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REGION OF WATERLOO WASTE MANAGEMENT MASTER PLAN

INTERIM REPORT NO. 5

SUSTAINABILITY EVALUATION OF RESIDUAL WASTE MANAGEMENT OPTIONS

Submitted to:

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REPORT

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Preamble

Waterloo Region is a community consisting of seven local area municipalities including the Cities of Cambridge, Kitchener and Waterloo, and the Townships of North Dumfries, Wellesley, Wilmot and Woolwich. The Region of Waterloo (Region) and the local area municipalities are responsible for providing different municipal services to its residents. In general, the Waste Management Division of the Region's Transportation & Environmental Services Department is responsible for providing residential waste collection, diversion and disposal services for Waterloo Region. Industrial, commercial and institutional waste diversion and disposal is governed by the Province of Ontario. The Waste Management Division is also responsible for operating the Region's one active landfill, five closed landfills, one bulk waste transfer facility, and six small vehicle transfer stations.

Long term strategic planning has laid the foundation for municipal waste management in Waterloo Region since the 1980's. Since the completion of the "1986 Region Waste Management Master Plan" (WMMP), the Region has adopted an integrated approach to waste management that balances the need for waste reduction and diversion services, as well as waste disposal. In 1998, the Region's Waterloo Waste Management Centre registered to the ISO 14001 standard. The Waterloo Waste Management Centre, which includes the Region's active landfill site, was the first municipal waste management facility in North America to do so. Continuous improvement to the Environmental Management System has resulted in successful re-registration to the standard ever since. Other recent key initiatives, which have resulted from the Region's approach to balanced waste management services, include a three-year (2005 – 2007) waste reduction sequencing plan, a focus on implementing Blue Box Best Practices, and the introduction of the green bin organics program to all single family households in Waterloo Region by 2010. Based on the guidance provided by the original 1986 WMMP, infrastructure modernization, service integration, and program initiatives have resulted in a threefold increase in the amount of material diverted from landfill disposal between 1995 and 2011 amidst a population increase of nearly 35% over the same period.

Building upon the successes and experience gained over the last 25 years, the Region is embarking on the development of a renewed strategy to guide waste management services over the next 20+ years. The Region of Waterloo is one of only a few municipalities in Ontario with significant remaining local landfill capacity. As such, the new WMMP will include careful consideration of post-diversion residual waste management options that are consistent with the Region's corporate and strategic vision. In addition, the new WMMP will address key challenges being faced by Waterloo Region, including:

- Regional growth;
- Regulatory demands and changing legislation;
- Increasing environmental protection measures;
- Evolving provincial waste management directives;
- Increasing demand for innovative and sustainable solutions;
- Public perception of emerging and evolving waste management opportunities; and
- The potential financial implications of long term management options.



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The WMMP study was initiated in March 2012 and is anticipated to be completed by the fall of 2013. The WMMP study will involve collaboration with a Steering Committee comprised of Region councillors and staff, and a Stakeholder's Group comprised of Waterloo Region residents and representatives of community and environmental organizations, business and industry organizations, area municipalities and universities, and technical consultants.

Over the study period, the Region will review current waste management programs and performance, identify opportunities to divert even more waste from landfill, identify options for future residual waste management and evaluate their sustainability, and recommend options for the long term management of Waterloo Region's residual waste. Tasks comprising the WMMP study will be documented in a series of Interim Reports and will culminate in a Final Waste Management Master Plan Report, each of which will be made available on the Region's Waste Management web page (<http://www.regionofwaterloo.ca/waste>).

The expected outcome of the study is an updated WMMP that:

- Has achieved meaningful involvement and public consultation early and throughout the process;
- Ensures decision-making processes are accessible, traceable & transparent;
- Considered partnerships with other municipalities, the private sector and the province;
- Is strongly aligned with the Region's corporate and strategic vision;
- Fairly balances regional dynamics (e.g., rural/urban differences);
- Identifies continued improvements to existing waste reduction and diversion programs;
- Identifies a recommended residual management strategy, including an implementation plan, financial resources, conceptual design(s), energy profile and regulatory implications;
- Remains flexible to respond to changes in policies, technologies, growth and the composition of the waste stream; and
- Will meet the needs of the community into the future.

Waterloo Region residents and businesses are encouraged to become involved in the WMMP Study by attending public information sessions, joining discussions on Twitter @WasteWR or on the Region of Waterloo Waste Management Facebook page, or by following study updates on the Waste Management Division website (www.regionofwaterloo.ca/waste). Residents or businesses can also sign up to receive updates about the WMMP by emailing waste@regionofwaterloo.ca.



