily required to allow use when agricultural land is not available, but operational storage is required. The amount of biosolids transferred to landfill since the mine application has become available was: 3,044 wet tonnes in 2016 and 14,216 Wet tonnes in 2015. These masses represent 40 and 172 days of biosolids

production respectively. It is understood that landfilling was required given that approximately 3 days of dewatered cake storage is currently available, not due to a lack of capacity for mine tailings rehabilitation or agricultural application. Operational storage on the order of 30 days of the 2051 biosolids production is required for the 2016 quantity of landfilled biosolids. Overall, siting the large scale storage required to address the limitations of the current 'just-in-time' strategy and avoid landfill disposal of NASM quality biosolids presents a substantial risk. Discussion for Removal of Alternative 2

4.2.1.2 Discussion for Removal of Current Approach with Solids Preparation before Digestion Alternative

The rationale for removing the Current Approach with Expanded Capacity Alternative presented above in Section 4.2.1.1 is applicable to the Current Approach with Solids Preparation before Digestion Alternative. The technical differences between these two alternatives consist mainly of upstream solids preparation for anaerobic digestion, and do not meaningfully change biosolids product generated or management considerations for the Region.

4.2.1.3 Discussion for Removal of Thermal Reduction with Energy Recovery Alternative

This alternative differs from the Thermal Reduction (No Energy Recovery) Alternative in terms of the assumed energy content of the biosolids product, and net energy balance from thermal reduction. Energy content of the current biosolids product must permit a net energy gain through combustion, and greater than 25% of the ash produced must be used rather than disposed to a landfill to meet best practices guidelines (CCME 2012). In general, energy recovery from solid residuals does not align with digestion, as a significant portion of the heat value of this material is removed through the digestion process.

A fluidized bed reactor is the most up to date technology that can accept biosolids with the lowest total solids content, while still generating net energy. The approximate cut-off of 28% solids approaches the quality produced by the Kitchener, Galt, and Waterloo facilities, but does not consider the additional reduction in heat value through upstream anaerobic digestion and biogas recovery. Implementation of an incineration and energy recovery approach may require additional infrastructure to remove the maximum amount of water from biosolids.

The planned combined heat and power engines to use biogas generated through anaerobic digestion aligns with a strategy of recovering energy at the treatment plant level, rather than optimizing processes for energy recovery from a new biosolids combustion process. Capital investment in the infrastructure necessary to recover heat or electricity from a second combustion process is not considered an efficient use of resources. Therefore, the Thermal Reduction with Energy Recovery Alternative is not considered to align with existing or planned infrastructure.

4.2.1.4 Discussion for Removal of Landfill All Biosolids Alternative

The Canada-Wide approach for the management of wastewater biosolids (2012) represents a key resource in terms of defining best practices. The CCME policy statement promotes use of biosolids as a resource for nutrients, organic matter, and / or energy.

Alternative 8 consists strictly of disposal and does not align with best practice principles for use the nutrients, organic matter or energy content of biosolids. The strategy does serve as an appropriate method of mitigating risk as modern landfills are considered an acceptable location for disposal in order to protect human health and the environment, as long as the landfill has a permit to accept municipal biosolids. Landfilling can be performed adhering to provincial and municipal standards; however it does not align with the Region of Waterloo strategic plan, specifically:

- Strategic Objective 3.1 Increase the amount of waste diverted from landfill, and
- 3.1.3 Evaluate alternative waste (solids waste, biosolids, and any other) disposal technologies (energy from waste).

Therefore disposal of biosolids to landfills is an appropriate contingency for biosolids management, but disposal of all biosolids to landfill does not align with national best practices presented by the CCME or the Region's strategic plan and therefore does not meet the minimum performance.

5.0 Conclusion and Short List

5.1 Short List of Alternatives

As noted in **Table 4-1: MPQ Summary**, the status quo alternatives are proposed to be removed from further consideration as the primary alternative for biosolids management but may form part of an overall strategy. Remaining alternatives that may be carried forward for as a short list for further analysis include:

- **Produce Fertilizer:** Consider implementation of one of the range of technologies available to produce a CFIA fertilizer product, either through centralized or decentralized implementation, as long as the technology is compatible with volume reduction through dewatering. This alternative will be renamed Alternative SL1 to indicate short list.
- **Produce Compost:** Consider implementation of a composting process capable of meeting Category A or B compost standards, either through centralized or decentralized implementation, as long as the entire facility can be covered and provided with odour control. This alternative will be renamed Alternative SL2 to indicate short list.
- **Produce Dry, Low Volume Fertilizer:** Consider production of a CFIA fertilizer product through implementation of a drying process likely through a centralized implementation, but decentralized options can be considered. This alternative will be renamed Alternative SL3 to indicate short list.
- **Thermal Reduction to Ash:** Reduce biosolids to ash, producing the minimum volume of residual product and identify use opportunities for ash aligning with CCME best practices through centralized implementation. This alternative will be renamed Alternative SL4 to indicate short list.

5.2 Conclusions

The four biosolids management alternatives identified in this Technical Memo represent a wide range of acceptable processing technologies and configurations. The facility-based evaluation exercise suggests that the implementation of a distributed processing approach for biosolids is best aligned with the Produce Fertilizer alternative. Produce Compost, Produce Dried, Low Volume Fertilizer, and Thermal Reduction to Ash (No Energy Recovery) may be considered at selected WWTP sites with large available site areas, or on a new, dedicated facility site. Storage requirements for management of waste sludge or dewatered cake have also been identified, with the goal of reducing operational risk and avoiding disposal.

6.0 References

- Canadian Council for Ministers of the Environment (CCME). 2012a. Canada-wide Approach for the Management of Wastewater Biosolids. PN 1477. Available Online: <http://www.ccme.ca/en/resources/waste/biosolids.html>. Last Accessed: April 13, 2017.
- Canadian Council for Ministers of the Environment (CCME). 2012b. Guidance Document For The Beneficial Use Of Municipal Biosolids, Municipal Sludge And Treated Septage. PN 1473. Available Online: http://www.ccme.ca/files/Resources/waste/biosolids/pn_1473_biosolids_guidance_eng_1.0.pdf. Last Accessed: April 13, 2017.
- CIMA+. 2017. Sludge and Biosolids Generation Rates Estimate memo.
- Dillon Consulting Limited (Dillon). 2016. Technical Memo #2: Existing Conditions Background Study (Draft).
- Dillon. 2016. Technical Memo #5: Long List of Biosolids Management Alternatives (Draft).
- Dillon. 2017. Technical Memo #6: Biosolids Quantity Forecast (Draft).
- Ontario Ministry of the Environment and Climate Change (MOECC). 2008. Design Guidelines for Sewage Works. Available Online: <https://www.ontario.ca/document/design-guidelines-sewage-works>. Last Accessed: April 13, 2017.
- United States Environmental Protection Agency (US EPA). 2003. Biosolids Technology Fact Sheet, Use of Incineration for Biosolids Management. Available Online: <https://nepis.epa.gov/Exe/ZyPDF.cgi/P10053DX.PDF?Dockkey=P10053DX.PDF>. Last Accessed: April 13, 2017.



APPENDIX H:

TM#8 – Evaluation of Short Listed Alternatives

Region of Waterloo Biosolids Strategy

Technical Memo #8
Evaluation of Short Listed Strategies

Final Draft
April 2018



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Acronyms

AS	Activated Sludge
ATAD	Autothermal Aerobic Digestion
BEAM	Biosolids Emissions Assessment Model
BMP	Biosolids Master Plan
CCME	Canadian Council of Ministers of the Environment
CFIA	Canadian Food Inspection Agency
CHP	Combined Heat and Power
EPA	Environmental Protection Act
GHG	Greenhouse Gas
GRCA	Grand River Conservation Authority
MLD	Million Litres / Day
LEED	Leadership in Energy and Environmental Design
MOECC	Ministry of Environment and Climate Change
MPQ	Minimum Performance Questions
NASM	Non-Agricultural Source Material
NMA	Ontario Nutrient Management Act, 2002, S.O. 2002, c. 4
OH&S	Ontario Health and Safety
PPE	Personal Protective Equipment
TM	Technical Memo
US EPA	United States Environmental Protection Agency
WAS	Waste Activated Sludge
WWTP	Wastewater Treatment Plant

1.0 Introduction

1.1 Project Purpose and Approach

The Region of Waterloo Biosolids Strategy was initiated in 2015, to develop an approach to manage biosolids in Waterloo Region to the year 2051. The strategy will take a critical look at current practices, and consider available and relevant technologies for processing biosolids. Alternative ways to manage biosolids will be evaluated against a range of criteria to develop a biosolids management strategy for the Region. This project will result with the selection of a preferred strategy that will be implemented in the Region over the next 35 years. The decision making process to select the preferred strategy will be documented in a report and be available for public review. Future projects will further refine the implementation details of the strategy including timing, sizing and location of any facilities.

The strategy is being developed in six stages, which will be outlined in a series of technical memos (TMs). The memos will form the basis for the final study document. The project stages include:

- Stage 1 – What are biosolids and what process is being followed to develop the strategy?
 - o TM1: The Environmental Assessment Process
- Stage 2 – What is the current situation related to biosolids in the Region and how will it change as the Region grows?
 - o TM2: Existing Conditions
 - o TM3: Biosolids Management Needs Forecast
- Stage 3: What are the project objectives, what technologies and strategies are being considered and how will a decision be made to select the recommended strategy?
 - o TM4: Evaluation Approach and Comparative Evaluation Criteria

- o TM5: Biosolids Technologies, End Uses, and Disposal
 - o TM6: Long List of Biosolids Management Alternatives
- Stage 4 – What alternatives from the long list could work in the Region of Waterloo? How can they be refined based on the project objectives? This stage involves evaluating the alternatives to identify a shorter list that will be evaluated in more detail
 - o TM7: Short List of Biosolids Management Alternatives
- Stage 5 – Based on the project objectives and evaluation criteria, what is the recommended strategy? The short listed alternatives are evaluated at this stage and a recommended strategy is brought forward for public input.
 - o TM8: Evaluation of Short Listed Alternatives
- Stage 6 – What is the best strategy to meet the project objectives?
 - o TM9: Recommended Biosolids Strategy
 - o Biosolids Strategy Document

The Region is committed to public engagement throughout the development of the strategy. The project team will seek to understand the priorities and concerns of community residents across Waterloo Region, as well as technical experts and other stakeholders.

A **sustainable strategy** is one that considers the future growth of the Region and looks to minimize potential landfill disposal requirements of biosolids.

Additional background information regarding the context of biosolids management in the Region of Waterloo is included in **TM 1**.

1.2 Purpose of this Technical Memo

The Evaluation of Short Listed Alternatives memorandum (TM8) provides a detailed evaluation of the short listed alternatives presented in TM7 against study objectives and performance criteria outlined in TM3. The criteria included in TM3 have been updated and refined based on input received from the public, stakeholders, technical

advisors, and the study team since the memo was initially developed. The evaluation process uses a combination of quantitative and qualitative factors. An objectives-based evaluation process was used, which determines what the recommended biosolids management strategy for Waterloo Region will be based on the alternative(s) with the best alignment with the objectives. The evaluation process may describe the merits and/or performance of each alternative in absolute terms, or by comparing the alternatives, but always seeking to present the alignment with the objective under consideration. The objectives based evaluation may conclude that more than one alternative is well aligned to the objectives, and multiple alternatives could become part of the recommended strategy moving forward.

1.3 Memo Structure

Technical Memo 8 is organized into six sections:

- 1. Chapter 1: Introduction**
- 2. Chapter 2: Evaluation Approach**
- 3. Chapter 3: Summary of Short Listed Alternatives**
 - **Appendix A:** Detailed Description of Alternative 1
 - **Appendix B:** Detailed Description of Alternative 2
 - **Appendix C:** Detailed Description of Alternative 3
 - **Appendix D:** Detailed Description of Alternative 4
- 4. Chapter 4: Evaluation of Short Listed Alternatives by Objective**
 - **Appendix E:** Detailed Evaluation Matrix
 - **Appendix F:** Climate Change Impact and Adaptation Assessment
- 5. Chapter 5: Overall Summary of Evaluation**
- 6. Chapter 6: Preliminary Preferred Alternative**

Chapter 1 provides an introduction to the memo, including the purpose and structure. Chapter 2 details the evaluation approach used to assess the short listed alternatives. Chapter 3 summarizes the key features of each of the four short listed

alternatives, and Chapter 4 provides a summary of the detailed evaluation completed for each of the short listed alternatives. The appendices contain more detailed information on how the evaluation was completed and specific information on the performance of each of the alternatives against the evaluation criteria. Chapter 5 provides a brief summary of the key notable items related to the performance of each of the alternatives. The final chapter outlines the recommended alternative(s) based on the evaluation completed and considerations in developing the preferred strategy for the Region which will be the focus of TM9.

2.0 Evaluation Approach

An objectives-based evaluation approach was used to identify the recommended Biosolids Management Strategy. This multi-disciplinary approach evaluates strategy alternatives against a set of integrated environmental, social and economic objectives.

Six objectives were developed based on consultation with key stakeholders (the “issues that matter”) and members of the community, alignment with the Region’s Strategic Plan, and input from the project’s technical team.

TM 3 outlined the evaluation approach followed for this study and described how the study objectives and criteria were developed. A two-phased evaluation was completed, with a long list of alternatives developed (TM5), which were then shortlisted using a series of Minimum Performance Questions (TM7). Based on the results of the Minimum Performance Questions evaluation, four alternatives were shortlisted for further consideration. This memo documents the evaluation completed for the four short listed alternatives. The corresponding indicators assigned to measure the performance of the alternatives against the criteria are provided in **Appendix E**.

2.1 Evaluation Criteria

The following provides a general overview of the evaluation criteria used to assess each objective. A detailed breakdown of each criteria and information used to complete the evaluation is included in **Appendix E**.

2.1.1 Align With Existing Infrastructure

Objective description: The Region has significant investment in infrastructure and a strategy that maximizes this investment is preferred.

The following was considered in the evaluation of this objective:

- How compatible is the alternative with existing Regional wastewater and biosolids processing infrastructure? This factor considered physical space requirements as well as the potential to optimize/modify existing processes using qualitative and quantitative measures.
- How much new supporting municipal infrastructure is required? This factor considered the need for new infrastructure to support the facility, such as a new water service, hydro, natural gas, etc. The extent of impacts beyond the facility site(s) are included in this factor using qualitative and quantitative measures.
- Does the alternative present synergies with other municipal initiatives? This factor considered if the alternative could be combined with other municipal initiatives/processes to minimize total Regional expenses using qualitative measures.
- How flexible is the alternative in adapting to changing government regulations, policies and market demands? This factor is considered adaptability of the alternative for the short term (over the next 10 years) and long term (to 2051) using qualitative indicators.
- Does the alternative accommodate future population growth? This factor considered if/how the alternative could be implemented in phases and impacts of population growth using quantitative measures.

2.1.2 Protect the Natural Environment

Object description: The preferred alternative should minimize impacts to the environment and surroundings.

The following was considered in the evaluation of this objective:

- What are the environmental effects of the alternative? This factor considered environmental benefits as well as potential risks. The focus for the evaluation was air, surface water, groundwater and soil using qualitative measures.
- Does the alternative use or generate energy? This factor assessed the net energy balance of each alternative using quantitative measures.
- Is the alternative adaptable to climate change impacts? This factor was a qualitative assessment of how different climate change scenarios would impact each alternative. The climate change scenarios were focussed on changes to temperature and precipitation.
- How much greenhouse gas emissions does the alternative produce? (Note: Greenhouse gases are any gas in the atmosphere that traps heat and contributes to global warming.) The quantitative evaluation was completed using the Biosolids Emissions Assessment Model (BEAM) to assess emissions from the biosolids process as well as trucking.
- Does the alternative maximize the amount of end product being diverted from landfill? Using both quantitative and qualitative measures, this factor considered the mass balance of the alternative's output, end use options, and the potential disposal quantities anticipated using quantitative and qualitative measures.

2.1.3 Protect Health and Safety

Objective description: The preferred alternative should minimize impacts to public and worker health and safety.

The following was considered in the evaluation of this objective:

- What are the relative health risks posed to the public for each alternative? Using qualitative measures, potential health risks to the public based on emission and trucking were considered.
- What are the relative health risks posed to workers for each alternative? The factor considered risks to workers directly involved in the biosolids management process and ultimately its impact on the workers handling of the end product.
- Does the alternative improve the quality of biosolids compared to the existing approach? This factor assessed the anticipated quality of the end product.
- Does the alternative meet industry best practices for protecting health and safety? The qualitative assessment considered the need for and extent of contingency plans for each strategy to address an adverse event.

2.1.4 Minimize and Manage Operational Risk

Objective description: The preferred alternative must allow the Region to provide continual, uninterrupted biosolids management service to the public.

The following was considered in the evaluation of this objective:

- How do the end use or disposal options affect the risk of disruption to biosolids management services? Qualitative evaluation of the type and number of end use options, potential of losing an intended end use and the consequences of doing so.
- Does the alternative reduce the volume/mass of end product to be managed? The factor assessed the volume and mass of the end product.
- How susceptible is the alternative to disruption in process and service delivery? Using a qualitative approach, this factor considered process

reliability, including how susceptible it is to disruptions due to maintenance and labour.

- How susceptible is the alternative to disruption in end product quality, management or storage? Using a qualitative approach, this factor considered how adaptable the strategy is to disruptions in the end product quality, storage and process logistics.

2.1.5 Protect Quality of Life

Objective description: The existing quality of life for citizens should be maintained when planning for biosolids infrastructure.

The following was considered in the evaluation of this objective:

- How will odour be managed? This factor considered the extent and dependability of odour mitigation required, potential for fugitive emissions that cannot reasonably be mitigated during the process, as well as potential odour associated with the end use.
- How will dust from process or trucking be managed related to nuisance effects? Potential dust sources were identified and the necessity for mitigation strategies was evaluated.
- How will noise be managed? The extent and dependability of noise mitigation required, during day and night-time operations, was evaluated.
- How will visual effects be managed? As part of the evaluation, parameters for siting any new facilities were determined, including visual impacts. This factor considered the complexity to mitigate impacts as well as the overall aesthetics of any proposed facilities.

- How will effects related to trucking be managed? The number of trucks and kilometers traveled (within the Region and beyond) using qualitative and quantitative measures were assessed.
- Can all components of biosolids management, end uses and/or disposal be managed within Waterloo Region? A qualitative assessment of the potential market for the end product(s) and disposal opportunities in the Region was assessed. This included a review of what other communities are doing as a benchmark.

2.1.6 Be Cost Effective and Provide Value

Objective description: The cost of the preferred alternative must be reasonable to the Region, both now and in the future.

The following was considered in the evaluation of this objective:

- How much will it cost to build this alternative? Capital costs were developed in 2018 dollars.
- How much will it cost over the lifetime of this alternative to operate? Operating costs were developed in 2018 dollars. Net present value was also developed for each alternative.
- Is there an opportunity to apply for carbon credits? (Note: Carbon credits are given to municipalities by the province for making proven efforts to reduce the gas emissions created.) A yes/no answer to the potential to apply for credits.
- What is the local economic benefit? This involved a qualitative assessment based on anticipated number of local jobs created during construction and operation.

- Is a biosolids product created that has value? If yes, what is the value? Qualitative and quantitative assessments based on end product value were conducted, including the volatility of the product value.
- Would the alternative involve an innovative approach that demonstrates leadership in the area of biosolids management? This involved a qualitative assessment of the potential to consider various sustainability awards/designations, including the National Biosolids Partnership, Envision, and Leadership in Energy and Environmental Design (LEED) to demonstrate a proactive approach and leadership in the management of biosolids through innovative solutions and contingency planning.

3.0 Summary of Short-listed Alternatives

The following section of the memo provides an overview of each shortlisted alternative and builds on the descriptions provided in TM5 and TM7. Additional information on each alternative is included in **Appendices B to E**. The facilities and associated renderings developed for this section include the following common elements: road access for trucking, an administration building, and a process building that contains an enclosed receiving area, process related equipment, 4 months of storage space for the processed product, and an odour control system.

3.1 Alternative 1 – Produce Fertilizer from Biosolids

This alternative would produce a fertilizer end product. Product volumes are estimated to range from 110% to 170% relative to current dewatered biosolids cake.

Technologies considered for this alternative would produce a fertilizer that meets the regulatory requirements under the Fertilizers Act administered by the Canadian Food Inspection Agency (CFIA). This alternative would provide the following end use or disposal options:

- Agricultural use as fertilizer;
- Non-agricultural soil amendment;
- Landfill use; or
- Landfill disposal.

A fertilizer product provides equal or greater opportunity for use in agriculture relative to existing practices, reduces restrictions on application, and improves the ability to store the product during periods when the preferred end use is not available. Storage configuration may differ however as the fertilizer storage can be in

liquid or solid form, depending on the process. Non-agricultural soil amendment options such as use for mine tailings reclamation remain available, with additional bulk fertilizer uses available (e.g., landscaping, golf courses). Adding more flexibility to end uses is considered a valuable feature as it mitigates risk if any one end use or disposal method is unavailable in the short or long-term.

Implementation of the alternative may be considered at one (1) central location for processing all biosolids generated within the Region (the “Centralized Alternative”), or at up to four (4) smaller locations, each handling a portion of the overall production (the “Decentralized Alternative”). Decentralized implementation of the alternative may reduce local trucking of dewatered biosolids cake prior to processing, provide greater process redundancy and reduce the footprint of individual facilities, particularly product storage areas. Decentralized implementation is potentially more costly and complex to implement as construction of several small processes may be more expensive than a single large process. Facilities such as receiving and administration must be duplicated, and the challenges associated with facility siting must be addressed for a number of locations rather than one dedicated area. A layout rendering of the site indicating the relative size and location of buildings on a hypothetical “green field” construction site is provided in **Figure 3-1**.

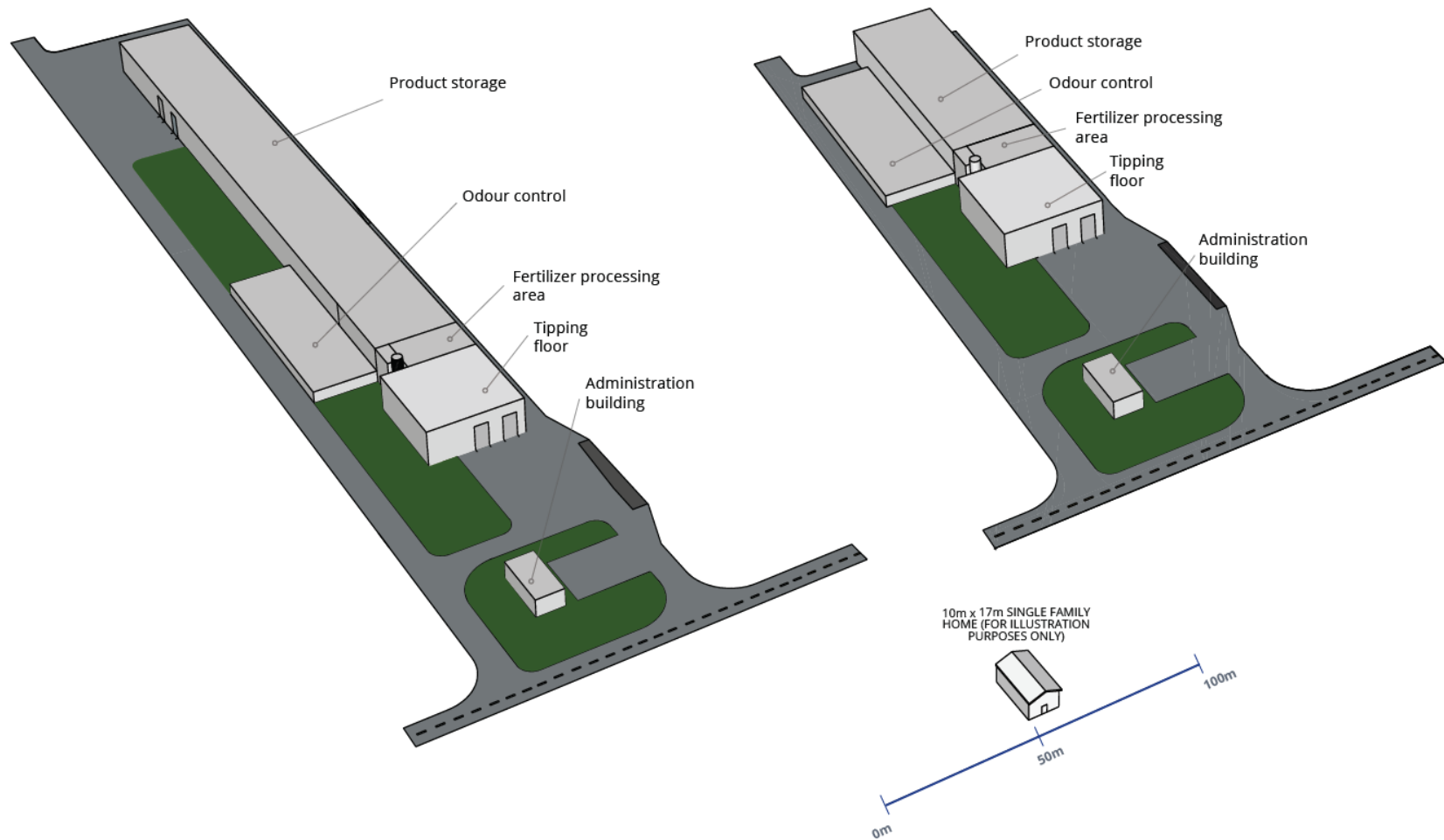
Construction of the new process may be considered with some or all components co-located with existing wastewater treatment plants (WWTPs) or located at new sites near the WWTPs. Site area constraints may limit the construction of storage at existing WWTPs, while co-location may allow some existing infrastructure, such as site access, servicing, administration, and product-receiving currently present, to be integrated with the new biosolids process. For the purposes of evaluating each alternative, we have considered construction of facilities for both the “Centralized Alternative” and “Decentralized Alternative” as stand-alone “green-field” sites with all components co-located on a single campus.

Additional detail on Alternative 1 is provided in **Appendix A**.

Figure 3-1 Schematic Representation of Site Layout Options for Alternative 1: Produce Fertilizer

OPTION B: Multiple Decentralized Facilities
(Only 1 Facility Shown)

OPTION A: Centralized Facility



3.2 Alternative 2 – Produce Compost from Biosolids

This alternative would utilize composting processes for stabilization. The alternative would consist of a single, centralized facility located downstream of the existing anaerobic digestion dewatering processes. The volume of product is anticipated to approximately double while the total mass of product is anticipated to be about 20% less than the current dewatered biosolids cake. Composting would be completed to a Category A quality standard, where biosolids are co-composted with other biomass (e.g., source separated organics, leaf and yard waste, purchased amendment like wood chips) in a mixture of up to 25% biosolids, minimum 75% amendment (dry mass basis). Category A compost has fewer restrictions associated with use than existing management processes in the Region.

This alternative would provide the following end use or disposal options:

- Agricultural use as compost;
- Non-Agricultural Soil Amendment (NASM), such as mine tailings reclamation;
- Landfill use; or
- Landfill disposal.

It is not feasible that a composting facility could be constructed in the space available at the existing WWTPs, and due to the siting challenges anticipated with multiple large facilities, only a central facility alternative was developed in detail for composting. A large building would be required to protect equipment and store the processed compost, as well as for controlling emissions such as odour, dust, and noise. A layout rendering of the site indicating the relative size and location of buildings on a hypothetical “green field” construction is provided in **Figure 3-2**.

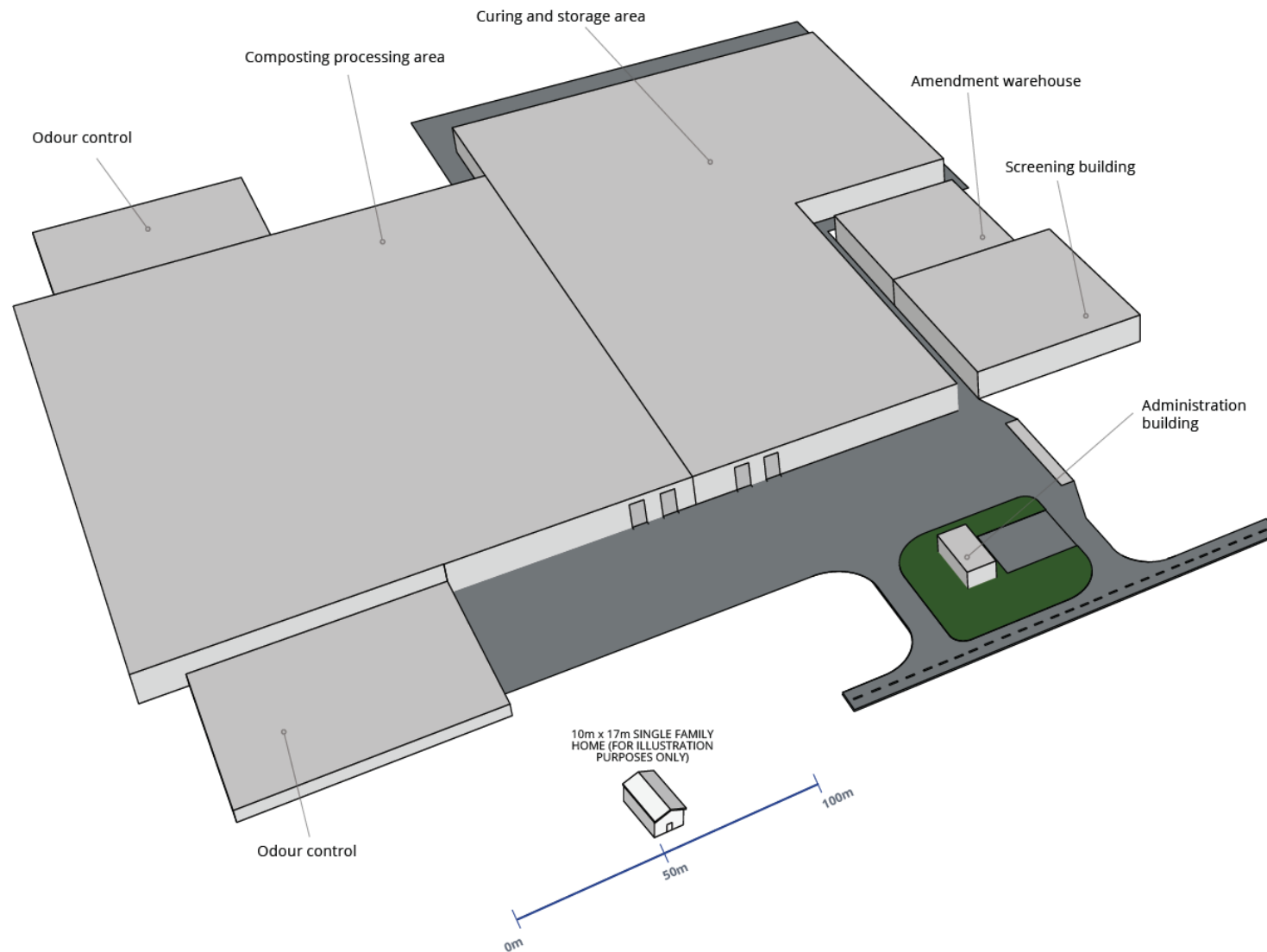
Local trucking to transfer dewatered cake to the composting site would be required, and the number of trucks at existing WWTPs would be similar to the current

approach. Composting to Category A quality would require transportation of dewatered biosolids to the composting site, trucking of additional amendment required for the composting process, and use of compost product primarily on agricultural land. Trucking requirements are described in detail in the alternative evaluation in **Appendix E**.

A storage facility (assumed to provide a 4-month product inventory) is required to protect compost from weather during storage and curing, as well as to control emission potential (e.g., particulate and odours) while facilitating multiple end uses. Allowing for inventory of the compost provides flexibility to accommodate demand from different users.

Additional detail on Alternative 2 is provided in **Appendix B**.

Figure 3-2 Schematic Representation of Site Layout for Alternative 2: Produce Compost



3.3 Alternative 3 – Produce Dried, Low-Volume Fertilizer from Biosolids

This alternative would implement a dryer technology after anaerobic digestion and dewatering to reduce the volume of dewatered cake and generate a biosolids-derived fertilizer product such as a pellet or similarly granular material.

The technologies proposed in this category would produce a substantially lower quantity of biosolids-derived fertilizer per capita compared with the current approach through the removal of most of the liquid contained in the biosolids cake.

The product would meet the United States Environmental Protection Agency (US EPA) definition of Class A biosolids, and stabilization processes in this configuration have been demonstrated to meet the requirements of a fertilizer as administered by CFIA. Based upon the enhanced stability of the dry product, storage requirements for the specified 4-month period are relatively small.

This alternative would provide the following end use or disposal options:

- Agricultural use as fertilizer;
- NASM, such as mine tailings reclamation;
- Landfill;
- Use as a renewable fuel in combustion; or
- Landfill disposal.

Multiple end uses would be beneficial as this mitigates risk and improves operational flexibility where any one end use or disposal method is unavailable in the short or long-term. The dried fertilizer generated from this alternative is suitable as a fuel for incineration or industry, and is commonly produced as an intermediate step as part of integrated drying/thermal reduction facilities. As a result, it produces an end

product that does not strictly rely on use as a soil amendment in agricultural or non-agricultural applications. It can be used directly as fuel in combustion processes that generate useful heat (steam) and electricity, or to provide energy for an industrial process, such as cement production.

Dryer processing equipment would be required either at WWTPs, or in a centralized facility. A building would be required to protect equipment and stored product, as well as controlling emissions such as odour and noise.

For a central facility, there would be a similar number of trucks required to transport dewatered cake from WWTPs to the central facility when compared with the current amount of truck traffic at WWTPs. The number of trucks required for delivery of the end product to end use or disposal would be substantially lower than the existing approach, due to the dried nature of the finished product. A layout rendering of the site indicating the relative size and location of buildings on a hypothetical “green field” construction is provided in **Figure 3-3**.

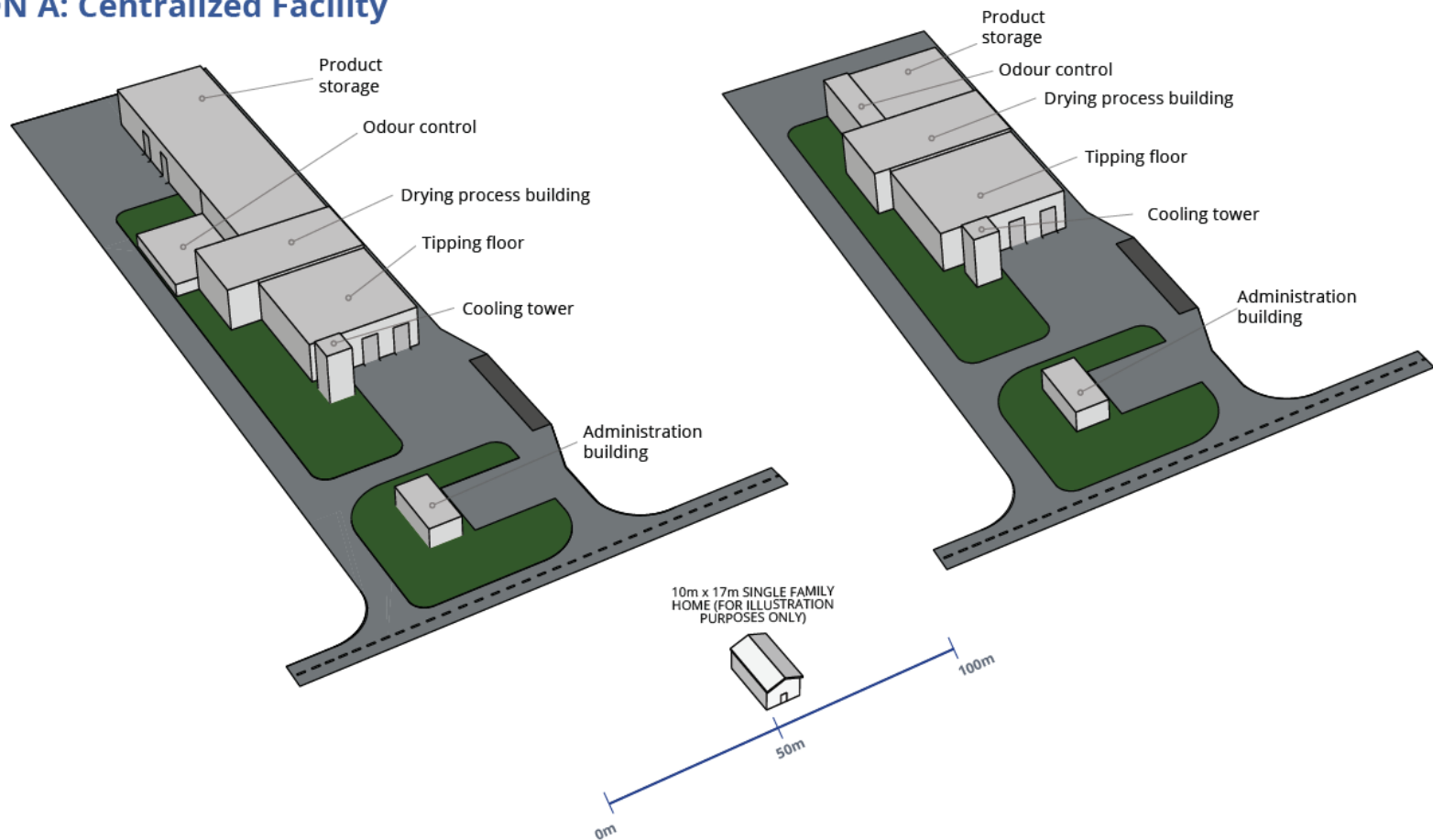
A storage system is required for the dry product; however, the substantially lower quantity of material requires a small footprint. Engineering controls to mitigate the risk of fires during production and storage are required for this process. Allowing for storage of the biosolids-derived fertilizer would provide flexibility by accommodating demand from different users.

Additional detail on Alternative 3 is provided in **Appendix C**.

Figure 3-3 Schematic Representation of Site Layout Options for Alternative 3: Produce Dry, Low Volume Fertilizer

OPTION B: Multiple Decentralized Facilities
(Only 1 Facility Shown)

OPTION A: Centralized Facility



3.4 Alternative 4 – Thermal Reduction of Biosolids to Ash

This alternative would utilize a core technology after the existing processes of anaerobic digestion and dewatering to reduce the volume of dewatered cake to ash for disposal in an approved landfill outside the Region or potentially for use as an industrial input. The limited energy recovered from the process would be used to preheat or dry dewatered biosolids cake in order to decrease the amount of supplementary fuel required. The most promising technology is a fluidized bed incinerator. The technologies proposed in this category would produce the lowest mass and volume of end product.

This alternative would provide the following end use or disposal options:

- Landfill disposal; or
- Use as an industrial input.

This alternative does not take advantage of the nutrient value of biosolids. The energy content of biosolids is used in combustion, but supplementary fuel such as natural gas is also required to maintain combustion temperatures given the moisture and volatile solids content of the current dewatered biosolids.

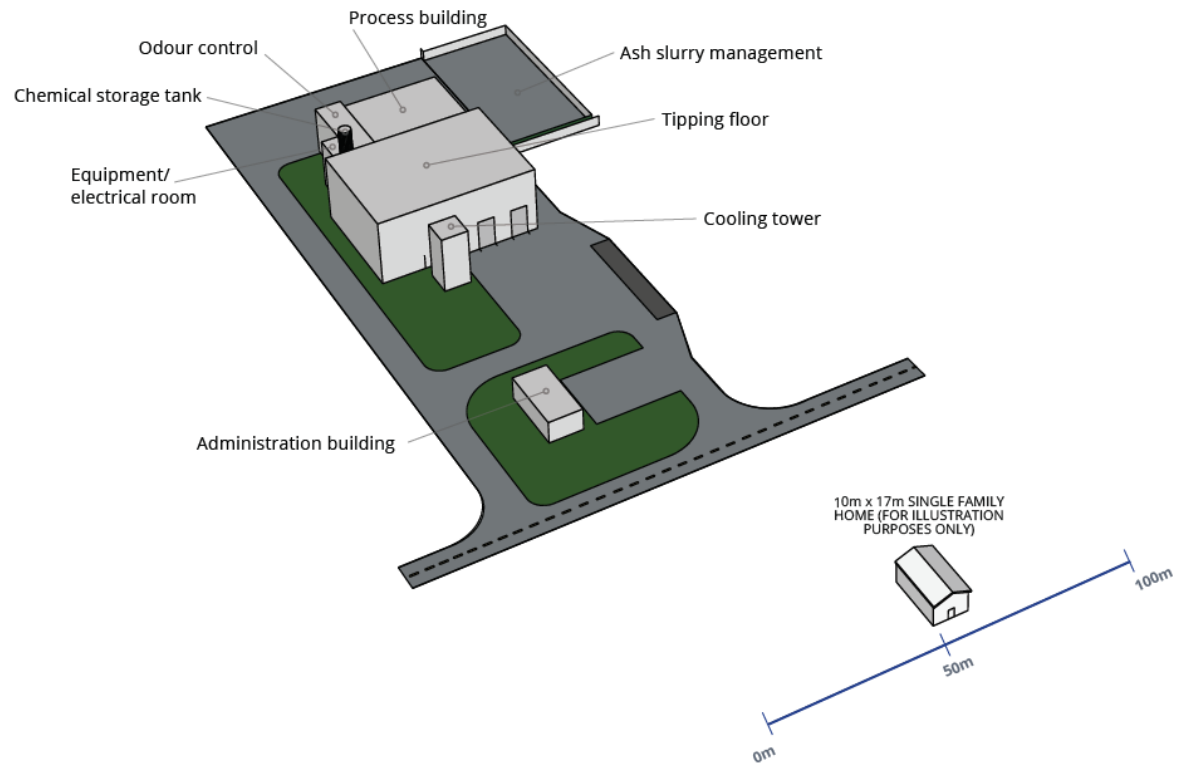
A new thermal reduction process would be implemented at a centralized facility. A building would be required to protect equipment, as well as controlling emissions to air such as air contaminants, odour and noise. A layout rendering of the site indicating the relative size and location of buildings on a hypothetical “green field” construction is provided in **Figure 3-4**.