Glossary of Terms

Industrial, Commercial and Institutional: Includes manufacturing establishments, goods and/or services retailers, and for-profit and not-for-profit institutions (e.g. schools, hospitals, places of worship, etc.). Waste management services for Waterloo Region's Industrial, Commercial and Institutional establishments are subject to eligibility and can be confirmed by contacting the Region's Waste Management Division.

Landfill Capacity: The total volume of waste, expressed in cubic metres, that a landfill site is designed and approved to hold.

Region of Waterloo: The regional level municipal government in Waterloo Region, established on January 1, 1973, and responsible for providing approximately 60 percent of municipal government services in the community, including public health, social services, planning, housing and community services, human resources and transportation and environmental services.

Residual Waste: Overall term for the waste remaining after waste has been diverted that requires final disposal at a landfill site or other type of waste disposal facility where the material is destroyed; also commonly referred to by the term "garbage."

Waste: A material that is discarded as no longer useful or required by an individual, a household, or a commercial / industrial operation, whether or not it may be disposed or diverted.

Waste Management Master Plan (WMMP): A comprehensive long-term strategy that identifies present and future waste management needs for Waterloo Region and establishes a direction for on-going development of the Region's integrated waste management system.

Waterloo Region: The geographic area comprised of the cities of Cambridge, Kitchener and Waterloo and the townships of North Dumfries, Wellesley, Wilmot and Woolwich.

WMMP Study: The process currently being undertaken by the Waste Management Division of the Region of Waterloo to build upon the success of the *1986 Region Waste Management Master Plan* and establish an updated WMMP that will guide waste management services over the next 20+ years.



Glossary of Abbreviations

GoldSET	Golder Sustainability Evaluation Tool
LCA	Life Cycle Analysis
MBT	Mechanical Biological Treatment
MCDA	Multi-Criteria Decision Analysis
MSAR	Mechanical Separation for Additional Recovery
Region	Region of Waterloo
TT	Thermal Treatment (combustion, pyrolysis, gasification)
WMMP	Waste Management Master Plan



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APPENDIX A

Detailed Criteria Evaluations



1.0 INTRODUCTION

Long term strategic planning has been the foundation for municipal waste management in Waterloo Region since the 1980's. Based on the guidance of the original *1986 Region Waste Management Master Plan* (WMMP) and resulting infrastructure modernization, service integration, and program initiatives, the amount of material diverted from landfill disposal tripled between 1995 and 2011, in spite of a population increase of nearly 35% over the same period. Building upon this success, the Region of Waterloo (Region) is currently working to develop a new waste management strategy. The updated WMMP study will guide waste management services over the next 20+ years.

The following Mission Statement, (published in 2012), defines the key goals for the WMMP study. This statement has guided this study at all stages, including sustainability evaluation which is present in this report.

To develop a sustainable waste management master plan, in consultation with the community, that is environmentally, socially and fiscally responsible while meeting the current and future needs of Waterloo Region.

The sustainability evaluation provides an overview of the relative strengths and weaknesses of each option, on the basis of environmental, social, economic and technical considerations. The sustainability evaluation does not offer a right or wrong answer regarding the option(s) to be retained; rather, it serves to inform the decision-making process that the Region will undergo in the preparation of its WMMP.

In order to further support the decision-making process, the options will also be evaluated in terms of their respective environmental footprints. This analysis will be based on a life cycle analysis (LCA) that will analyse and quantify each option's impact on the environment. The results of this specific environmental analysis will be presented in a separate report.

The degree of sustainability of the studied residual waste management options has been evaluated in order to inform the Region and stakeholders of the environmental, social, economic and technical strengths and weaknesses of the options, relative to each other. This document is the fifth in a series of reports that collectively will form the *Region of Waterloo Waste Management Master Plan*.

The goal and objectives of the sustainability evaluation are:

Goal: To integrate sustainability considerations early in the decision-making process to allow the Region and stakeholders to make well-founded decisions regarding the preferred option(s) in the *Waste Management Master Plan*.

Objectives:

- To prepare an evaluation framework based on sustainability criteria that align with the Region's environmental, social, economic and technical goals;
- To evaluate the performance of each residual waste management option against these environmental, social, economic and technical criteria; and



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- To perform a sensitivity analysis to assess the robustness of the evaluation criteria framework.

The report is divided into several sections, beginning with a description of the sustainability evaluation methodology, detailing the various steps that led to the final sustainability results. Next, the evaluation criteria, the scoring schemes and the weightings that were used in the analysis are presented. The sustainability results are then presented in the form of a ranking of options based on a single score system. Finally the report presents the results of a sensitivity analysis that was conducted in order to assess the robustness of the rankings.