There would be a similar number of trucks required to transport dewatered cake from the existing WWTPs to the central facility when compared with the current approach. The number of trucks required to handle the ash product would be the

lowest of any alternative. Depending on the final destination for the ash, the vehicle kilometers travelled to truck the ash is likely to be the lowest per capita of all the alternatives. A storage system is required for the ash product; however, the substantially lower quantity of material requires a relatively small footprint. Ash slurry is directed to geomembrane containers, located in an impermeable concrete containment area. Filtrate from dewatering may be directed back to the thermal reduction process for reuse or collected for disposal. The geomembrane containers produce a semi-dry ash product with 50% dry solids. Additional thermal drying may be applied to increase solids content if required for specific applications. This approach to ash slurry management has been implemented at other Ontario thermal reduction facilities.

Additional detail on Alternative 4 is provided in **Appendix D**.

Figure 3-4 Schematic Representation of Site Layout for Alternative 4: Thermal Reduction to Ash



4.0 Evaluation of Short Listed Alternatives

The short listed alternatives were evaluated against the criteria related to each of the six project objectives. Each criterion had one or more indicators that were used to assess the performance of the alternative, as described in **Appendix E**.

4.1 Objective: Align with Existing Infrastructure

Alignment with existing infrastructure is central to a successful biosolids management strategy. Alignment would allow for continued utilization of the investments made by the Region to-date. All of the short listed alternatives would align with the use of existing infrastructure to some extent, in particular with dewatering equipment and the existing configuration of wastewater treatment plants across the Region. However, Alternative 1 (Produce Fertilizer) is less optimally designed to utilize dewatering equipment due to the need for a lower solids content in the product (water is added back in some processes). In addition, Alternative 2 (Produce Compost) occupies a large footprint, and would therefore present challenges to site within the Region.

Alternative 3 (Produce Dried, Low Volume Fertilizer) performs strongly with this objective due to the relatively smaller footprint and ability to integrate well with existing systems at the three main wastewater treatment plants (Kitchener, Waterloo, and Galt), if a decentralized approach is taken. Similarly, Alternative 4 (Thermal Reduction) occupies a very small footprint and is compatible with the Region's existing dewatering approach.

New supporting municipal infrastructure may be required for any new centralized processing facility for any of the alternatives, depending on the site selected. For purposes of this evaluation, it is assumed that a facility would be located in an

existing serviced area within the Region, and as such there would be limited new infrastructure in the way of water, sanitation, natural gas, cooling infrastructure, solid waste management, or electricity required for any of the alternatives. The exception to this assumption is Alternative 2 (Produce Compost), which due to its large footprint would likely need to be sited in a less developed area and may therefore require a larger degree of new servicing infrastructure. Some roadway upgrades or access roads to existing wastewater treatment plants may be needed should a new decentralized processing facility for any of the alternatives be co-located near the existing WWTPs, in particular for the Waterloo and Galt treatment plants.

With respect to potential for aligning with other Regional waste management operations in the future, Alternative 2 (Composting) offers this possibility for its organic waste program, and Alternative 4 (Thermal Reduction to Ash) offers this possibility to integrate with solid waste management operations. In both instances, further discussion and assessment of alignment with waste management objectives would be required in the future.

All of the alternatives comply with current Provincial and Federal regulations, which generally are not anticipated to change in a way that would affect operations should any of the alternatives be implemented. However, the potential to reduce biosolids to ash under Alternative 4 could be limited by new regulations around air emissions for incineration of organic material. Policies that consider a landfill organics ban in Ontario currently are focussed on residential organic solid waste, and likely would not affect biosolids. There remains some risk that in the future a provincial policy could restrict the use of landfill as a contingency measure for Alternatives 1, 2 and 3. This would affect the Region's operations and make a stronger case for alternatives that reduce the volume of biosolids and offer improved flexibility in timing of land application and storage.

As the Region grows and the population expands, all of the alternatives, with the exception of Alternative 4 (Thermal Reduction to Ash), offer the potential to be

phased and expanded over time to accommodate higher biosolids loads. Alternative 4 presents a challenge as an incinerator would need to be run at optimal capacity at all times for purposes of energy efficiency.

Alternatives 1, 2 and 3 create a product that can be sold and that has value for the Region. The value of the product and stability of the market for it varies across the alternatives, with the dried fertilizer product from Alternative 3 scoring highest due to quality and reduced volume. This is followed by the fertilizer from Alternative 1 and finally the compost product from Alternative 2.

Overall, all the alternatives align well with this objective, with a higher performance from Alternative 3 (Produce Dried, Low Volume Fertilizer) due to compatibility with existing infrastructure systems, scalability of the technology, and flexibility conferred by the reduced volume of the final product. **Table 4-1** provides a summary of the evaluation result for all alternatives based on the criteria under this objective.

Table 4-1 Align with Existing Infrastructure: Alternatives Assessment

Criteria	Produce Fertilizer		Produce Compost	Produce Dried, Low Volume Fertilizer		Thermal Reduction to Ash
	Centralized	Decentralized		Centralized	Decentralized	
How compatible is the alternative with existing Regional wastewater and biosolids processing infrastructure?						
How much new supporting municipal infrastructure is required (e.g. roads, power and water services, etc.)?						
What is the potential for aligning with other municipal initiatives in the future?						
How flexible is the alternative in adapting to changing government regulations, policies and market demands?						
Does the alternative allow us to accommodate future population growth?						
 NOT WELL ALIGNED  SOMEWHAT ALIGNED  WELL ALIGNED  VERY WELL ALIGNED						

4.2 Objective: Protect the Natural Environment

Protection of the natural environment is one of the key issues that mattered to the public as informed by early consultation on the development of the Biosolids Strategy. For each of the alternatives, the effects of the processing, transportation, and end use stages were assessed, in order to determine the risks and potential effects of the alternative on the environment. Soil, groundwater, surface water, and the atmosphere were considered as the main receptors of any impacts from the various stages of the alternatives.

At the processing stage, Alternative 1 (Produce Fertilizer) involves the use of process vessels that hold liquid content and require addition of chemicals to aid processing, which could potentially leak out of the vessel and present a risk of contamination of environmental receptors, particularly soil and groundwater. This risk can be effectively mitigated through secondary containment. The relatively large site footprint of for this alternative could have additional impacts for surrounding ecology depending on the location of siting.

Alternative 2 (Produce Compost) involves collecting water that may drain from the composting material, depending on the technology adopted, and therefore presents a risk of contamination of soil and groundwater, which can be mitigated through collection systems and containment. This alternative has a potentially very large site footprint that may have impacts to the environment, although, as with Alternative 1, this would depend on siting.

Alternative 3 (Produce Dried, Low Volume Fertilizer) presents a low potential for risk to the environment at the processing stage, as the primary function of the process is the removal of water and pathogens and there are no chemical inputs to the process.

Alternative 4 (Thermal Reduction to Ash) creates a potential for release of emissions of gases to the atmosphere. This risk can be partially mitigated through the use of

scrubbers and other air quality control measures; however GHG emissions are not likely to be reduced for this alternative.

At the transportation stage, the alternatives with the largest volumes of output would create a relatively higher risk for potential accidents and accompanying spills.

At the end use stage, Alternatives 1, 2, and 3 create a product that is intended for land application. Although concentrations would be reduced below the regulatory limits for the type of fertilizer or compost, there is a potential risk of the presence of residual pathogens or other compounds in the material. Runoff from lands where the material is applied would need to be avoided in order to limit the potential risk to water quality and aquatic ecology as a result of the high organic and nutrient content material entering into adjacent water bodies or leaching to ground water. However, Alternative 3 has the flexibility to be used as an energy source, should this become an issue in the future. Alternative 4 creates an ash product with no organic matter but a potentially high concentration of metals. Monitoring of the final product would need to be carried out and the material would need to be disposed of at an appropriate landfill.

The detailed climate change impacts and adaptation analysis for all alternatives are included in **Appendix F**. In general, the findings indicate that processing infrastructure for all alternatives is not anticipated to be vulnerable to climate change impacts. Potential increased flooding considerations can be addressed through siting and design. Power outages from increased freezing rain, ice storms and wind are not anticipated to be substantive and can also be mitigated through design of back-up power systems. The decentralized layout approach for Alternative 1 and Alternative 3 could present additional vulnerabilities to climate change risk if located within floodplain zones at the existing WWTP's.

For Alternatives 1, 2 and 3, the availability of agricultural land for end use may be impacted by climate change, depending on year-to-year variation in growing season length. There is potential for increased demand due to overall longer growing

seasons into the future. Trucking of products from for all four alternatives to end use or disposal destinations may experience increased disruption from flooding, freezing rain and ice storms, though this is not anticipated to have a significant impact on operations.

With respect to greenhouse gas emissions, Alternative 1 has a moderate level of emissions as a result of the chemical nature of the process and heat and energy requirements. As a primarily biological process, Alternative 2 presents low levels of greenhouse gas (GHG) emissions, which would result mostly from trucking and some heating of the facility. Similarly, Alternative 3 would result in low levels of emissions due to efficiency of the process and reduced trucking requirements for the end product. Alternatives 1, 2 and 3 all have the potential to offset GHG emissions by displacing commercial fertilizer through agricultural land application, although this has not been quantitatively assessed at this stage. Alternative 4 has a moderate level of associated GHG emissions as a result of the incineration process, energy demand, and off-gases from the process. Greenhouse gas emissions were estimated using the Region's BEAM model. The results were not able to be validated as it is a proprietary model.

Overall, Alternative 1 is not well aligned with the objective to protect the natural environment due to site footprint, potential for contamination from chemicals involved in the process, and GHG emissions. Alternative 2 is somewhat aligned. Although the footprint is large and significant trucking would be needed to deliver amendment material to the processing facility, impacts would depend on site configuration. Alternative 3 is very well aligned, due to very limited potential for environmental impacts, an efficient process that produces low levels of GHGs, a reduced volume of material and pathogens within it, low levels of trucking, and a broader range of end use options. Alternative 4 is somewhat aligned, with limitations due to the potential for fugitive emissions from the processing stage and no currently identified end users for the resulting ash, which requires landfilling. **Table**

4-2 provides a summary of the evaluation result for all alternatives based on the criteria under this objective.

Table 4-2 Protect the Natural Environment: Alternatives Assessment

Criteria	Produce Fertilizer		Produce Compost	Produce Dried, Low Volume Fertilizer		Thermal Reduction to Ash
	Centralized	Decentralized		Centralized	Decentralized	
What are the environmental effects of the facility?						
What are the environmental effects of transport?						
What are the environmental effects of the end uses?						
What is the energy balance? Is it possible to recover energy?						
Is the alternative adaptable to climate change impacts (extreme temperatures and weather events (frequency, intensity, duration, and magnitude))?						

EVALUATION OF SHORT LISTED ALTERNATIVES

Criteria	Produce Fertilizer		Produce Compost	Produce Dried, Low Volume Fertilizer		Thermal Reduction to Ash
	Centralized	Decentralized		Centralized	Decentralized	
How much greenhouse gas emissions does the alternative produce?						
How much risk is there that material generated from the process will be landfilled?						



4.3 Objective: Minimize and Manage Operational Risk

The ability to offer continual biosolids management service with built-in resiliency to manage potential disruptions is an important consideration in the selection of a preferred alternative.

In terms of foreseeable changes to relevant regulations, Alternative 1 (Produce Fertilizer), Alternative 2 (Produce Compost), and Alternative 3 (Produce Dried, Low-Volume Fertilizer) all offer primary end uses that are unlikely to be disrupted by regulatory changes and which represent best practice in the area of biosolids management. Although Alternative 4 (Thermal Reduction to Ash) offers limited end uses, it also offers operational resilience, with no foreseeable changes to policy or regulations that would alter the potential to implement this approach.

Alternatives that significantly reduce volume of the end product would aid in the operational flexibility and security of the Region's Strategy, allowing for reduced areas for storage of processed biosolids and lower trucking requirements. As such, Alternatives 3 and 4 are particularly well aligned with this objective, while Alternatives 1 and 2 result in an increased volume of final product over the dewatered cake, and are therefore less well aligned with the objective.

All alternatives have a low level of susceptibility to consequences of disruption in maintenance, end product quality, management or transfer to a storage facility, and to limitations in storage capacity, as the amount of storage provided meets with policy and best practices in the field of biosolids management.

Alternative 1 is highly adaptable to disruptions in maintenance and labour supply as the process could be shut down temporarily if needed, and lower staffing levels can be maintained. Alternative 2 requires high levels of staff to maintain continuous trucking and facility management and is therefore somewhat susceptible to

disruptions. However, this alternative requires relatively low maintenance levels. Alternative 4 requires continuous staffing and supervision of the processing facility, with operation of processes such as boilers, and would require complete shutdown for maintenance, and is therefore very susceptible to disruptions. Alternative 3 would also potentially require boiler operations.

All alternatives offer high levels of product reliability and constitute established technologies in the industry. They are therefore well aligned with the objective in terms of low susceptibility to process disruptions.

Overall, Alternative 1 is well aligned with this objective, with some limitations due to potentially larger volume of the final product. Alternative 2 is somewhat aligned, due to volume of the compost product and risk presented by the large volume of amendment required to supplement the biosolids material as well as the larger staffing levels for the processing and transportation stages of management.

Alternative 3 is very well aligned, with significantly reduced volume of end product and a well-established range of technologies that offer reliability and require fairly low staffing levels. The dry state of Alternative 3 allows slightly easier handling during land application. Alternative 4 is well aligned with this objective, with a relatively small volume of end product produced, although the process requires full-time staffing and has the highest sensitivity to start-up and shut, and therefore the greatest risk related to process disruption. **Table 4-3** provides a summary of the evaluation result for all alternatives based on the criteria under this objective.

Table 4-3 Minimize and Manage Operational Risk: Alternatives Assessment

Criteria	Produce Fertilizer		Produce Compost	Produce Dried, Low Volume Fertilizer		Thermal Reduction to Ash
	Centralized	Decentralized		Centralized	Decentralized	
How do the end use or disposal options affect the risk of disruption to biosolids management services?						
Does the alternative reduce the volume/mass of end product to be managed?						
How susceptible is the alternative to disruption in maintenance and labour supply?						
How susceptible is the alternative to a process disruption?						
How susceptible is the alternative to disruption in end product quality, management or storage?						
NOT WELL ALIGNED SOMEWHAT ALIGNED WELL ALIGNED VERY WELL ALIGNED						

4.4 Objective: Protect Quality of Life

Maintaining the existing quality of life for residents of the Region is important when planning for biosolids management infrastructure. The various stages of managing biosolids, from processing to end use, would have varying potential impacts on the surrounding community. These are captured by the criteria under this objective.

Odour is an important issue to the community, and is addressed in all alternatives through containment and design of any potential facilities through enclosure of all processing and material handling with odour treatment to limit the potential for fugitive emissions. Alternative 1 (Produce Fertilizer) and Alternative 2 (Produce Compost) have the potential for some odour release given the type of end product and size of facility involved. Alternatives 3 (Produce Dry, Low-Volume Fertilizer) and Alternative 4 (Thermal Reduction to Ash) have a limited potential for odour release.

With respect to dust, Alternative 1 has limited potential for dust release, because the product has higher moisture content and Alternative 2 has some potential depending on the type of organic amendment that is utilized for creating the compost product. Alternative 3 also has some potential given the dry nature of the end product. Alternative 4 has a very low potential for dust release due to collection of ash using a wet scrubber and management as a slurry.

Noise is another key consideration in facility design, and for purposes of this master planning exercise it is assumed that any noise impacts will be mitigated using enclosures, barriers, and / or low noise equipment to control noise to acceptable levels at the property line. Noise dampening would be installed to reduce effects on surrounding receptors for all alternatives. The primary source of noise disturbance would therefore come from trucking associated with the alternative. Alternatives 1 and 2 require a fairly high volume of trucking, while Alternatives 3 and 4 require a fairly low volume of trucking and would therefore be better aligned with the objective in terms of managing noise.

Visual impacts would need to be determined based on a site selected for construction of a processing facility. In general, the alternatives with lower footprints are assumed to have a correspondingly lower potential visual impact. Impacts related to the height of infrastructure are considered similar for each alternative. Alternative 2 and the centralized layout for Alternative 1 would have the greatest impact on vistas, with the decentralized layout for Alternative 1 as well as the configuration of Alternatives 3 and 4 having a fairly low potential for visual impacts.

Source water impacts are also dependent on siting. For the decentralized layouts for Alternatives 1 and 3, should these be sited in proximity to the Kitchener, Waterloo, Galt, and Ayr Treatment Plants, there would be considerations for protection of source water based policies in the Region's Official Plan and on flood plain mapping retrieved from the Grand River Conservation Authority (GRCA) for these locations.

Restricting biosolids management operations within the Region would likely not allow for alternatives with a land application end use since locations for both agricultural and non-agricultural uses would be at the discretion of the contracted haulage company and may include sites outside the Region.

Overall, Alternatives 1 and 2 are not well aligned due to their potentially large footprint and trucking noise associated with the end use stage, as well as the potential for fugitive odours. Alternative 3 is well aligned, as a result of reduced volume of end product, which allows for a high degree of containment and less trucking that may impact surrounding communities. Alternative 4 is very well aligned, also due to volume reduction and the resulting limited trucking associated with the alternatives, as well as the ability to contain processing and limit odours and noise.

Table 4-4 provides a summary of the evaluation result for all alternatives based on the criteria under this Objective.

Table 4-4 Protect Quality of Life: Alternatives Assessment

Criteria	Produce Fertilizer		Produce Compost	Produce Dried, Low Volume Fertilizer		Thermal Reduction to Ash
	Centralized	Decentralized		Centralized	Decentralized	
How will odour be managed?						
How will dust from process or trucking be managed related to nuisance effects?						
How will noise be managed?						
How will visual effects be managed?						
How will effects related to trucking be managed?						

EVALUATION OF SHORT LISTED ALTERNATIVES

Criteria	Produce Fertilizer		Produce Compost	Produce Dried, Low Volume Fertilizer		Thermal Reduction to Ash
	Centralized	Decentralized		Centralized	Decentralized	
What are the potential impacts to source water protection?	Site dependent*		Site dependent*	Site dependent*		
Can all components of biosolids management, end uses and/or disposal be managed within Waterloo Region?						
 NOT WELL ALIGNED  SOMEWHAT ALIGNED  WELL ALIGNED  VERY WELL ALIGNED						

* Site selection criteria would include source water protection risk reduction and engineering controls would be used to mitigate risks identified for individual sites

4.5 Objective: Protect Health and Safety

All four alternatives short listed for detailed evaluation meet regulatory and industry best practice standards regarding health and safety. Each of the alternatives involves varying processing components and levels of trucking as well as types of end products, which would affect the relative risks associated with implementation.

Potential safety risks to the public for Alternative 1 (Produce Fertilizer) would be related to potential fugitive emissions from the processing facility, which would be mitigated through containment measures. At the transportation stage, a traffic accident could result in the potential accidental spill of fuel or, if transporting raw materials, spill of chemicals such as lime used as amendment for the process. A spill of the fertilizer product is not anticipated to have negative impacts on human health and safety, although clear up will depend on whether the product is in solid, moist or liquid form. For Alternative 2 (Produce Compost), the health and safety risks would be associated with release of emissions from the facility. The relatively higher level of trucking associated with this alternative would mean a moderate increase in potential for traffic incidents. Alternative 3 (Produce Dried, Low Volume Fertilizer) and Alternative 4 (Thermal Reduction to Ash) both involve relatively low levels of trucking and reduced potential for fugitive emissions. Although both of these alternatives also involve emissions from combustion of natural gas, this would be managed through containment and air scrubbers.

Health risks to workers under normal operating conditions for Alternative 1 include exposure to corrosive chemicals and dust, as well as high temperature and pressure systems. These risks are mitigated through appropriate operator training, Personal Protective Equipment (PPE) worn by workers, as well as engineering controls and ventilation appropriate for area classifications and for odour and dust control. The processing stage for Alternative 2 does not involve chemicals and therefore the main risks are from odour, dust, and emissions from stored dewatered biosolids. As with Alternative 1, these risks are controlled via the use of PPE worn by workers, through

the forced ventilation of odour, and through dust control. Alternative 3 features both high temperature and high pressure processes, along with hot liquids emerging from the dryer vessel, which require more advanced engineering controls, appropriately trained and qualified operations staff, monitoring of processing for fire risk, and appropriate PPE worn by workers. No chemicals are involved in the process. Alternative 4 involves extreme heat as part of the processing stage, which presents a risk that is managed by appropriate monitoring of the process and safety procedures and may require specialized PPE to be worn. No chemicals are involved in this alternative.

Undesirable constituents such as pathogens are largely reduced in the case of all the short listed alternatives, as the final product is designed to meet regulatory standards and reduces pathogens below existing levels and below detection limits for indicator pathogens. In the case of Alternative 4, they are removed entirely. Safe handling practices if applied correctly will manage any risk associated with land application of the product for Alternatives 1, 2, and 3. Metal concentrations for these three alternatives are expected to be approximately the same (mg/kg dry solids), but may increase in the case of Alternative 4 where the ash product retains only the inorganic fraction of the dewatered biosolids.

The likelihood of a major accident or adverse effect across all alternatives is very low provided standard operating procedures are followed and the appropriate safety procedures are followed. The type of adverse events that could occur includes chemical spills, for Alternative 1, and fire or combustion, for Alternatives 2, 3, and 4. Mitigation of these risks would be achieved through facility and equipment design to separate process and staff areas, and adequate cooling and fire isolation measures.

Overall, Alternative 1 is well aligned with the intent of this objective due to limited risks and simple containment and safety procedures. Alternative 2 is somewhat aligned with this objective, as there is a risk of combustion of dry compost material

that is stored. Alternatives 3 and 4 are well aligned, as the processing technology has a proven track record for safety and there are no chemicals involved in the process.

Table 4-5 provides a summary of the evaluation result for all alternatives based on the criteria under this objective.

Table 4-5 Protect Health and Safety: Alternatives Assessment

Criteria	Produce Fertilizer		Produce Compost	Produce Dried, Low Volume Fertilizer		Thermal Reduction to Ash
	Centralized	Decentralized		Centralized	Decentralized	
What are the relative health risks posed to the public?						
What are the relative health risks posed to workers?						
Does the alternative reduce or eliminate undesirable components in the biosolids?						
What is the potential nature of an accident or adverse event?						
NOT WELL ALIGNED SOMEWHAT ALIGNED WELL ALIGNED VERY WELL ALIGNED						

4.6 Objective: Be Cost Effective and Provide Value

The long term economic sustainability of the alternative is an important element of the evaluation. The life cycle cost of the alternatives was assessed based on capital construction cost, operating cost with utilities, maintenance, and staffing. Construction of any new facility was assumed to take place in 2023, operating for the full planning horizon to 2051.

Alternative 1 (Produce Fertilizer) has a range of life cycle costs depending on the type of technology employed. A centralized layout has a lower cost than a decentralized layout, given the reduced construction, operating, and maintenance costs. Alternative 2 (Produce Compost) has a fairly high life cycle cost, associated with the construction of the large facility and the cost of ongoing staffing. The centralized layout for Alternative 3 (Produce Dried, Low Volume Fertilizer) performs very well on cost, given the efficiency of the dryer technology options available and the potential for partial automation of the system which reduces staffing costs. The decentralized layout does not perform as well, due to the cost of multiple dryers and associated construction for multiple facilities. Alternative 4 (Thermal Reduction to Ash) has a moderately high life cycle cost, as the technology requires 24/7 staffing and must be run at full efficiency at all times, which may raise the cost of electricity supply to the process.

The cost of implementing an alternative at different points across the planning horizon was also considered. With Alternatives 1, 2, and 4, a significant amount of investment can be saved by the Region over the planning period by delaying the implementation of the alternative and continuing with the current biosolids management process. This is primarily due to a substantial up-front capital cost, where overall project cost is reduced if capital expenditure is delayed. For Alternative 3, however, the annualized cost is very similar to the existing biosolids management process as savings through the delay of capital investment are largely offset by an escalation in trucking costs for the present approach compared with lower trucking

costs for dry product produced through this alternative. As such, the cost of managing biosolids in the Region with this alternative is not dependent upon timing of implementation, and the Region can expect a consistent annual cost over the planning period. **Figure 10-5** illustrates the costs that could be anticipated to be expended by the Region depending upon the timing of implementation of each of the alternatives.

The potential to obtain carbon credits for each alternative was also assessed. Currently, there is no protocol available within the Cap and Trade framework to facilitate this. Should this option become available in the future, carbon credits may be possible to obtain for Alternatives 1 and 2 where energy consumption could be offset by the resulting displacement of commercial fertilizer. Alternatives 3 and 4 rely on natural gas as a heat and energy source and would likely not be eligible for carbon credits in the long run.

The local economic benefit of each alternative was assessed based on the number of potential jobs created by implementation of the alternative. For this criterion, the centralized layout of Alternative 1 performed less well than the decentralized layout, as the latter with multiple sites has the potential for higher local job creation. Alternative 2 would have a fairly high number of jobs created, including for the transportation stage of the management process. With a single facility, the centralized layout for Alternative 3 would create fewer jobs than the decentralized layout. Alternative 4 requires relatively few staff, although they would need to be well-trained.

The end product of Alternatives 1, 2, and 3 has value as a high organic matter product, and could potentially be sold to recoup some of the cost of processing and transportation. While the value of alternative 1 and 2 is primarily through agricultural use, alternative 3 has a potential use as a fuel which may increase its overall desirability. The commercial value of the product would depend on a variety of factors, including market conditions at the time of sale, distance from facility, and the

timing of implementation of the alternative. These factors are difficult to predict for the planning horizon and may benefit from a market study as part of subsequent planning studies. The ash from Alternative 4 could potentially be transferred to a cement kiln as an input, although no such opportunities currently exist within the Region. As such, it is assumed that this material would be landfilled. Given the volatility and uncertainty of the value of the end product material the cost analysis did not include any remuneration to the Region for its sale in this assessment.

Depending on the design of the facilities and the operating approach, all of the alternatives offer an opportunity for leadership and innovation in sustainability and best practice management of biosolids. There are a number of green building and green infrastructure standards that could be adopted at the time of detailed design as the Region moves forward with implementation of the Strategy.

Overall, the centralized layout under Alternative 1 well aligned due to the lower life cycle cost, while the decentralized layout with a higher life cycle cost is not well aligned. Alternative 2 is not well aligned due to the cost associated with a larger footprint site and higher trucking requirements. The centralized layout for Alternative 3 is very well aligned, due to the life cycle cost and value of the end product. The decentralized layout involves a much higher cost is therefore not as well aligned; however, this layout may be preferred to allow for greater flexibility and incremental implementation of Alternative 3. Alternative 4 is only somewhat aligned, based on life cycle costs and the lack of value in the end product of ash which would likely be landfilled.

Table 4-6 provides a summary of the evaluation result for all alternatives based on the criteria under this objective.

Figure 4-1 Life Cycle Cost Variation Based on Implementation Timing

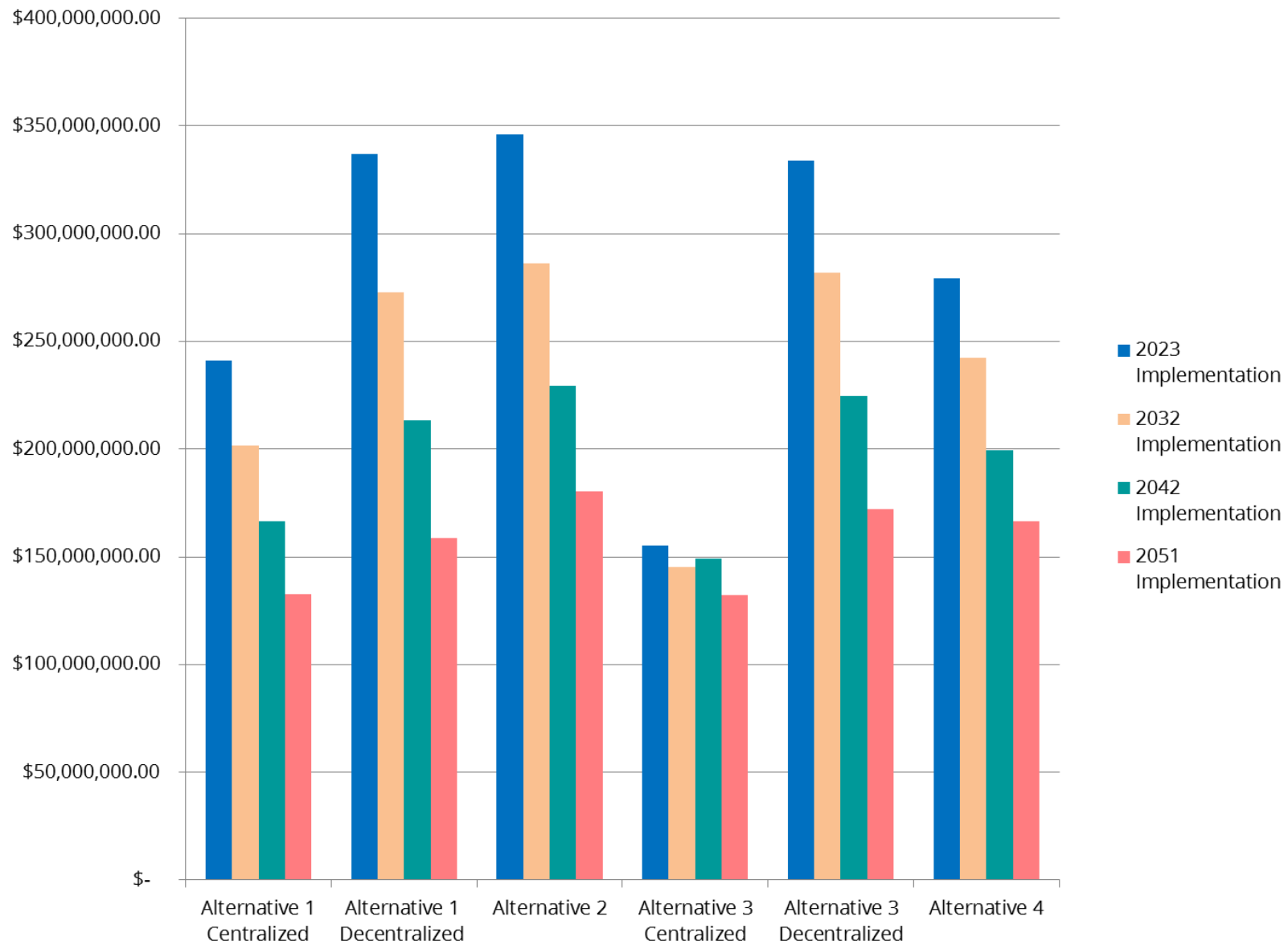
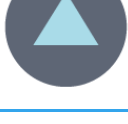
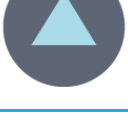
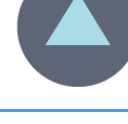


Table 4-6 Be Cost Effective and Provide Value: Alternatives Assessment

Criteria	Produce Fertilizer		Produce Compost	Produce Dried, Low Volume Fertilizer		Thermal Reduction to Ash
	Centralized	Decentralized		Centralized	Decentralized	
What is the relative life cycle cost?						
How does life cycle cost vary based on timing of implementation within the planning period?						
Is there an opportunity to apply for carbon credits?						
What is the local economic benefit?						
Is a biosolids end product created that has value? If yes, what is its value?						N/A

EVALUATION OF SHORT LISTED ALTERNATIVES

Criteria	Produce Fertilizer		Produce Compost	Produce Dried, Low Volume Fertilizer		Thermal Reduction to Ash
	Centralized	Decentralized		Centralized	Decentralized	
Would the alternative involve an innovative approach that demonstrates leadership in the area of biosolids management?						
	 NOT WELL ALIGNED	 SOMEWHAT ALIGNED	 WELL ALIGNED	 VERY WELL ALIGNED		

5.0 Overall Summary of Evaluation

The objective-by-objective evaluation outlined in Chapter 4 provides a summary of the performance of each of the alternatives relative to each of the objectives. Based on the evaluation, this section summarizes some of the key strengths and areas of concern for each of the alternatives.

Alternative 1 (Produce Fertilizer) provides a mechanism for recovering the nutrient value of biosolids by turning this material into a marketable product that is lower in pathogens and meets the quality standards set by the Canadian Food Inspection Agency. In a centralized layout, this alternative is very expensive to construct due to the size of the facility footprint, which includes a very large storage area. The size of the footprint may also result in siting challenges in the Region. This alternative does involve chemical and moisture inputs and would likely result in a product that is greater in volume than the current dewatered biosolids. It also involves relatively higher storage and trucking requirements, with resulting impacts to the natural environment and quality of life for the surrounding community.

Alternative 2 (Produce Compost) has a very large footprint associated with the facility. It is also characterized by relatively high trucking requirements due to the introduction of a large volume of amendment material that would need to be transported, stored and added to the biosolids composting process. The compost material would require some direct handling within the facility by workers, with resulting exposure to odours and dust, depending on the type of mechanical equipment used. The capital and operating costs of implementing Alternative 2 are also quite high based on facility and storage size, amount of land and staffing requirements.

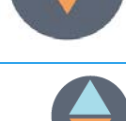
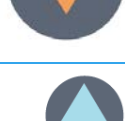
Alternative 3 (Produce Dried, Low Volume Fertilizer) provides a mechanism to reduce the volume of biosolids, reduce pathogens, and meet the requirements of the CFIA fertilizer end product through drying and without the input of chemicals. The

significant reduction in trucking and ability to utilize the end product for a variety of end uses provides improved operational flexibility and security in the long term. The centralized facility size results in reasonably low costs and the configuration allows for good management of any impacts to quality of life or the natural environment. Extensive engineering controls are required as part of Standard Operating Procedures. The dryer technology is highly reliable, common in North America, and reasonably cost effective to operate in a centralized layout, although the cost (both capital and operating) would be relatively high in a decentralized configuration.

Alternative 4 (Thermal Reduction to Ash) allows for the significant reduction in volume of biosolids to an end product that would likely be disposed of at a landfill. There is no potential to recover the nutrient value of biosolids. There is, however, the potential that the ash may be classified as a hazardous waste, depending on the concentration of heavy metals within it. The emissions from the incinerator process could be controlled, although the GHG emissions associated with operating the incinerator would be relatively high. There would also be reduced flexibility in modifying operations in the short term as the incinerator would need to be built to a large capacity and then run at that capacity from the start of implementation. The very low levels of trucking and containment of the facility within a small site footprint allow for good management of impacts to quality of life.

Table 5-1 provides a summary of the evaluation result for all alternatives against each of the Strategy objectives.

Table 5-1 Evaluation Summary

Criteria	Produce Fertilizer		Produce Compost	Produce Dried, Low Volume Fertilizer		Thermal Reduction to Ash
	Centralized	Decentralized		Centralized	Decentralized	
Align with Existing Infrastructure						
Protect the Natural Environment						
Protect Health and Safety						
Minimize and Manage Operational Risk						
Protect Quality of Life						
Be Cost Effective and Provide Value						
 NOT WELL ALIGNED  SOMEWHAT ALIGNED  WELL ALIGNED  VERY WELL ALIGNED						

6.0 Preferred Alternative and Recommendations

In selecting the preferred alternative to form the basis for the Biosolids Management Strategy for the Region, the complete evaluation was taken into consideration. This included the key issues of concern, in particular those related to quality of life and environmental effects of the alternatives, which were developed based on direct input from the community. As noted in Chapter 2, the objectives-based evaluation is not a scoring system but rather a reasoned approach to considering each alternative from a variety of angles and perspectives, allowing for consideration of how well each alternative independently meets the project objectives. The evaluation summary provided in Chapters 4 and 5 consider each of the alternatives in terms of their performance against these Strategy objectives. This chapter now provides a relative comparison of the alternatives, to identify the alternative or group of alternatives that will be carried forward for inclusion in the proposed Strategy for the Region.

As discussed in Chapter 5, each of the alternatives was assessed for performance against the Strategy's objectives. To summarize, Alternative 1 (Produce Fertilizer) provides a means to create a high-value product for the Region but is expensive and would be difficult to site based on the large scale footprint due to the finished product storage requirements. Alternative 2 (Produce Compost) also provides a high-value product, but based on the large site footprint and trucking requirements would likely not be suitable as a preferred alternative for the Region. Alternative 4 (Thermal Reduction to Ash) provides a proven process for biosolids disposal that reduces volume and associated trucking, but does not allow for recovery of nutrient value, and has a high cost associated with it.

Alternative 3 (Produce Dried, Low Volume Fertilizer) offers the ability to significantly reduce volume and accordingly reduce trucking and potential environmental impacts

while creating a high-value fertilizer product with a broad range of end uses. This alternative aligns very well with the “align with existing infrastructure” and “protect the natural environment” objectives in both a centralized and decentralized layout. Alternative 3 performs the strongest against these two objectives compared to all the other alternatives, although Alternative 4 is also well aligned with the existing infrastructure objective.

Alternative 3 offers a reliable set of technologies with safety controls that would be operated by trained staff. Similar to Alternative 1 and 4, it is therefore well aligned with the “protect health and safety” objective. The ability to substantially reduce volume and storage requirements and be less susceptible to disruptions to processing or end product quality without significant impacts to operational risk allows Alternative 3 to be very well aligned on the “minimize and manage operational risk” objective. It performs the strongest on this factor compared to all other alternatives.

The reduced trucking and ability to control noise, odour, and other impacts to the community associated with Alternative 3 aligns well with the “protect quality of life” objective, although Alternative 4 performs better due to greater trucking reduction and control of odours and noise from operations. The cost of implementing the centralized version of Alternative 3 is the lowest of all the alternatives by a considerable margin and is therefore very well aligned with the “be cost effective and provide value” objective. The cost associated with a decentralized layout may be much higher depending upon how each decentralized facility is associated with an existing wastewater plant and the amount of new infrastructure and features required.

In reviewing the evaluation for each alternative and the comparative analysis completed in **Table 5-1**, Alternative 3 stands out as the alternative with the strongest alignment with the Strategy objectives. Characteristics of Alternative 3 provide long term security and flexibility in operations and allow for continuation of the current

approach (with the implementation of short term storage at existing facilities) or early implementation (if that route is preferred). It also provides a consistent annualized cost of processing biosolids for the Region regardless of when the alternative is implemented over the planning period. The volume reduction conferred through the drying process, the limited impacts to the environment, and protection of quality of life for the surrounding community are also key advantages of this alternative.

The smaller facilities that do not currently have anaerobic digestion, and dewatering have unique considerations, including smaller quantities of biosolids generated, and more flexibility with respect to storage and removal of material from the sites. The existing approach may be more viable for a longer period than those WWTP with anaerobic digestion and dewatering. The smaller facilities may be well served by inclusion in the centralized version of Alternative 3 as described above, or with a decentralized plant to serve these plants more locally.. Serving a group of smaller WWTP with a new facility would reduce the site footprint requirements and allow for a smaller scale, localized solution. Alternative 2 would not be considered as a preferred alternative due to the large site and trucking requirements, resulting in siting difficulties and high cost of implementation. Alternative 4 has benefits in terms of volume reduction and efficiency of management, but would not be preferred due to the loss of nutrient value of biosolids. However, this alternative may be considered at the time of implementation if there is an opportunity to capitalize on synergies with other waste management streams at the Region, in particular solid waste.

A centralized layout for Alternative 3 to produce dried, low volume fertilizer is therefore the preferred alternative, and is recommended as the basis for the Region's Biosolids Strategy moving forward. The details of the recommended implementation approach are discussed in TM9.

References

- Canadian Council for Ministers of the Environment (CCME). 2012a. Canada-wide Approach for the Management of Wastewater Biosolids. PN 1477. Available Online: <http://www.ccme.ca/en/resources/waste/biosolids.html>. Last Accessed: April 13, 2017.
- Canadian Council for Ministers of the Environment (CCME). 2012b. Guidance Document For The Beneficial Use Of Municipal Biosolids, Municipal Sludge And Treated Septage. PN 1473. Available Online: http://www.ccme.ca/files/Resources/waste/biosolids/pn_1473_biosolids_guidance_eng_1.0.pdf. Last Accessed: April 13, 2017.
- CIMA+. 2017. Sludge and Biosolids Generation Rates Estimate memo.
- Dillon Consulting Limited (Dillon). 2016. Technical Memo #2: Existing Conditions Background Study (Draft).
- Dillon. 2016. Technical Memo #5: Long List of Biosolids Management Alternatives (Draft).
- Dillon. 2017. Technical Memo #6: Biosolids Quantity Forecast (Draft).
- Ontario Ministry of the Environment and Climate Change (MOECC). 2008. Design Guidelines for Sewage Works. Available Online: <https://www.ontario.ca/document/design-guidelines-sewage-works>. Last Accessed: April 13, 2017.
- United States Environmental Protection Agency (US EPA). 2003. Biosolids Technology Fact Sheet, Use of Incineration for Biosolids Management. Available Online: <https://nepis.epa.gov/Exe/ZyPDF.cgi/P10053DX.PDF?Dockkey=P10053DX.PDF>. Last Accessed: April 13, 2017

Appendix A
Alternative 1:
Produce Fertilizer

1.0 Description

This alternative would implement a stabilization technology after anaerobic digestion to generate a biosolids derived fertilizer product. Candidate technologies proposed in this category may include:

- Thermal or Combined hydrolysis;
- Alkaline stabilization.
- Autothermal Aerobic Digestion (ATAD)

The quantity of biosolids generated is dependent on technology selected. Each technology would be implemented after digestion and would make use of the existing dewatering capacity, with a new core technology to generate a biosolids-derived fertilizer. The ATAD technology is a liquid process that would be considered only for small facilities presently generating un-dewatered biosolids. The fertilizer product generated may range in moisture content from 15% to 55% solids depending on technology implemented and may contain varying quantities of chemical amendments to achieve desired quality. The anticipated per-capita quantity of biosolids produced through a fertilizer process may vary. Some technologies produce a dried fertilizer using a chemical amendment, and would generate approximately the same amount of product as the existing dewatered biosolids cake (25% solids) from the Waterloo, Galt and Kitchener WWTPs. Other processes, particularly hydrolysis, produce a liquid product approximately $\frac{2}{3}$ greater in volume than the present 25% biosolids cake.

Candidate technologies would generate a product meeting the United States Environmental Protection Agency (US EPA) definition of Class A biosolids. Processes in the proposed configuration have been demonstrated to meet the requirements of a fertilizer under the Fertilizers Act as administered by Canadian Food Inspection Agency (CFIA). Based upon the enhanced stability of the dewatered cake, the duration of product storage may be extended to achieve greater operational

flexibility and reduce the potential requirement for landfilling in periods when land application is not available.

2.0 End Use Summary

Technologies considered for this alternative would produce a fertilizer that meets the regulatory requirements under the Fertilizers Act administered by the CFIA. This alternative would provide the following end use or disposal options:

- Agricultural use as fertilizer;
- Non-agricultural use as soil amendment or for land reclamation;
- Landfill use as a substitute for existing daily cover material; or
- Landfill disposal at approved sites.

A fertilizer product provides equal or greater opportunity for use in agriculture relative to existing practices, reduces restrictions on application as described in the Nutrient Management Act (NMA) and improves the ability to store the product for use during periods when the preferred end-use is not available. Non-agricultural soil amendment options such as the existing mine tailings pond reclamation remains available, with additional bulk fertilizer uses available (e.g. landscaping / golf courses). Adding more flexibility to end uses is considered a valuable feature as it mitigates risk if any one end use or disposal method is unavailable in the short or long-term.

The potential for cost recovery through product sales has been investigated but is not considered in the financial analysis of this alternative.

3.0 Alignment with Objectives

3.1 Alignment with Existing Biosolids Infrastructure

The “Produce Fertilizer” alternative has been reviewed for alignment with existing infrastructure in within the Region.

- The “Produce Fertilizer” alternative is compatible with existing infrastructure. Processes handling dry cake (e.g. alkaline stabilization) are able to integrate well with existing solids management and dewatering, although moisture adjustment is typically required. Processes accepting a liquid feedstock (ATAD or Hydrolysis) do not make optimal use of existing dewatering but are compatible with existing anaerobic digestion facilities.
- Fertilizer producing processes are relatively small. Co-location could be possible for processing facilities only. Operational requirements for storage of 4 months of product make co-location of complete systems less likely
- Utility consumption varies between individual technologies. In general, electricity is required to operate facility processes and natural gas is required as thermal input. Utility requirements for the centralized configurations of the alkaline stabilization and hydrolysis processes are provided below:
 - **Alkaline Stabilization Centralized**
 - o Electrical Utility: 8,900 kWh/d
 - o Water Utility: 30 m³/d
 - o Natural Gas Utility: 190 GJ/d
 - o Wastewater Utility: 30 m³/d
 - **Alkaline Stabilization Decentralized** (All Facilities Combined)
 - o Electrical Utility: 9,500 kWh/d
 - o Water Utility: 115 m³/d
 - o Natural Gas Utility: 195 GJ/d
 - o Wastewater Utility: 115 m³/d

- **Hydrolysis Centralized**
 - o Electrical Utility: 10,400 kWh/d
 - o Water Utility: 140 m³/d
 - o Natural Gas Utility: 85 GJ/d
 - o Wastewater Utility: negligible
- **Hydrolysis Decentralized (All Facilities Combined)**
 - o Electrical Utility: 12,600 kWh/d
 - o Water Utility: 135 m³/d
 - o Natural Gas Utility: 100 GJ/d
 - o Wastewater Utility: negligible
- **ATAD (Decentralized facility in vicinity of Ayr WWTP)**
 - o Electrical Utility: 2800 kWh/d
 - o Water Utility: negligible
 - o Natural Gas Utility: 5 GJ/d
 - o Wastewater Utility: 25 m³/d

3.2 Protection of Natural Environment

This alternative is anticipated to have relatively minor impacts on the natural environment. Organic content and nutrients retained within the product have beneficial impacts when land-applied to soil. Benefits of fertilizer product use include:

- Retention of organic material in the dried or liquefied product
- Nitrogen content may be enhanced due to alkaline addition by some processes
- Phosphorous retention in product
- Reduction in ammonia directed to groundwater following land application

ALTERNATIVE 1: PRODUCE FERTILIZER

- Limited impact on surface water anticipated through land application relative to existing practices. Liquid product may have specific considerations to mitigate impact.
- Reduced impact on air quality through decreased odour release from stabilized product relative to existing practices

All facilities are net consumers of energy as described above.

Transportation requirements for each alternative are described in detail below for each technology alternative. The total range of biosolids feedstock product volume quantity to be managed and vehicle kilometers travelled is summarized for each alternative below. Technologies producing fertilizer do not necessarily result in a reduced volume of final product. Product volumes relative to raw feedstock range from an estimated **169%** for hydrolysis, to **110%** for dry alkaline stabilized products.

3.3 Protection of Quality of Life

- Processes may have some associated odour and dust generation. Containment of processes in buildings and use of odour control systems may mitigate these effects. These include:
 - o Conducting air dispersion modeling to obtain data on odour emissions and areas of impact (US EPA, 2000);
 - o Siting buffers from sensitive receptors (Ontario Ministry of the Environment, 2012);
 - o Use of “fast-acting doors” at delivery entranceways (Ontario Ministry of the Environment 2012); and
 - o Maintaining proper operation conditions and contact time in the odour control systems to ensure system is performing to the necessary degree (US EPA, 2000).
- Processes are typically fully enclosed in buildings and do not have large associated stacks etc. that would cause a visual/aesthetic impact

ALTERNATIVE 1: PRODUCE FERTILIZER

- Fertilizer processes often generate a product that is not substantially smaller than incoming feedstock and some cases may result in a volume increase. The need to truck large volumes of product results in a substantial number of total vehicle kilometers travelled. Trucking is summarized quantitatively in the sections below

3.4 Protection of Health and Safety

- Biosolids product material is stable with relatively little risk to public in the event of a spill or other such event.
- Fertilizer processes may involve a combination of thermal, chemical or physical treatment to the biosolids material. Operators of processes are anticipated to require enhanced PPE for safety.
- Appropriate PPE will be required when handling fertilizer materials for land application, with consideration for the specific fertilizer product being used.

4.0 Technology Implementation

4.1 System Components

This technology would be implemented with the following components:

- Administration and operations facilities
- Site servicing and roadway access
- Product receiving facilities
- Short term (10-day) operational storage of dewatered cake feedstock
- Core processing technology producing a fertilizer product
- Biosolids product dewatering (ATAD process only)
- Operational storage of fertilizer product (4 month), consisting of an enclosed building or liquid storage tanks

ALTERNATIVE 1: PRODUCE FERTILIZER

- Odour mitigation (containment within buildings and treatment through dedicated facilities such as biofilters)

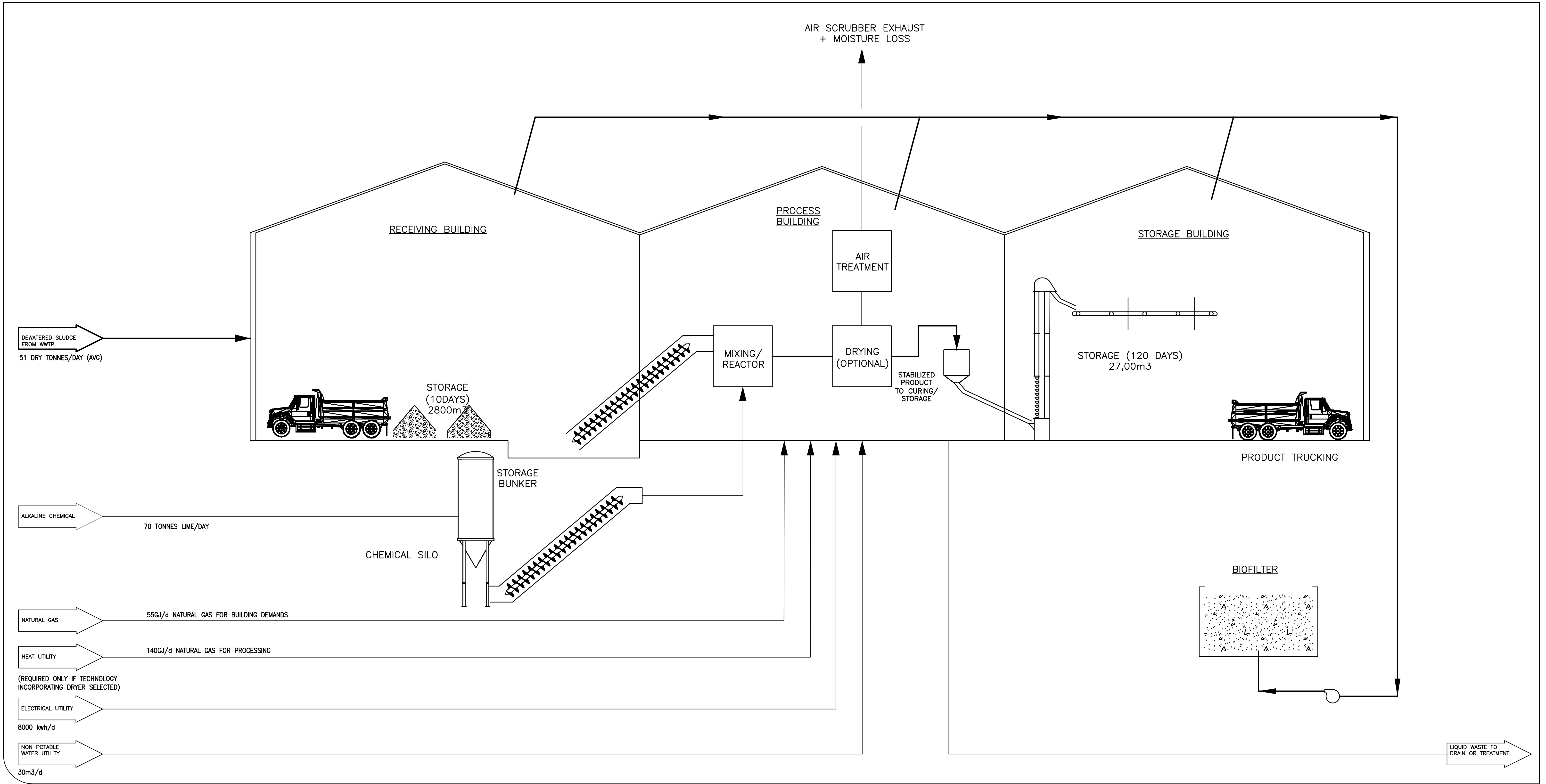
Implementation of a process at locations receiving un-dewatered biosolids directly would also require the construction of liquid storage tanks, and may also require equipment to dewater liquid biosolids to produce a 25% biosolids cake prior to processing.

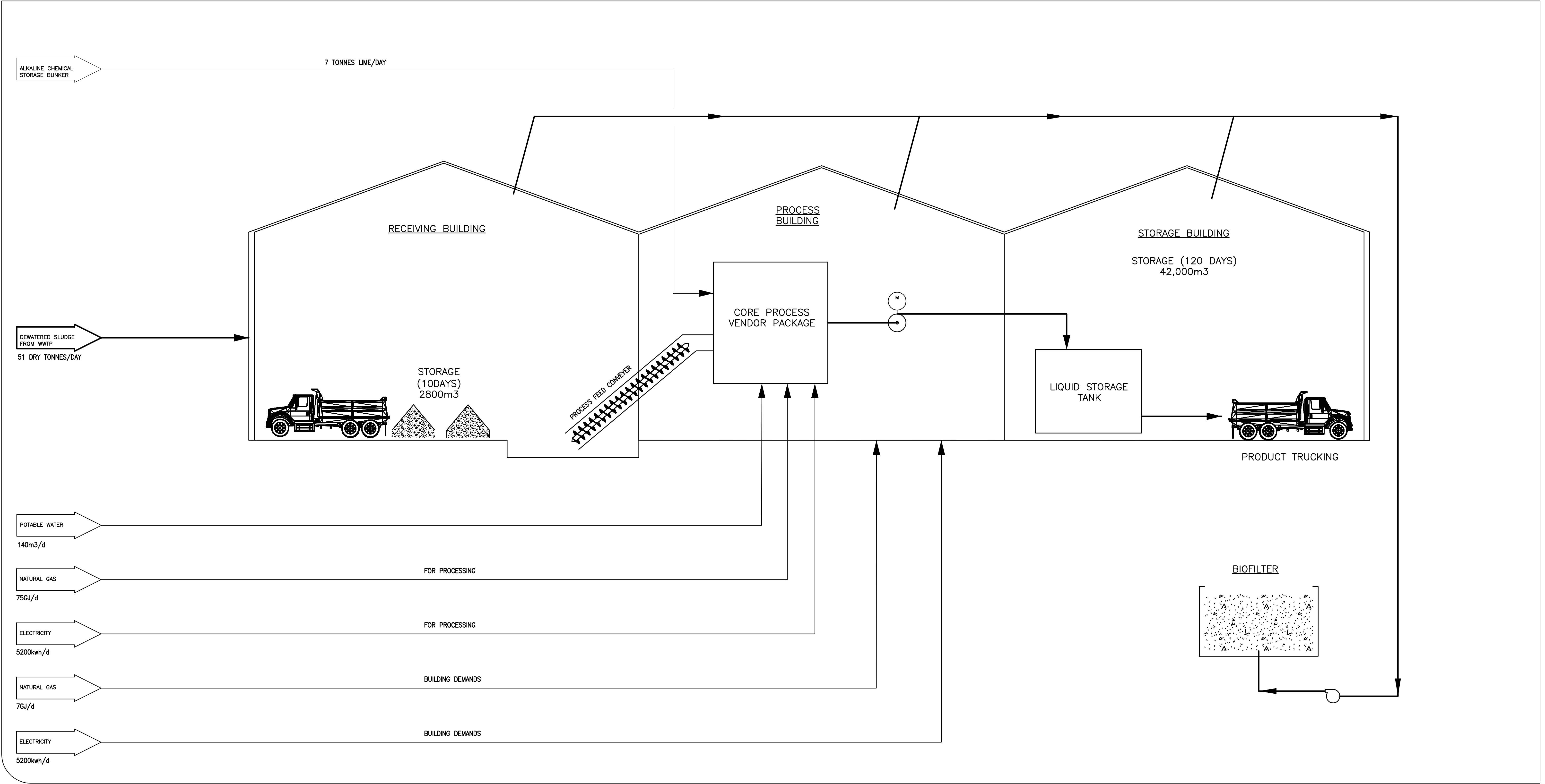
Implementation of the alternative may be considered at a one (1) location for processing all biosolids generated within the Region “Centralized Alternative”, or at up to four (4) smaller locations, each handling a portion of the overall production “Decentralized Alternative”. Decentralized implementation of the alternative may reduce local trucking of dewatered biosolids cake prior to processing by allowing co-location with existing dewatering, provide greater process redundancy and reduce the footprint of individual facilities, particularly the product storage areas required in a single location. Decentralized implementation is potentially more costly and complex to implement as some infrastructure (such as material receiving administration and site access roadways) must be duplicated for each facility and challenges associated with facility siting must be addressed for a number of locations rather than one dedicated area.

Construction of the new Centralized or Decentralized process may be considered with some or all components co-located with existing WWTPs or located at new sites. Site area constraints may limit the construction of storage at existing WWTPs, while co-location may allow some existing infrastructure such as site access, servicing, administration and product receiving currently present to be integrated with the new biosolids process. For the purposes of evaluating each alternative, we have considered construction of facilities for both the “Centralized Alternative” and “Decentralized Alternative” at stand-alone sites with all components on a single campus.

4.2 Centralized System Configuration

The following sections describe the construction of a centralized process for managing biosolids. Two technology alternatives, alkaline stabilization and hydrolysis have been considered for this approach. A block-flow diagram depicting the main components of the alternative along with a preliminary summary of mass flows and utility demands are provided in **Figure 1** and **Figure 3**. A two-dimensional layout of a system producing fertilizer (common to both alkaline stabilization and hydrolysis processes) is provided in **Figure GA1**.





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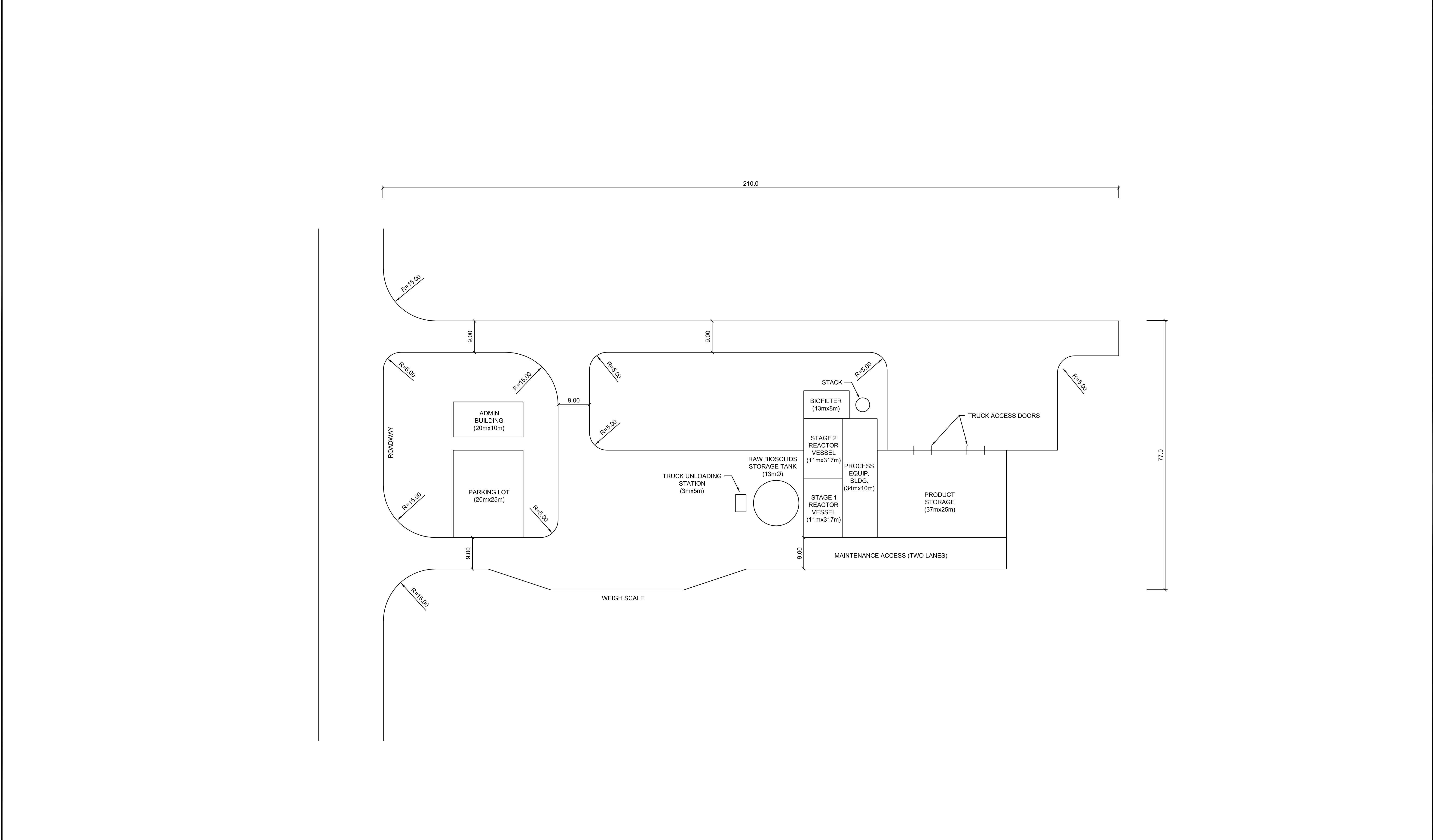
BIOSOLIDS FACILITY

**CONCEPTUAL GENERAL ARRANGEMENT
ALTERNATIVE 1A
ALKALINE STABILIZED OR HYDROLYSIS
PRODUCE FERTILIZER (CENTRALIZED)**

PROJECT NO.
15-2281

SHEET NO.

GA1



PRELIMINARY



DILLON
CONSULTING

						DESIGN BMB	REVIEWED BY	PROJECT NO. 15-2281
						DRAWN SMZ/HJF	CHECKED BY	
						DATE DECEMBER 2017		
						SCALE 1:500		
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CONCEPTUAL GENERAL ARRANGEMENT ALTERNATIVE 1C ATAD PRODUCE FERTILIZER (CENTRALIZED)								

Internal Transfers and Trucking

The requirement for internal transfers and trucking required to: a) move biosolids produced at WWTPs to processing facilities, and b) from processing facilities to end-use has been considered.

Internal transfers achieve two objectives:

- Anaerobic digestion and dewatering of waste activated sludge (WAS) from other facilities with no biosolids processing facilities
- Dewatering of aerobically digested biosolids from facilities with existing liquid biosolids treatment processes.

Internal transfers of biosolids are required to transport dewatered biosolids cake produced at large facilities, including material previously received from small facilities, to a centralized biosolids processing location. The estimated trucking requirements to transport material from large facilities to a hypothetical centralized facility are shown in **Tables B-1** and **B-2**. The centralized facility distance represents an average distance from the urban centre of the city to the region boundary and is used for high-level comparative purposes only

Transfers are assumed using the following truck sizes:

- Transfer of liquid biosolids from small facilities: 18 m³ truck
- Transfer of liquid biosolids from large facilities for dewatering: 43m² truck
- Internal transfer of dewatered biosolids between facilities, or transfer of final product to end use using a 35 tonne truck, with a volume of up to 70 m³

The size of trucks for each type of transportation has been established from the Region's existing practices, or the practices of 3rd party biosolids management companies.

Biosolids produced by the alternative will be transported by truck to an end-use location. End use locations are assumed based on the average of known distances to available land reclamation sites or landfills and a median distance to current agricultural land application. Responsibility for providing trucking may be assigned to end-users or facility operators. Total vehicle kilometers to end use are summarized in **Table B1** and **B2**. Trucking requirements are estimated based on product volumes. It is assumed for the purposes of this assessment that the fertilizer product produced by this alternative has the following densities per cubic metre:

- 1.10 wet tonnes alkaline stabilized product per wet tonne of cake.
- 1.69 wet tonnes of thermal hydrolysis product per wet tonne of cake
- 0.55 wet tonnes of ATAD-digested biosolids (dewatered) per wet tonne of cake

The mass of internal transfers between facilities and to end use, the total truck trips and total vehicle kilometers travelled are summarized in **Tables B1** and **B2**. Individual tables show the total relative trucking requirements for Alkaline Stabilization or Hydrolysis technology alternatives. Daily truck trips are presented as the average value on an annual mass loading basis. Actual numbers of trucks per day may vary, particularly for transportation stages where less than one full truck per day is required.

ALTERNATIVE 1: PRODUCE FERTILIZER

Table B-1: Transfer and End-Use Trucking - Alternative 1 Hydrolysis Centralized Layout

Trucking Source / WWTP	Amount Dry Biosolids (kg/d)	Solids Content of Biosolids	Mass of Wet Biosolids (kg/d)	Trucks Per Day	Trucking Destination	Round-Trip Trucking Distance (Km/Trip)	Total Vehicle Kilometers (Km/Year)
Internal Transfer of Biosolids for Dewatering							
St. Jacobs	165	2%	8,250	0.46	Waterloo	20	3,360
Wellesley	187	2%	9,350	0.52	Waterloo	45	8,550
Heidelberg	13	2%	660	0.04	Waterloo	30	420
Conestogo	8	2%	385	0.02	Waterloo	25	200
Foxboro	17	2%	825	0.05	Waterloo	65	1,105
Preston	1,914	3%	76,560	1.78	Galt	20	13,000
Hespeler	1,023	1%	127,875	7.10	Kitchener	30	77,820
New Hamburg	880	2%	48,889	2.72	Kitchener	48	47,616
Ayr	396	5%	8,426	0.47	Kitchener	46	7,866
Subtotal Distance							159,937
Internal Transfer of Dewatered Biosolids for Processing							
Elmira	2,882	25%	11,528	0.33	Central Processing Location	61	7,321
Waterloo	12,313	25%	49,254	1.41		42	21,588
Kitchener	23,342	25%	93,368	2.67		47	45,778
Galt	12,837	25%	51,348	1.47		53	28,140
Subtotal Distance							102,827
External Transfer of Process Biosolids to End-Use							
Central Processing Location	51,374		226,047	6.46	Land Application	261	615,045
Total Distance							877,809

ALTERNATIVE 1: PRODUCE FERTILIZER

Table B-2: Transfer and End-Use Trucking - Alternative 1 - Hydrolysis Centralized Layout

Trucking Source / WWTP	Amount Dry Biosolids (kg/d)	Solids Content of Biosolids	Mass of Wet Biosolids (kg/d)	Trucks Per Day	Trucking Destination	Round-Trip Trucking Distance (Km/Trip)	Total Vehicle Kilometers (Km/Year)
Internal Transfer of Biosolids for Dewatering							
St. Jacobs	165	2%	8,250	0.46	Waterloo	20	3,360
Wellesley	187	2%	9,350	0.52	Waterloo	45	8,550
Heidelberg	13	2%	660	0.04	Waterloo	30	420
Conestogo	8	2%	385	0.02	Waterloo	25	200
Foxboro	17	2%	825	0.05	Waterloo	65	1,105
Preston	1,914	3%	76,560	1.78	Galt	20	13,000
Hespeler	1,023	1%	127,875	7.10	Kitchener	30	77,820
New Hamburg	880	2%	48,889	2.72	Kitchener	48	47,616
Ayr	396	5%	8,426	0.47	Kitchener	46	7,866
						Subtotal Distance	159,937
Internal Transfer of Dewatered Biosolids for Processing							
Elmira	2882	25%	11,528	0.33	Central Processing Location	61	7,321
Waterloo	12,313	25%	49,254	1.41		42	21,588
Kitchener	23,342	25%	93,368	2.67		47	45,778
Galt	12,837	25%	51,348	1.47		53	28,140
						Subtotal Distance	102,827
External Transfer of Process Biosolids to End-Use							
Central Processing Location	51,374	15%	374,291	9.92	Land Application	261	944,738
						Total Distance	1,207,502

ALTERNATIVE 1: PRODUCE FERTILIZER

Costs for trucking have been estimated using standard transportation costs available from existing transportation of biosolids within the Region. The following costs have been estimated existing contracts, considering distance travelled and cost per tonne transported.

- Large volume liquid sludge transfer: \$0.2/km/tonne
- Small volume liquid sludge transfer: \$0.11/km/tonne
- Cake transfer, or product transfer to end use: \$0.17/km/tonne

The **Tables B-3** and **B-4** present the total annual trucking.

Table B-3: Costing Trucking - Alternative 1 - Alkaline Stabilization Centralized

Contract	Type	Rate (\$/Tonne/km or \$/m ³)	From	To	Tonnes/year 2051	km per load	\$/Year 2051
Preston Sludge	Liquid Transfer	\$0.20	Preston	Galt	27,944	20	\$110,939
Aerobic Sludge Management	Liquid Transfer	\$0.11	St. Jacobs	Waterloo	3,011	20	\$6,891
			Wellesley	Waterloo	3,413	45	\$17,572
			Heidelberg	Waterloo	241	30	\$827
			Conestogo	Waterloo	141	25	\$402
			Foxboro	Waterloo	301	65	\$2,240
			Hespeler	Kitchener	46,674	30	\$160,213
			New Hamburg	Kitchener	17,844	48	\$98,003
			Ayr	Kitchener	3,075	46	\$16,186
Cake Management	Cake Transfer	\$0.17	Elmira	Central Location	4,208	61	\$43,276
			Waterloo	Central Location	17,978	42	\$128,360
			Kitchener	Central Location	34,079	47	\$272,294
			Galt	Central Location	18,742	53	\$167,273
Cake Management	Product Transfer	\$0.17	Central Location	Land Application	82,507	261	\$3,658,511
						Total Cost	\$4,682,985

Greenhouse Gas Analysis Summary

A summary of CO₂ Emissions Equivalents calculated using the BEAM model for centralized alkaline stabilization is presented below in **Table B-5**.

Table B-5: Alternative 1 Alkaline Stabilization Centralized Layout – Greenhouse Gas Analysis Summary

Unit Processes & Inputs	CO ₂ Emissions Equivalents (tonnes/year)
Lime production	23,625
Natural gas use for processing and building heating	3,503
Electricity use in alkaline stabilization and building demands	140
Transportation	1,145
CO₂ equivalents	28,289 6100 cars (EPA calculator)

Assumptions:

- Class A quality is used as the surrogate for CFIA fertilizer pathogen content requirements
- Amount of lime required is much higher than the BEAM default and has been incorporated at 1.4 dry tonnes lime per dry tonne biosolids processed
- Natural gas for product drying has been incorporated as 71 m³ natural gas per dry tonne biosolids processed based upon vendor input
- Natural gas for building demands is derived from a unit-area-based estimate for typical utility consumption
- Electricity requirements are incorporated as 150 kWh per dry tonne of biosolids processed based upon vendor input
 - o This is more lower than the BEAM default which references electricity use for supplemental heat to achieve class A quality (in the case assumed natural gas is used for supplemental heating)

ALTERNATIVE 1: PRODUCE FERTILIZER

- o Electricity for building demands is derived from a unit-area-based estimate for typical utility consumption.
- Cement kiln dust or other alkaline waste products are commonly used to produce fertilizer in Ontario. Production of Lime is responsible for all scope 3 emissions for this alternative, and greenhouse gas emissions are very low for Scope 1 and 2. Therefore using cement kiln dust or other alkaline by-products from other industries can offset approximately 90% of the greenhouse gas emissions reported in **Table B-5** from this alternative.

Alternative Costing

The cost of implementation for a system producing fertilizer has been evaluated, considering the equipment cost, site construction cost associated with the components listed in Section 4.0 and operating and maintenance costs. Costs were established through input from equipment vendors, standard unit pricing and Dillon's professional experience.

Capital Cost

Capital costing has been developed for each alternative. Costs consider the following:

- Capital equipment purchase
- Site preparation
- Construction of process buildings and site roadways
- Building services and supporting equipment

Capital purchases include installation markups of between 0% and 20% per item. Standard subcontractor and general contractor markups of 15% and 5% respectively have been considered where appropriate. In addition to the total "direct" cost of construction, standard "indirect" markups have been included to

reflect the assumed actual cost of implementation, and uncertainty at this level of design

Operating Cost

Operating costs have been established for each alternative. Where possible, costs have been estimated using technology specific utility consumptions and operating requirements based on discussions with vendors. Preliminary operating cost estimates are established primarily to demonstrate the relative cost to operate different process equipment alternatives. Additional operating costs associated with staff facilities are anticipated to be minor, and would be established based on Operating costs include the following:

- Electrical utility costs
- Water utility costs
- Natural gas cost for process equipment and building heating
- Process chemical consumption (where appropriate)
- Allowance for routine maintenance and spare parts (typically 1% of equipment value per year)
- Operations staff costs. We have assumed that each facility alternative would require a complement of five full time equivalents (FTE) at a total cost of \$100,000/year each.

Life Cycle Cost

Life cycle costing was established in 2018 dollars to allow comparison of overall costs associated with each alternative (**Table B-6**). Life cycle costing was completed with the following assumptions:

- 4% Net Present Value Discount Rate
- 2% Annual inflation for costs associated with labour, capital expenditures and consumables

ALTERNATIVE 1: PRODUCE FERTILIZER

- 5% annual inflation associated with electricity costs
- 2023 construction date for the alternative, with associated capital expenditure in 2023 this
- Consideration for end-of-life replacement of equipment
- Consideration of trucking costs

Lifecycle costing estimates have been developed to provide a consistent basis for comparison of technologies, with consideration given to the impact of annual operating cost on the overall cost of implementing each alternative. The construction date, interest rates and operating costs may be refined through further design. The range of costs presented represents the differences between the various technologies considered.

Table B-6: Life Cycle Cost Estimate - Alternative 1 Centralized Layout

No.	Item Description	Estimated Cost
1.	Capital Cost	\$45,500,000 - \$51,700,000
2.	Bundled Servicing*	\$14,100,000 - \$29,500,000
3.	Chemical Consumption	\$22,800,000 - \$11,100,000
4.	Average Equipment Replacement	\$22,400,000 - \$23,800,000
5.	Routine Maintenance	\$3,200,000 - \$9,600,000
6.	Labour	\$9,800,000
7.	Trucking Cost	\$68,800,000 - \$105,400,000
Total Life Cycle Cost		\$186,600,000 - \$240,900,000

*Note: Related to utility consumption and waste disposal only, does not include the extension of new services

4.3 Decentralized System Configuration

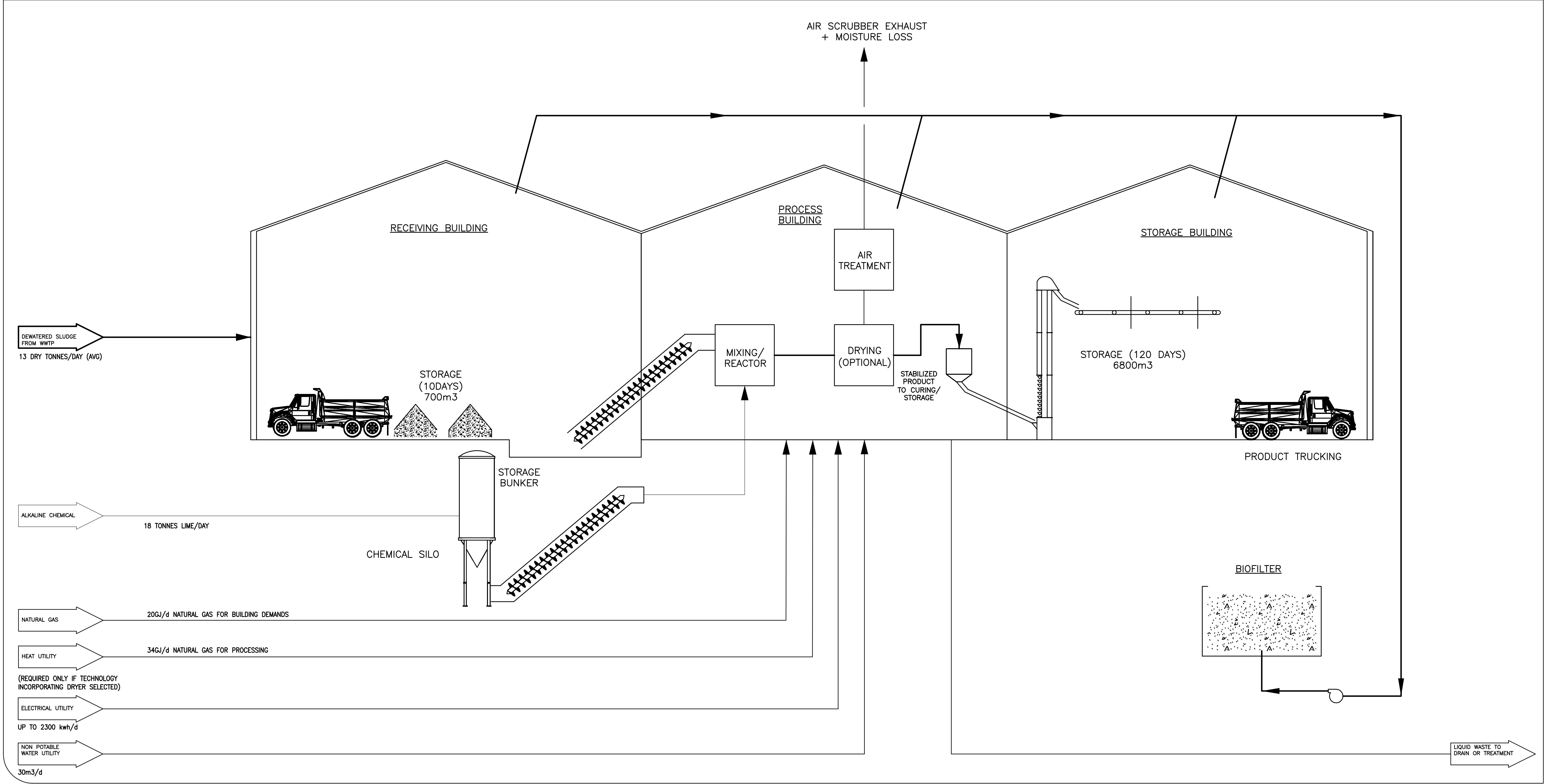
The following sections describe the construction of a decentralized process for managing biosolids. Two technology alternatives, alkaline stabilization and hydrolysis have been considered for this approach for a Region-wide management approach. A third technology, ATAD, is considered specifically for processing biosolids only from small treatment facilities.

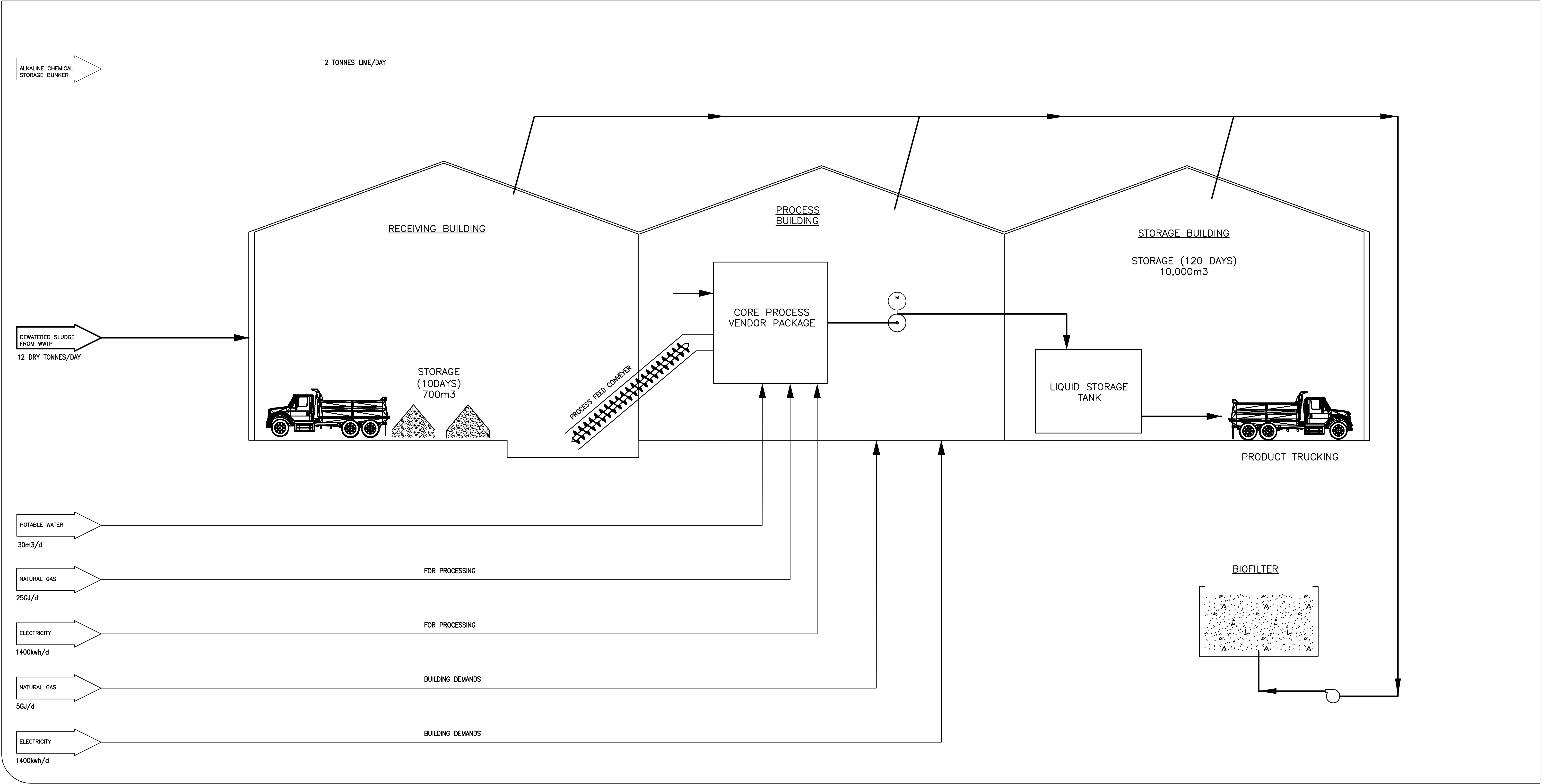
Construction of decentralized facilities is assumed to be similar in approach to construction of a single centralized facility for each alternative as described in Section 4.2. Decentralized facilities may be co-located with existing facilities, with the option for sharing some site components to reduce costs but this has not been assumed at the present time to allow for more flexibility in siting.

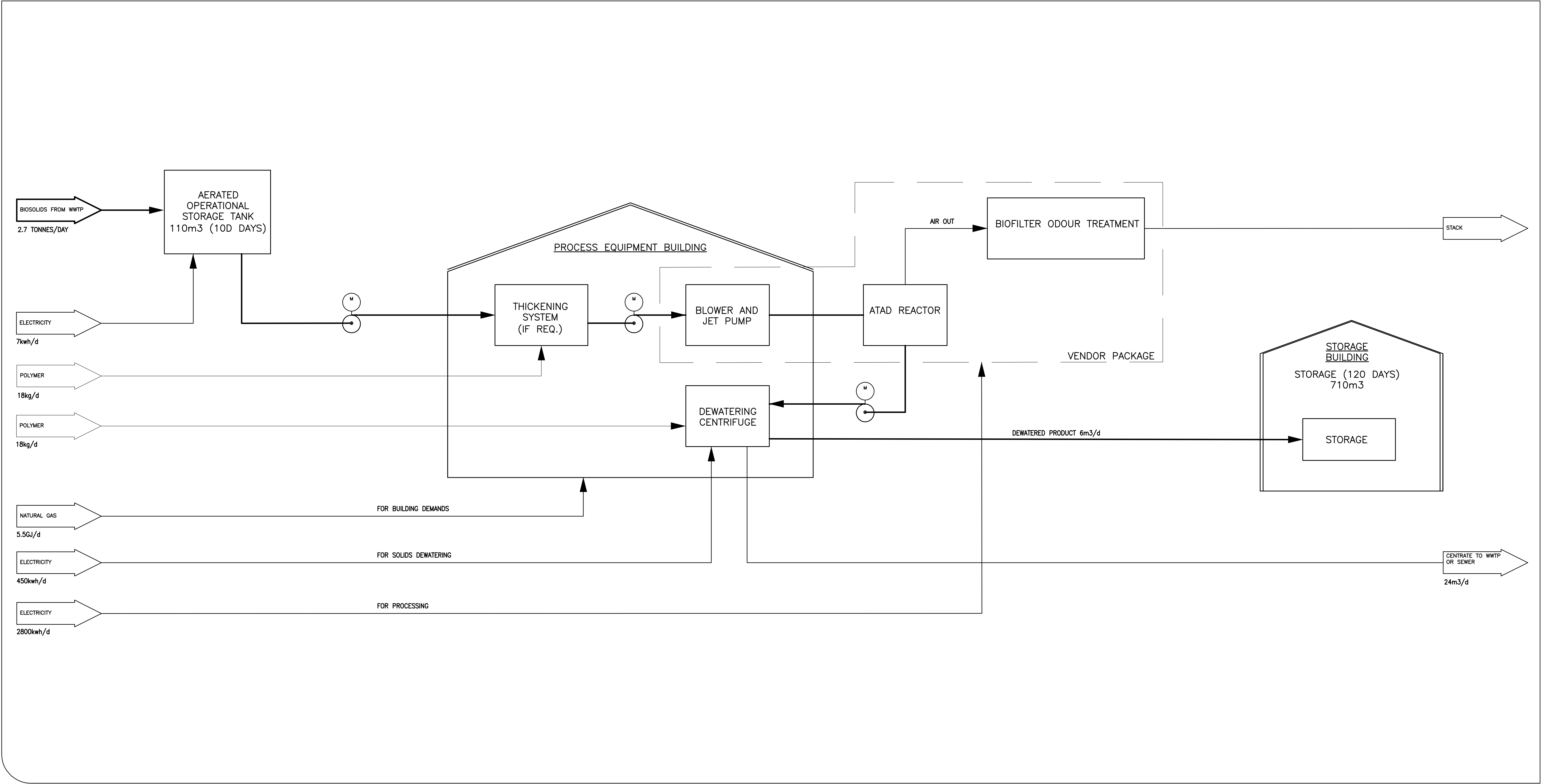
It is assumed that in the case of all but the smallest decentralized facility (in the vicinity of the Ayr WWTP) incoming biosolids feed quality would remain consistent with the centralized facility alternative. The decentralized facility in the vicinity of Ayr WWTP includes additional liquid storage and dewatering to allow processing of liquid sludge from small facilities without dewatering capabilities. The ATAD alternative is specific to the decentralized facility at this location only.