2.0 METHODOLOGY

The study methodology is premised on the concepts of sustainability. It has been designed to generate a list of options and to then evaluate fatal flaws, sustainability and environmental footprint of each option in order to provide a comprehensive picture of the relative strengths and weaknesses of each option. These four steps are depicted in Figure 1.

Step 1: Residual Waste Management Technology Options

This step included listing and defining all possible residual waste management technology options available to the Region. This list was created based on a literature review and Golder's professional experience in the waste management sector.

Step 2: Fatal flaw analysis

The options then underwent a fatal flaw analysis that was designed to refine the residual waste management technology options list by eliminating the options that did not satisfy the minimum requirements established by the Region. Sections 2.1 and 2.2 describe the detailed methodology for this second step. For further details on the fatal flaw results, please refer to "Interim Report No. 3 - Review and Preliminary Evaluation of Residual Management Options".

Step 3: Sustainability evaluation (GoldSET[®])

The options that successfully passed the fatal flaw analysis were carried forward for further evaluation based on a sustainability framework powered by Golder's sustainability tool (GoldSET[®]). This tool evaluated each option on the basis of environmental, social, economic and technical criteria. This third step resulted in a general ranking of the options based on a single score system and graphical output that shows how each option scored relative to each other in terms of environmental, social, economic and technical sustainability.

Step 4: Environmental footprint evaluation (LCA)

The fourth step of the study evaluation approach will analyse options in terms of their respective environmental footprints through a life cycle analysis (LCA) which will further analyse and quantify each option's impact on the environment. The results of this analysis, coupled with the results of step 3's GoldSET analysis, will then be used to identify the preferred residual waste management option(s) for the Region, which will in turn be combined with policy measures and waste reduction and diversion opportunities being identified by the Region through concurrent studies.

The present report details the methodology and the results of the first three steps of the overall sustainability approach. Step 4, which will be performed using a life cycle analysis (LCA), will be the object of a separate report.

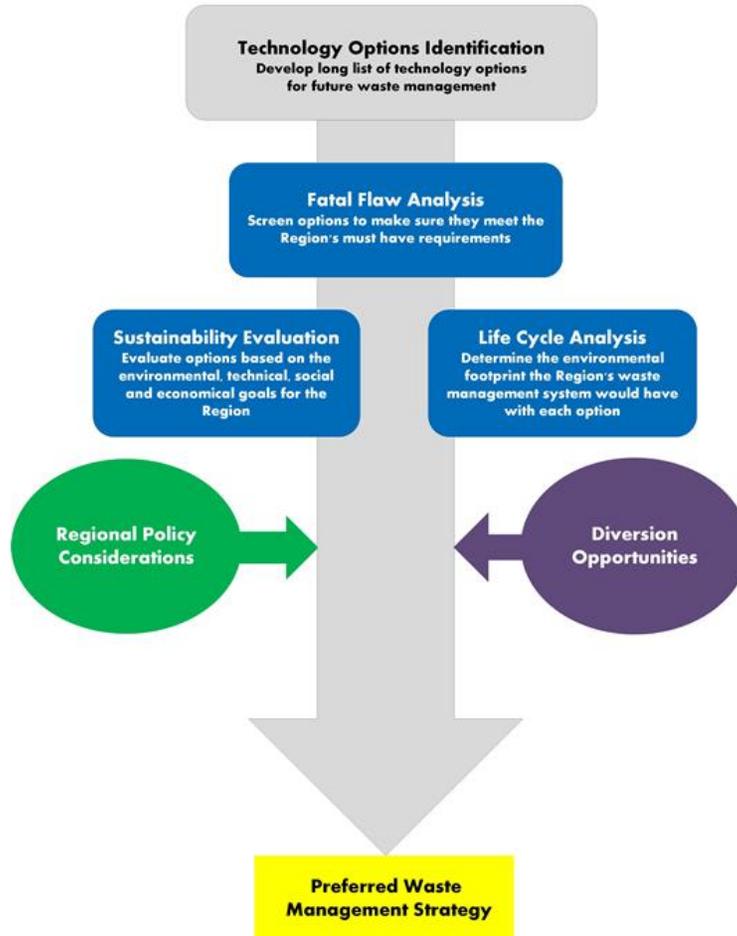


Figure 1: General Sustainability Evaluation Approach

2.1 List of Technology Options

Before commencing the sustainability evaluation process, all possible residual waste management options available for the Region needed to be identified. The following technology options were identified:

- Landfill Disposal (expansion or greenfield)
- Landfill Mining
- Thermal Treatment (combustion, pyrolysis, gasification)
- Mechanical Separation for Additional Recovery
- Mechanical Biological Treatment (MBT)



■ Steam Classification

Detailed descriptions of these options can be found in “Interim Report No. 3 – Review and Preliminary Evaluation of Residual Waste Management Options.”