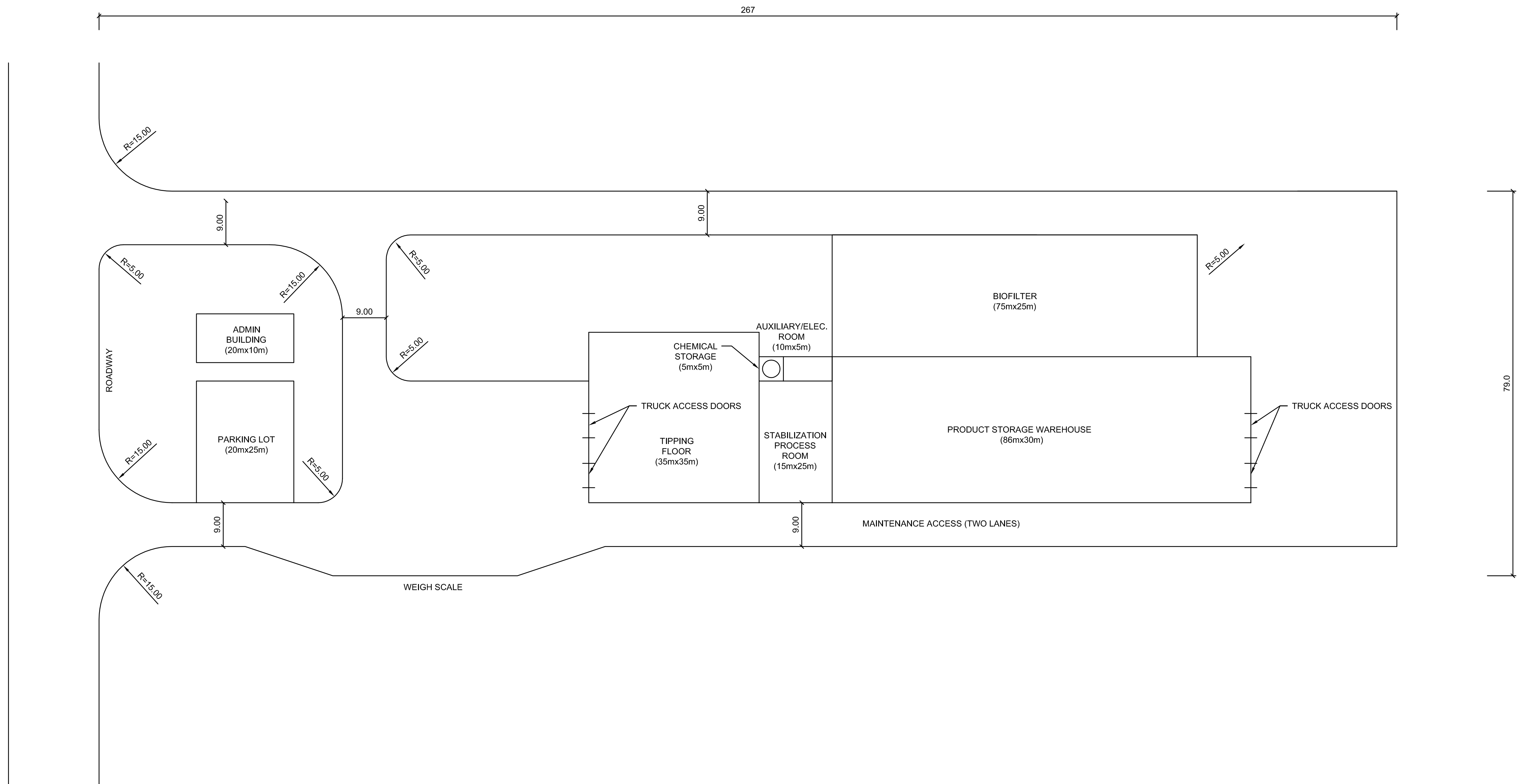
Diagrams depicting the main components of a representative decentralized alkaline stabilization and hydrolysis technologies including major mass flows and utility demands are provided in **Figures 2, 4, and 5**.

A two-dimensional layout of a “green field” decentralized fertilizer facility employing a hydrolysis or alkaline stabilization process is provided in **Figure GA2**. A two-dimensional layout of an ATAD system producing fertilizer is provided in **Figure GA3**









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BIOSOLIDS FACILITY

**CONCEPTUAL GENERAL ARRANGEMENT
ALTERNATIVE 1A
ALKALINE STABILIZED OR HYDROLYSIS
PRODUCE FERTILIZER (DECENTRALIZED)**

PROJECT NO.
15-2281

SHEET NO.

GA2

Internal Transfers and Trucking

Internal transfers of biosolids through a decentralized process are simplified relative to the Centralized facility concept.

- All biosolids produced at facilities in the vicinity of existing WWTPs (Kitchener WWTP, Waterloo WWTP, Galt WWTP and Ayr WWTP) are assumed to require near zero VKMT based upon locating new infrastructure at or near the WWTPs
- Internal transfer allowances are made for transport of biosolids from Preston WWTP to Galt WWTP
- Internal transfer allowance is made for transport of small facilities including Hespeler to Ayr WWTP
- It is assumed in the decentralized facility concept that the facility in the vicinity of Ayr will receive all inter-facility transport aside from material originating at Preston WWTP

Transfers are assumed using the following truck sizes:

- Transfer of liquid biosolids from small facilities: 18 m³ truck
- Transfer of liquid biosolids from large facilities for dewatering (e.g. Preston to Galt): 43 m³ truck
- Internal transfer of dewatered biosolids between facilities, or transfer of final product to end use using a 35 tonne truck, with a volume of up to 70 m³

The size of trucks for each type of transportation has been established from the Region's existing practices, or the practices of 3rd party management companies.

Biosolids produced by the alternative will be transported by truck to an end-use location. Responsibility for providing trucking may be assigned to end-users or facility operators. The distance to end-use has been established independently for

ALTERNATIVE 1: PRODUCE FERTILIZER

each decentralized facility based on the relative distance between the nearby WWTP and the assumed end-use location.

For the purposes of this analysis, incorporation of an ATAD facility may be considered equivalent to the decentralized Alkaline Stabilization alternative as the product quality and quantity in and out of the facility does not change.

Total trucking requirements for Alkaline Stabilization and Hydrolysis alternatives are summarized below in **Tables B-7** and **B-8**.

ALTERNATIVE 1: PRODUCE FERTILIZER

Table B-7: Transfer and End-Use Trucking - Alternative 1 - Alkaline Stabilization Decentralized Layout

Trucking Source / WWTP	Amount Dry Biosolids	Solids Content of Biosolids	Mass of Wet Biosolids	Trucks Per Day	Trucking Destination	Round-Trip Trucking Distance	Total Vehicle Kilometers Traveled
	(kg/d)		(kg/d)			(Km/Trip)	(Km/Year)
Internal Transfer of Biosolids for Dewatering and Processing							
Preston	1,914	3%	27,944	1.78	Galt	20	13,000
St. Jacobs	165	2%	3,011	0.46	Ayr	96	16,195
Wellesley	187	2%	3,413	0.52	Ayr	80	15,276
Heidelberg	13	2%	241	0.04	Ayr	88	1,226
Conestogo	8	2%	141	0.02	Ayr	95	760
Foxboro	17	2%	301	0.05	Ayr	75	1,282
Hespeler	1,023	1%	46,674	7.10	Ayr	59	153,046
New Hamburg	880	2%	17,844	2.72	Ayr	66	65,472
Elmira	2,882	25%	4,208	0.64	Ayr	105	24,523
						Subtotal Distance	290,781
External Transfer of Process Biosolids to End-Use							
Ayr	5,570	23%	11,336	0.64	Land Application	280	65,240
Waterloo	11,924	23%	33,360	1.36	Land Application	280	119,520
Kitchener	21,043	23%	53,160	2.40	Land Application	280	245,840
Galt	12,837	23%	34,880	1.47	Land Application	280	147,400
						Total Distance	868,781

ALTERNATIVE 1: PRODUCE FERTILIZER
Table B-8: Transfer and End-Use Trucking - Alternative 1 - Hydrolysis Decentralized Layout

Trucking Source / WWTP	Amount Dry Biosolids (kg/d)	Solids Content of Biosolids	Mass of Wet Biosolids (kg/d)	Trucks Per Day	Trucking Destination	Round-Trip Trucking Distance (Km/Trip)	Total Vehicle Kilometers Traveled (Km/Year)
Internal Transfer of Biosolids for Dewatering and Processing							
Preston	1,914	3%	76,560	1.78	Galt	20	13,000
St. Jacobs	165	2%	8,250	0.46	Ayr	96	16,195
Wellesley	187	2%	9,350	0.52	Ayr	80	15,276
Heidelberg	13	2%	660	0.04	Ayr	88	1,226
Conestogo	8	2%	385	0.02	Ayr	95	760
Foxboro	17	2%	825	0.05	Ayr	75	1,282
Hespeler	1,023	1%	127,875	7.10	Ayr	59	153,046
New Hamburg	880	2%	48,889	2.72	Ayr	66	65,472
Elmira	2,882	25%	11,528	0.64	Ayr	105	24,523
						Subtotal Distance	290,781
External Transfer of Process Biosolids to End-Use							
Ayr	5,570	15%	37,656	1.08	Land Application	280	110,040
Waterloo	11,924	15%	80,606	2.30	Land Application	240	201,840
Kitchener	21,043	15%	142,251	4.06	Land Application	280	415,520
Galt	12,837	15%	86,778	2.48	Land Application	275	248,875
						Total Distance	1,267,056

ALTERNATIVE 1: PRODUCE FERTILIZER

ALTERNATIVE 1: PRODUCE FERTILIZER

Costs for trucking have been estimated using standard transportation costs available from existing transportation of biosolids within the region. The following costs have been estimated existing contracts, considering distance travelled and cost per tonne transported.

- Large volume liquid sludge transfer: \$0.2/km/tonne
- Small volume liquid sludge transfer: \$0.11/km/tonne
- Cake transfer, or product transfer to end use: \$0.17/km/tonne

The **Tables B-9 and B-10** present the total annual trucking cost for both the alkaline stabilization and hydrolysis process alternatives:

ALTERNATIVE 1: PRODUCE FERTILIZER

Table B-9: Trucking Cost - Alternative 1 - Alkaline Stabilization Decentralized Layout

Contract	Type	Rate (\$/Tonne or \$/m³)	From	To	Tonnes/year 2051	km per load	\$/Year 2051
Preston Sludge	Liquid Transfer	\$ 0.20	Preston	Galt	27,944	20	\$110,939
Aerobic Sludge Management	Liquid Transfer	\$0.11	St. Jacobs	Ayr	3,011	96	\$33,214
			Wellesley	Ayr	3,413	80	\$31,395
			Heidelberg	Ayr	241	88	\$2,415
			Conestogo	Ayr	141	95	\$1,527
			Foxboro	Ayr	301	75	\$2,598
			Hespeler	Ayr	46,674	59	\$315,085
			New Hamburg	Ayr	17,844	66	\$134,755
			Elmira	Ayr	4,208	105	\$50,455
Cake Management	Product Transfer	\$ 0.17	Ayr	Land Application	8,133	280	\$381,121
			Waterloo	Land Application	17,409	240	\$710,289
			Kitchener	Land Application	30,723	280	\$1,462,402
			Galt	Land Application	18,742	275	\$876,189
						Total Cost	\$4,118,385

Table B-10: Transfer and End-Use Trucking - Alternative 1 - Decentralized Hydrolysis Transportation Costs

Contract	Type	Rate (\$/Tonne or \$/m ³)	From	To	Tonnes/year 2051	Km per load	\$/Year 2051
Preston Sludge	Liquid Transfer	\$0.20	Preston	Galt	27,944	20	\$110,939
Aerobic Sludge Management	Liquid Transfer	\$0.11	St. Jacobs	Ayr	3,011	96	\$33,214
			Wellesley	Ayr	3,413	80	\$31,395
			Heidelberg	Ayr	241	88	\$2,415
			Conestogo	Ayr	141	95	\$1,527
			Foxboro	Ayr	301	75	\$2,598
			Hespeler	Ayr	46,674	59	\$315,085
			New Hamburg	Ayr	17,844	66	\$134,755
Cake Management	Product Transfer	\$0.17	Elmira	Ayr	4,208	105	\$50,455
			Ayr	Land Application	13,744	280	\$654,234
			Waterloo	Land Application	29,421	240	\$1,200,388
			Kitchener	Land Application	51,921	280	\$2,471,463
			Galt	Land Application	31,674	275	\$1,480,760
						Total Cost	\$6,489,227

Greenhouse Gas Analysis Summary

A summary of CO₂ Emissions Equivalents calculated using the BEAM model for decentralized alkaline stabilization is presented below.

Table B-11: Greenhouse Gas Analysis - Alkaline Stabilization Decentralized Layout

Unit Processes & Inputs	CO2 Emissions Equivalents (tonnes/year)
Lime production	23,324
Natural gas use for processing and building heating	3,633
Electricity use in alkaline stabilization and building demands	68
Transportation	1,133
CO ₂ equivalents	28,158

6000 cars (EPA calculator)

Assumptions:

- Class A quality is used as the surrogate for CFIA fertilizer pathogen content requirements
- Amount of lime required is much higher than the BEAM default and has been incorporated at 1.4 dry tonnes lime per dry tonne biosolids processed
- Natural gas for product drying has been incorporated as 71 m³ natural gas per dry tonne biosolids processed based upon vendor input
- Natural gas for building demands is derived from a unit-area-based estimate for typical utility consumption
- Electricity requirements are incorporated as 150 kWh per dry tonne of biosolids processed based upon vendor input
 - This is more lower than the BEAM default which references electricity use for supplemental heat to achieve class A quality (in the case assumed natural gas is used for supplemental heating)

ALTERNATIVE 1: PRODUCE FERTILIZER

- o Electricity for building demands is derived from a unit-area-based estimate for typical utility consumption.
- Cement kiln dust or other alkaline waste products are commonly used to produce fertilizer in Ontario. Production of Lime is responsible for all scope 3 emissions for this alternative, and greenhouse gas emissions are very low for Scope 1 and 2. Therefore using cement kiln dust or other alkaline by-products from other industries can offset approximately 90% of the greenhouse gas emission from this alternative.

Alternative Costing

The cost of implementation for a system producing fertilizer has been evaluated considering the components described in Section 4.0. Costing for decentralized alternatives presented below represent the total system-wide implementation of all four decentralized facilities. The cost of the ATAD alternative for the facility in the vicinity of Ayr WWTP is presented separately as a stand-alone decentralized process.

Life Cycle Cost

Life cycle costing was established in 2018 dollars to allow comparison of overall costs associated with each alternative. Life cycle costing was completed with the following assumptions:

- 4% Net Present Value Discount Rate
- 2% Annual inflation for costs associated with labour, capital expenditures and consumables
- 5% annual inflation associated with electricity costs
- 2023 construction date for the alternative, with capital expenditure for this
- Consideration for end-of-life replacement of equipment
- Consideration of trucking costs

ALTERNATIVE 1: PRODUCE FERTILIZER

Lifecycle costing estimates have been developed to provide a consistent basis for comparison of technologies, with consideration given to the impact of annual operating cost on the overall cost of implementing each alternative. The construction date, interest rates and operating costs may be refined through further design.

The following life cycle costs were established:

**Table B-12: Life Cycle Cost Estimate - Alternative 1 Produce Fertilizer
Decentralized Facilities Combined**

No.	Item description	Estimated Cost
1.	Capital Cost	\$89,100,000 - \$94,900,000
2.	Bundled Servicing*	\$19,100,000 - \$32,500,000
3.	Chemical Consumption	\$30,100,000 - \$17,600,000
4.	Average Equipment Replacement	\$44,700,000 - \$42,800,000
5.	Routine Maintenance	\$6,200,000 - \$17,700,000
6.	Labour	\$30,400,000 - \$27,400,000
7.	Trucking Cost	\$65,800,000 - \$103,900,000
Total Life Cycle Cost		\$285,300,000 - \$336,800,000
*Note: Related to utility consumption and waste disposal only, does not include the extension of new services		

Appendix B
Alternative 2:
Produce Compost

1.0 Description

This alternative would implement composting for stabilization that integrates with the current dewatering infrastructure following anaerobic digestion. There are two categories of compost in the Ontario Compost Quality Standards (MOECC, 2012) that all biosolids as a feedstock. Category A where biosolids are co-composted with minimum 75% (dry mass basis) other biomass (e.g. source separated organics, leaf and yard waste, purchased amendment like woodchips) with mixture up to 25% biosolids, and Category B where biosolids can be composed with amendment (typically wood chips) in a ratio selected to maintain key properties for composting such as carbon to nitrogen ratio (C:N). Only Category A composting processes have been considered for implementation. The Compost Quality Standard (MOECC, 2012) requires compost to be maintained at 40% moisture content (60% solids) during curing. Since other sources of organic material added as feedstock to the biosolids are partially recycled through the process by screening finished material the total quantity of finished compost is increased by amendment but not by the 3:1 input ratio. A mass balance of inputs and output is presented in this section.

Candidate technologies generating a compost product would consist of mechanically turned aerated piles or tunnels designed to achieve higher rates of composting and reduced footprint relative to more conventional processes. Technologies would be required to process material, using working areas for equipment such as tipping floors and composting vessels within buildings to limit odour and aesthetic impacts.

The analysis of this alternative has considered trucking, costing and operational considerations assuming organic amendment sourced from within the Region. Given the large quantity of amendment material required to produce a Class A product, a cost associated with amendment acquisition would significantly impact the financial feasibility of this alternative.

The potential for cost recovery through product sales has been investigated but is not considered in the financial analysis.

2.0 End Use Summary

Technologies considered for this alternative would be capable of generating a compost product meeting a Category A standard. This alternative would provide the following end use or disposal options:

- Agricultural use as compost;
- Non-agricultural use as soil amendment or for land reclamation;
- Landfill use as a substitute for existing daily cover material; or
- Landfill disposal at approved sites.

A compost product provides a greater opportunity for use in agriculture relative to existing processes, and the potential to market the biosolids-derived product for wider use outside the Region. Non-agricultural end-uses for the product would also remain available. Composting also enhances the flexibility to store product for extended periods of time.

3.0 Alignment with Review Objectives

3.1 Alignment with Existing Biosolids Infrastructure

The “Produce Compost” alternative has been reviewed for alignment with existing infrastructure within the Region.

- The alternative is compatible with existing infrastructure. The composting process is able to accept biosolids cake as a feedstock, which would be managed using mobile equipment and conveyors at the site.

ALTERNATIVE 2: PRODUCE COMPOST

- Management of Source Separated Organics (SSO), could be considered through a biosolids composting process, provided appropriate consideration was given to facility loading and design. Managing SSO with biosolids is not currently a preferred alternative for solid waste management in the Region, and a strong driver for biosolids management with SSO was not identified through this process.
- Processing technology may be adapted to changing loading, or variations in population. Parallel composting bays or tunnels are typically operated with longer retention time initial when mass flows are lower, but could be brought in and out of service as-required to accommodate the changes in quantity of biosolids over time. The facility will be sized for the identified maximum throughput capacity within the planning period. Due to the size of processes required, construction of additional composting vessels, material management areas and curing/storage facilities beyond the initial design levels (2051 quantity) may not be possible on selected site footprints.
- Composting processes are large and it is unlikely that a system capable of accommodating all biosolids produced by the Region could be co-located with the site of an existing wastewater treatment facility.
- Utility consumption associated with the composting process is significant, primarily due to the large number of mechanical components associated with the process, and demands associated with building servicing and odour control. Estimated utilities include:
 - o Electrical Utility: 28,000 kWh/d
 - o Water Utility: 115 m³/d
 - o Natural Gas Utility: 162 GJ/d
 - o Wastewater Utility: 108 m³/d

3.2 Protection of Natural Environment

This alternative is anticipated to have relatively minor impacts on the natural environment. Organic content and nutrients retained within the product may have

beneficial impacts when land-applied to soil. Benefits of compost product use include:

- Retention of organic material in the dried product and additional organic nutrients from the addition of amendment and bulking agents
- Retention of nutrients including nitrogen and phosphorous in product
- Reduction of metals concentration through blending of biosolids with amendment material. Category A compost quality places limits on metals concentration which represent an improvement over existing practices.
- Limited impact on surface water through addition of stabilized solid product to soil
- Reduced impact on air quality through decreased odour release from stabilized product

The composting process will be a net consumer of energy and is not expected to offer opportunities for energy recovery.

Transportation requirements are described in detail below for this alternative. The addition of substantial quantities of amendment, and a low final product density result in an overall increase in product volume relative to biosolids feedstock. Product volume is estimated to be **197%** of raw biosolids cake volume. Reduction of organic material through the composting process and blending with amendment results in a low density product with a mass of **79%** of incoming biosolids.

3.3 Protection of Quality of Life

- Composting processes may have some associated odour and dust generation, particularly associated with the delivery of feedstock and amendment and removal of product. Odour generation from composting processes is significant. Full containment of the process, including tipping floors and product curing areas and implementation of building odour control systems are required to mitigate these effects. These planning and mitigation actions may include:

ALTERNATIVE 2: PRODUCE COMPOST

- o Conducting air dispersion modeling obtain data on odour emissions and areas of impact (US EPA, 2000);
 - o Maintaining optimal carbon to nitrogen and carbon to sulphur ratios to reduce formation of volatile odourous compounds (Ontario Ministry of the Environment, 2012);
 - o Processing of biosolids within 24 hour of receiving (Ontario Ministry of the Environment, 2012);
 - o Siting buffers from sensitive receptors (Ontario Ministry of the Environment, 2012);
 - o Use of “fast-acting doors” or “a double door air-lock system” at delivery entranceways (Ontario Ministry of the Environment 2012);
 - o Conducting activities in consideration of meteorological conditions to avoid the concentration of odours at ground level (Ontario Ministry of the Environment, 2012);
 - o Maintaining proper operation conditions and contact time in the odour control systems to ensure system is performing to the necessary degree (US EPA, 2000);
- Processes are typically fully enclosed in buildings and do not have large associated stacks etc. aside from odour control system discharges that would cause a visual/aesthetic impacts. The size of the facility required to manage compost at a centralized location is large and site selection criteria will be required to mitigate the potential for visual/aesthetic impacts.
 - Composting produces a large volume product with a comparatively lower density than other alternatives. Large volume trucks may be used to transport an equal number of tonnes of end product than other processes producing a lower volume and higher density product. Since the mass of compost product is lower than the current quantity of dewatered cake, and

the product from alternative 1. The total vehicle kilometers travelled, to use product is anticipated to be lower than the current approach and alternative 1.

3.4 Protection of Health and Safety

- Worker health and safety concerns will include the number of fixed and mobile equipment units required for processing
- Fugitive odours and hazardous gases (e.g. ammonia, methane or hydrogen sulfide gas) released from stored biosolids may present an indoor air quality risk
- Proper monitoring of moisture content and temperature within the composting and curing process, and in amendment storage is required to reduce the risk of fires. Building safety systems and sprinklers will be required to mitigate this risk.
- Compost is a stable product and poses little risk to the public in the event of a spill during transport.

4.0 Technology Implementation

4.1 System Components

This technology would be implemented with the following components:

- Administration and operations facilities
- Site servicing and roadway access
- Product receiving facilities including amendment receiving building and biosolids receiving/tipping floor
- Short term (10-day) operational storage of dewatered cake feedstock incorporated into tipping floor area

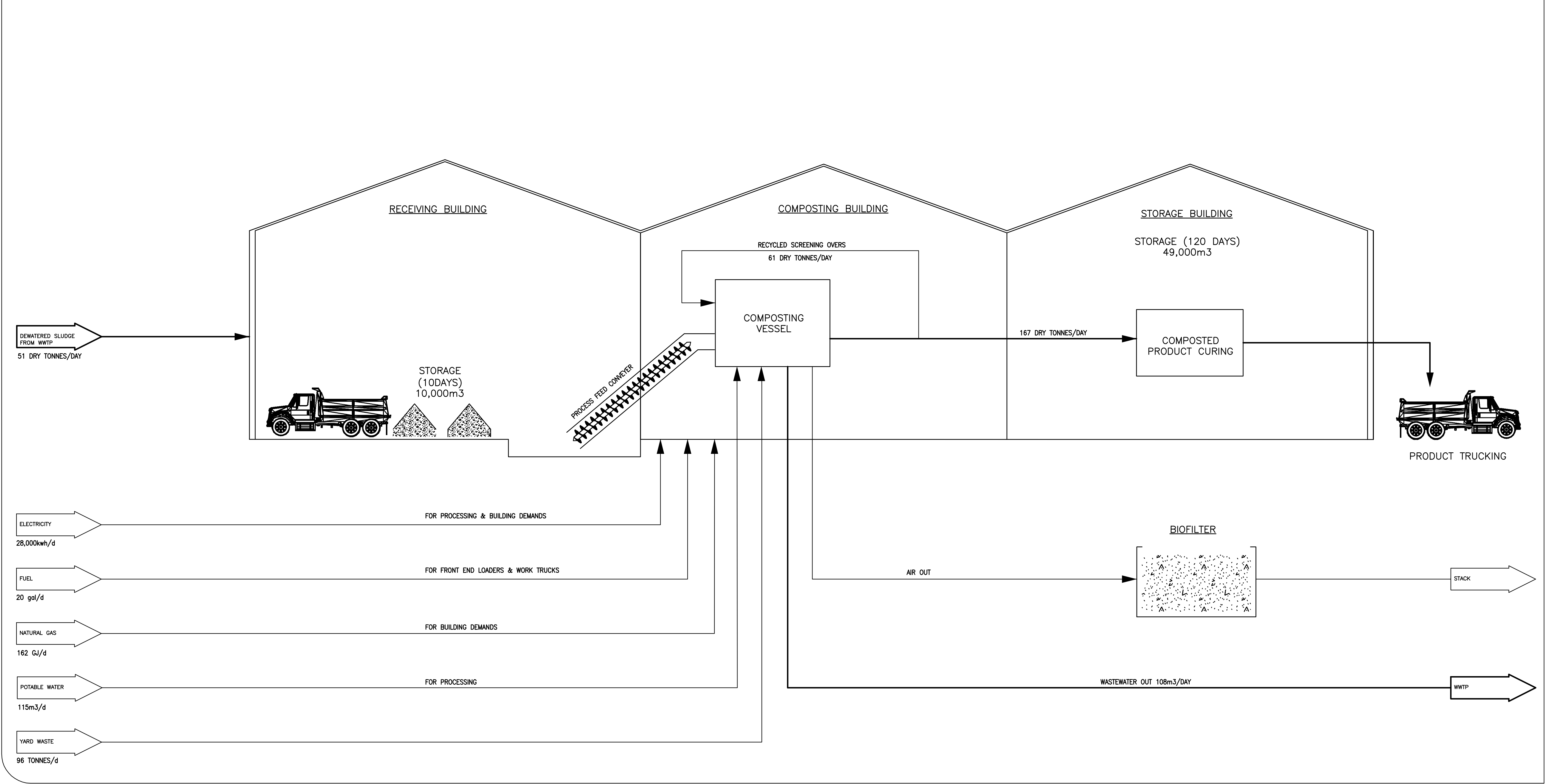
ALTERNATIVE 2: PRODUCE COMPOST

- In-vessel composting process including product conveyors, aeration and product handling equipment
- Product curing areas (enclosed)
- Operational storage of composted biosolids product (4 month), consisting of an enclosed building
- Odour mitigation (containment within buildings and treatment through dedicated facilities such as biofilters) integrated with the composting process and appropriately sized to treat additional enclosed areas containing odorous material.

Implementation of this alternative would consist of the construction of a new facility on a dedicated site accommodating all biosolids generated from within the Region. Construction of multiple “decentralized” sites is not considered practical due to the relative size that would be required for the individual decentralized sites.

A block-flow diagram depicting the main components of the alternative along with a preliminary summary of mass flows and utility demands is provided in **Figure 6**.

A two-dimensional layout of a centralized “green field” composting system is provided in **Figure GA4**.



BIOSOLIDS MASTER PLAN

ALTERNATIVE 2
PRODUCE COMPOST
CENTRALIZED
FIGURE 6

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4.2 Internal Transfers and Trucking

The requirement for internal transfers and trucking required to move biosolids from producing WWTPs to processing facilities and from processing facilities to end-use has been considered.

Internal transfer of biosolids achieves two objectives:

- Anaerobic digestion and dewatering of waste activated sludge (WAS) from facilities with no biosolids processing
- Dewatering of aerobically digested biosolids from facilities with existing liquid biosolids treatment processes.

Internal transfers are required to transport dewatered biosolids cake produced at large facilities, including material previously received from small facilities, to a centralized biosolids processing location. The estimated trucking requirements to transport material from large facilities to the centralized facility under consideration are shown below. The centralized facility distance represents an average distance from the urban centre of the city to the region boundary, and is used for high-level comparative purposes only.

Transfers are assumed using the following truck sizes:

- Transfer of liquid biosolids from small facilities: 18 m³ truck
- Transfer of liquid biosolids from large facilities (e.g. Preston) for dewatering: 43 m³ truck
- Internal transfer of dewatered biosolids between facilities, or transfer of final product to end use using a 35 tonne truck, with a volume of up to 70 m³

Leaf and yard waste (LYW) is considered as an organic amendment material necessary to facilitate the composting process. Approximately 1.9 dry tonnes of LYW is required per dry tonne of biosolids feedstock. We have assumed that LYW material could be sourced locally from within the Region at the quantity required if this alternative is selected. Trucking

ALTERNATIVE 2: PRODUCE COMPOST

The size of trucks for each type of transportation has been established from the Region's existing practices, or the practices of 3rd party biosolids management companies.

Biosolids produced by the alternative will be transported by truck to an end-use location. End use disposal locations are assumed based on the average of known distances to available land reclamation sites or landfills and a median distance to current agricultural land application. Responsibility for providing trucking may be assigned to end-users or facility operators. Total vehicle kilometers to end use are summarized below. It is assumed for the purposes of this assessment that product has a density of 0.4 tonnes per cubic metre and the total mass of product in wet tonnes is 79% of the wet tonnes of raw biosolids feedstock.

The mass of internal transfers between facilities and to end use, the total truck trips and total vehicle kilometers travelled are summarized in **Table C-1** and **C-2** below. Individual tables show the total relative trucking for the composting process. Daily truck trips are presented as the average value on an annual mass loading basis. Actual numbers of trucks per day may vary, particularly for transportation stages where less than one full truck per day is required.

TableC-1: Alternative 2 Transportation Distance Summary

Trucking Source / WWTP	Amount Dry Biosolids (kg/d)	Solids Content of Biosolids	Mass of Wet Biosolids (kg/d)	Trucks Per Day	Trucking Destination	Round-Trip Trucking Distance (Km/Trip)	Total Vehicle Kilometers Traveled (Km/Year)
Internal Transfer of Biosolids for Dewatering							
St. Jacobs	165	2%	8,250	0.46	Waterloo	20	3,360
Wellesley	187	2%	9,350	0.52	Waterloo	45	8,550
Heidelberg	13	2%	660	0.04	Waterloo	30	420
Conestogo	8	2%	385	0.02	Waterloo	25	200
Foxboro	17	2%	825	0.05	Waterloo	65	1,105
Preston	1,914	3%	76,560	1.78	Galt	20	13,000
Hespeler	1,023	1%	127,875	7.10	Kitchener	30	77,820
New Hamburg	880	2%	48,889	2.72	Kitchener	48	47,616
Ayr	396	5%	8,426	0.47	Kitchener	46	7,866
						Subtotal Distance	159,937
Internal Transfer of Dewatered Biosolids for Processing							
Elmira	2,882	25%	11,528	0.33	Central Processing Location	61	7,321
Waterloo	12,313	25%	49,254	1.41		42	21,588
Kitchener	23,342	25%	93,368	2.67		47	45,778
Galt	12,837	25%	51,348	1.47		53	28,140
						Subtotal Distance	102,827
Leaf and Yard Waste Amendment Transfer							
LYW	95,111	55%	172,929	7.69		51	141,703

ALTERNATIVE 2: PRODUCE COMPOST

Trucking Source / WWTP	Amount Dry Biosolids (kg/d)	Solids Content of Biosolids	Mass of Wet Biosolids (kg/d)	Trucks Per Day	Trucking Destination	Round-Trip Trucking Distance (Km/Trip)	Total Vehicle Kilometers Traveled (Km/Year)
External Transfer of Process Biosolids to End-Use							
Central Processing Location	51,374	60%	162,343	4.64	Land Application	261	441,852
						Total Distance	846,318

ALTERNATIVE 2: PRODUCE COMPOST

Table C-2: Alternative 2 Transportation Cost Summary

Contract	Type	Rate (\$/Tonne or \$/m³)	From	To	Tonnes/year 2051	km per load	\$/Year 2051
Preston Sludge	Liquid Transfer	\$0.20	Preston	Galt	27,944	20	\$110,939
Aerobic Sludge Management	Liquid Transfer	\$0.11	St. Jacobs	Waterloo	3,011	20	\$6,891
			Wellesley	Waterloo	3,413	45	\$17,572
			Heidelberg	Waterloo	241	30	\$827
			Conestogo	Waterloo	141	25	\$402
			Foxboro	Waterloo	301	65	\$2,240
			Hespeler	Kitchener	46,674	30	\$160,213
			New Hamburg	Kitchener	17,844	48	\$98,003
			Ayr	Kitchener	3,075	46	\$16,186
Cake Management	Cake Transfer	\$0.17	Elmira	Central Location	4,208	61	\$43,276
			Waterloo	Central Location	17,978	42	\$128,360
			Kitchener	Central Location	34,079	47	\$272,294
			Galt	Central Location	18,742	53	\$167,273
LYW	Solids Transfer	\$0.17	Leaf and Yard Waste	Central Location	63,119	51	\$541,878
Cake Management	Product Transfer	\$0.17	Central Location	Land Application	59,255	261	\$2,627,476
Total Cost						\$4,193,829	

4.3 Greenhouse Gas Analysis Summary

A summary of CO₂ Emissions Equivalents calculated using the BEAM model for centralized composting is presented below.

Table C-3: Alternative 2 Centralized Layout Greenhouse Gas Analysis Summary

Unit Processes & Inputs	CO ₂ Emissions Equivalents (tonnes/year)
Diesel used in processing and applying compost to land	1,612
Electricity used in composting and building demands	436
Natural gas used for processing and building heating	3,014
Nitrous oxide released	9,134
Carbon Sequestration credit from compost applied to soil	-4,688
Transportation	1104
CO ₂ equivalents	10,612

2300 Cars (EPA calculator)

Assumptions:

- Composting is based upon 25% solids cake composting in-vessel with amendment
- With the exception of selecting digestion ahead of composting the BEAM default inputs for compost blending were used
 - o It is noted that Category A compost requires a higher rate of amendment use than is considered in the default assumptions within the model
 - o Using the higher rate of amend addition tends to increase C:N ratio and decrease nitrogen related greenhouse gas emissions; however it is anticipated that leaf and yard waste (lower C:N than the sawdust product assumed in BEAM) will make up a substantial portion of the

amendment, and screenings will also make up a portion of amendment

- o The default assumptions for amendment are anticipated to reasonably represent the C:N ratio for the full scale operations, and have been used to estimate emission; however the amendment inputs could be refined to better represent the proposed approach which would lead to a lower emission rate than is presented in **Table C-3**.
- Electricity requirements were based upon 540 kWh per tonne dry biosolids processed based upon input from vendors which is substantially greater than BEAM defaults. It is considered likely that the complexity of the enclosed process has greater electricity demand than the default BEAM assumptions
- Overall the assumptions for composting are conservative, and represent the highest likely emissions. Operating the facility with a high C:N ratio, and displacing commercial fertilizer would make composting a greenhouse gas sink for the Region, and it should be considered the most preferred process alternative in terms of the greenhouse gas emission rate.

4.4 Alternative Costing

The cost of implementation for a system producing fertilizer has been evaluated, considering the equipment cost, site construction cost associated with the components listed in Section 4.1 and operating and maintenance costs. Costs were established through input from equipment vendors, standard unit pricing and Dillon's professional experience.

4.5 Capital Cost

Capital costing has been developed for each alternative. Costs consider the following:

- Capital equipment purchase
- Site preparation
- Construction of process buildings and site roadways
- Building services and supporting equipment

Capital purchases include installation markups of between 0% and 20% per item. Standard subcontractor and general contractor markups of 15% and 5% respectively have been considered where appropriate. In addition to the total “direct” cost of construction, standard “indirect” markups have been included to reflect the assumed actual cost of implementation, and uncertainty at this level of design

4.6 Operating Cost

Operating costs have been established for each alternative. Where possible, costs have been estimated using technology specific utility consumptions and operating requirements based on discussions with vendors. Preliminary operating cost estimates are established primarily to demonstrate the relative cost to operate different process equipment alternatives. Additional operating costs associated with staff facilities are anticipated to be minor, and would be established based upon detailed design and operations planning. Operating costs include the following:

- Electrical utility costs
- Water utility costs
- Natural gas cost for process equipment and building heating
- Process chemical consumption (where appropriate)
- Allowance for routine maintenance and spare parts (typically 1% of equipment value per year)
- Operations staff costs. Based on vendor input we have assumed 14 operations staff is required for the facility. The increase in staff complement

is due in part to the number of mobile equipment operators required to manage raw material and composted product

Trucking costs associated with each alternative are summarized separately in Section 4.2. An additional cost associated with the periodic end-of-life replacement of capital equipment has been considered. This is not shown as part of the annual operating costs but is carried in the life cycle costing of each alternative.

4.7 Life Cycle Cost

Life cycle costing was established 2018 dollars to allow comparison overall costs associated with each alternative. Life cycle costing was completed with the following assumptions:

- 4% Net Present Value Discount Rate
- 2% Annual inflation for costs associated with labour, capital expenditures and consumables
- 5% annual inflation associated with electricity costs
- 2023 construction date for the alternative, with capital expenditure for this
- Consideration for end-of-life replacement of equipment
- Consideration of trucking costs. Trucking costs exclude the transport of amendment blended with biosolids through the composting process.

Lifecycle costing estimates have been developed to provide a consistent basis for comparison of technologies, with consideration given to the impact of annual operating cost on the overall cost of implementing each alternative. The construction date, interest rates and operating costs may be refined through further design. The range of capital costs presented represents the difference between core technology providers, and would be evaluated during the detailed design of the facility in terms of a value based comparison.

**Table C-4 Life Cycle Cost Estimate - Alternative 4
Centralized Facility**

No.	Item description	Estimated Cost
1.	Capital Cost	\$85,200,000 - \$134,300,000
2.	Bundled Servicing*	\$60,400,000
3.	Chemical Consumption	\$22,500,000
4.	Average Equipment Replacement	\$18,400,000
5.	Routine Maintenance	\$12,900,000
6.	Labour	\$27,400,000
7.	Trucking Cost (incl. amendment)	\$65,600,000
Total Life Cycle Cost		\$292,400,000 - \$341,500,000
*Note: Related to utility consumption and waste disposal only, servicing of a greenfield site not included.		

Appendix C
Alternative 3:
Produce Dried,
Low-Volume
Fertilizer

1.0 Description

This alternative would implement a dryer technology after existing anaerobic digestion and dewatering to reduce the volume of dewatered cake and generate a biosolids derived fertilizer product. The dried product will have lower overall mass and increased bulk density. Biosolids dryer technology assessed for this alternative would be receiving the current biosolids cake as feedstock.

The technology proposed in this category will produce a substantially lower quantity of biosolids derived fertilizer per capita compared with the current approach (up to 75% less). The dried product generated by this alternative may range in moisture content from 85% to 95% solids.

The dryer will generate a product meeting the US EPA definition of Class A biosolids. Stabilization processes in this configuration have been demonstrated to meet the regulatory requirements of a fertilizer under the Fertilizers Act as administered by CFIA. Based upon the enhanced stability of the dried material, the duration of product storage may be extended to achieve greater operational flexibility and reduce the potential requirement for landfilling in periods when land application is not available.

2.0 End Use Summary

This alternative will produce a fertilizer that meets the regulatory requirements under the Fertilizers Act administered by CFIA. This alternative would provide the following end use or disposal options:

- Agricultural use as fertilizer;
- Non-agricultural use as soil amendment or for land reclamation;
- Landfill use as a substitute for existing daily cover material; or

ALTERNATIVE 3: PRODUCE DRIED LOW VOLUME FERTILIZER FROM BIOSOLIDS

- Landfill disposal at approved sites.

A fertilizer product provides equal or greater opportunity for use in agriculture relative to existing practices, reduces restrictions on application based upon the requirements of the NMA and improves the ability to store the product for use during periods when the preferred end-use is not available. Non-agricultural soil amendment options such as the existing mine tailings pond reclamation remains available, with additional bulk fertilizer uses available (e.g. landscaping / golf courses). Adding more flexibility to end uses is considered a valuable feature as it mitigates risk if any one end use or disposal method is unavailable in the short or long-term.

The potential for cost recovery through product sales has been investigated but is not considered in the financial analysis of this alternative.

3.0 Alignment with Review Objectives

3.1 Alignment with Existing Biosolids Infrastructure

The “Produce Dried Low-Volume Fertilizer” alternative has been reviewed for alignment with existing infrastructure within the Region.

- The alternative is compatible with existing infrastructure. Process uses existing dewatering equipment. Biosolids drying reduces biosolids mass by removing water.
- The process is capable of accepting dry cake or liquid feedstock without modification needed to the processing prior to drying; however the evaluation completed is based upon the existing dewatering biosolids after anaerobic digestion.

ALTERNATIVE 3: PRODUCE DRIED LOW VOLUME FERTILIZER FROM BIOSOLIDS

- Utility consumption varies between centralized and decentralized options. In general, electricity is required to operate facility processes and natural gas is required as thermal input. Utility requirements are provided below:

Centralized Configuration

- o Electrical Utility: 4800 kWh/d
- o Water Service: 195 m³/day
- o NG Service: 483 GJ/day
- o WW Utility: 188 m³/day

Decentralized Configuration

- o Electrical Utility: 5860 kWh/d
- o Water Service: 195 m³/day
- o NG Service: 484 GJ/day
- o WW Utility: 188 m³/day

3.2 Protection of Natural Environment

This alternative is anticipated to have relatively minor impacts on the natural environment. Organic content and nutrients retained within the product have beneficial impacts when land-applied to soil. Benefits of fertilizer product use include:

- Retention of organic material in the dried product
- Volatilization of ammonia during drying, reducing ammonia in end product that could be affect groundwater following land application
- Phosphorous retention in product
- No change from current practice regarding impact on surface water quality

ALTERNATIVE 3: PRODUCE DRIED LOW VOLUME FERTILIZER FROM BIOSOLIDS

- Reduced impact on air quality through decreased odour release from stabilized product

All facilities are net consumers of energy as described above.

Transportation requirements are described in detail below for each technology alternative. The total range of vehicle kilometers travelled is summarized for each alternative below. Biosolids drying will result in a reduced volume by removing water from the final product. A **72%** reduction in trucking is estimated as a result of drying the product.

3.3 Protection of Quality of Life

- Processes may have some associated odour and dust generation. Odour is controlled by installing all equipment in buildings and maintaining negative pressure in buildings. All captured air is treated in a biofilter.
- Processes are typically fully enclosed in buildings and typically do not require large stacks for dispersion that would cause a visual/aesthetic impact.
- Drying process generates a product that has less volume than incoming feedstock. Reduction in trucking volume results in a decrease in total number of vehicle kilometers travelled. Trucking is summarized quantitatively in the sections below.
- Noise mitigation – all equipment in buildings with proper engineering controls to mitigate the potential for off-site impacts.

3.4 Protection of Health and Safety

- Engineering controls will consist of forced ventilation and a biofilter for odour and dust control. Insulation and guards will be used for protection from high temperature areas of the process. Operators of processes are anticipated to

ALTERNATIVE 3: PRODUCE DRIED LOW VOLUME FERTILIZER FROM BIOSOLIDS

require PPE for safety. Special qualifications may be required for some employees due to the nature of the process.

- Biosolids product material is stable with relatively little risk to public in the event of a spill or other such event.

4.0 Technology Implementation

4.1 System Components

This technology would be implemented with the following components:

- Administration and operations facilities
- Site servicing and roadway access
- Product receiving facilities
- Short term (10-day) operational storage of dewatered cake feedstock
- Core processing technology is a biosolids dryer producing a fertilizer product
- Cooling tower
- Operational storage of fertilizer product (4 month), consisting of an enclosed building
- Odour mitigation (containment within buildings and treatment through dedicated facilities such as biofilters)

Implementation of a process at locations receiving un-dewatered biosolids directly would also require the construction of liquid storage tanks, and would also require equipment to dewater liquid biosolids to produce a 25% biosolids cake prior to processing.

Implementation of the alternative may be considered at a one (1) location for processing all biosolids generated within the Region “Centralized Alternative”, or at up to four (4) smaller locations, each handling a portion of the overall production “Decentralized Alternative”. Decentralized implementation of the alternative may

ALTERNATIVE 3: PRODUCE DRIED LOW VOLUME FERTILIZER FROM BIOSOLIDS

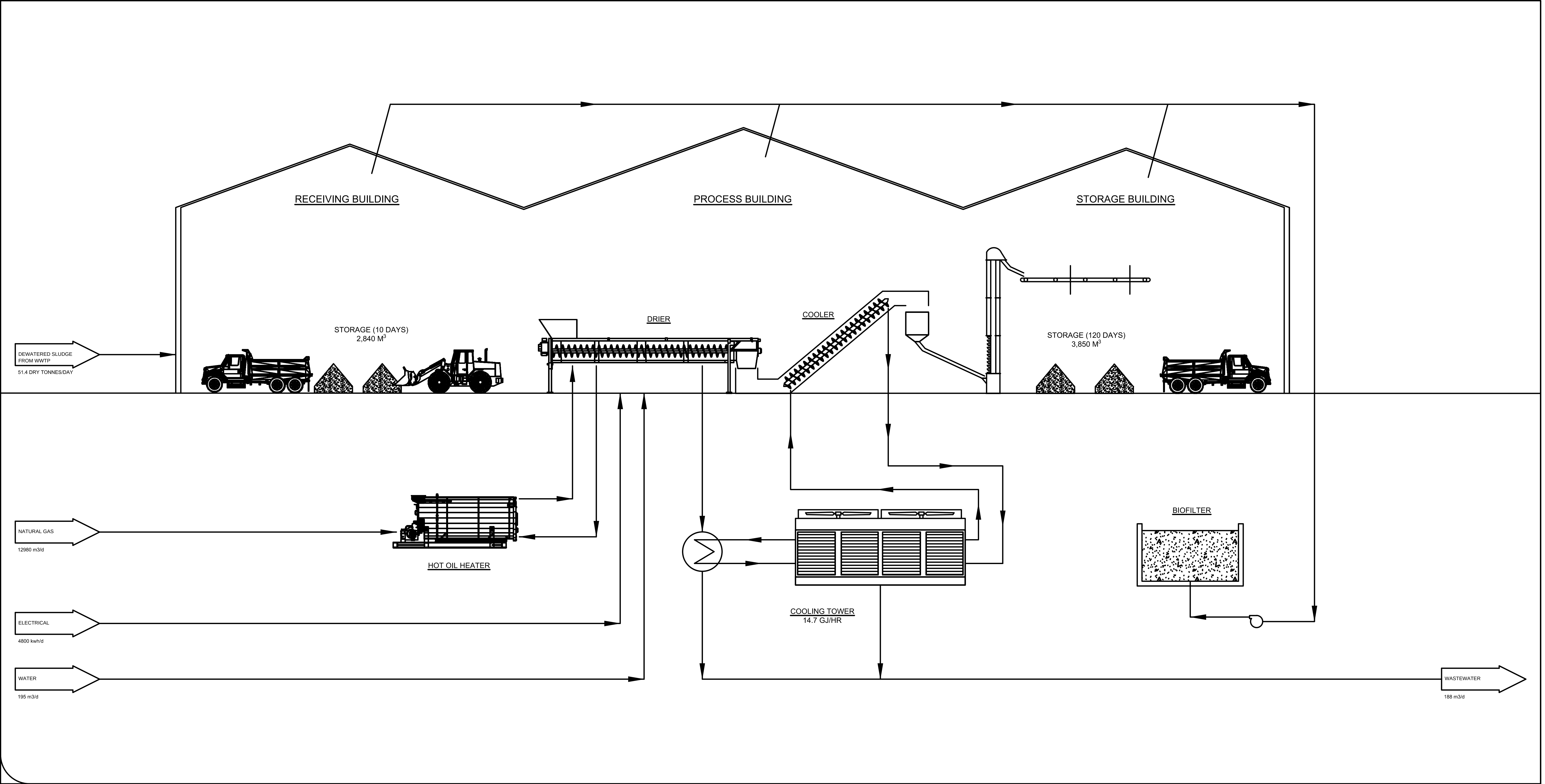
reduce local trucking of dewatered biosolids cake prior to processing, provide greater process redundancy and reduce the footprint of individual facilities, particularly the product storage areas required. Decentralized implementation is potentially more costly and complex to implement as some infrastructure (such as material receiving administration and site access roadways) must be duplicated for each facility and challenges associated with facility siting must be addressed for a number of locations rather than one dedicated area.

Construction of the new process may be considered with some or all components co-located with existing WWTPs or located at new sites. Site area constraints may limit the construction of storage at existing WWTPs, while co-location may allow some existing infrastructure such as site access, servicing, administration and product receiving currently present to be integrated the new biosolids process. For the purposes of evaluating each alternative, we have considered construction of facilities for both the “Centralized Alternative” and “Decentralized Alternative” on undisturbed sites with all components co-located on a single campus.

4.2 Centralized System Configuration

The following sections describe the construction of a centralized drying facility for managing biosolids. A block-flow diagram depicting the main components of the alternative along with a preliminary summary of mass flows and utility demands is provided in **Figure 7**.

A two-dimensional layout of a centralized “green field” dryer system is provided in **Figure GA5**.



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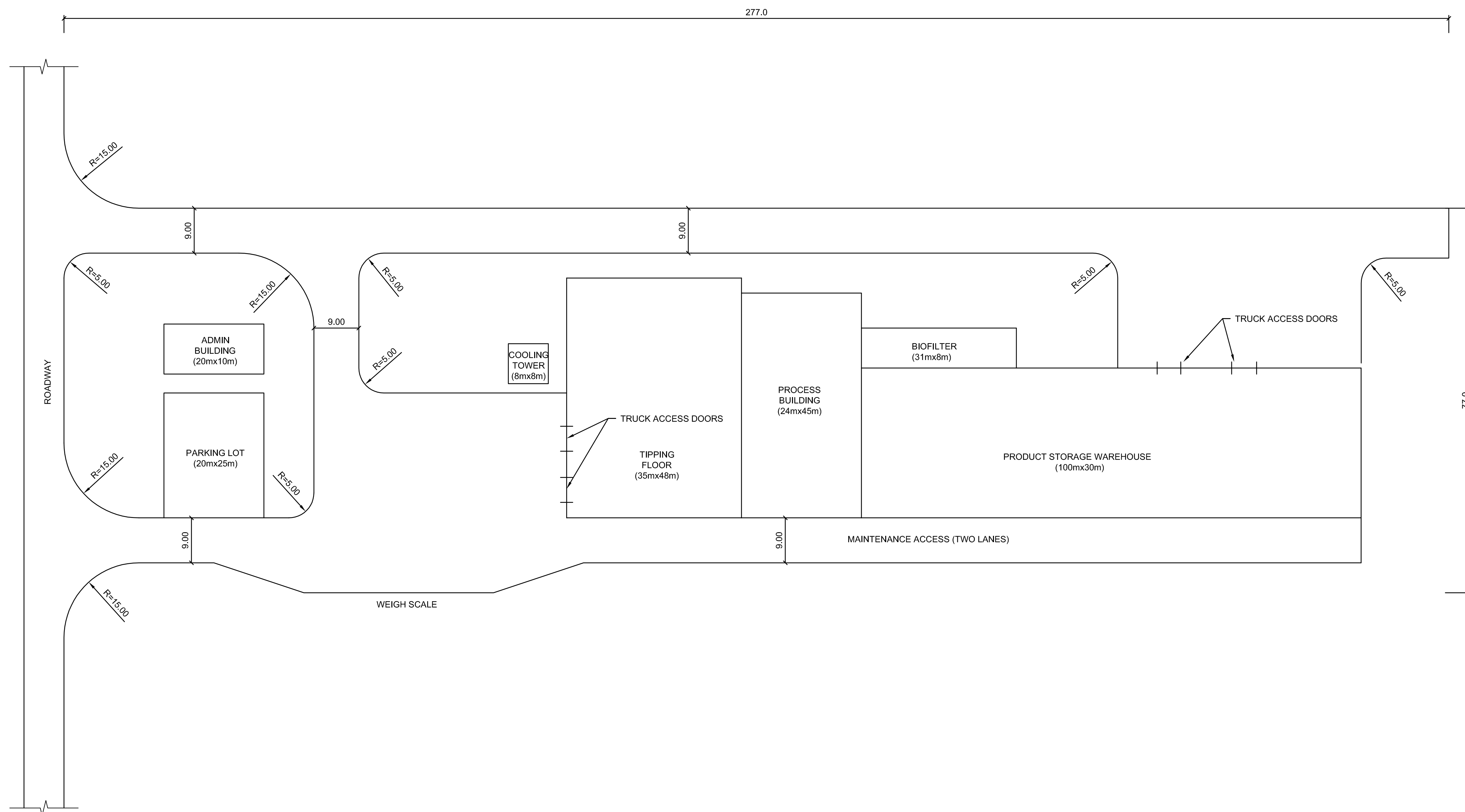


PROJECT: 15 2281
STATUS: DRAFT
DATE: DECEMBER 2017

CREATED BY: BCJ
CHECKED BY: PJH
DESIGNED BY:

BIOSOLIDS MASTER PLAN

ALTERNATIVE 3
CENTRALIZED BIOSOLIDS DRYING
FIGURE 7



Conditions of Use

Verify elevations and/or dimensions on drawing prior to use.
Report any discrepancies to Dillon Consulting Limited.

Do not scale dimensions from drawing.

Do not modify drawing, re-use it, or use it for purposes other than those intended at the time of its preparation without prior written permission from Dillon Consulting Limited.

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BIOSOLIDS FACILITY

**CONCEPTUAL GENERAL ARRANGEMENT
ALTERNATIVE 3
PRODUCE DRY FERTILIZER
(CENTRALIZED)**

PROJECT NO.
15-2281

SHEET NO.

GA5

Internal Transfers and Trucking

The requirement for internal transfers and trucking required to move biosolids from producing WWTPs to processing facilities and from processing facilities to end-use has been considered. Internal transfer of biosolids is assumed to achieve dewatering of biosolids from facilities with existing liquid biosolids treatment processes.

Internal transfers of biosolids are required to transport dewatered biosolids cake produced at large facilities, including material previously received from small facilities, to a centralized biosolids processing location. The estimated trucking requirements to transport material from large facilities to a hypothetical centralized facility are shown below. The centralized facility distance represents an average distance from the urban centre of the city to the region boundary and is used for high-level comparative purposes only

Transfers are assumed using the following truck sizes:

- Transfer of liquid biosolids from small facilities: 18 m³ truck
- Transfer of liquid biosolids from large facilities for dewatering: 43 m³ truck
- Internal transfer of dewatered biosolids between facilities, or transfer of final product to end use using a 35-tonne truck, with a volume of up to 70 m³

The sizes of trucks for each type of transportation have been established from the Region's existing practices, or the practices of 3rd party management companies.

Biosolids produced by the drying technology will be transported by truck to an end-use location. End use locations are assumed based on the average of known median distance to current agricultural land application. Land reclamation and landfill disposal are acceptable for dried biosolids, but not considered likely for large quantities given 4 months of product storage to facilitate agricultural use. Responsibility for providing trucking may be assigned to end-users or facility operators. Total vehicle kilometers to end use are summarized in **Table D-** and **D-**

ALTERNATIVE 3: PRODUCE DRIED LOW VOLUME FERTILIZER FROM BIOSOLIDS

2. Trucking requirements are estimated based on the following product volumes. It is assumed for the purposes of this assessment that feedstock has a density of one tonne per cubic meter, and that dried product has a density of 1.6 tonnes per cubic meter.

The mass of internal transfers between facilities and to end use, the total truck trips and total vehicle kilometers travelled are summarized in the tables below. Daily truck trips are presented as the average value on an annual mass loading basis. Actual numbers of trucks per day may vary, particularly for transportation stages where less than one full truck per day is required.

ALTERNATIVE 3: PRODUCE DRIED LOW VOLUME FERTILIZER FROM BIOSOLIDS

Table D-1: Alternative 3 Centralized Layout - Transportation Distance Summary

Trucking Source / WWTP	Amount Dry Biosolids (kg/d)	Solids Content of Biosolids	Mass of Wet Biosolids (kg/d)	Trucks Per Day	Trucking Destination	Round-Trip Trucking Distance (Km/Trip)	Total Vehicle Kilometers Traveled (Km/Year)
Internal Transfer of Biosolids for Dewatering							
St. Jacobs	165	2%	8,250	0.46	Waterloo	20	3,360
Wellesley	187	2%	9,350	0.52	Waterloo	45	8,550
Heidelberg	13	2%	660	0.04	Waterloo	30	420
Conestogo	8	2%	385	0.02	Waterloo	25	200
Foxboro	17	2%	825	0.05	Waterloo	65	1,105
Preston	1,914	3%	76,560	1.78	Galt	20	13,000
Hespeler	1,023	1%	127,875	7.10	Kitchener	30	77,820
New Hamburg	880	2%	48,889	2.72	Kitchener	48	47,616
Ayr	396	5%	8,426	0.47	Kitchener	46	7,866
						Subtotal Distance	159,937
Internal Transfer of Dewatered Biosolids for Processing							
Elmira	2,882	25%	11,528	0.33	Central Processing Location	61	7,321
Waterloo	12,313	25%	49,254	1.41		42	21,588
Kitchener	23,342	25%	93,368	2.67		47	45,778
Galt	12,837	25%	51,348	1.47		53	28,140
						Subtotal Distance	102,827
External Transfer of Process Biosolids to End-Use							
Central Processing Location	51,374	90%	58,182	1.63	Land Application	261	155,457
						Total Distance	418,220

ALTERNATIVE 3: PRODUCE DRIED LOW VOLUME FERTILIZER FROM BIOSOLIDS

Costs for trucking have been estimated using standard transportation costs available from existing transportation of biosolids within the region. The following costs have been estimated existing contracts, considering distance travelled and cost per tonne transported.

- Large volume liquid sludge transfer: \$0.2/km/tonne
- Small volume liquid sludge transfer: \$0.11/km/tonne
- Cake transfer, or product transfer to end use: \$0.17/km/tonne

Table D-2 below presents the total annual trucking cost.

ALTERNATIVE 3: PRODUCE DRIED LOW VOLUME FERTILIZER FROM BIOSOLIDS

Table D-2 Alternative 3 Centralized Transportation Cost Summary

Contract	Type	Rate (\$/Tonne or \$/m3)	From	To	Tonnes/year	km per load	\$/Year
Preston Sludge	Liquid Transfer	\$0.20	Preston	Galt	27,944	20.00	\$110,939
Aerobic Sludge Management	Cake Transfer	\$0.11	St. Jacobs	Waterloo	3,011	20.00	\$6,891
			Wellesley	Waterloo	3,413	45.00	\$17,572
			Heidelberg	Waterloo	241	30.00	\$827
			Conestogo	Waterloo	141	25.00	\$402
			Foxboro	Waterloo	301	65.00	\$2,240
			Hespeler	Kitchener	46,674	30.00	\$160,213
			New Hamburg	Kitchener	17,844	48.00	\$98,003
			Ayr	Kitchener	3,075	46.00	\$16,186
Cake Management	Cake Transfer	\$0.17	Elmira	Central Location	4,208	60.50	\$43,276
			Waterloo	Central Location	17,978	42.00	\$128,360
			Kitchener	Central Location	34,079	47.00	\$272,294
			Galt	Central Location	18,742	52.50	\$167,273
Cake Management	Product Transfer	\$0.17	Central Location	Land Application	21,236	260.83	\$923,866
						Total Cost	\$1,948,341

Greenhouse Gas analysis summary

A summary of CO₂ Emissions Equivalents calculated using the BEAM model for centralized thermal drying is presented below.

Table D-3: Thermal Drying Centralized

Unit Processes & Inputs	CO2 Emissions Equivalents (tonnes/year)
Natural gas use for processing and building heating	11,422
Electricity use in thermal drying and building demands	181
Transportation	545
CO2 equivalents	12,148

2600 cars (EPA calculator)

Assumptions:

- Based upon all dry mass of biosolids dewatered to 25% solids, and thermal drying to 90% solids
- BEAM Default natural gas and electricity demands were used for processing emissions
 - o Refinements based upon inputs from vendor for energy use could be considered
 - o Electricity for building demands is derived from a unit-area-based estimate for typical utility consumption.

Alternative Costing

The cost of implementation for a centralized system producing dried low volume fertilizer has been evaluated, considering the equipment cost, site construction cost

ALTERNATIVE 3: PRODUCE DRIED LOW VOLUME FERTILIZER FROM BIOSOLIDS

associated with the components listed in Section 4.0, and operating and maintenance costs. Costs were established through input from equipment vendors, standard unit pricing and Dillon's professional experience.

Capital Cost

Capital costing has been developed for each alternative. Costs consider the following:

- Capital equipment purchase
- Site preparation
- Construction of process buildings and site roadways
- Building services and supporting equipment

Capital purchases include installation markups of between 0% and 20% per item. Standard subcontractor and general contractor markups of 15% and 5% respectively have been considered where appropriate. In addition to the total "direct" cost of construction, standard "indirect" markups have been included to reflect the assumed actual cost of implementation, and uncertainty at this level of design.

Operating Cost

Operating costs have been established for the alternative. Where possible, costs have been estimated using technology specific utility consumptions and operating requirements based on discussions with vendors. Preliminary operating cost estimates are established primarily to demonstrate the relative cost to operate different process equipment alternatives. Additional operating costs associated with staff facilities are anticipated to be minor, and would be established based on Operating costs include the following:

ALTERNATIVE 3: PRODUCE DRIED LOW VOLUME FERTILIZER FROM BIOSOLIDS

- Electrical utility costs
 - Water utility costs
 - Natural gas cost for process equipment and building heating
 - Allowance for routine maintenance and spare parts (typically 1% or equipment value per year)
 - Operations staff costs. We have assumed that each facility alternative would require a complement of five full time equivalents
- Trucking costs associated with this alternative are summarized separately in the preceding sections. An additional cost associated with the periodic end-of-life replacement of capital equipment has been considered. This is not shown as part of the annual operating costs but is carried in the life cycle costing of each alternative.

Life Cycle Cost

Life cycle costing was established 2018 dollars to allow comparison overall costs associated with the alternative. Life cycle costing was completed with the following assumptions:

- 4% Net Present Value Discount Rate
- 2% Annual inflation for costs associated with labour, capital expenditures and consumables
- 5% annual inflation associated with electricity costs
- 2023 construction date for the alternative, with capital expenditure for this
- Consideration for end-of-life replacement of equipment
- Consideration of trucking costs

Lifecycle costing estimates have been developed to provide a consistent basis for comparison of technologies, with consideration given to the impact of annual operating cost on the overall cost of implementing each alternative. The

ALTERNATIVE 3: PRODUCE DRIED LOW VOLUME FERTILIZER FROM BIOSOLIDS

construction date, interest rates and operating costs may be refined through further design.

The following life cycle costs were established:

Table D-4 Life Cycle Cost Estimate - Alternative 3 Drying Centralized Facility

No.	Item description	Estimated Cost
1.	Capital Cost	\$51,500,000
2.	Bundled Servicing*	\$26,400,000
3.	Chemical Consumption	\$2,500,000
4.	Average Equipment Replacement	\$29,300,000
5.	Routine Maintenance	\$3,600,000
6.	Labour	\$11,700,000
7.	Trucking Cost	\$30,300,000
Total Life Cycle Cost		\$155,300,000
*Note: Related to utility consumption and waste disposal only, does not include the extension of new services		

4.3 Decentralized System Configuration

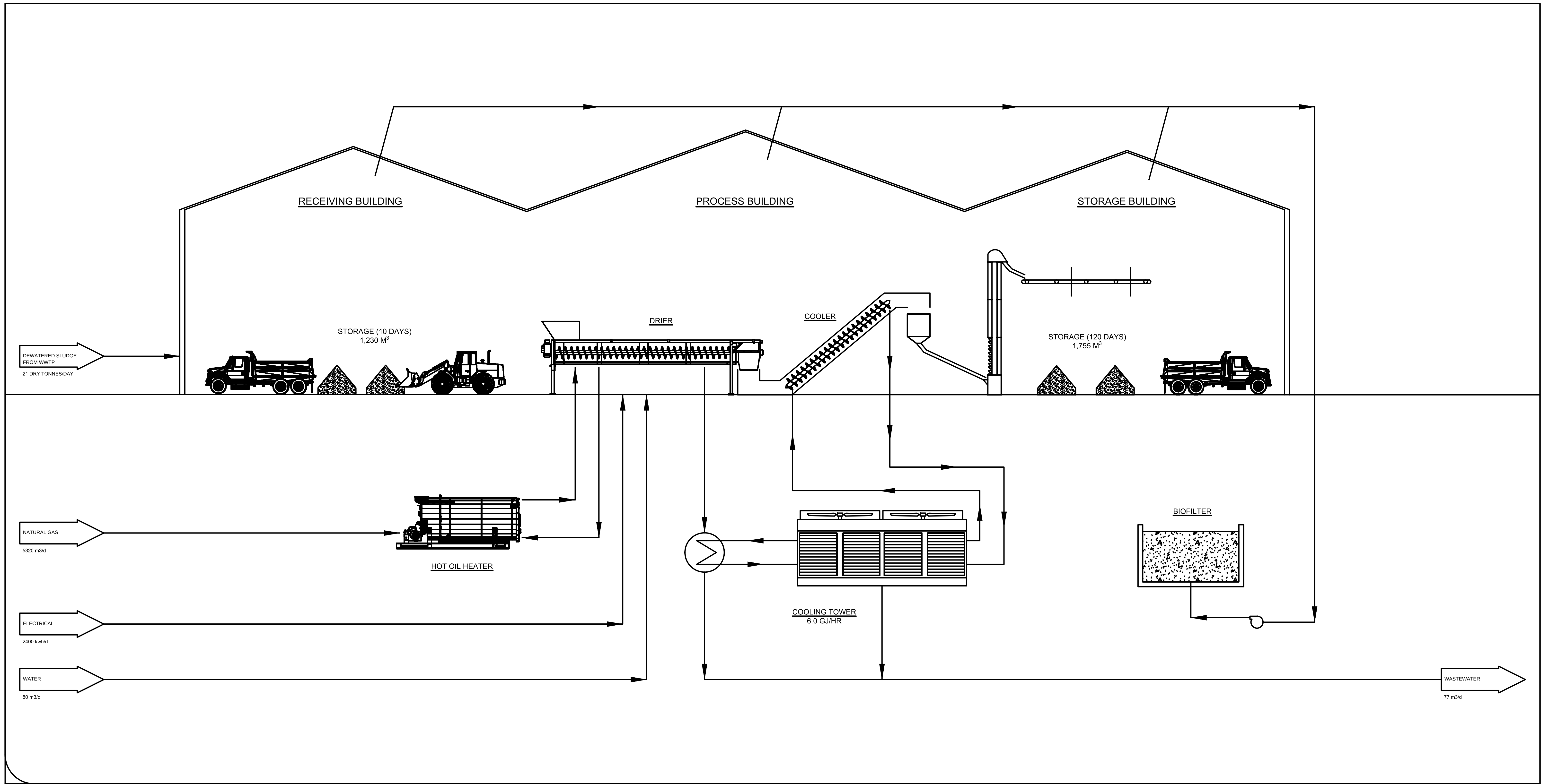
The following sections describe the construction of a decentralized process for managing biosolids. Construction of decentralized facilities is assumed to be similar in approach to construction of a single centralized facility for each alternative as described in Section 4.2. Decentralized facilities may be co-located with existing facilities, with the option for sharing some site components to reduce costs, but this has not been assumed at the present time to allow for more flexibility in siting.

It is assumed that in the case of all but the smallest decentralized facility (in the vicinity of the Ayr WWTP) incoming biosolids feed quality would remain consistent with the centralized facility alternative. The decentralized facility in the vicinity of

ALTERNATIVE 3: PRODUCE DRIED LOW VOLUME FERTILIZER FROM BIOSOLIDS

Ayr WWTP includes additional liquid storage and dewatering to allow processing of liquid sludge from small facilities without dewatering capabilities.

A diagram depicting the main components of a representative decentralized including major mass flows and utility demands is provided in **Figure 8**. A two-dimensional layout for a decentralized facility is shown on **Figure GA6**.



BIOSOLIDS MASTER PLAN

**ALTERNATIVE 3
DECENTRALIZED BIOSOLIDS DRYING
KITCHENER
FIGURE 8**

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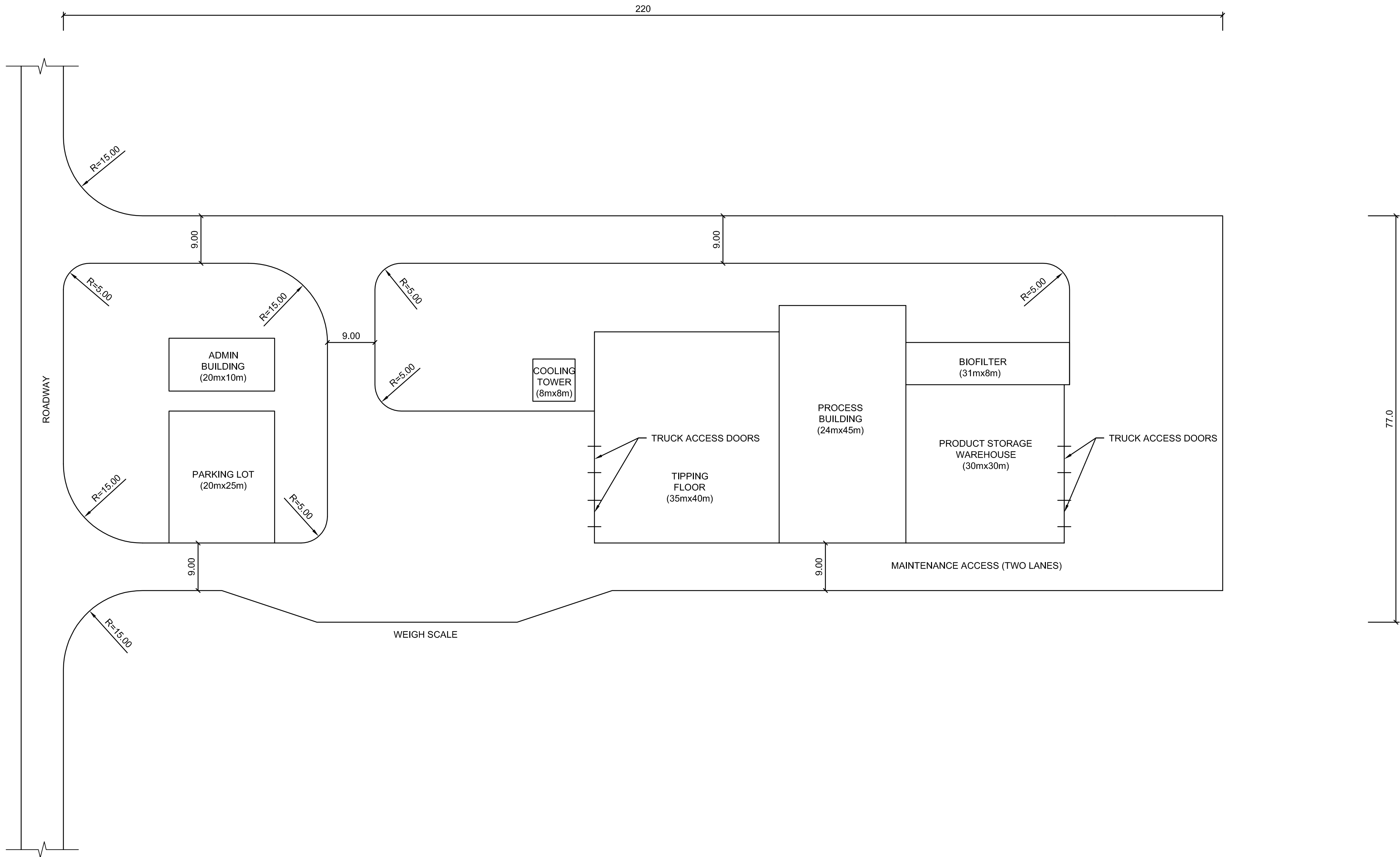
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BIOSOLIDS FACILITY	PROJECT NO. 15-2281
CONCEPTUAL GENERAL ARRANGEMENT ALTERNATIVE 3 PRODUCE DRY FERTILIZER - WATERLOO (DECENTRALIZED)	SHEET NO. GA6

Internal Transfers and Trucking

Internal transfers of biosolids through a decentralized process are simplified relative to the centralized facility concept described in Section 4.0 with the following key differences:

- All biosolids produced at facilities in the vicinity of existing WWTPs (Kitchener WWTP, Waterloo WWTP, Galt WWTP and Ayr WWTP) are assumed to require near zero VKMT for transport prior to processing due to co-location at or near existing WWTPs
- Internal transfer allowances are made for transport of biosolids from Preston WWTP to Galt WWTP
- Internal transfer allowance is made for transport of small facilities to Ayr WWTP.
- It is assumed in the decentralized facility concept that the facility in the vicinity of Ayr will receive all inter-facility transport aside from material originating at Preston WWTP

Transfers are assumed using the following truck sizes:

- Transfer of liquid biosolids from small facilities: 18m³ truck
- Transfer of liquid biosolids from large facilities for dewatering (e.g. Preston to Galt): 43m³ truck
- Internal transfer of dewatered biosolids between facilities, or transfer of final product to end use using a 35-tonne truck, with a volume of up to 70m³

The sizes of trucks for each type of transportation have been established from the Region's existing practices, or the practices of 3rd party management companies.

Biosolids produced by the alternative will be transported by truck to an end-use location. Responsibility for providing trucking may be assigned to end-users or

ALTERNATIVE 3: PRODUCE DRIED LOW VOLUME FERTILIZER FROM BIOSOLIDS

facility operators. The distance to end-use has been established independently for each decentralized facility based on the relative distance between the nearby WWTP and the assumed end-use location.

Total trucking requirements for the decentralized biosolids drying alternative are summarized in **Table D-5**.

ALTERNATIVE 3: PRODUCE DRIED LOW VOLUME FERTILIZER FROM BIOSOLIDS

Table D-5: Alternative 3 Decentralized Transportation Distance Summary

Trucking Source / WWTP	Amount Dry Biosolids (kg/d)	Solids Content of Biosolids	Mass of Wet Biosolids (kg/d)	Trucks Per Day	Trucking Destination	Round-Trip Trucking Distance (Km/Trip)	Total Vehicle Kilometers Traveled (Km/Year)
Internal Transfer of Biosolids for Dewatering and Processing							
Preston	1,914	3%	76,560	1.78	Galt	20	13,000
St. Jacobs	165	2%	8,250	0.46	Ayr	96	16,195
Wellesley	187	2%	9,350	0.52	Ayr	80	15,276
Heidelberg	13	2%	660	0.04	Ayr	88	1,226
Conestogo	8	2%	385	0.02	Ayr	95	760
Foxboro	17	2%	825	0.05	Ayr	75	1,282
Hespeler	1,023	1%	127,875	7.10	Ayr	59	153,046
New Hamburg	880	2%	48,889	2.72	Ayr	66	65,472
Elmira	2,882	25%	11,528	0.64	Ayr	105	24,523
						Subtotal Distance	290,781
External Transfer of Process Biosolids to End-Use							
Ayr	5,570	90%	6,308	0.18	Land Application	280	18,200
Waterloo	11,924	90%	13,504	0.38	Land Application	240	33,360
Kitchener	21,043	90%	23,831	0.67	Land Application	280	68,320
Galt	12,837	90%	14,538	0.41	Land Application	275	40,975
						Total Distance	451,636

ALTERNATIVE 3: PRODUCE DRIED LOW VOLUME FERTILIZER FROM BIOSOLIDS

Costs for trucking have been estimated using standard transportation costs available from existing transportation of biosolids within the region. The following costs have been estimated from existing contracts, considering distance travelled and cost per tonne transported.

- Large volume liquid sludge transfer: \$0.2/km/tonne
- Small volume liquid sludge transfer: \$0.11/km/tonne
- Cake transfer, or product transfer to end use: \$0.17/km/tonne

Table D-6 presents the total annual trucking cost for the decentralized biosolids drying alternative:

ALTERNATIVE 3: PRODUCE DRIED LOW VOLUME FERTILIZER FROM BIOSOLIDS

Table D-6: Alternative 3 Decentralized Layout - Transportation Cost Summary

Contract	Type	Rate (\$/Tonne or \$/m3)	From	To	Tonnes/year 2051	km per load	\$/Year 2051
Preston Sludge	Transfer	\$0.20	Preston	Galt	27,944	20.00	\$110,939
Aerobic Sludge Management	Transfers	\$0.11	St. Jacobs	Ayr	3,011	96.40	\$33,214
			Wellesley	Ayr	3,413	80.40	\$31,395
			Heidelberg	Ayr	241	87.60	\$2,415
			Conestogo	Ayr	141	95.00	\$1,527
			Foxboro	Ayr	301	75.40	\$2,598
			Hespeler	Ayr	46,674	59.00	\$315,085
			New Hamburg	Ayr	17,844	66.00	\$134,755
			Elmira	Ayr	4,208	104.80	\$50,455
Cake Management	Product Transfer	\$0.17	Ayr	Land Application	2,259	280.00	\$107,533
			Waterloo	Land Application	4,836	240.00	\$197,302
			Kitchener	Land Application	8,534	280.00	\$406,223
			Galt	Land Application	5,206	275.00	\$243,386
						Total Cost	\$1,636,827

Greenhouse Gas Analysis Summary

A summary of CO₂ Emissions Equivalents calculated using the BEAM model for decentralized thermal drying is presented below.

Table D-7: Greenhouse Gas Analysis Summary - Thermal Drying Decentralized Layout –

Unit Processes & Inputs	CO2 Emissions Equivalents (tonnes/year)
Natural gas use for processing and building heating	11,332
Electricity use in thermal drying and building demands	180
Transportation	589
CO2 equivalents	12,102

2600 cars (EPA calculator)

Assumptions:

- Based upon all dry mass of biosolids dewatered to 25% solids, and thermal drying to 90% solids
- BEAM Default natural gas and electricity demands were used for processing emissions
 - o Refinements based upon inputs from vendor for energy use could be considered
 - o Electricity for building demands is derived from a unit-area-based estimate for typical utility consumption.

Alternative Costing

The cost of implementation has been evaluated considering the components described in Section 4.0. Costing for decentralized alternatives presented below represent the total system-wide implementation of all four decentralized facilities.

Capital Cost

Capital costs include the following:

- Capital equipment purchase
- Site preparation
- Construction of process buildings and site roadways
- Building services and supporting equipment

Capital purchases include installation markups of between 0% and 20% per item. Standard subcontractor and general contractor markups of 15% and 5% respectively have been considered where appropriate. In addition to the total “direct” cost of construction, standard “indirect” markups have been included to reflect the assumed actual cost of implementation, and uncertainty at this level of design.

Operating Cost

Operating costs have been established for each of the four decentralized facilities considering the individual components described in Section 4.0. Operating costs are represented as the sum of all four decentralized facilities for the biosolids drying alternative.

Life Cycle Cost

Life cycle costing was established 2018 dollars to allow comparison overall costs associated with each alternative. Life cycle costing was completed with the following assumptions:

ALTERNATIVE 3: PRODUCE DRIED LOW VOLUME FERTILIZER FROM BIOSOLIDS

- 4% Net Present Value Discount Rate
- 2% Annual inflation for costs associated with labour, capital expenditures and consumables
- 5% annual inflation associated with electricity costs
- 2023 construction date for the alternative, with capital expenditure for this
- Consideration for end-of-life replacement of equipment
- Consideration of trucking costs

Lifecycle costing estimates have been developed to provide a consistent basis for comparison of technologies, with consideration given to the impact of annual operating cost on the overall cost of implementing each alternative. The construction date, interest rates and operating costs may be refined through further design.

ALTERNATIVE 3: PRODUCE DRIED LOW VOLUME FERTILIZER FROM BIOSOLIDS

Table D-8 Life Cycle Cost Estimate – Alternative 3 Decentralized Layout (All Facilities Combined Cost)

No.	Item description	Estimated Cost
1.	Capital Cost	\$136,700,000
2.	Bundled Servicing*	\$46,400,000
3.	Chemical Consumption	\$7,000,000
4.	Average Equipment Replacement	\$63,600,000
5.	Routine Maintenance	\$7,700,000
6.	Labour	\$46,900,000
7.	Trucking Cost	\$25,800,000
Total Life Cycle Cost		\$334,100,000
*Note: Related to utility consumption and waste disposal only, servicing of a greenfield site not included.		

Appendix D
Alternative 4:
Thermal Reduction
to Ash

1.0 Description

This alternative would implement a thermal reduction technology to reduce the dewatered biosolids feedstock to ash for use as an industrial input, or disposal in landfill. Energy recovered from the process would be used to preheat combustion air to limit the amount of supplementary fuel required. This technology is capable of handling dry cake and, to a limited extent, liquid feedstock.

The thermal reduction technology would be implemented after digestion and existing dewatering. This technology would produce the lowest mass and volume end product. The ash product generated by this technology would be quenched with cooling water and sent to the ash dewatering step. A dewatering process such as outdoor geotextile bags will be used to dewater the ash to 50% moisture content.

Thermal reduction produces an ash with no organic content. The ash will retain any phosphorus and metals that were present in the dewatered biosolids. All nitrogen is lost in the thermal reduction process.

2.0 End Use Summary

Thermal reduction will produce a dewatered ash product. This alternative would provide the following end use or disposal options:

- Use as an industrial input such as feedstock for cement production; or
- Landfill disposal at approved sites.

This alternative does not take advantage of the nutrient value of the biosolids. The energy content of biosolids is used in combustion, but supplementary fuel is also required to maintain combustion temperatures given the moisture and volatile solids content of the current biosolids product. Reduction of organics and the retention of metals will cause the concentration of metal in the ash to be

significantly greater than in the dewatered biosolids. This will likely require landfill disposal for the ash.

3.0 Alignment with Review Objectives

3.1 Alignment with Existing Biosolids Infrastructure

The “Thermal Reduction to Ash” alternative has been reviewed for alignment with existing infrastructure within the Region.

- Alternative is compatible with existing infrastructure. Process uses existing dewatering equipment. Thermal reduction of biosolids drying reduces biosolids mass by removing water and organic material.
- Process is capable of accepting dry cake or liquid feedstock without modification needed to the processing prior to dewatering. Thermal reduction unit will use existing dewatered biosolids.
- In general, electricity is required to operate facility processes and natural gas is required as thermal input.
- Utility requirements for a centralized thermal reduction facility are provided below:
 - o Electrical Utility: 19,200 kWh/d
 - o Water Service: 55 m³/day
 - o NG Service: 881 GJ/day
 - o WW Utility: 50 m³/day

3.2 Protection of Natural Environment

Benefits of ash product include:

- No use of land for end use, and therefore no related risks
- No change from current practice regarding impact on surface water quality
- Reduced impact on air quality through decreased odour release from stabilized product

The thermal reduction facility will be a net consumer of energy as described above. This alternative is the largest consumer of electricity and natural gas.

Trucked volume is described in detail below for the thermal reduction alternative, including the total range of vehicle kilometers travelled. Biosolids thermal reduction will result in a reduced volume by removing all organics and volatile inorganics from the final product.

3.3 Protection of Quality of Life

- Ash has significantly reduced odor potential compared to wet biosolids. Odour is controlled by installing all equipment in buildings and maintaining negative pressure in buildings. All captured air is treated in a biofilter.
- Processes are typically fully enclosed in buildings. Process may be configured without large visible stacks / cooling towers depending on final design and air dispersion requirements and should have minimal visual/aesthetic impact
- Thermal reduction process generates a product that has less volume than incoming feedstock. Reduction in trucking volume results in a decrease in total number of vehicle kilometers travelled. Trucking is summarized quantitatively in the sections below.
- Noise mitigation – all equipment in buildings with engineering controls in place to mitigate off site impacts

3.4 Protection of Health and Safety

- Engineering controls will consist of forced ventilation and a biofilter for odour and dust control. Piping insulation will be used for protection from exhaust piping. Quench water reduces the temperature of the ash. Operators of processes are anticipated to require PPE for safety, particularly those individual working in the vicinity of the incinerator unit.
- Ash product material is stable with relatively little risk to public in the event of a spill or other such event

4.0 Technology Implementation

4.1 System Components

This technology would be implemented with the following components:

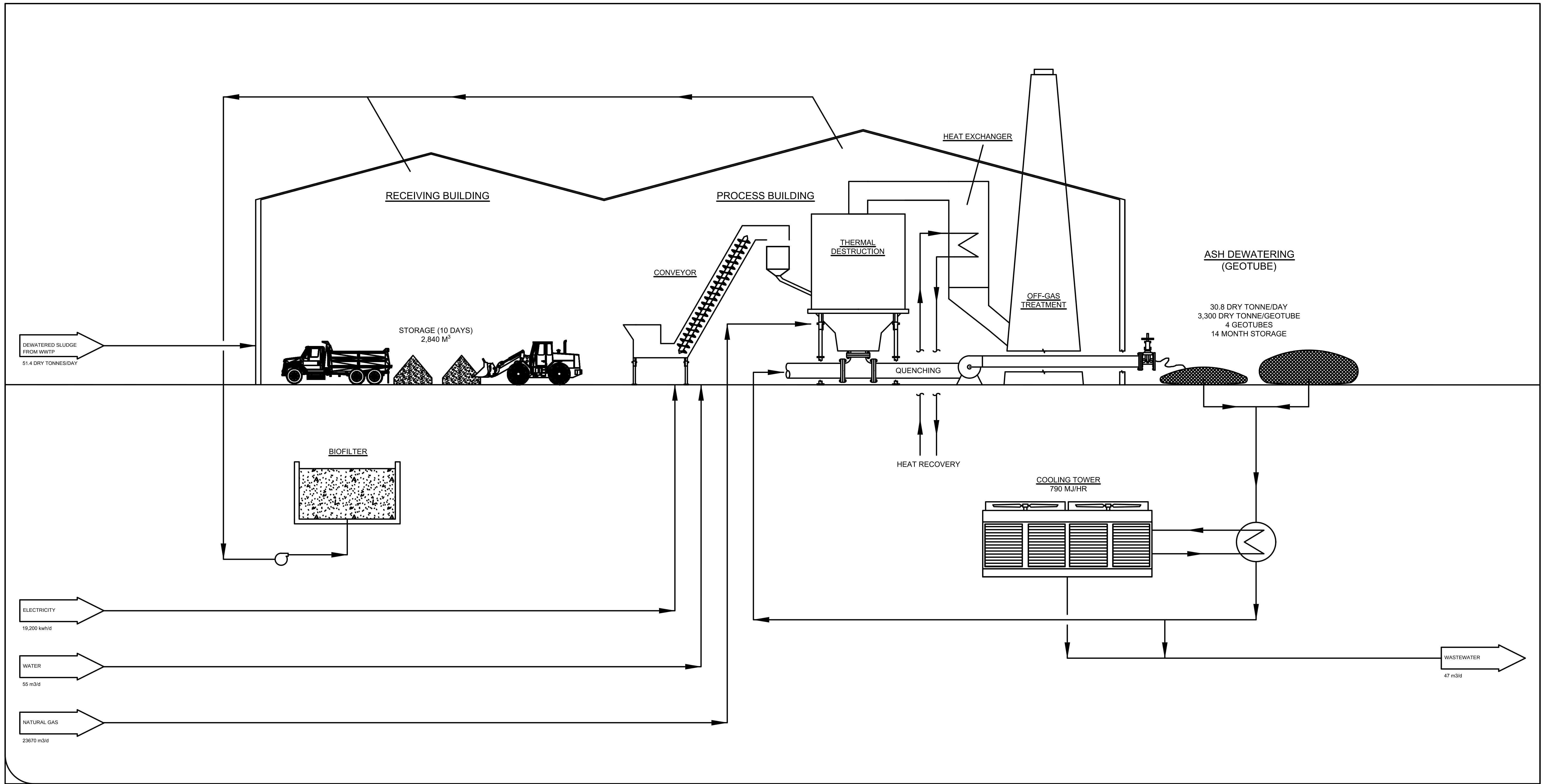
- Administration and operations facilities
- Site servicing and roadway access
- Product receiving facilities
- Short term (10-day) operational storage of dewatered cake feedstock
- Biosolids thermal reduction technology
- Off gas treatment
- Cooling tower
- Geotubes with 6+ months of storage in the tubes
- Odour mitigation (containment within buildings and treatment through dedicated facilities such as biofilters)

Implementation of the alternative will be considered at a one (1) location for processing all biosolids generated within the Region.

The configuration and associated costs presented in the sections that follow assume a new stand-alone thermal reduction facility; however the size of facility required and product storage requirements are more likely to allow co-location with one existing facility. Construction of the new process may be considered with some or all components co-located with existing WWTPs or located at a new site. Site area constraints may limit the construction of storage at existing WWTPs, while co-location may allow some existing infrastructure such as site access, servicing, administration and product receiving currently present to be integrated the new biosolids process.

4.2 Centralized System Configuration

The following sections describe the construction of a centralized thermal reduction facility for managing biosolids. A block-flow diagram depicting the main components of the alternative along with a preliminary summary of mass flows and utility demands is provided in **Figure 9**. A two-dimensional layout of the facility configuration is provided in **Figure GA7**.



BIOSOLIDS MASTER PLAN

**ALTERNATIVE 4
THERMAL DESTRUCTION BIOSOLIDS**
FIGURE 9

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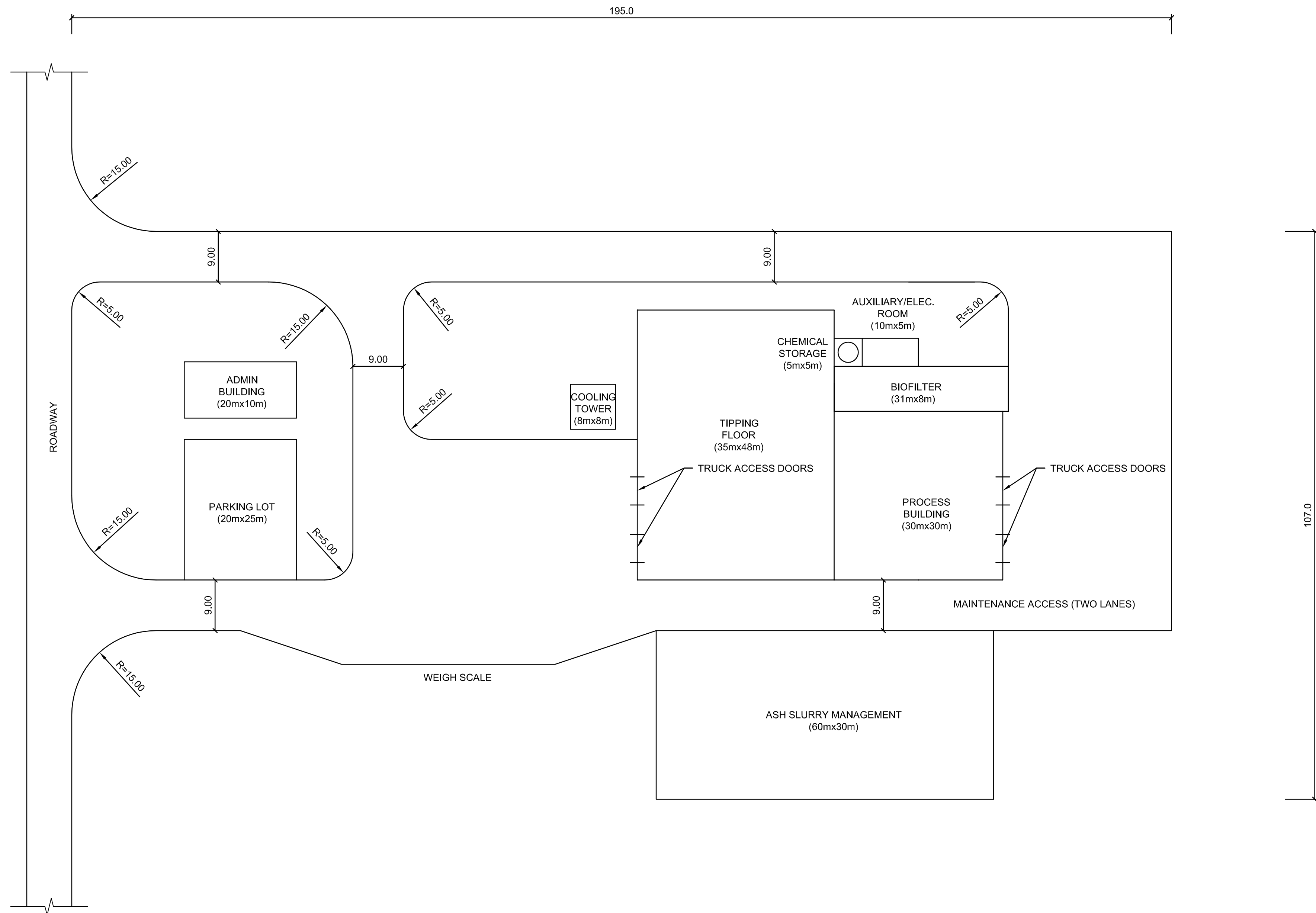
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BIOSOLIDS FACILITY

**CONCEPTUAL GENERAL ARRANGEMENT
ALTERNATIVE 4
THERMAL REDUCTION
(CENTRALIZED)**

PROJECT NO.
15-2281

SHEET NO.

GA7

Internal Transfers and Trucking

The requirement for internal transfers and trucking required to move biosolids from producing WWTPs to processing facilities and from processing facilities to end-use has been considered. Internal transfer of biosolids is assumed to achieve dewatering of biosolids from facilities with existing liquid biosolids treatment processes.

Internal transfers of biosolids are required to transport dewatered biosolids cake produced at large facilities, including material previously received from small facilities, to a centralized biosolids processing location. The estimated trucking requirements to transport material from large facilities to a hypothetical centralized facility are shown below. The centralized facility distance represents an average distance from the urban centre of the city to the region boundary and is used for high-level comparative purposes only.

Transfers are assumed using the following truck sizes:

- Transfer of liquid biosolids from small facilities: 18m³ truck
- Transfer of liquid biosolids from large facilities for dewatering: 43m³ truck
- Internal transfer of dewatered biosolids between facilities, or transfer of final product to end use using a 35-tonne truck, with a volume of up to 70m³

The size of trucks for each type of transportation has been established from the Region's existing practices, or the practices of 3rd party management companies.

Ash produced by the drying technology will be transported by truck to an end-use location. End use disposal locations are assumed based on the average of known distances to available land reclamation sites or landfills and a median distance to current agricultural land application. Responsibility for providing trucking may be

ALTERNATIVE 4 THERMAL REDUCTION TO ASH

assigned to end-users or facility operators. Total vehicle kilometers to end use are summarized below. Trucking requirements are estimated based on the following product volumes. It is assumed for the purposes of this assessment that feedstock has a density of one tonne per cubic meter, and that dried product has a density of 1.6 tonnes per cubic meter.

The mass of internal transfers between facilities and to end use, the total truck trips and total vehicle kilometers travelled are summarized in **Table E-1** below. Daily truck trips are presented as the average value on an annual mass loading basis. Actual numbers of trucks per day may vary, particularly for transportation stages where less than one full truck per day is required.

ALTERNATIVE 4 THERMAL REDUCTION TO ASH

Table E-1: Alternative 4 Centralized Layout - Transportation Distance Summary

Trucking Source / WWTP	Amount Dry Biosolids	Solids Content of Biosolids	Mass of Wet Biosolids	Trucks Per Day	Trucking Destination	Round-Trip Trucking Distance	Total Vehicle Kilometers Traveled
	(kg/d)		(kg/d)			(Km/Trip)	(Km/Year)
Internal Transfer of Biosolids for Dewatering							
St. Jacobs	165	2%	8,250	0.46	Waterloo	20	3,360
Wellesley	187	2%	9,350	0.52	Waterloo	45	8,550
Heidelberg	13	2%	660	0.04	Waterloo	30	420
Conestogo	8	2%	385	0.02	Waterloo	25	200
Foxboro	17	2%	825	0.05	Waterloo	65	1,105
Preston	1,914	3%	76,560	1.78	Galt	20	13,000
Hespeler	1,023	1%	127,875	7.10	Kitchener	30	77,820
New Hamburg	880	2%	48,889	2.72	Kitchener	48	47,616
Ayr	396	5%	8,426	0.47	Kitchener	46	7,866
Subtotal Distance							159,937
Internal Transfer of Dewatered Biosolids for Processing							
Elmira	2,882	25%	11,528	0.64	Central Processing Location	61	14,157
Waterloo	12,313	25%	49,254	1.15		42	17,598
Kitchener	23,342	25%	93,368	2.17		47	37,271
Galt	12,837	25%	51,348	1.19		53	22,890
Subtotal Distance							91,916
External Transfer of Process Biosolids to End-Use							
Central Processing Location	51,374	NA	61,649	1.76	Landfill	338	217,334
Total Distance							469,187

ALTERNATIVE 4 THERMAL REDUCTION TO ASH

Costs for trucking have been estimated using standard transportation costs available from existing transportation of biosolids within the region. The following costs have been estimated existing contracts, considering distance travelled and cost per tonne transported.

- Large volume liquid sludge transfer: \$0.2/km/tonne
- Small volume liquid sludge transfer: \$0.11/km/tonne
- Cake transfer, or product transfer to end use: \$0.17/km/tonne

Table E-2 presents the total annual trucking.

ALTERNATIVE 4 THERMAL REDUCTION TO ASH

Table E-2: Alternative 4 Centralized Layout - Transportation Cost Summary

Contract	Type	Rate (\$/Tonne or \$/m3)	From	To	Tonnes/year 2051	Km per load	\$/Year 2051
Preston Sludge	Liquid Transfer	\$0.20	Preston	Galt	27,944	20.00	\$110,939
Aerobic Sludge Management	Liquid Transfer	\$0.11	St. Jacobs	Waterloo	3,011	20.00	\$6,891
			Wellesley	Waterloo	3,413	45.00	\$17,572
			Heidelberg	Waterloo	241	30.00	\$827
			Conestogo	Waterloo	141	25.00	\$402
			Foxboro	Waterloo	301	65.00	\$2,240
			Hespeler	Kitchener	46,674	30.00	\$160,213
			New Hamburg	Kitchener	17,844	48.00	\$98,003
Cake Management	Cake Transfer	\$0.17	Ayr	Kitchener	3,075	46.00	\$16,186
			Elmira	Central Location	4,208	60.50	\$43,276
			Waterloo	Central Location	17,978	42.00	\$128,360
			Kitchener	Central Location	34,079	47.00	\$272,294
			Galt	Central Location	18,742	52.50	\$167,273
Cake Management	Product Transfer	\$0.17	Central Location	Landfill	22,502	338.00	\$1,292,964
						Total Cost	\$2,317,439

Greenhouse Gas Analysis Summary

A summary of CO₂ Emissions Equivalents calculated using the BEAM model for centralized thermal reduction is presented below.

Table E-3: Greenhouse Gas Analysis Summary - Thermal Reduction Centralized Layout –

Unit Processes & Inputs	CO2 Emissions Equivalents (tonnes/year)
Natural gas use for processing and building heating	17,537
Electricity use in thermal reduction and building demands	310
Methane released	19
Nitrous oxide released	12,976
Transportation	626
CO2 equivalents	31,469

6700 Cars (EPA calculator)

Assumptions:

- The type of incinerator used in the model is fluidized bed incinerator
- Thermal reduction is based upon 25% solids content
- Biomass combustion emissions are not included in total CO₂ equivalents
- Sludge is digested prior to thermal reduction
- Total nitrogen and total phosphorus contents are default inputs at 5% and 1.9% respectively
- Electricity for building demands is derived from a unit-area-based estimate for typical utility consumption
- Natural gas for product thermal reduction and building heating combined has been incorporated as 497 m³ natural gas per dry tonne biosolids processed based upon vendor input

Alternative Costing

The cost of implementation for a centralized system producing dried low volume fertilizer has been evaluated, considering the equipment cost, site construction cost associated with the components listed in Section 4.1, and operating and maintenance costs. Costs were established through input from equipment vendors, standard unit pricing and Dillon's professional experience.

Capital Cost

Capital costing has been developed for each alternative. Costs consider the following:

- Capital equipment purchase
- Site preparation
- Construction of process buildings and site roadways
- Building services and supporting equipment

Capital purchases include installation markups of between 0 %and 20% per item. Standard subcontractor and general contractor markups of 15% and 5% respectively have been considered where appropriate. In addition to the total "direct" cost of construction, standard "indirect" markups have been included to reflect the assumed actual cost of implementation, and uncertainty at this level of design

Capital cost for the thermal reduction alternative is summarized below:

Operating Cost

Operating costs have been established for the alternative. Where possible, costs have been estimated using technology specific utility consumptions and operating

ALTERNATIVE 4 THERMAL REDUCTION TO ASH

requirements based on discussions with vendors. Preliminary operating cost estimates are established primarily to demonstrate the relative cost to operate different process equipment alternatives. Additional operating costs associated with staff facilities are anticipated to be minor, and would be established based on the following:

- Electrical utility costs
 - Water utility costs
 - Natural gas cost for process equipment and building heating
 - Allowance for routine maintenance and spare parts (typically 1% or equipment value per year)
 - Operations staff costs. We have assumed that each facility alternative would require a complement of five full time equivalents
- Trucking costs associated with this alternative are summarized separately in the preceding sections. An additional cost associated with the periodic end-of-life replacement of capital equipment has been considered. This is not shown as part of the annual operating costs but is carried in the life cycle costing of each alternative.

Operating costs for the thermal reduction alternative are presented below:

Life Cycle Cost

Life cycle costing was established 2018 dollars to allow comparison overall costs associated with the alternative. Life cycle costing was completed with the following assumptions:

- 4% Net Present Value Discount Rate
- 2% Annual inflation for costs associated with labour, capital expenditures and consumables
- 5% annual inflation associated with electricity costs

ALTERNATIVE 4 THERMAL REDUCTION TO ASH

- 2023 construction date for the alternative, with capital expenditure for this
- Consideration for end-of-life replacement of equipment
- Consideration of trucking costs

Lifecycle costing estimates have been developed to provide a consistent basis for comparison of technologies, with consideration given to the impact of annual operating cost on the overall cost of implementing each alternative. The construction date, interest rates and operating costs may be refined through further design.

The following life cycle costs were established:

Table E-4: Life Cycle Cost Estimate - Alternative 4 Centralized Layout

No.	Item description	Estimated Cost
1.	Capital Cost	\$110,200,000
2.	Bundled Servicing*	\$62,700,000
3.	Chemical Consumption	\$2,500,000
4.	Average Equipment Replacement	\$45,900,000
5.	Routine Maintenance	\$10,200,000
6.	Labour	\$11,700,000
7.	Trucking Cost	\$36,100,000
Total Life Cycle Cost		\$279,300,000
*Note: Related to utility consumption and waste disposal only, servicing of a greenfield site not included.		

Appendix F

Detailed Evaluation Matrix

For Alternatives 1 and 3, cells are merged to indicate criteria is unaffected by location of alternative – same evaluation result for both centralized and decentralized options.

	CRITERIA	INDICATORS	Alternative 1 - Produce Fertilizer		Alternative 2 - Produce Compost	Alternative 3 - Produce Dried, Low Volume Fertilizer		Alternative 4 - Thermal Reduction to Ash
			Centralized Implementation	Decentralized Implementation		Centralized Implementation	Decentralized Implementation	
1	Alignment with Existing Biosolids Infrastructure and Management							
1.1	How compatible is the alternative with existing Regional wastewater and biosolids processing infrastructure?	Degree to which the alternative allows or facilitates energy recovery as biogas using existing anaerobic digestion and combined heat and power infrastructure.	Hydrolysis ahead of anaerobic digestion enhances biogas generation but is not considered for installation in this configuration. All other fertilizer technologies maintain current biogas collection volumes.		Maintains current biogas collection volume.	Maintains current biogas collection volume.		Maintains current biogas collection volumes
		What is the feasibility of locating the facility at or adjacent to an existing WWTP?	Low feasibility – Necessary footprint for storage unlikely to allow facility to be located adjacent to existing WWTPs.	Feasible – Facilities could be sited at Waterloo and Galt. Additional property required at Kitchener facility.	Low feasibility – Size of footprint unlikely to allow co-location of facility	Moderate feasibility – Size required for process and storage of centralized facility may be difficult to co-locate with an existing facility particularly at the Galt and Waterloo facilities.	Feasible – Facilities could be sited at Waterloo and Galt. Additional property required at Kitchener facility.	Feasible – Regional facility could be sited at Waterloo or Galt. Additional property required at Kitchener Facility.
		Does the alternative use existing dewatering equipment?	Yes, however hydrolysis process does not make optimal use of existing dewatering capabilities.		Yes	Yes		Yes
		Does the alternative use existing WWTP solids product without needing to modify process prior to dewatering?	Technology is compatible with existing WWTP processes. Hydrolysis after dewatering is not optimal to make use of existing dewatering component of current facilities in existing configuration as solids content would need to be reduced through re-addition of water.		Technology is compatible with existing WWTP processes	Technology is compatible with existing WWTP processes; dryer will use dewatered biosolids after digestion.		Technology is compatible with existing WWTP processes; thermal reduction unit will use dewatered biosolids after AD treatment.
1.2	How much new supporting municipal infrastructure is required (e.g. roads, power and water services, etc.)?	Relative extent of new services required related to: Water	29 – 137 m³/day	115 – 125 m³/d	115 m³/d	195 m³/day		55 m³/day
		Relative extent of new services required related to: Natural gas	183 – 188 GJ/day	195 – 200 GJ/day	162 GJ/day	483 GJ/day	484 GJ/day	881 GJ/day
		Relative extent of new services required related to: Electrical service	8,900 – 10,400 kWh/d	9,500 – 12,600 kWh/d	27,800 kWh/d	4,800 kWh/d	5,860 kWh/d	19,200 kWh/d
		Relative extent of new services required related to: Roads	Offsite roadway requirements consistent with other technology alternatives		Offsite roadway requirements consistent with other technology alternatives	Offsite roadway requirements consistent with other technology alternatives		Offsite roadway requirements consistent with other technology alternatives

	CRITERIA	INDICATORS	Alternative 1 - Produce Fertilizer		Alternative 2 - Produce Compost	Alternative 3 - Produce Dried, Low Volume Fertilizer		Alternative 4 - Thermal Reduction to Ash
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		Relative extent of new services required related to: Non-contact cooling infrastructure	Cooling infrastructure not required		Cooling infrastructure not required	Cooling tower required		Cooling tower required
		Relative extent of new services required related to: Sanitary sewer	29 m³/d	115 m³/d	108 m³/d	188 m³/day		47 m³/day
		Relative extent of new services required related to: Solid waste	No new waste stream created.		No new waste stream created.	No new waste stream created.		Ash produced represents new waste stream. Approximately 62 wet tonnes of waste/day is projected at 2051 ultimate loading
1.3	What is the potential for aligning with other municipal initiatives in the future?	Degree of synergies with other Region processes and facilities	No current opportunities for synergies with solid waste management. Planning will be revisited in 2019.		No current opportunities for synergies with solid waste management. Planning will be revisited in 2019	No current opportunities for synergies with solid waste management. Potential for co-incineration of pellets with solid waste. Planning will be revisited in 2019		Municipal solid waste feedstock could be incorporated in the future.
		Is there a defined beneficial use opportunity for the end product?	Yes		Yes	Yes		No
1.4	How flexible is the alternative in adapting to changing government regulations, policies and market demands?	Vulnerability over the next 10 years, or over the full planning period to 2051, to a change in: Agricultural policy	Technology represents a "best practice" approach in agriculture that is anticipated to be in line with current and future policy.		Technology represents a "best practices" approach that is anticipated to be in line with current and future policy.	Technology represents a "best practices" approach that is anticipated to be in line with current and future policy.		N/A
		Vulnerability over the next 10 years to a change in: Markets for biosolids derived agricultural products	Anticipated to be a preferred product by market. Some vulnerability to competition from other fertilizers, or demand for specific nutrient content.		Anticipated to be a preferred product by market. Some vulnerability to competition from other compost sources and market demands.	Anticipated to be a preferred product by market. Some vulnerability to competition from other fertilizers, or demand for specific nutrient content.		N/A
		Vulnerability over the next 10 years to a change in: Industrial demand for inputs	Unknown industrial demand		Unknown industrial demand	Potential demand from greenhouse operations or for a fuel source		Potential demand from cement manufacturing

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		Vulnerability over the next 10 years, or over the full planning period to 2051, to a change in: Process related air quality restrictions	Air emissions from alternative are minimal and unlikely to be affected by changing regulations.		Air emissions from alternative are minimal and unlikely to be affected by changing regulations.	Air emissions from alternative are minimal and unlikely to be affected by changing regulations.		Alternative would be designed to meet current regulations. Changes to regulations may require upgrades.
		Vulnerability over the next 10 years, or over the full planning period to 2051, to a change in: Landfill or solid waste policy	Landfill policy changes unlikely to affect alternative.		Landfill policy changes unlikely to affect alternative.	Landfill policy changes unlikely to affect alternative.		Landfill policy changes unlikely to affect alternative.
		Vulnerability over the next 10 years, or over the full planning period to 2051, to a change in: Land reclamation policy	Land reclamation policy change unlikely to affect alternative.		Land reclamation policy change unlikely to affect alternative.	Land reclamation policy change unlikely to affect alternative		N/A
1.5	Does the alternative allow us to accommodate future population growth?	Degree to which the alternative is capable of being implemented in phases	Phasing is possible.		Phasing may be possible depending on composting process selected.	Dryers could be installed in phases		Phased implementation not possible, single full scale unit needed initially.
		Can the process operate efficiently at initial loading (turn-down)?	Facility may be run for less time initially when loading is lower		Turn-down is possible by having fewer vessels in operation, or longer residence times may be considered.	Turn-down is possible based on multiple units or phased installation		Turn-down is possible although energy efficiency is reduced
		Flexibility in adapting to differential population growth that is higher than estimated between WWTPs	Flexible to population growth. Intermittent equipment operation frequency may be increased to provide additional capacity.		Flexible to population growth. System is designed to operate continuously and may require expansion if maximum capacity is exceeded.	Flexible to population growth		Not flexible to population growth
		Flexibility to future expansion requirements after 2051	Facility may be able to accommodate higher throughput through increased system uptime if required post-2051		Tunnel or vessel based process could potentially be expanded over time; sizing is specific to population and loading estimates.	Can be designed with space for an additional unit(s).		Can be designed with space for an additional unit(s).

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2	Protect the Natural Environment							
2.1	What are the environmental effects of the facility?	Risks and concerns related to: Soil quality	Low risk: Potential for leakage from liquid containing process vessels, secondary containment may be required.	Very low risk: unlikely for future adverse impact on environment.	Very low risk: unlikely for future adverse impact on environment.	Very low risk: unlikely for future adverse impact on environment.		
		Risks and concerns related to: Groundwater quality	Low risk: Potential for leakage from liquid containing process vessels is a risk to groundwater contamination, secondary containment may be required.	Very low risk: unlikely for future adverse impact on environment.	Very low risk: unlikely for future adverse impact on environment	Low risk: Potential for leakage from dewatering of ash slurry is a risk to groundwater contamination, secondary containment may be required.		
		Risks and concerns related to: Surface water quality	Very low risk: All runoff to be contained and managed within facilities or on impermeable areas. All liquid waste discharges to sewer.	Very low risk: All runoff to be contained and managed within facilities or on impermeable areas. All liquid waste discharges to sewer	Very low risk: All runoff to be contained and managed within facilities or on impermeable areas. All liquid waste discharges to sewer	Very low risk: All runoff to be contained and managed within facilities or on impermeable areas. All liquid waste discharges to sewer		
		Risks and concerns related to: Ambient air quality	Moderate risk: Odour control must be managed through appropriate mitigation. Some risk of odour release during raw feedstock receiving and product distribution mitigated through building enclosures.	Moderate risk: Odour control must be managed through appropriate mitigation. Some risk of odour release during raw feedstock receiving and product distribution mitigated through building enclosures.	Low risk: Odour control must be managed through appropriate mitigation. Some risk of odour release during raw feedstock receiving and product distribution mitigated through building enclosures. Dry product anticipated to have limited odour release.	Low risk: Odour control and incineration stack emissions must be managed through appropriate mitigation. Some risk of odour release during raw feedstock receiving mitigated through building enclosures. Ash product anticipated to have limited odour release.		
2.2	What are the environmental effects of biosolids transport?	What are the risks associated with the number of trucks?	Moderate risk: Substantial number of vehicle kilometers travelled per year	Moderately high risk: Substantial number of vehicle kilometers travelled per year	Low risk: Reduced number of vehicle kilometers travelled per year	Minimal risk: Reduced number of vehicle kilometers travelled per year		
		What are the potential consequences of a spill during transport?	Potential for localized impact to soil, surface water and ground water from deposition of material. Liquid fertilizer spills are difficult to contain and clean up.	Potential for localized impact to soil, surface water and ground water from deposition of material. Spilled solid material simple to recover.	Potential for localized impact to soil, surface water and ground water from deposition of material. Spilled solid material simple to recover.	Potential for localized impact to soil, surface water and ground water from deposition of material. Spilled solid material simple to recover.		

	CRITERIA	INDICATORS	Alternative 1 - Produce Fertilizer		Alternative 2 - Produce Compost	Alternative 3 - Produce Dried, Low Volume Fertilizer		Alternative 4 - Thermal Reduction to Ash
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2	Protect the Natural Environment							
2.3	What are the environmental effects of the end uses?	Risks and concerns related to: Soil quality	Protection of soil quality: 1) Residual organic material in digested biosolids, 2) Value of nutrients including phosphorus and nitrogen – nitrogen content is enhanced through alkaline addition Enhancement of soil: supply of micronutrients not found in conventional fertilizers, improves biomass yield Risks: Use subject to limits related to soil nutrient quality.	Protection of soil quality: 1) Residual organic material in digested biosolids and contributions from bulking agents, 2) Value of nutrients including phosphorous and nitrogen Risks: Use subject to limits related to soil nutrient quality.	Protection of soil quality: 1) Organic material retained in dried material Nitrogen content is significantly reduced due to volatilization of ammonia during processing, 2) Phosphorus content is retained in dried product, 3) May be used as daily cover at suitable landfill to avoid using clean fill, 4) May be burned for fuel Risks: Use subject to limits related to soil nutrient quality.	Protection of soil quality: Not applicable, no organic material remaining after incineration and material not intended to be used in land application practices Risks: No ammonia remaining after incineration, phosphorus retained in ash		
		Risks and concerns related to: Groundwater quality	Protection of groundwater quality: CFIA fertilizer with metals and pathogens below limits designed to enhance environmental quality Risks: Appropriate application practices required to mitigate runoff and groundwater impacts due to nutrient content of material.	Protection of groundwater quality: Class A compost with metals and pathogens below limits designed to enhance environmental quality Risks: Appropriate application practices required to mitigate runoff and groundwater impacts due to nutrient content of material.	Protection of groundwater quality: Volatilization of ammonia during processing may minimize potential nitrate impacts on groundwater from land application Risks: Reduced risk due to ammonia volatilization during processing.	No significant benefits or risks related to groundwater quality		
		Risks and concerns related to: Surface water quality	Protection of surface water quality: CFIA fertilizer with metals and pathogens below limits designed to enhance environmental quality, slow release fertilizer (less nutrient leaching/loss during rain events in comparison to commercial fertilizers) Risks: Appropriate application practices required to mitigate runoff and groundwater impacts due to nutrient content of material.	Protection of surface water quality: Class A compost with metals and pathogens below limits designed to enhance environmental quality Risks: Appropriate application practices required to mitigate runoff and groundwater impacts due to nutrient content of material.	Protection of surface water quality: CFIA fertilizer with metals and pathogens below limits designed to enhance environmental quality Risks: Appropriate application practices required to mitigate runoff and groundwater impacts due to nutrient content of material.	No significant benefits or risks related to surface water quality		

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2	Protect the Natural Environment							
		Risks and concerns related to: Ambient air quality	Protection of air quality: Stabilization process mitigates fugitive emissions from product reduces odours due to product decomposition Risks: Product degradation or gradual decrease in pH may result in ammonia release related to alkaline amendment.	Protection of air quality: Stabilization process mitigates fugitive emissions from product, reducing odours caused by product decomposition Risks: Risks are minimal from stabilized product	Protection of air quality: Dried product will have less odour in comparison to fertilizer and compost final products Risks: Reduced risk due to removal of volatile organic compounds in comparison to baseline case (dewatered biosolids)	Protection of air quality: Removal of organics reduces odour as compared to baseline case (dewatered biosolids) Risks: Potential for fugitive emissions from stack		
2.4	What is the energy balance? Is it possible to recover energy?	Net energy balance	Negative energy balance (net consumption). Heat recovery may be considered in process equipment.	Negative energy balance (net consumption).	Negative energy balance (net consumption). Heat recovery may be considered in process equipment.	Negative energy balance (net consumption). Heat recovery may be considered in process equipment.		
2.5	Is the alternative adaptable to climate change impacts (e.g. extreme temperatures, weather events [frequency, intensity, duration, and magnitude])?	What is the degree of compatibility of each alternative to changes in temperature and precipitation associated with climate change?	Processing infrastructure is not anticipated to be vulnerable to climate change. Potential increased flooding considerations can be addressed through siting and design.	Processing infrastructure is not anticipated to be vulnerable to climate change. Potential increased flooding considerations can be addressed through siting and design.	Processing infrastructure is not anticipated to be vulnerable to climate change. Potential increased flooding considerations can be addressed through siting and design.	Processing infrastructure is not anticipated to be vulnerable to climate change. Potential increased flooding considerations can be addressed through siting and design.		
		What is the degree of vulnerability of the processing facilities?	Power outages from increased freezing rain, ice storms and wind are not anticipated to be substantive and can also be mitigated through design of back-up power systems.	Power outages from increased freezing rain, ice storms and wind are not anticipated to be substantive and can also be mitigated through design of back-up power systems.	Power outages from increased freezing rain, ice storms and wind are not anticipated to be substantive and can also be mitigated through design of back-up power systems.	Power outages from increased freezing rain, ice storms and wind are not anticipated to be substantive and can also be mitigated through design of back-up power systems.		

	CRITERIA	INDICATORS	Alternative 1 - Produce Fertilizer		Alternative 2 - Produce Compost	Alternative 3 - Produce Dried, Low Volume Fertilizer		Alternative 4 - Thermal Reduction to Ash
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2	Protect the Natural Environment							
		What is the degree of vulnerability of end uses to climate risks?	Availability of agricultural land for end use may be impacted by climate change. Potential for increased demand due to longer growing season. Trucking of product to end user may experience increased disruption from flooding, freezing rain and ice storms though not anticipated to have a significant impact	Availability of agricultural land for end use may be impacted by climate change. Potential for increased demand due to longer growing season. Trucking of product to end user may experience increased disruption from flooding, freezing rain and ice storms though not anticipated to have a significant impact		Availability of agricultural land for end use may be impacted by climate change. Potential for increased demand due to longer growing season. Trucking of product to end user may experience increased disruption from flooding, freezing rain and ice storms though not anticipated to have a significant impact		Climate change not expected to impact landfilling. Trucking of material may experience some increased disruption from flooding, freezing rain and ice storms though not anticipated to have a significant impact

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2	Protect the Natural Environment							
2.6	Production of greenhouse gas emissions by the alternative. (Note: Greenhouse gases are any gases in the atmosphere that traps heat and contribute to global warming)	Predicted GHG emissions from process and trucking and end use from the Region’s BEAM Model.	2051 design capacity process emissions will vary based upon technology selected and raw material input selected. Alkaline stabilization is used as representative technology with up to 33,000 tonnes CO₂e emitted. Alkaline by-product replacing lime removes Scope 3 emissions reducing overall emissions by 70%. Trucking emissions related to a centralized fertilizer production facility are anticipated to range from 1,200 – 1,600 tonnes CO₂e / year.	2051 design capacity process emissions will vary based upon technology selected and input selected. Alkaline stabilization is used as representative technology with up to 35,000 tonnes CO₂e emitted. Alkaline by-product replacing lime removes Scope 3 emissions reducing overall emission by 70%. Decentralized implementation of the same process does not change emission estimates in the BEAM Model for biosolids processing. Additional facility energy demand increase estimated Scope 1 and 2 emission by about 20% (roughly equal to natural gas increase). Trucking emissions related to decentralized fertilizer production are anticipated to range from 1,200 – 1,700 tonnes CO₂e / year.	2051 design capacity process emissions will vary based upon technology selected and amendment selected. In-vessel technology with mainly BEAM default composting values includes up to 6,500 tonnes CO₂e emitted. Allowing for potentially high C:N ratio associated with 25% biosolids blending with woodchips only to meet Category A criteria could reduce net GHG emissions to zero. Where it can be demonstrated that compost is displacing commercial fertilizers the BEAM model estimates - 264 tonnes CO₂e per year (negative), providing a total CO₂e reduction of 7,000 tonnes. It is not clear that these GHG “credits” would meet the requirements of any protocol for cap and trade systems in place to date. Given that a similar discount for fertilizer displacement is not applied to Alternatives 1 and 3, for purposes of this evaluation the BEAM output of 6,500 tonnes CO₂e will be utilized. Trucking emissions related to a centralized composting facility are anticipated to be 900 tonnes CO₂e / year.	2051 design capacity process emissions will vary based upon technology selected and input selected. Based upon the concept configuration to date a conservative estimate using BEAM default values for electricity and natural gas demand is 11,000 tonnes CO₂e. Trucking emissions related to a centralized dry / low volume fertilizer production facility are anticipated to be 600 tonnes CO₂e / year.	2051 design capacity process emissions will vary based upon technology selected and input selected. Based upon the concept configuration to date a conservative estimate using BEAM default values for electricity and natural gas demand is 11,000 tonnes CO₂e. Trucking emissions related to a decentralized dry / low volume fertilizer production approach are anticipated to be 1,000 tonnes CO₂e / year.	2051 design capacity process emissions will vary based upon technology selected and input selected. Based upon the concept configuration to date a conservative estimate using concept design values for electricity and natural gas demand is 31,000 tonnes CO₂e. It is assumed that an SNCR will be required for NOx control, and removal of this control device would reduce Scope 1 emission by approximately 12%. Trucking emissions related to a centralized thermal reduction facility are anticipated to be 500 tonnes CO₂e / year.

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2	Protect the Natural Environment							
2.7	How much risk is there that material generated from the process will be landfilled?	What is the relative probability of landfilling material generated?	Very low probability of landfilling: Would only be required if land application was not permitted for extended period of time and all suitable storage was full	Very low probability of landfilling: Would only be required if land application was not permitted for extended period of time and all suitable storage was full	Very low probability of landfilling: Would only be required if land application was not permitted for extended period of time and all suitable storage was full	Very high probability of landfilling: Ash is anticipated to be landfilled, some may be diverted for industrial use if end-product has market demand.		

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3	Minimize and Manage Operational Risk							
3.1	How do the end use or disposal options affect the risk of disruption to biosolids management services?	What is the likelihood of the intended end use or disposal methods no longer being feasible in the long term?	Very low probability of losing land application: 1) CFIA fertilizer product, 2) Land application regulations are not under consideration		Low probability of losing land application: 1) Category A compost is an established beneficial use, 2) Land application regulations are not under consideration	Very low probability of losing land application: 1) CFIA fertilizer product, 2) Land application regulations are not under consideration		Landfill disposal may be more difficult or expensive in future
		What is the consequence of the intended end use or disposal methods no longer being feasible in the long term?	Loss of land application would require use for land reclamation, landfill daily cover (solid fertilizer product only), or landfilling.		Loss of land application would require use for land reclamation, landfill daily cover, or landfilling.	Loss of land application would require use as land reclamation, fuel, or landfilling.		Loss of a landfill would require finding an alternative disposal outlet.
		What is the likelihood of all the intended end use or disposal methods no longer being feasible in the long term?	Approach offers multiple potential end uses, and represents a best-practice for agricultural and land application. Preferred end use is likely to remain available, and loss of all end uses is unlikely.		Approach offers multiple potential end uses, and represents a best-practice for agricultural and land application. Preferred end use is likely to remain available, and loss of all end uses is unlikely.	Approach offers multiple potential end uses, and represents a best-practice for agricultural and land application. Preferred end use is likely to remain available, and loss of all end uses is unlikely.		Low probability of losing landfill disposal as an end-use options
3.2	Does the alternative reduce the volume/mass of end product to be managed?	What is the degree of reduction of the volume/mass of end product?	Approach is expected to result in a 110% increase in product volume and mass (alkaline stabilization) relative to incoming cake quantity, or a 167% increase for hydrolysis		Approach is expected to result in a 197% increase in product volume relative to incoming cake quantity. Approach is expected to result in a 21% reduction in product mass relative to incoming cake mass.	Approach is expected to result in an 87% reduction in product volume relative to incoming cake quantity. Change in mass not defined.		Approach is expected to result in a 91% reduction in product volume relative to incoming cake quantity. Change in mass not defined.
3.3	How susceptible is the alternative to disruption in maintenance and labour supply?	How adaptable is the alternative to disruptions in maintenance at the facility?	Very adaptable as process requires only 50% uptime and can more easily be shut down for short term than other alternatives.		Very adaptable as process has low maintenance requirements.	Moderate level of adaptability as process requires 90% uptime and may need to be shut down for maintenance		Low level of adaptability as process requires continuous operation.
		How adaptable is the alternative to disruptions in labour supply at the facility?	System requires operator attention and is susceptible to labour disruption. Staffing levels are low.	System requires operator attention and is susceptible to labour disruption. Multiple locations will require additional staff.	Very susceptible to labour disruption (trucking in and out, only partial automation of facility).	Somewhat adaptable to maintenance requirements as process would be impacted by maintenance interruptions.	Susceptible to labour disruption (trucking in and out, only partial automation of facility). Multiple locations will require additional staff.	Very susceptible to labour disruption (trucking in and out, only partial automation of facility). 24/7 staffing required for operations.

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3	Minimize and Manage Operational Risk							
3.4	How susceptible is the alternative to a process disruption?	How adaptable is the alternative to disruptions in raw material delivery?	Short term delivery disruptions may be accommodated through operational storage of raw materials and equipment redundancy		Short term delivery disruptions would quickly result in operational issues due to the large quantity of amendment required.	Short term delivery disruptions may be accommodated through operational storage of raw materials		Short term delivery disruptions may be accommodated through operational storage of raw materials.
		How adaptable is the alternative to disruptions in utility servicing?	Alternative is unlikely to be able to remain operational in the event of a utility servicing interruption. Limited standby power provided to allow safer shut down of operations only.		Alternative is unlikely to be able to remain operational in the event of a utility servicing interruption. Limited standby power provided to allow safer shut down of operations only.	Alternative is unlikely to be able to remain operational in the event of a utility servicing interruption. Limited standby power provided to allow safer shut down of operations only.		Alternative is unlikely to be able to remain operational in the event of a utility servicing interruption. Limited standby power provided to allow safer shut down of operations only.
		What is the percentage of uptime for the facility?	Alternative is assumed to have approximately 50% uptime at maximum design throughput		100% uptime (biological composting process). Material handling may operate with lower uptime requirements	90% uptime expected		90% uptime expected
		How reliable is the process?	Process is well-established and reliable.		Process is simple and reliable.	Dryer technology options considered are reliable		Fluidized bed incinerator is reliable
		What is the consequence of an upset?	Temporary shut down for repairs – parts generally easily replaceable. Air handling system failures could result in unacceptable odour release.		No significant consequences as process does not involve major mechanical components. Air handling system failures could result in unacceptable odour release.	Temporary shut down for repairs – parts generally easily replaceable.		Extended shut down for repairs to manage operating and safety concerns.

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3	Minimize and Manage Operational Risk							
3.5	How susceptible is the alternative to disruption in end product quality, management or storage?	How adaptable is the alternative to disruptions in end product quality, management or transfer to storage facility, and to limitations in storage capacity?	Highly adaptable, proven technology. If disruption in process causes reduced product quality, alternative end use options exist which avoid landfilling. Moderate susceptibility to storage capacity limitations given the volume of material being produced as output Moderate susceptibility to storage capacity limitations given the volume of material being produced as output	Highly adaptable, proven technology. If disruption in process causes reduced product quality, alternative end use options exist which avoid landfilling. Moderate susceptibility to storage capacity limitations given the volume of material being produced as output Total storage volume unaffected by location. Moderate susceptibility to storage capacity limitations given the volume of material being produced as output. Multiple sites increase flexibility in location of storage facilities	Moderately adaptable to product quality disruptions. If disruption in process causes reduced product quality, alternative end use options exist which avoid landfilling. High susceptibility to storage capacity limitations given the volume of material being produced as output	Very highly adaptable, proven technology. Reprocessing of finished material possible if end product does not meet quality standards. Low susceptibility to storage capacity limitations given the volume of material being produced as output.	Very highly adaptable, proven technology. Reprocessing of finished material possible if end product does not meet quality standards. Total storage volume unaffected by location. Low susceptibility to storage capacity limitations given the volume of material being produced as output. Multiple sites increase flexibility in location of storage facilities	Highly adaptable, proven technology. Very low susceptibility to storage capacity limitations given the volume of material being produced as output

	CRITERIA	INDICATORS	Alternative 1 - Produce Fertilizer		Alternative 2 - Produce Compost	Alternative 3 - Produce Dried, Low Volume Fertilizer		Alternative 4 – Thermal Reduction to Ash
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4	Protect Quality of Life							
4.1	How will odour be managed?	What is the degree of fugitive odour emissions that cannot be mitigated from the process? Fugitive sources may include ventilation, process stack, cooling towers, and entrances/exits.	Fugitive odours associated with handling of biosolids feedstock and products will be contained within buildings and ventilated through odour control systems. Odours may be associated with handling of alkaline amendment materials and transport/storage of alkaline-stabilized product.	Fugitive odours associated with handling of biosolids feedstock and products will be contained within buildings and ventilated through odour control systems. Odours may be associated with handling of alkaline amendment materials and transport/storage of alkaline-stabilized product. Multiple sites increases risk of fugitive emission	Fugitive odours associated with handling of biosolids feedstock and products will be contained within buildings and ventilated through odour control systems. Cured compost has significantly reduced odour potential relative to digested biosolids cake.	Fugitive odours associated with handling of biosolids feedstock and products will be contained within buildings and ventilated through odour control systems. Dry biosolids have significantly reduced odour potential than wet biosolids.	Fugitive odours associated with handling of biosolids feedstock and products will be contained within buildings and ventilated through odour control systems. Dry biosolids have significantly reduced odour potential than wet biosolids Multiple sites increases risk of fugitive emission	Fugitive odours associated with handling of biosolids feedstock and products will be contained within buildings and ventilated through odour control systems. Vapors from outdoor dewatering of ash product and air emissions from stack present a small risk of odour release.
		What is potential odour emission rate from the product during end use?	Emission rate during end-use is not known. Some ammonia release is possible.		Emission rate during end-use is not known. Emission release is expected to be low.	Emission rate during end-use is not known. Emission release is expected to be low.		Negligible emissions from end product
		What is the relative complexity and dependability of mitigation measures to meet odour regulations?	Complex odour mitigation system required with high reliability will be required. Odours are controlled by: 1) Enclosed operations with all equipment in buildings, 2) Negative pressure in buildings, 3) Material delivered in buildings, 4) All captured air treated in odour treatment system.		Complex odour mitigation system required with moderate reliability Odours are controlled by: 1) Enclosed operations with all equipment in buildings, 2) Negative pressure in buildings, 3) Material delivered in buildings, 4) All captured air treated in odour treatment system.	Moderately complex odour mitigation system required with very high reliability. Odours are controlled by: 1) Enclosed operations with all equipment in buildings, 2) Negative pressure in buildings, 3) Material delivered in buildings, 4) All captured air treated in odour treatment system. Dried fertilizer product has significantly reduced odour potential than wet biosolids		Moderately complex odour system required with very high reliability. Odours are controlled by: 1) Enclosed operations with all equipment in buildings, 2) Negative pressure in buildings, 3) Material delivered in buildings, 4) All captured air treated in odour treatment system. Ash has significantly reduced odour potential than wet biosolids.

	CRITERIA	INDICATORS	Alternative 1 - Produce Fertilizer		Alternative 2 - Produce Compost	Alternative 3 - Produce Dried, Low Volume Fertilizer		Alternative 4 – Thermal Reduction to Ash
			Centralized Implementation	Decentralized Implementation		Centralized Implementation	Decentralized Implementation	
4	Protect Quality of Life							
4.2	How will dust from process or trucking be managed related to nuisance effects?	What is the potential for dust generation for any of the processes and/or steps with each alternative?	Dust emission is possible through alkaline amendment addition, drying, and finished product load out. Dust control required to mitigate fugitive dust emissions.	Limited potential for dust emission from product. Some potential for dust emission from amendment used in processing.	Dry biosolids have potential for dust release during transport and land application		Dewatered ash has little potential for dust formation	
		What is the relative complexity and dependability of mitigation measures to meet dust mitigation regulations?	Containment of process within building enclosures will mitigate dust released and potential impacts on neighbours.	Containment of process within building enclosures will mitigate dust released and potential impacts on neighbours.	Containment of process within building enclosures will mitigate dust released and potential impacts on neighbours.		Containment of process within building enclosures will mitigate dust released and potential impacts on neighbours.	
4.3	How will noise be managed?	What is the relative complexity of mitigation measures to meet noise regulations?	All equipment will be located in buildings with sound dampening for HVAC equipment and building envelopes for main process	All equipment will be located in buildings with sound dampening for HVAC equipment and building envelopes for main process	All equipment will be located in buildings with sound dampening for HVAC equipment and building envelopes for main process		All equipment will be located in buildings with sound dampening for HVAC equipment and building envelopes for main process	
		What is the dependability of the noise mitigation measures?	Noise enclosures (buildings) anticipated to be dependable and sound dampening	Noise enclosures (buildings) anticipated to be dependable and sound dampening	Noise enclosures (buildings) anticipated to be dependable and sound dampening		Noise enclosures (buildings) anticipated to be dependable and sound dampening	

	CRITERIA	INDICATORS	Alternative 1 - Produce Fertilizer		Alternative 2 - Produce Compost	Alternative 3 - Produce Dried, Low Volume Fertilizer		Alternative 4 – Thermal Reduction to Ash
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4	Protect Quality of Life							
		What is the peak hourly trucking rate?	Approximately 6 trucks/day (raw feedstock delivery), and 7-8 trucks/day (product removal) Peak hourly rates may depend on worker shift schedules short term operational needs and annual fluctuations in biosolids production.	Kitchener facility: Approximately 3-4 trucks/day out for product removal Waterloo facility: Approximately 1-2 trucks/day out for product removal Galt facility: Approximately 1-3 trucks/day in and out for both raw feedstock delivery and product removal Ayr facility: Up to 12 trucks/day in for raw feedstock delivery, 1 truck/day out for product removal Peak hourly rates may depend on worker shift schedules short term operational needs and annual fluctuations in biosolids production. Trucks in to Kitchener and Waterloo facilities are neglected as WWTP and biosolids processing facilities may be on or near the same location.	Approximately 14 trucks/day (raw feedstock delivery, including amendment material), and 5 trucks/day (product removal) Peak hourly rates may depend on worker shift schedules short term operational needs and annual fluctuations in biosolids production.	Approximately 6 trucks/day (raw feedstock delivery), and 2 trucks/day (product removal) Peak hourly rates may depend on worker shift schedules, short term operational needs, and annual fluctuations in biosolids production.	Kitchener facility: Approximately 1 truck/day out for product removal Waterloo facility: Approximately 1 truck/day out for product removal Galt facility: Approximately 1-2 trucks/day in for raw feedstock delivery and 1 truck/day out for product removal Ayr facility: Up to 12 trucks/day in for raw feedstock delivery, 1 truck/day out for product removal Peak hourly rates may depend on worker shift schedules short term operational needs and annual fluctuations in biosolids production. Trucks in to Kitchener and Waterloo facilities are neglected as WWTP and biosolids processing facilities may be on or near the same location.	Approximately 5 trucks/day (raw feedstock delivery), and 2 trucks/day (product removal) Peak hourly rates may depend on worker shift schedules, short term operational needs, and annual fluctuations in biosolids production.
		Are there sources of noise operating 24 hrs/day?	Yes, HVAC and odour control systems operate 24 hrs/day. Process may operate 24 hrs/day if required.		Yes, HVAC and odour control systems operate 24 hrs/day. Process will operate 24 hrs/day.	Yes, HVAC and odour control systems operate 24 hrs/day. Process may operate 24 hrs/day if required.		Yes, facility will operate 24 hrs/day

	CRITERIA	INDICATORS	Alternative 1 - Produce Fertilizer		Alternative 2 - Produce Compost	Alternative 3 - Produce Dried, Low Volume Fertilizer		Alternative 4 – Thermal Reduction to Ash
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4	Protect Quality of Life							
		What is the level of night-time noise?	Night-time noise would be assessed through design. Noise anticipated from fixed sources (HVAC, odour control), with minimal mobile sources (trucks and loading equipment).		Night-time noise would be assessed through design. Noise anticipated from fixed sources (HVAC, odour control, process equipment), with minimal mobile sources (trucks and loading equipment).	Night-time noise would be assessed through design. Noise anticipated from fixed sources (HVAC, odour control), with minimal mobile sources (trucks and loading equipment).		Night-time noise would be assessed through design. Noise anticipated from fixed sources (HVAC, odour control, process equipment, with minimal mobile sources (trucks and loading equipment).
4.4	How will visual effects be managed?	Will material storage be inside the structure?	Product and equipment is fully enclosed.		Product and equipment is fully enclosed.	Product and equipment is fully enclosed.		Product and equipment is fully enclosed.
		Can buildings be implemented to mitigate visual impacts?	Building finishes may be selected to mitigate visual impacts.		Building finishes may be selected to mitigate visual impacts	Building finishes may be selected to mitigate visual impacts.		Building finishes may be selected to mitigate visual impacts.
		How large/high are buildings? What is the height and area requirements of infrastructure (e.g. stack, silos)?	Receiving building assumed to be ~12m in height. Storage building assumed to be ~10m in height. Odour control stack height must be established but is anticipated to be greater than tallest building height.		Highest structure is the building at ~12m. Odour control stack height must be established but is anticipated to be greater than tallest building height.	Highest structure is the building at 15 m. Exhaust stack height will not exceed height of building (limited aesthetic impact). Odour control stack height must be established but is anticipated to be greater than tallest building height.		Highest structure is the building at 15m. Exhaust stack height will not exceed height of building (limited aesthetic impact).
4.5	How will effects related to trucking be managed?	Annual number of trucks and vehicle kilometers travelled (VKMT).	Approximately 9,300 – 10,300 truck trips for 878,000 – 1,207,000 VKMT per year	Approximately 6,700 to 8,900 truck trips for 869,000 – 1, 267,000 VKMT per year	Approximately 11,400 total truck trips per year for 846,000 VKMT per year (including LYW)	Approximately 7,500 total truck trips per year for 418,000 VKMT per year	Approximately 5,400 total truck trips per year for 424,000 VKMT per year	Approximately 7,600 truck trips per year for 480,000 VKMT per year
		Annual number of truck trips required locally within the Region vs. out of the Region	Approximately 2,400 – 3,400 of the total truck trips are land application in rural areas, which may be out of region	Approximately 2,400 – 3,600 truck trips are to land application in rural areas, which may be out of region	Approximately 1,700 total truck trips per year are to land application, which may be out of region.	Approximately 600 total truck trips per year to land application, which may be out of region.	Approximately 6600 total truck trips per year to land application, which may be out of region	Approximately 640 truck trips per year to landfill, which may be out of region
		Number of trucks in and out of a biosolids processing facility per day	6 trucks in to facility 7 trucks out of facility	13 trucks into facilities (combined) 7 trucks out of facilities (combined) Daily trucking may not occur at decentralized facilities depending on loading	14 trucks in to facility (including amendment material) 5 trucks out of facility	6 trucks in to facility 2 trucks out of facility	13 trucks in to facilities (combined) 2 trucks out of facilities (combined) Daily trucking may not occur at decentralized facilities depending on loading	6 trucks in to facility 2 trucks out of facility

	CRITERIA	INDICATORS	Alternative 1 - Produce Fertilizer		Alternative 2 - Produce Compost	Alternative 3 - Produce Dried, Low Volume Fertilizer		Alternative 4 – Thermal Reduction to Ash
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4	Protect Quality of Life							
		Comparison made relative to existing conditions of 6,800 trucks per year and 1,500,000 VKMT required to transport dewatered cake to current end uses.	Alternative provides a reduction in VKMT, but results in an increase of total truck trips.		Alternative provides a reduction in VKMT, but results in an increase of total truck trips.	Alternative provides a reduction in VKMT, but results in an increase of total truck trips.	Alternative provides a reduction in VKMT and total truck trips	Alternative provides a reduction in VKMT, but results in an increase of total truck trips.
4.6	What are the potential impacts to source water protection?	Consider impacts of the facility and end use	Sourcewater protection considerations are site specific and must be reviewed once a location is selected	Existing sites are near Grand River and could impact source water protection Source water protection considerations for each facility include: Kitchener WWTP: Located on a floodplain, area of intrinsic vulnerability Waterloo WWTP: Located on a floodplain, in WHPA-D zone, Wellhead Water Quantity Zone, and is an area on intrinsic vulnerability Galt WWTP: Located on a floodplain, in a WHPA-C, WHPA-E, WHPA-GUDI, and high WHPA vulnerability area, in a Wellhead Water Quantity Zone, and is an area of intrinsic vulnerability Ayr WWTP: Located on a floodplain, is a SGRA, and an area of intrinsic vulnerability	Sourcewater protection considerations are site specific and must be reviewed once a location is selected	Sourcewater protection considerations are site specific and must be reviewed once a location is selected	Existing sites are near Grand River and could impact source water protection Source water protection considerations for each facility include: Kitchener WWTP: Located on a floodplain, area of intrinsic vulnerability Waterloo WWTP: Located on a floodplain, in WHPA-D zone, Wellhead Water Quantity Zone, and is an area on intrinsic vulnerability Galt WWTP: Located on a floodplain, in a WHPA-C, WHPA-E, WHPA-GUDI, and high WHPA vulnerability area, in a Wellhead Water Quantity Zone, and is an area of intrinsic vulnerability Ayr WWTP: Located on a floodplain, is a SGRA, and an area of intrinsic vulnerability	Sourcewater protection considerations are site specific and must be reviewed once a location is selected

	CRITERIA	INDICATORS	Alternative 1 - Produce Fertilizer		Alternative 2 - Produce Compost	Alternative 3 - Produce Dried, Low Volume Fertilizer		Alternative 4 – Thermal Reduction to Ash
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4	Protect Quality of Life							
4.7	Can all components of biosolids management, end uses and/or disposal be managed within Waterloo Region?	Is the end product being used or disposed of in another community?	The fraction of land application within the Region and outside the Region must be determined. Disposal outside the Region may occur should landfilling be required.	The fraction of land application within the Region and outside the Region must be determined. Disposal outside the Region may occur should landfilling be required.	The fraction of land application within the Region and outside the Region must be determined. Disposal outside the Region may occur should landfilling be required.	The fraction of land application within the Region and outside the Region must be determined. Disposal outside the Region may occur should landfilling be required.	Ash to be disposed of at landfill outside the Region	

	CRITERIA	INDICATORS	Alternative 1 - Produce Fertilizer		Alternative 2 - Produce Compost	Alternative 3 - Produce Dried, Low Volume Fertilizer		Alternative 4 – Thermal Reduction to Ash
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5	Protect Health and Safety							
5.1	What are the relative health risks posed to the public for each alternative?	What is the relative rate of emissions to air from process stacks, trucking all products, dust from material handling?	Moderate air emissions from combustion of natural gas increase for thermal processes. Process stacks anticipated to provide air emission controls to a common standard required for environmental protection. Trucking may cause releases to roadways causing odour, dust, and nuisance. Substantial vehicle air emissions due to large number of VKMT.	Air emissions from combustion of natural gas for building heating only Process stacks anticipated to provide air emission controls to a common standard required for environmental protection. Trucking may cause releases to roadways causing odour, dust, and nuisance Substantial vehicle air emissions due to large number of VKMT.	More substantial air emissions from combustion of natural gas increase for thermal processes. Process stacks anticipated to provide air emission controls to a common standard required for environmental protection. Trucking may cause releases to roadways causing odour, dust, and nuisance. Relatively low vehicle air emissions due to smaller number of VKMT.	More substantial air emissions from combustion of natural gas increase for thermal processes Process stacks anticipated to provide air emission controls to a common standard required for environmental protection. Trucking may cause releases to roadways causing odour, dust, and nuisance Air emissions from combustion of natural gas increase Low vehicle air emissions due to low VKMT.		
		What are the risks associated with trucking biosolids between processing facilities or storage sites?	Trucking of raw material and product presents a risk of traffic accidents resulting in spillage of fuel and potentially of chemical amendment used in the processing facility. Spill of fertilizer material not considered to be a risk to health and safety. Trucking levels are very high resulting in a proportional increase in accident risk.	Trucking of raw material and product presents a risk of traffic accidents resulting in spillage of fuel. Spill of compost material not considered to be a risk to health and safety. Trucking levels are relatively high resulting in a proportional increase in accident risk.	Trucking of raw material and product presents a risk of traffic accidents resulting in spillage of fuel and potentially of chemical amendment used in the processing facility. Spill of fertilizer material not considered to be a risk to health and safety. Trucking levels are relatively low.	Trucking of raw material and product presents a risk of traffic accidents resulting in spillage of fuel and potentially of chemical amendment used in the processing facility. Spill of fertilizer material not considered to be a risk to health and safety. Trucking levels are relatively low.		

	CRITERIA	INDICATORS	Alternative 1 - Produce Fertilizer		Alternative 2 - Produce Compost	Alternative 3 - Produce Dried, Low Volume Fertilizer		Alternative 4 – Thermal Reduction to Ash
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5	Protect Health and Safety							
		What are the risks associated with end use or disposal of product?	Studies investigating the relationship of land application of biosolids and human health have indicated that there is no association between proper application processes and human health concerns.	Studies investigating the relationship of land application of biosolids and human health have indicated that there is no association between proper application processes and human health concerns	Studies investigating the relationship of land application of biosolids and human health have indicated that there is no association between proper application processes and human health concerns	Studies investigating the relationship of land application of biosolids and human health have indicated that there is no association between proper application processes and human health concerns	Appropriately licensed and designed landfill can safely accept the material	
5.2	What are the relative health risks posed to workers for each alternative?	What is the level of engineering controls needed?	Engineering controls needed to manage rotating equipment (conveyors), chemical feed systems and mixers, and product thermal treatment equipment; controls for forced ventilation for odour and dust control	Engineering controls for forced ventilation for odour and dust control	Engineering controls for forced ventilation for odour and dust control	Engineering controls for forced ventilation for odour and dust control, and piping insulation for protection from heat sources	Engineering controls for forced ventilation for odour and dust control, and piping insulation for protection from heat sources	
		How much personal protective equipment is required?	Safety glasses, leather gloves, steel toed boots, long pants, hearing protection around fixed and mobile equipment. Additional PPE is anticipated due to potential for chemical exposure.	Safety glasses, leather gloves, steel toed boots, long pants, hearing protection around fixed and mobile equipment.	Safety glasses, leather gloves, steel toed boots, long pants, hearing protection around fixed and mobile equipment.	Safety glasses, leather gloves, steel toed boots, long pants, hearing protection around fixed and mobile equipment.	Safety glasses, leather gloves, steel toed boots, long pants, hearing protection around fixed and mobile equipment and adequate protection from incinerator heat.	
		How much direct handling of biosolids is involved?	Some management of biosolids received at facilities through mobile equipment and exposed bunker storage in worker areas. No direct handling of material through processing stages	Some management of biosolids received at facilities through mobile equipment and exposed bunker storage in worker areas. No direct handling of material through processing stages	Some management of biosolids received at facilities through mobile equipment and exposed bunker storage in worker areas. No direct handling of material through processing stages	Some management of biosolids received at facilities through mobile equipment and exposed bunker storage in worker areas. No direct handling of material through processing stages	Some management of biosolids received at facilities through mobile equipment and exposed bunker storage in worker areas. No direct handling of material through processing stages	
		Are there high temperature processes or potential for fires?	High temperature processes (with appropriate controls) are present. Drying stages may be present in process and risk of fire must be managed through proper monitoring, cooling solids and minimizing dust	No high temperature processes but some; risk of fire due to heat generated by composting must be managed through proper monitoring of product temperature and moisture	High temperature process; risk of fire must be managed through proper monitoring, cooling solids and minimizing dust	High temperature process; risk of fire must be managed through proper monitoring and safety controls		

	CRITERIA	INDICATORS	Alternative 1 - Produce Fertilizer		Alternative 2 - Produce Compost	Alternative 3 - Produce Dried, Low Volume Fertilizer		Alternative 4 – Thermal Reduction to Ash
			Centralized Implementation	Decentralized Implementation		Centralized Implementation	Decentralized Implementation	
5	Protect Health and Safety							
		Are there high pressure processes?	High pressure processes may be present, specifically for the hydrolysis technology alternative.		Process is at atmospheric pressure	Process is at atmospheric pressure. High pressure equipment may be present related to process cooling or heat recovery.		Process is at atmospheric pressure. High pressure equipment may be present related to process cooling or heat recovery.
		Are there indoor air quality considerations in the work environment	Potential for fugitive odours and potential H ₂ S release from raw product. Potential for ammonia release from chemical amendment or final product.		Potential for fugitive odours and potential H ₂ S release from raw product, fugitive odours from active composting process. Potential for ammonia odour and dust release from product.	Potential for fugitive odours and potential H ₂ S release from raw product. Potential dust release from dried biosolids.		Potential for fugitive odours and potential H ₂ S release from raw product. Potential dust release from dried biosolids.
		Are there requirements to handle concentrated or corrosive chemicals?	Concentrated chemicals such as alkaline agents may be required for processing. Direct handling by operators to be avoided.		Chemicals not required	Chemicals not required		Chemicals not required
5.3	Does the alternative reduce or eliminate undesirable components in the biosolids?	Does the process reduce concentrations of organic chemicals such as personal care products?	No data is currently available on pharmaceuticals and personal care products		Literature suggests composting processes may degrade organic compounds such as personal care products	No data is currently available on pharmaceuticals and personal care products. Slight reduction in volatile organic compounds.		All organics removed in incineration – no issue with personal care products
		Is the concentration of pathogens and indicator organisms reduced below the concentrations observed in existing products?	Process generating CFIA fertilizer reduces pathogens below existing levels to meet applicable thresholds. Unclear if pathogens will still be detectable.		Pathogens reduced due to elevated temperature of composting process. Concentrations will be reduced to below applicable threshold for Category A compost product.	Pathogens reduced due to high temperature and desiccation. Process generating CFIA fertilizer reduces pathogens below existing levels to meet applicable thresholds. Unclear if pathogens will still be detectable.		Pathogens removed due to high temperature
		Will the metal concentration in the final product be higher than the existing product as a result of processing?	Metals concentration on a mass per wet tonne basis should remain relatively constant.		Metal concentration (mg/kg) is expected to decrease through addition of amendment product to biosolids.	Metal concentration (mg/kg) will not change on dry-tonne basis. Concentration of metals on a wet-tonne basis may increase.		Metal concentration (mg/kg) will increase from wet biosolids to dewatered ash.
		Is the product used in agriculture?	Yes		Yes	Yes		No

	CRITERIA	INDICATORS	Alternative 1 - Produce Fertilizer		Alternative 2 - Produce Compost	Alternative 3 - Produce Dried, Low Volume Fertilizer		Alternative 4 – Thermal Reduction to Ash
			Centralized Implementation	Decentralized Implementation		Centralized Implementation	Decentralized Implementation	
5	Protect Health and Safety							
		What is the level/number of regulatory controls needed for the alternative?	Regulatory controls will be consistent with those required for application of other CFIA-approved fertilizer products. Regulatory controls will be required for air and noise emissions from facility operations.	Regulatory controls will be consistent with those required for application of other Category A compost products. Regulatory controls will be required for air and noise emissions from facility operations.	Regulatory controls will be consistent with those required for application of other CFIA-approved fertilizer products. Regulatory controls will be required for air and noise emissions from facility operations.	Regulatory controls will be required for air and noise emissions from facility operations.	Regulatory controls will be required for air and noise emissions from facility operations.	
5.4	What is the potential nature of an accident or adverse event?	What is the nature of an accident or adverse event	Adverse event may include chemical spill of alkaline amendment, fire in dryer stage of alkaline process or vessel or piping failure in hydrolysis process,	Adverse event would be fire within composting process or amendment material storage due to excessive heat build-up and/or insufficient moisture	Adverse event would likely be a fire due to combustion of dried solids or due to equipment failure, or a combination of both	Failure of ash removal from exhaust resulting in particles discharged to atmosphere or exhaust stack fire due to uncombusted organic matter		
		What is the potential of an adverse event?	Adverse event likelihood is very low	Adverse event likelihood is very low	Adverse event likelihood is very low	Adverse event likelihood is very low		
		What is the consequence of an adverse event?	Potential severe health and safety consequences for workers present. Damage to facility.	Potential severe health and safety consequences for workers present. Damage to facility.	Potential severe health and safety consequences for workers present. Damage to facility	Environmental impacts due to ash release. Damage to facility.		
		What is the complexity of mitigation required to mitigate adverse events?	Mitigation through intrinsically safe equipment design, proper controls, proper separation of process and staff areas	Fire isolation walls between process trains, segregation of material and product storage areas. Process and storage building will be sprinklered	Fire isolation walls between process area and storage area minimizes risk; process and storage building will be sprinklered. Solids cooler and indoor storage keeps risk of fire in storage area low; potential risk of fire only in dryer	Interlock between incinerator temperature and biosolids feed system, sensors for explosive gas/natural gas leak		

	CRITERIA	INDICATORS	Alternative 1 - Produce Fertilizer		Alternative 2 - Produce Compost	Alternative 3 - Produce Dried, Low Volume Fertilizer		Alternative 4 – Thermal Reduction to Ash
			Centralized Implementation	Decentralized Implementation		Centralized Implementation	Decentralized Implementation	
6	Be Cost Effective and Provide Value							
6.1	What is the relative capital cost?	Capital cost in 2018 dollars	\$52,000,000 to \$59,000,000	Kitchener WWTP vicinity facility: \$33,000,000 to \$35,000,000 Waterloo and Galt WWTP vicinity facilities: \$26,000,000 to \$27,000,000 Ayr vicinity facility: \$20,000,000 to \$21,000,000 Total: \$104,000,000 to \$110,000,000	\$96,000,000 to \$154,000,000	\$59,000,000	Kitchener WWTP vicinity facility: \$42,000,000 Waterloo WWTP vicinity facility: \$33,000,000 Galt WWTP vicinity facility: \$32,000,000 Ayr WWTP vicinity facility: \$29,000,000 Total: \$137,000,000	\$126,000,000
6.2	What is the relative operating cost?	Operating and trucking costs in 2018 dollars	Operating Costs: \$2,400,000 to \$2,800,000/year Trucking Cost: \$4,600,000 to \$6,600,000/year Total: \$7,000,000 to \$9,400,000/year	Operating Costs: Kitchener WWTP vicinity facility: \$1,300,000 to \$1,600,000/year Waterloo WWTP vicinity facilities: \$1,200,000 to \$1,300,000/year Galt WWTP vicinity facilities: \$1,200,000 to \$1,300,000/year Ayr vicinity facility: \$800,000 to \$900,000/year Overall Trucking Cost: \$4,100,000 to \$6,500,000/year Total: \$8,600,000 - \$11,600,000/year	Operating Costs: \$5,800,000/year Trucking Cost: \$4,200,000/year (including amendment transfer) Total: \$10,000,000/year	Operating Costs: \$3,500,000/year Trucking Cost: \$1,900,000/year Total: \$5,400,000/year	Operating Costs: Kitchener vicinity facility: \$2,300,000/year Waterloo vicinity facility: \$1,800,000/year Galt vicinity facility: \$1,800,000/year Overall Trucking Cost: \$1,600,000/year trucking cost Total: \$7,500,000/year	Operating Costs: \$5,800,000/year Trucking Cost: \$2,300,000/year Total: \$8,100,000/year
6.3	What is the relative life cycle cost including trucking?	Life cycle cost based upon implementation in 2023 operating until 2051 represented as NPV 2018 dollars	\$187,000,000 to \$241,000,000	\$285,000,000 to \$336,000,000	\$292,000,000 to \$342,000,000	\$155,000,000	\$334,000,000	\$279,000,000

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			Centralized Implementation	Decentralized Implementation		Centralized Implementation	Decentralized Implementation	
6	Be Cost Effective and Provide Value							
6.4	How does life cycle cost vary based on implementation timing?	Life cycle cost estimate comparison based on implementation in 2023; 2033; 2043; and 2051	Significant annual cost over existing	Significant annual cost over existing	Significant annual cost over existing	Similar annual cost compared to existing biosolids management approach; no significant change based on implementation timing	Significant annual cost over existing	Significant annual cost over existing
6.5	Is there an opportunity to apply for carbon credits? (Note: Carbon credits are given to municipalities by the province for making proven efforts to reduce the gas emissions created.)	No protocol currently available for carbon credits available in the current cap and trade framework.	Carbon credits not anticipated		Carbon credits not anticipated	Carbon emissions increase due to natural gas use		Carbon emissions increase due to natural gas use
6.6	What is the local economic benefit?	How many local jobs would it create? Characterize and report number of jobs from facility.	5 FTE positions assuming: scale house operator (1), office manager(1), operators(2) and equipment driver(1)	20 FTE positions at the facilities Per facility: scale house operator (1), office manager(1), operators(2) and equipment driver(1)	13 FTE positions at the facility Facility Managers (2), Labourer (3), Loader Operators (6), Mechanic (1), Maintenance Assistant (1),	6 FTE positions at the facility Operator (4); Maintenance (1); Loader Driver (1)	24 FTE positions at the facilities Per facility: Operator (4); Maintenance (1); Loader Driver (1)	6 FTE positions at the facility Operator (4); Maintenance (1); Loader Driver (1)
6.7	Is a biosolids end product created that has value? If yes, what is its value?	Vendor input on product value in terms of potential revenue beyond trucking cost?	High potential for revenue generation		Very high potential for revenue generation	High potential value for land application purposes due to reduced volume (less water); however, value for land application impacted because ammonia nitrogen is removed Dry product is valued for BTU content for burning		Not applicable - not able to quantify value of ash in industrial use.
		What is the certainty/volatility of the product value?	Long term price stability for product is unknown.		Long term price stability for product is unknown.	Long term price stability for product is unknown.		Long term price stability for product in industrial use is unknown.

	CRITERIA	INDICATORS	Alternative 1 - Produce Fertilizer		Alternative 2 - Produce Compost	Alternative 3 - Produce Dried, Low Volume Fertilizer		Alternative 4 – Thermal Reduction to Ash
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6	Be Cost Effective and Provide Value							
6.8	Would the alternative involve an innovative approach that demonstrates leadership in the area of biosolids management?	Future consideration to be given to National Biosolids Partnership/Envision/LEED Silver (for Administrative Buildings) to demonstrate leadership.	Approach would demonstrate achievement of a "best practice" approach beyond minimum NASM quality standards. Facility could be constructed with energy efficient (LEED etc.) features to demonstrate leadership.	Approach would demonstrate achievement of a "best practice" approach beyond minimum NASM quality standards. Facility could be constructed with energy efficient (LEED etc.) features to demonstrate leadership.	Approach would demonstrate achievement of a "best practice" approach beyond minimum NASM quality standards. Facility could be constructed with energy efficient (LEED etc.) features to demonstrate leadership.	Approach would demonstrate achievement of a "best practice" approach beyond minimum NASM quality standards. Facility could be constructed with energy efficient (LEED etc.) features to demonstrate leadership.	Facility could be constructed with energy efficient (LEED etc.) features to demonstrate leadership.	

Appendix F
Climate Change
Impact and
Adaptation
Assessment

1.0 Introduction/Overview

The project alternatives were screened under a lens of climate change resilience. The screening consisted of four components:

1. Identification of potential climate hazards
2. Identification of potential vulnerabilities from project and climate Interactions;
3. Determination of mitigation of potential vulnerabilities; and
4. Ranking of project alternatives in the context of potential climate impacts.

The assessment is appropriate for high-level planning purposes for the consideration of impacts by alternative. A more detailed analysis of project and site-specific climate change impacts should be completed as the project evolves and the preferred alternative and location(s) are finalized.

2.0 Identification of Climate Hazards

Climate hazards were determined from assessing both baseline information and future climate projections. Baseline information obtained from Climate Normals Station Data found in the National Climate Archive maintained by Environment Canada (Environment Canada, 2017). The 1981-2010 climate normal from the Waterloo Wellington A meteorological station were used to represent the historical climate for the region.

Future climate projections were based on data obtained from the public domain. The primary source of data was obtained from the study by the Interdisciplinary Centre on Climate Change (IC3) (2015) based in the University of Waterloo, entitled *Localized Climate Projections for Waterloo Region*. The study includes projections for three different timeframes (2020s, 2050s, and 2080s) and three

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scenarios that consider various action on carbon reduction going forward. For the purpose of this assessment, projections for both the period of 2050s and 2080s using the business-as-usual scenario were carried forward in the assessment. The period of 2050s was considered as it aligns with the Region of Waterloo Biosolids Strategy, which has a timeline to 2051. The 2080s projections are also included to provide a further looking, 'worst case' scenario of climate change projections for consideration of potential impacts. Additional information for consideration of specific vulnerabilities, was obtained from the report *Climate Change and Agricultural Production in the Region of Waterloo: Identifying Risks, Vulnerabilities and Adaptation Strategies* (Fuchs, C., Lam, S., McLean, A., and Spanton, A, 2016) as well as a study by the Ontario Climate Consortium and Toronto and Region Conservation (OCC) (2015) entitled *Climate Change vulnerability Assessment of Ontario's Electrical Transmission Sector*.

A summary of the Historical Climate and the Future Projections for select climate parameters are presented in Table E-1.

Table E-1 – Historical and Future Climate Projections

Climate Parameter	Historical Climate ^{1,2}	Future Projections 2050s ²	Future Projections 2080s ²
Mean Temperature (°C)	7	10	12
Extreme Heat days	8	32	60
Extreme Cold days	22	6	4
Days below freezing	150	118	92
Freeze-thaw cycles	85	80	70
Degree Days (heating)	4,194	3,300	2,800
Degree Days (cooling)	201	420	690
Precipitation (mm)	917	1,012	1,027
Day with precipitation	166	162	162
Days with precipitation >10mm	29	32	33
Days with precipitation >25mm	5	7	7
Snowfall (cm)	210	180	145
Max wet spell (days)	8-10	8-10	8-10
Max dry spell (days)	31-34	31-34	31-34
Environment Canada (2017) (University of Waterloo, 2015)			

The primary climate conditions projected to change in the Waterloo Region include:

- Temperature
 - o Annual mean temperatures are projected to increase by 3-5°C.
 - o The number of extreme heat days (daily maximum temperature exceeding 30°C) are projected to increase to 60 from the current 10

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under the worst case scenario. The number of extreme cold temperatures (daily minimum temperature below -15°C) to reduce to as few as 6 days from the current 22 days per year under the worst case scenario.

- o Mean temperatures in March are projected to be above freezing rather than currently below.
 - o Higher temperatures in summer.
- Precipitation
 - o Total annual precipitation is projected to increase as much as 8-12%. Rainfall intensities are projected to increase as well as the frequency of large-magnitude rainfall events.
 - o Snowfall is projected to decrease due to warmer temperatures.
 - o Freezing rain events are expected to increase by 40% by the 2050s and 45% by the 2080s for the months of December to February. For the months of November, March and April, freezing rain is projected to decrease by 10% and 15% for the 2050s and 2080s, respectively.
- Wind
 - o Increased wind gust events are projected due to an increase in the frequency of both large-scale frontal storms and local convective windstorms, with gusts greater than 40km/h increasing by 10-20% and those greater than 70km/h increasing by 20-40%

3.0 Identification of Potential Vulnerabilities from Project and Climate Interactions

The various components of each Project alternative with the potential for assessment of climate interactions were identified and presented in Table 2.

Table E-2 – Key Infrastructure Components Identified for Assessment

Process Infrastructure or End Use Component	Alternative 3 - Produce Fertilizer	Alternative 3 - Produce Fertilizer	Alternative 4 - Produce Compost	Alternative 5- Produce Low Volume Fertilizer (centralized)	Alternative 5- Produce Low Volume Fertilizer (decentralized)	Alternative 6 - Thermal Reduction to Ash (not Energy Recovery)
	(Centralized Implementation)	(Decentralized Implementation)		(Centralized Implementation)	(Decentralized Implementation)	
Process Infrastructure	Anaerobic Digestion	Anaerobic Digestion	Anaerobic Digestion	Anaerobic Digestion	Anaerobic Digestion	Anaerobic Digestion
	Larger Storage Building	Larger Storage Buildings	Larger Storage Building	Smaller Storage Building	Smaller Storage Buildings	Smaller Storage Building
	Dewatering	Dewatering	Dewatering	Dewatering	Dewatering	Dewatering
	Fertilizer process as a stabilization technology	Fertilizer process as a stabilization technology	Composting for stabilization - Mixing with bulking agent	Fertilizer process as a stabilization technology	Fertilizer process as a stabilization technology	Thermal reduction – likely fluidized bed incinerator
			Composting vessel	Dryer technology	Dryer technology	Cooling system
	Blending, Process, and/or Storage tanks	Blending, Process, and/or Storage tanks	Curing for further stabilization			Heat recovery infrastructure
	Compost cooling (generally lasts for 30 days)					
End Use	Land application – more restricted	Land application – more restricted	Land application – more restricted	Land application – less restricted	Land application – less restricted	Land application
	High requirements for climate controls	High requirements for climate controls	High requirements for climate controls	Low requirements for climate control	Low requirements for climate control	Very low requirements for climate control
	Trucking of end product	Trucking of end product	Trucking of end product	Trucking of end product	Trucking of end product	Trucking of end product

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The relevant climate parameters and their potential interactions on infrastructure are presented in Table 3.

Table E-3 – Potential climate and Infrastructure Interactions

Climate Parameter	Potential interactions	Infrastructure
Temperature	• More winter days above freezing will affect road maintenance, reduce heating demand • Higher summer temperatures will increase cooling demand • Longer growing seasons • Increased risk of crop losses due to early frost • Increased odour potential due to warmer temperatures in summer	Processing Infrastructure • Cooling tower • Climate control systems for storage End Use • Receipt and usage at land application site • Climate control systems for storage • Application on agricultural land
Wind Gusts / High Winds	Power outages Communications interference	Processing Infrastructure • Climate control systems for storage • Dewatering system • Dryer • Product conveyors • Mixers
Freezing rain events and ice storms	Power outages Disruption to transportation networks Communications interference	Processing Infrastructure • Climate control systems for storage • Thermal reduction plant • Dewatering system • Dryer • Product conveyors • Mixers • End Use • Trucking
Heavy rain fall	Flooding could disrupt transportation networks Flooding could impact processing facility and storage building.	Processing Infrastructure • Storage building End Use • Trucking • Application on agricultural land • Increased flooding

4.0 Identification of Mitigation for Potential Vulnerabilities

Each alternative was assessed to identify potential areas where the climate hazards may interact with processes/assets to generate vulnerabilities. The vulnerabilities with potential for notable interactions with the facility or processes have been carried forward and classified as to whether or not they can be addressed through engineering design and/or operational controls. The results are summarized in **Table E-4**.

Table E-4 – Key Infrastructure Components Identified for Assessment

Climate Effect		Alternative 3 - Produce Fertilizer (Centralized Implementation)	Alternative 3 - Produce Fertilizer (Decentralized Implementation)	Alternative 4 - Produce Compost	Alternative 5- Produce Low Volume Fertilizer (Centralized Implementation)	Alternative 5- Produce Low Volume Fertilizer (Decentralized Implementation)	Alternative 6 - Thermal Reduction to Ash (not Energy Recovery)
Temperature Increased cooling demand in summer and decreased cooling demand in winter	Facility	-Enclosed storage with climate controls	-Enclosed storage with climate controls	-Enclosed storage with climate controls	-Enclosed storage with climate controls	-Enclosed storage with climate controls	-Adjustments to heating and cooling systems
		-Adjustments to heating and cooling systems	-Adjustments to heating and cooling systems	-Adjustments to heating and cooling systems	-Adjustments to heating and cooling systems	-Adjustments to heating and cooling systems	
	End Use	N/A	N/A	N/A	N/A	N/A	N/A
Temperature Earlier start to growing season	Facility	-Potential reduction in storage requirements for winter/spring	-Potential reduction in storage requirements for winter/spring	-Potential reduction in storage requirements for winter/spring	-Potential reduction in storage requirements for winter/spring	-Potential reduction in storage requirements for winter/spring	N/A
	End Use	-Higher demand for fertilizer product	-Higher demand for fertilizer product	-Higher demand for compost product	-Higher demand for fertilizer product	-Higher demand for fertilizer product	N/A
		-Longer season – increased trucking demand	-Longer season – increased trucking demand	-Longer season – increased trucking demand	-Longer season – increased trucking demand	-Longer season – increased trucking demand	
High Winds Increased Power outages	Facility	Back-up power generation	Back-up power generation	Back-up power generation	Back-up power generation	Back-up power generation	Back-up power generation
	End Use	N/A	N/A	N/A	N/A	N/A	N/A

Climate Effect		Alternative 3 - Produce Fertilizer (Centralized Implementation)	Alternative 3 - Produce Fertilizer (Decentralized Implementation)	Alternative 4 - Produce Compost	Alternative 5- Produce Low Volume Fertilizer (Centralized Implementation)	Alternative 5- Produce Low Volume Fertilizer (Decentralized Implementation)	Alternative 6 - Thermal Reduction to Ash (not Energy Recovery)
Freezing Rain Ice Storms	Facility	Back-up power generation	Back-up power generation	Back-up power generation	Back-up power generation	Back-up power generation	Back-up power generation
	Power Outages	End Use	N/A	N/A	N/A	N/A	N/A
Freezing Rain Ice Storms	Facility	-storage management	-storage management	-storage management	-storage management	-storage management	-storage management
	Trucking disruption	End Use	-scheduling changes / planning	-scheduling changes / planning	-scheduling changes / planning	-scheduling changes / planning	-scheduling changes / planning
Heavy Rain Fall	Facility	- considerations during siting and design of facility	- considerations during siting and design of facility	- considerations during siting and design of facility	- considerations during siting and design of facility	- considerations during siting and design of facility	- considerations during siting and design of facility
	Flooding	End Use	-manage trucking disruption	-manage trucking disruption	-manage trucking disruption	-manage trucking disruption	-manage trucking disruption

Green = all or mostly addressed through mitigation. Yellow = minor disruption or partially addressed through mitigation. Red = cannot be mitigated by design or management.

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In all alternatives, design considerations can mitigate effects from increased temperatures. The longer growing season in some respects is a benefit to alternatives that include composting or fertilizer as an end-product, as it may reduce storage demand over winter with the earlier start to the season and/or increase demand for product. Though there are concerns of negative impacts from changing precipitation patterns, soil erosion and soil moisture (Fuchs, C., Lam, S., McLean, A., and Spanton, A, 2016), those aspects could be mitigated by proper management (erosion control, irrigation and crop selection) by the end user.

Increased high winds and increases in freezing rain and ice storms primarily have the potential to increase power outages, affecting all alternatives. Design considerations such as back-up power systems can mitigate the potential impact. Additionally, findings of the *Climate Change vulnerability Assessment of Ontario's Electrical Transmission Sector* (OCC) (2015) suggest that the Ontario electrical system has considerable built-in redundancy and maintenance and operational procedures that in most cases severe climate events are not likely to significantly affect the delivery of service.

Lastly, increased heavy rain fall has the potential to result in increased flooding events. This has the potential to affect any design alternative and is largely dependent upon siting considerations. This can be mitigated through siting and design considerations. Potential disruption to trucking of product to the end user may not be able to be entirely mitigated, however it would be a minor disruption that can be managed through scheduling and route selection.

5.0 Ranking of Project Alternatives

The climate hazards, interactions, vulnerabilities, and mitigation measures were considered for each alternative. Overall, all alternatives experience the same potential interactions and can equally address climate change vulnerabilities through design and management considerations.

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6.0 References

Environment Canada (2017). Canadian Climate Normals – 1981-2010 Climate Normals & Averages. Retrieved from: http://climate.weather.gc.ca/climate_normals/

Fuchs, C., Lam, S., McLean, A., and Spanton, A (2016). Climate Change and Agricultural Production in the Region of Waterloo: Identifying Risks, Vulnerabilities and Adaptation Strategies. May 11, 2016. Retrieved from: www.wrfoodsystem.ca/files/www/Climate_change_and_agricultural_production.pdf

Interdisciplinary Centre on Climate Change [IC3]. (2015). Localized Climate Projections for Waterloo Region. Retrieved from https://uwaterloo.ca/environment/sites/ca.environment/files/uploads/files/waterloo_region_climate_projections_final_revised30oct2015.pdf

OCC (2015). Climate Change Vulnerability Assessment of Ontario's Electrical Transmission Sector. Ontario Climate Consortium and Toronto and Region Conservation. July, 2015.

Ontario Ministry of the Environment, Waste Management Policy Branch. (July 2012). Guideline for the Productions of Compost in Ontario.

United States Environmental Protection Agency (US EPA). (September 2000). Biosolids and Residuals Management Fact Sheet Odor Control in Biosolids Management.



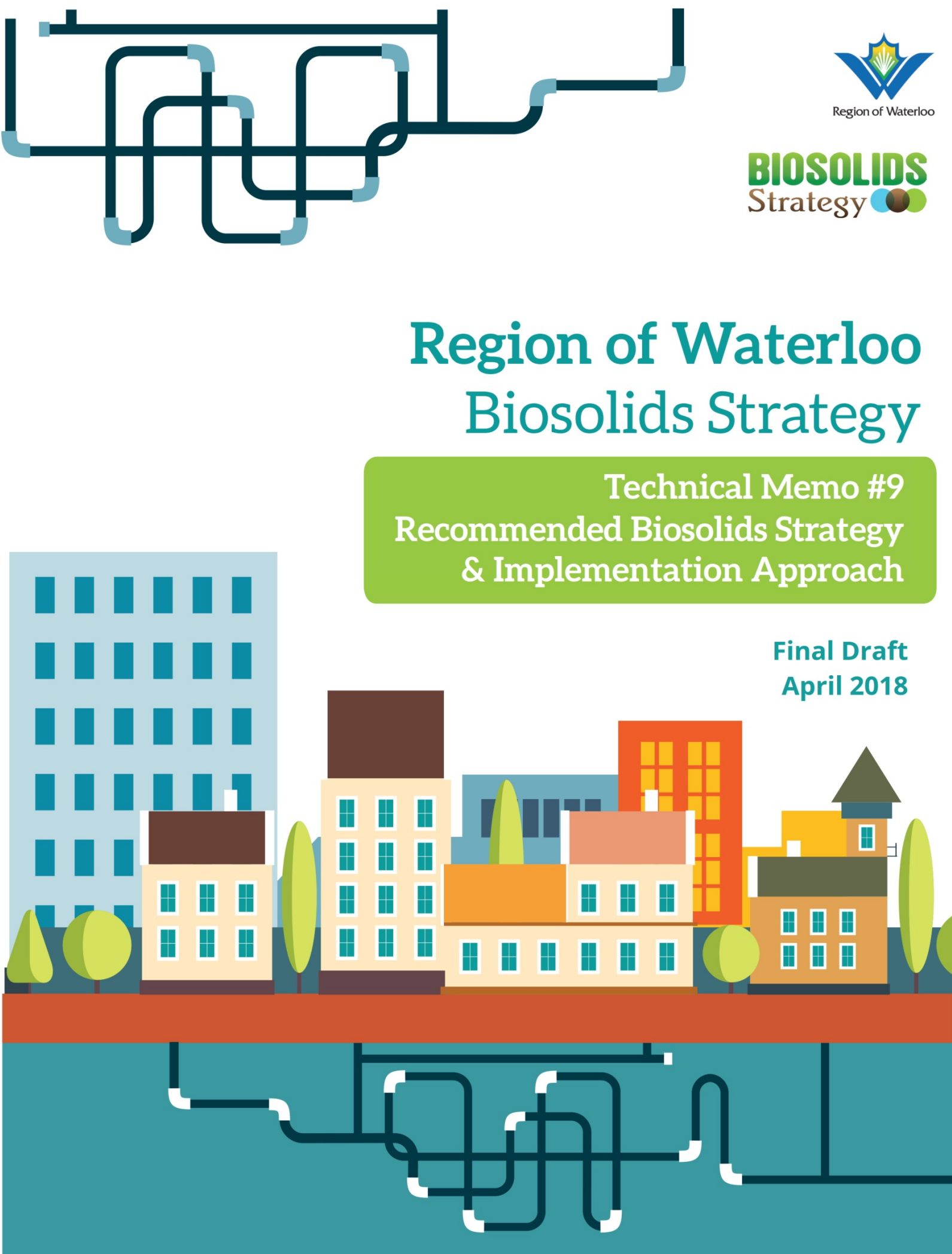
APPENDIX I:

**TM#9 – Preferred Alternative and
Implementation**

Region of Waterloo Biosolids Strategy

Technical Memo #9
Recommended Biosolids Strategy
& Implementation Approach

Final Draft
April 2018



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Acronyms

AS	Activated Sludge
ATAD	Autothermal Aerobic Digestion
BEAM	Biosolids Emissions Assessment Model
BMP	Biosolids Master Plan
CCME	Canadian Council of Ministers of the Environment
CFIA	Canadian Food Inspection Agency
CHP	Combined Heat and Power
EPA	Environmental Protection Act
GHG	Greenhouse Gas
GRCA	Grand River Conservation Authority
MLD	Million Litres / Day
LEED	Leadership in Energy and Environmental Design
MOECC	Ministry of Environment and Climate Change
MPQ	Minimum Performance Questions
NASM	Non-Agricultural Source Material
NMA	Ontario Nutrient Management Act, 2002, S.O. 2002, c. 4
OH&S	Ontario Health and Safety
PPE	Personal Protective Equipment
TM	Technical Memo
US EPA	United States Environmental Protection Agency
WAS	Waste Activated Sludge
WWTP	Wastewater Treatment Plant

1.0 Introduction

1.1 Project Purpose and Approach

The Region of Waterloo Biosolids Strategy was initiated in 2015, to develop an approach to manage biosolids in Waterloo Region to the year 2051. The strategy takes a critical look at current practices, and considers available and relevant technologies for processing biosolids. Alternative ways to manage biosolids have been evaluated against a range of criteria to develop a biosolids management strategy for the Region. This project will result in the selection of a preferred strategy that will be implemented in the Region over the next 35 years. The decision-making process to select the preferred strategy will be documented in a report and be available for public review. Future projects will further refine the implementation details of the strategy including timing, sizing and location of any facilities.

The strategy has been developed in six stages, outlined in a series of technical memos (TMs). The memos form the basis for the final study document. The project stages include:

- Stage 1 – What are biosolids and what process is being followed to develop the strategy?
 - o TM1: The Environmental Assessment Process
- Stage 2 – What is the current situation related to biosolids in the Region and how will it change as the Region grows?
 - o TM2: Existing Conditions
 - o TM3: Biosolids Management Needs Forecast
- Stage 3: What are the project objectives, what technologies and strategies are being considered and how will a decision be made to select the recommended strategy?
 - o TM4: Evaluation Approach and Comparative Evaluation Criteria

- o TM5: Biosolids Technologies, End Uses, and Disposal
 - o TM6: Long List of Biosolids Management Alternatives
- Stage 4 – What alternatives from the long list could work in the Region of Waterloo? How can they be refined based on the project objectives? This stage involves evaluating the alternatives to identify a shorter list that will be evaluated in more detail
 - o TM7: Short List of Biosolids Management Alternatives
- Stage 5 – Based on the project objectives and evaluation criteria, what is the recommended strategy? The short listed alternatives are evaluated at this stage and a recommended strategy is brought forward for public input.
 - o TM8: Evaluation of Short Listed Alternatives
- Stage 6 – What is the best strategy to meet the project objectives?
 - o TM9: Recommended Biosolids Strategy
 - o Biosolids Strategy Document

The Region has been committed to public engagement throughout the development of the strategy. The project team sought to understand the priorities and concerns of community residents across Waterloo Region, as well as technical experts and other stakeholders.

A **sustainable strategy** is one that considers the future growth of the Region and looks to minimize potential landfill disposal requirements of biosolids.

Additional background information regarding the context of biosolids management in the Region of Waterloo is included in Technical Memo 1.

1.2 Purpose of this Technical Memo

This memo carries forward the preferred alternative, a centralized layout for the alternative to produce dried, low volume fertilizer identified in TM8. The final decision-making process to select this alternative is summarized, and the implementation approach to move it forward described in line with the Municipal

Class Environmental Assessment process and the recommended approach to enhanced community engagement undertaken by the Region thus far in the Biosolids Strategy process.

1.3 Memo Structure

Technical Memo 9 is organized into five sections:

- 1. Chapter 1: Introduction**
- 2. Chapter 2: Summary of Evaluation Approach**
- 3. Chapter 3: Summary of Alternatives**
- 4. Chapter 4: Developing the Preferred Alternative**
- 5. Chapter 5: Implementation Approach**

Chapter 1 provides an introduction to the memo, including the purpose and structure. Chapter 2 details the approach used to assess the short listed alternatives. Chapter 3 summarizes the long list of alternatives considered and provides a summary of key features of the short listed alternatives. Chapter 4 provides a more detailed description of the preferred alternative. Chapter 5 highlights the implementation approach and considerations to be carried forward.

2.0 Summary of Evaluation Approach

An objectives-based evaluation approach was used to identify the preferred Biosolids Management alternative. This multi-disciplinary approach evaluated the short-listed alternatives against a set of integrated environmental, social and economic objectives.

Seven objectives were developed based on the issues that matter derived from consultation with key stakeholder and members of the community, alignment with the Region's Strategic Plan, and input from the project's technical team.

A two-phased evaluation was completed, with a long list of alternatives developed (TM5), which were then shortlisted using a series of Minimum Performance Questions (TM7). Based on the results of the Minimum Performance Questions evaluation, four alternatives were shortlisted for further consideration and then evaluated. TM 8 provides an overview of the evaluation criteria used to assess each objective, along with the evaluation results. The four alternatives that were determined through the shortlisting process to be feasible in the Region of Waterloo and therefore meriting detailed consideration were:

- Alternative 1: Produce Fertilizer
- Alternative 2: Produce Compost
- Alternative 3: Produce Dried, Low Volume Fertilizer
- Alternative 4: Thermal Reduction to Ash (No Energy Recovery) (Note: The bracketed part stating 'No Energy Recovery' is not included from this point forward for brevity purposes).

The implementation of Alternatives 1 and 3 may be considered at one central location for processing all biosolids generated within the Region (the "Centralized Alternative"), or at up to four smaller locations, each handling a portion of the overall

production (the “Decentralized Alternative”). The decentralized Alternative may be co-located at existing WWTPs, allowing for the potential integration of existing infrastructure such as site access, servicing, administration, and product-receiving, with the new biosolids processing facility. The following sections provide an overview of the key features of the each of the four alternatives.

The life Cycle Costs assume a 2023 construction date for each alternative, and includes trucking costs and end-of -life equipment replacement. Further details on life cycle cost calculations are presented in the appendix material of TM8 (Appendix A-E). Greenhouse gas emissions are based on tonnes of CO₂ produced per year.

2.1 Alternative 1 – Produce Fertilizer

Alternative 1 assumes the biosolids would processed to produce a fertilizer product. This alternative has been assumed to meet the requirements for a Canadian Food Inspection Agency (CFIA) approved fertilizer, to achieve a reasonable level of marketability. Candidate technologies for the production of a CFIA approved fertilizer from biosolids include:

- Thermal or combined hydrolysis;
- Alkaline stabilization; or
- Autothermal Aerobic Digestion (ATAD).

Decentralized and Centralized options were considered for this Alternative. The facility would have space to store 4 months’ of fertilizer product.

Table 2-1 presents the cost, GHG emission, daily trucking requirements, and end use possibilities for these options.

Table 2-1 Summary of Key Characteristics for Alternative 1: Produce Fertilizer

	Centralized Layout	Decentralized Layout (all facilities combined)
Life Cycle Cost	\$186M - \$239M	\$291 – \$340M
GHG Emissions in CO₂ Equivalents/year (including trucking)	Approx. 35,000 tonnes	Approx. 37,000 tonnes
Daily Trucking - In	7 trucks	14 trucks
Daily Trucking - Out	7 trucks	7 trucks
End Use(s)	Agricultural soil amendment; Non-agricultural soil amendment; or Landfill use or disposal.	

2.2 Alternative 2 – Produce Compost

Alternative SL2 would process the biosolids to produce a Category A quality standard compost product, where biosolids are co-composted with other biomass, in a mixture of up to 25% biosolids, and a minimum 75% amendment material (e.g., wood chips, leaf and yard waste). Decentralized implementation is not considered for Alternative SL2, due to the necessary size of the facility and space restrictions at the existing plant sites when considering co-locating the facility. The facility would have space to store 4 months' of compost product.

Table 2-2 presents the cost, GHG emission, daily trucking requirements, and end use possibilities.

Table 2-2 Summary of Key Characteristics for Alternative 2: Produce Compost

	Centralized Layout
Life Cycle Cost	\$297M - \$346M
GHG Emissions in CO ₂ Equivalents/year (including trucking)	Approx. 7,400 tonnes
Daily Trucking – In	14 trucks (including amendment material)
Daily Trucking – Out	5 trucks
End Use(s)	Agricultural soil amendment; Non-agricultural soil amendment; or Landfill use or disposal.

2.3 Alternative 3 – Produce Dried, Low-Volume Fertilizer

Alternative 3 would add further drying to the Region's current biosolids management process to substantially reduce the total amount of product. The product would be a fertilizer that could also be used as a fuel in certain applications. The facility would have space to store 4 months' of fertilizer product.

Both Centralized and Decentralized implementation are considered for Alternative 3, to explore the potential for added operational and implementation flexibility for the Region.

Table 2-3 presents the cost, GHG emission, daily trucking requirements, and end use possibilities.

Table 2-3 Summary of Key Characteristics for Alternative SL3: Produce Dried, Low-Volume Fertilizer

	Centralized Layout	Decentralized Layout (all facilities combined)
Life Cycle Cost	\$156M	\$335M
GHG Emissions in CO₂ Equivalents/year (including trucking)	Approx. 11,600 tonnes	Approx. 12,000 tonnes
Daily Trucking – In	6 trucks	13 trucks
Daily Trucking – Out	2 trucks	3 trucks
End Use(s)	• Agricultural soil amendment; Non-agricultural soil amendment Fuel source; or Landfill use or disposal.	

2.4 Alternative 4 – Thermal Reduction to Ash

This alternative would reduce the current digested and dewatered biosolids to ash for use as an industrial input such as in the making of cement, or for disposal in a landfill. A limited amount of storage would be needed for this alternative. In the Region of Waterloo, there is no current industrial use for the ash, therefore the product would likely be disposed of at a Provincially-approved landfill outside the Region.

Decentralized implementation is not considered for Alternative 4, due to the cost limitations of the technology involved.

Table 2-4 presents the cost, GHG emission, daily trucking requirements, and end use possibilities.

Table 2-4 Summary of Key Characteristics for Alternative SL4:Thermal Reduction to Ash

	Centralized Layout
Life Cycle Cost	\$270M
GHG Emissions in CO₂ Equivalents/year (including trucking)	Approx. 31,500 tonnes
Daily Trucking – In	6 trucks
Daily Trucking – Out	1 truck
End Use(s)	Landfill

3.0 Selecting a Technology Alternative

The selection of the preferred alternative to form the basis for the Region's Biosolids Management Strategy included the consideration of key issues of concern, in particular those related to quality of life and environmental effects of the alternatives, which were developed based on direct input from the community. As noted in TM8, the objectives-based evaluation is not a scoring system but rather a reasoned approach to considering each alternative from a variety of angles, allowing for a consideration of how well each alternative independently meets the project objectives. The evaluation summary provided in TM 8 considered each of the alternatives in terms of their performance against these Strategy objectives. As discussed in TM 8, each of the alternatives was assessed for performance against the Strategy's objectives.

To summarize, Alternative 1 (Produce Fertilizer) provides a means to create a high-value product for the Region but is expensive and would be difficult to site based on the large scale footprint due to the finished product storage requirements. Alternative 2 (Produce Compost) also provides a very high-value product, but based on the large site footprint and trucking requirements would likely not be suitable as a preferred alternative for the Region. Alternative 4 (Thermal Reduction to Ash) provides a proven process for biosolids disposal that reduces volume and associated trucking, but does not allow for recovery of nutrient value, and has a high cost associated with it.

Alternative 3 (Produce Dried, Low Volume Fertilizer) offers the ability to significantly reduce volume and accordingly reduce trucking and environmental impacts while creating a high-value fertilizer product with a broad range of end uses. This alternative aligns very well with the "align with existing infrastructure" and "protect the natural environment" objectives in both a centralized and decentralized layout.

Alternative 3 performs the most strongly against these two objectives compared to all the other alternatives, although Alternative 1 and Alternative 4 are also well aligned with the existing infrastructure objective.

Alternative 3 offers a reliable set of technologies with safety controls that would be operated by trained staff. Similar to Alternative 1 and 4, it is therefore well aligned with the “protect health and safety” objective. The ability to substantially reduce volume and storage requirements and not be susceptible to disruptions to processing or end product quality without significant impacts to operational risk allows Alternative 3 to be very well aligned on the “minimize and manage operational risk” objective. In fact, it performs the most strongly on this factor compared to all other alternatives.

The cost of implementing the centralized version of Alternative 3 is the lowest of all the alternatives by a considerable margin and is therefore very well aligned with the “be cost effective and provide value” objective. The cost associated with a decentralized layout is much more uncertain depending upon how each decentralized facility is associated with an existing wastewater plant and the amount of new infrastructure and features required.

In reviewing the evaluation for each alternative and the comparative analysis completed in TM8, Alternative 3 stands out as the alternative with the strongest alignment with the Strategy objectives. Characteristics of Alternative 3 provide long term security and flexibility in operations and allow for continuation of the current approach (with the implementation of short term storage at existing facilities) or early implementation (if that route is preferred). The volume reduction conferred through the drying process, the limited impacts to the environment, and protection of quality of life for the surrounding community are also key advantages of this alternative. Both the centralized and decentralized layouts may be considered as the Region moves forward with future implementation under Phase 3 of the Municipal Class Environmental Assessment process.

Alternative 1 may be examined as a potential alternative to be considered on a case-by-case basis for the smaller, aerobic plants in the Region in the future, along with other potential technologies that do not require dewatering of biosolids prior to treatment. At the present time however, the need to create a fertilizer has not been identified. Alternative 2 would not be considered as a preferred alternative due to the large site and trucking requirements, resulting in siting difficulties and high cost of implementation. Alternative 4 has benefits in terms of volume reduction and efficiency of management, but would not be preferred due to the loss of nutrient value of biosolids. However, this alternative may be considered at the time of implementation if there is an opportunity to capitalize on synergies with other waste management streams at the Region, in particular solid waste.

3.1 Recommended Alternative: Centralized Facility to Produce Dried, Low-Volume Fertilizer from Biosolids

This alternative would implement a dryer technology after anaerobic digestion and dewatering to reduce the volume of dewatered cake and generate a biosolids-derived fertilizer product such as a pellet or similarly granular material. The technologies proposed in this category would produce a substantially lower quantity of biosolids end product per capita compared with the current approach through the removal of most of the liquid contained in the biosolids cake.

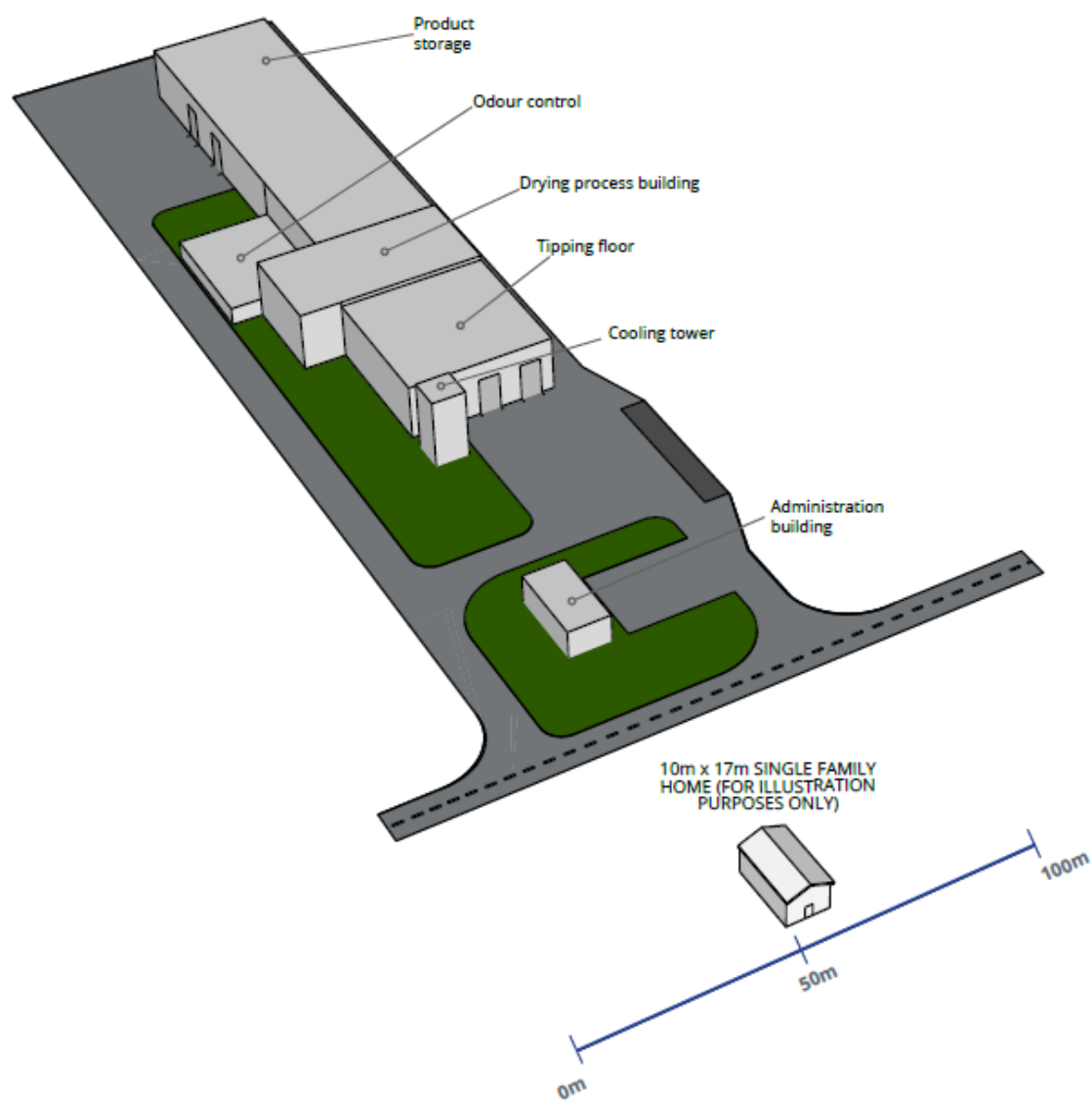
The product would meet the United States Environmental Protection Agency (US EPA) definition of Class A biosolids, and stabilization processes in this configuration have been demonstrated to meet the requirements of a fertilizer as administered by CFIA. Based upon the enhanced stability of the dry product, storage requirements for the specified 4-month period are relatively small. This alternative would provide the following end use or disposal options:

- Agricultural use as fertilizer;
- NASM, such as mine site tailings pond reclamation;
- Landfill daily cover;
- Use as a renewable fuel in combustion; or
- Landfill disposal.

The decentralized layout for Alternative 3 that is described in TM8 may also be maintained as an option for consideration due to the potential benefits from locating adjacent to existing WWTPs and potential for incremental implementation of the drying facility.

Figure 3-1 presents a schematic layout for this alternative.

Figure 3-1 Schematic Representation of Centralized Site Layout for Alternative SL3: Produce Dry, Low Volume Fertilizer



4.0 Biosolids Strategy - Implementation Approach

The existing approach for end-use of biosolids in the Region works well and incorporates best management practice. Biosolids are currently used as a soil amendment in agricultural land in Southwestern Ontario and in the rehabilitation of mine tailings areas in Sudbury. Whenever these two options are not available, then the Region must send the biosolids to a landfill for disposal. Landfilling of biosolids should be the last resort as it does not follow best management practices. The addition of short term (up to 10 days) storage at the three major wastewater plants (Kitchener, Galt and Waterloo) would provide operational security and flexibility to the current system and would minimize the need for landfilling of biosolids.

The current system is cost effective and provides value to the Region; however, there are long term risks associated with it as well. For example, the current agricultural use can only be applied periodically to the agronomic limit. The possibility of sudden refusal for land application by the land owner is also a risk.

While the proposed processing alternative of producing dry fertilizer product also provides value to the Region, it does require the investment of a large amount of capital and necessitates the need to select a site. It is recommended that the Region immediately install short term storage at the three major wastewater plants and continue to explore methods for extending the current end-use options available to the Region.

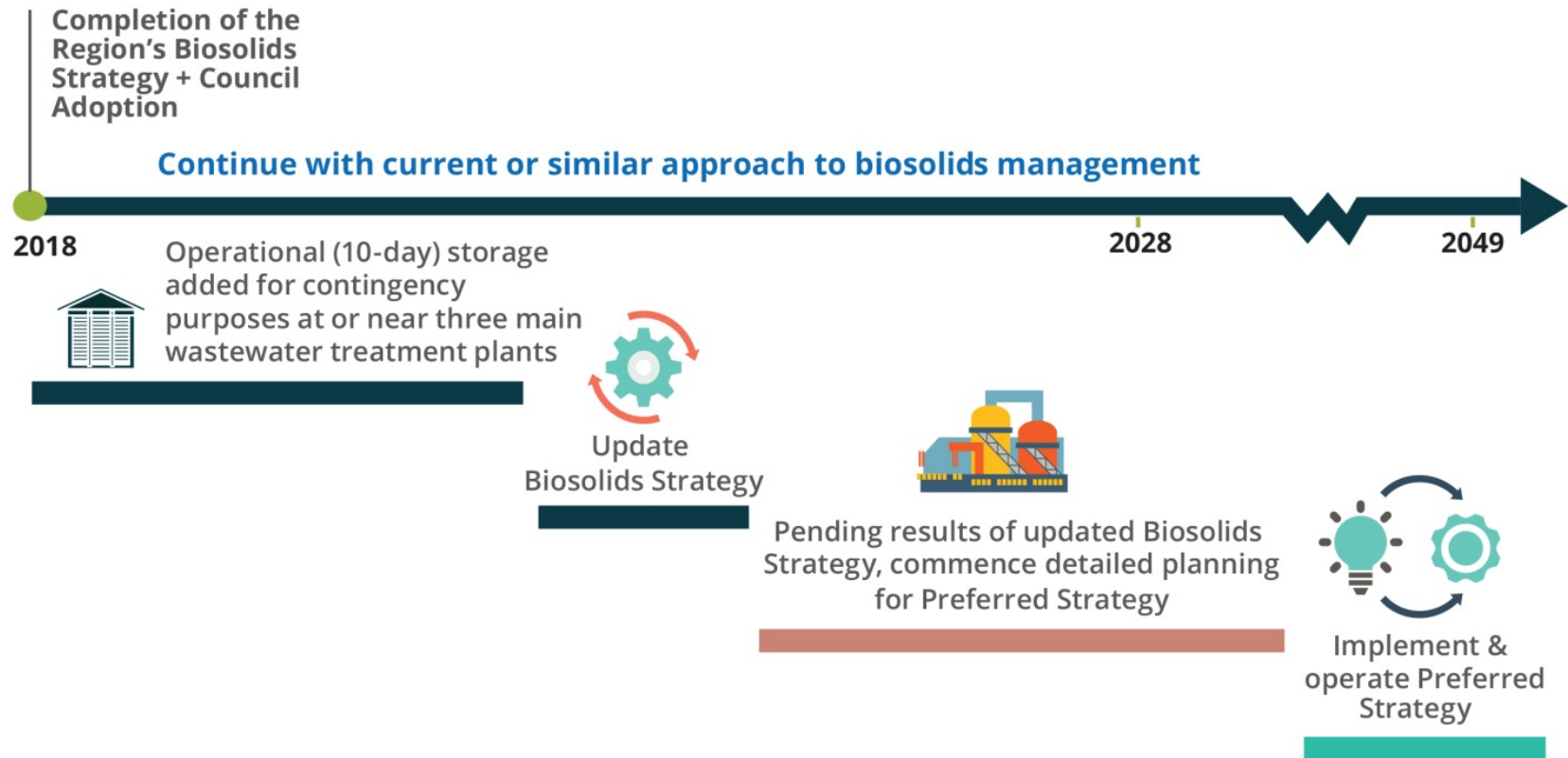
Implementation of the processing alternative of constructing a facility or facilities to produce low volume dried fertilizer should occur in the future when internal Region factors such as contract extension and short term storage needs and external factors such as regulation changes dictate the need for this facility. The timing of the implementation should be such that it is initiated well in advance of the need

recognizing the extended timeline required to site, design, obtain approvals and construct such a facility or facilities.

It is not possible to propose a date to start to implement the new facility(s) at this time as these factors controlling the timing are either unknown or out of the control of the Region. The Region should continually review the assumptions and considerations documented in the final 2018 Biosolids Master Plan and monitor the factors that will dictate the need to initiate the process to develop the new processing facility.

The Biosolids Strategy therefore consists of two phases: maintaining the current approach with implementation of short term storage to support operational needs, and future implementation of a centralized drying facility(s) located within the Region to support long term biosolids management needs, as illustrated on **Figure 4-1**.

4-1 Implementation Approach for the Biosolids Strategy



Phase 2 implementation timing would be dependent on a range of factors, including (but not limited to):



The implementation approach therefore involves two key phases, as described in the following sections.

4.1 Phase 1: Integration of Operational Storage at Existing WWTP Facilities

The addition of short term (up to 10 days) storage at the three major wastewater plants (Kitchener, Galt and Waterloo) would provide operational security and flexibility to the current system and would minimize the need for landfilling of biosolids.

Operational storage is an integral part of the strategy, and is intended to be part of the development of the new centralized processing facility. However, if implementation of this facility is not undertaken immediately, there would be a need to develop operational storage at existing facilities to improve flexibility and mitigate challenges associated with everyday situations where biosolids cannot be transported immediately to end-uses.

Operational storage of the biosolids produced at the three largest facilities (Kitchener, Waterloo and Galt WWTPs) in the Region is a key aspect of continuing the current biosolids end use and disposal approach, lowering operational risk with the potential to facilitate use of biosolids in order to avoid landfill disposal. New storage will also be useful infrastructure between WWTP biosolids production, and any proposed processing technology. The focus of discussion at this stage is storage of dewatered cake at Kitchener (Manitou Drive), Waterloo, and Galt dewatering facilities. Compact footprint has been considered a priority in order to facilitate siting.

The storage approach discussed in this document is intended to provide storage for the existing NASM quality cake only on an interim basis when due to operational issues the material cannot be transported off-site under the current just in time schedule. Storage requirements for products generated by the short list of proposed

alternatives are addressed as part of the detailed process description for each short list alternative in Appendix H.

This short term storage at the plants would offset the need for short term storage at a new centralized processing facility. Short term storage at the centralized plant could be decreased in size considerably.

Short term operational storage at the existing plants will have the following features:

- Location at the three facilities (Kitchener, Galt and Waterloo) presently producing dewatered cake. We have assumed that liquid sludge produced at small facilities may be managed for short periods of time onsite if required and that the primary risk to operations is end-use management interruptions rather than transport between facilities.
- Operational storage will consist of bunker-type cake storage with the following features:
 - o Enclosed fixed roof building structure
 - o Bunker constructed with 3m concrete push walls on three sides for containment of cake
 - o Appropriate ventilation and air quality control measures

The following supportive studies are currently anticipated to be required towards implementing operational storage:

- Schedule A Class EA (preliminary design and detailed design).

Table 5-1 provides a summary of the estimated construction cost of operational storage at each of the main existing wastewater treatment plants in the Region.

Table 4-1 Summary of Operational Storage Implementation Assessment

Wastewater Treatment Plant	2016 Total Biosolids Production (Dry Tonnes / day)	Cake Volume m ³ /day	Volume generated in 10 days (m ³)	Estimated Construction Cost (Low End)	Estimated Construction Cost (High End)
Kitchener	13	53	532	\$1,100,000	\$2,500,000
Waterloo	8	33	334	\$900,000	\$2,100,000
Galt + Preston	9	35	349	\$900,000	\$2,200,000

Values presented in **Table 5-1** are order of magnitude opinion of probable cost (Class V, Level 1, Class D Cost Estimate). Engineering is estimated as 15% of the total construction cost and a contingency of 20% of the total cost has been included in this estimate.

4.2 Phase 2: Implementation of a Centralized Processing Facility to Produce Dried, Low Volume Fertilizer

Implementation of a centralized facility (or decentralized facilities, as the need is determined) to produce low volume dried fertilizer should occur in the future when internal Region factors, such as greater risks related to maintaining existing methods and short term storage needs, and external factors such as regulation changes or funding opportunities (through Federal or Provincial programs) dictate the need for the facility(s). The timing of the implementation should be such that it is initiated well in advance of the need recognizing the extended timeline required to site, design, obtain approvals and construct the facility(s).

A date to start to implement the new facility(s) is not being proposed at this time as the factors controlling the timing are either unknown or out of the control of the Region. The Region should continually review the assumptions and considerations documented in the final 2018 Biosolids Master Plan and monitor the factors that will dictate the need to initiate the process to develop the new processing facility(s).

As noted in Appendix H, the smaller wastewater treatment facilities that do not currently have anaerobic digestion and dewatering have unique considerations, including smaller quantities of biosolids generated, and more flexibility with respect to storage and removal of material from sites. The existing approach may therefore be continued for the smaller plants even after the implementation of the new centralized facility; alternatively, other localized processing solutions for these smaller plants may be considered at the time of implementation.

Based on the feedback received from the community on the “issues that matter” and the implementation approach, the following are some preliminary recommendations for the Region to consider in the siting of the new processing facility through future phases of the Environmental Assessment process. The following supportive studies are currently anticipated to be required towards implementing the recommended strategy:

- Update to Biosolids Strategy
- Schedule C Class EA (preliminary design and detailed design).

Zoning

The selected site for placement of the new processing facility(s) should be located in an appropriately industrially zoned area, in line with the local and Regional official plans, municipal standards, and design criteria.

Access and Traffic Management

Mitigation of truck traffic impacts to the surrounding community will be essential to the long term success of the Strategy. Placement and selection of truck access points

to the facility(s) should be situated to reduce noise and traffic impacts. Appropriate access will be required for emergency vehicles as well.

Site Footprint & Growth Potential

The site footprint provided in this strategy provides a high-level overview of the potential space that would be required to accommodate all components of the processing facility(s) and associated storage. However, this will be further refined through subsequent studies including a Schedule C Class EA. The selection of potential sites for consideration should also take into account long-term growth and expansion needs for the facility(s).

Proximity to Sensitive Environmental Receptors

Protection of the natural environment is a key part of the Strategy and will provide a set of considerations in selection of a site for a new facility(s). Proximity to sensitive environmental receptors as well as hazard areas such as floodplains should be considered in the selection of appropriate sites for consideration.

Proximity to Non-Industrial Development

Should the need arise for a new facility, protecting quality of life for any non-industrial neighbours such as residential communities would need to be considered as an integral component of the Strategy objectives. In addition to reducing traffic and associated noise impacts to the community, overall noise, odour, and nuisance disturbances to the facility(s) neighbours should be mitigated at the fence line of the facility(s) to limit exposure to these elements.

4.3 Conclusion

In developing the Biosolids Strategy, the Region has conducted an in-depth objectives-based assessment of the alternatives for managing biosolids in the Region, integrating stakeholder, community, and technical feedback along each step

of the process. As the Region moves forward with the Environmental Assessment process to implement the Master Plan, the following key steps should be integrated:

- Ongoing regular review of the assumptions and considerations in the Master Plan to check for consistency with the evolving needs of the Region and latest state of technology options;
- Consideration of community concerns received through the process of developing the Master Plan in the selection of potential sites for the new processing facility(s);
- Continuation of enhanced community engagement through subsequent phases of the Municipal Class Environmental Assessment process to provide the community with opportunities to be involved in providing input towards future decisions related to implementation of the Master Plan; and
- Consideration of potential funding opportunities for the new processing facility through Public-Private Partnerships (P3s) or other federal/provincial infrastructure grant/incentive programs.

This Master Plan is intended to form a supportive guide towards the long term management of biosolids in the Region to 2051, and will therefore be an important tool in communicating the Region's approach both for internal staff as well as for the wider community. An update to the Master Plan should be considered at around the 10-year mark to maintain relevancy with the most contemporary technologies and alternatives available at that time to carry the Region through the next long term planning horizon.

References

CIMA+. 2017. Sludge and Biosolids Generation Rates Estimate memo.

Dillon Consulting Limited (Dillon). 2016. Technical Memo #2: Existing Conditions Background Study (Draft).

Dillon. 2016. Technical Memo #5: Long List of Biosolids Management Alternatives (Draft).

Dillon. 2017. Technical Memo #6: Biosolids Quantity Forecast (Draft).

Dillon. 2017. Technical Memo #7: The Long List of Alternatives (Draft).

Dillon. 2018. Technical Memo #8: Evaluation of Short Listed Alternatives (Draft).