2.2 Fatal Flaw Analysis

The fatal flaw analysis is the second step of the sustainability evaluation process being implemented over the course of the WMMP study. It is designed to refine the residual waste management options list by eliminating the options that do not satisfy what is considered by the Region to be the minimum requirements.

In order to complete this step of the evaluation process, Golder, in collaboration with the WMMP Project Team and Steering Committee, developed a list of properties that an option must possess to merit further consideration in the study. These properties, termed the “fatal flaw criteria,” are outlined in Table 1.

Table 1: Fatal Flaw Criteria

<i>Integration</i>	<i>Recovery</i>	<i>Reliability</i>
<ul style="list-style-type: none"> ■ The residual waste management option is compatible with existing Regional and local Municipal Official Plan policies, with or without amendments. ■ The residual waste management option is compatible with existing and planned Regional waste management infrastructure. ■ The residual waste management option has the capability to meet or exceed provincial regulatory requirements and standards. 	<ul style="list-style-type: none"> ■ The residual waste management option supports the waste management hierarchy by having the capability to recover resources. These may include, but are not limited to, one or more of the following: <ul style="list-style-type: none"> ■ Recyclables (e.g. metals, glass, other inerts); ■ Refuse derived fuel; ■ Biofuel; ■ Compost; and/or ■ Energy (energy-from-waste, and including landfill gas). 	<ul style="list-style-type: none"> ■ The residual waste management option can be expanded to meet changing capacity needs or to provide for opportunities for collaboration with other waste management service providers. ■ The residual waste management option has a proven operating history at a reasonable capacity. For the purposes of the WMMP Study, this is defined as having full-scale commercial operations experience for at least one year on a generally continuous basis, processing municipal solid waste. ■ The residual waste management option has the ability to address capacity requirements for a minimum of 20 years.

Each option had to meet all the criteria in order to proceed to the next stage of the evaluation process. Options that did not meet these criteria were considered to have a fatal flaw and were not carried forward to Step 3 in the evaluation process. Section 3.1 presents the results of the fatal flaw analysis.



2.3 Development of Multi-Criteria Analysis Framework

The decision-support process employed during this GoldSET evaluation is based on the broadly-accepted multi-criteria decision analysis (MCDA) methodology (Keeney & Raiffa 1976; Belton & Stewart 2003). MCDA is a term that describes a variety of approaches to assess options based on multiple decision criteria or objectives. This approach allows the systematic comparison of options based on multiple evaluation criteria that may be grouped together into environmental, social, economic and technical dimensions. While subjectivity (i.e. professional judgment) is inherent in MCDA and decision-making in general, the process provides a system to reduce the subjectivity, to make the decision process traceable and to facilitate the transmission of results to the various stakeholders. This approach is often hierarchical, allowing criteria to be geared towards goals. When the decision is optimized using appropriately selected sustainability criteria, it can lead to lower risks and greater opportunities.

MCDA typically involves using a structured and transparent methodology to:

- 1) Score or rank options on each decision criterion within each dimension;
- 2) Aggregate the scores or ranks based on the relative weights given to the decision criteria or to the dimensions (environmental, social, economic and technical).

This approach makes the decision criteria explicit and can facilitate cooperation among multiple stakeholders during the decision-making process. Results of the evaluation can be expressed in multiple levels of detail, using a display of results, by dimension, goals or evaluation criteria, thereby facilitating communication to the decision makers and stakeholders. However, MCDA will not make the decision. MCDA will aid decision-makers in making *their* decision through a systematic and transparent assessment.

For the purposes of the Region's Waste Management Master Plan, Golder built a specific waste management framework using its in-house GoldSET[®] application. The framework was based on the Region's Environmental Sustainability Strategy (ROW, 2009) and integrated issues and values that were important for the Region of Waterloo and for the various stakeholders.

The framework considers the four dimensions of sustainable development: environmental, social, economic and technical.

The main steps involved in the construction of this framework were:

- 1) Identification of goals and evaluation criteria for each of the four sustainability dimensions;
- 2) Development of scoring schemes for each evaluation criterion; and
- 3) Establishment of relative weights for each of the four sustainability dimensions.

The details regarding these steps are presented in the following sections.

2.4 Identification of Goals and Evaluation Criteria

The general structure proposed for the multi-criteria framework is composed of three layers, as shown in Figure 2. This hierarchic structure organizes four key dimensions (environmental, social, economic and technical) into specific goals that must be accounted for in the evaluation of the performance of each residual waste



management option. The extent to which a goal is being met by an option is assessed using a suite of evaluation criteria specific to each goal within every dimension.

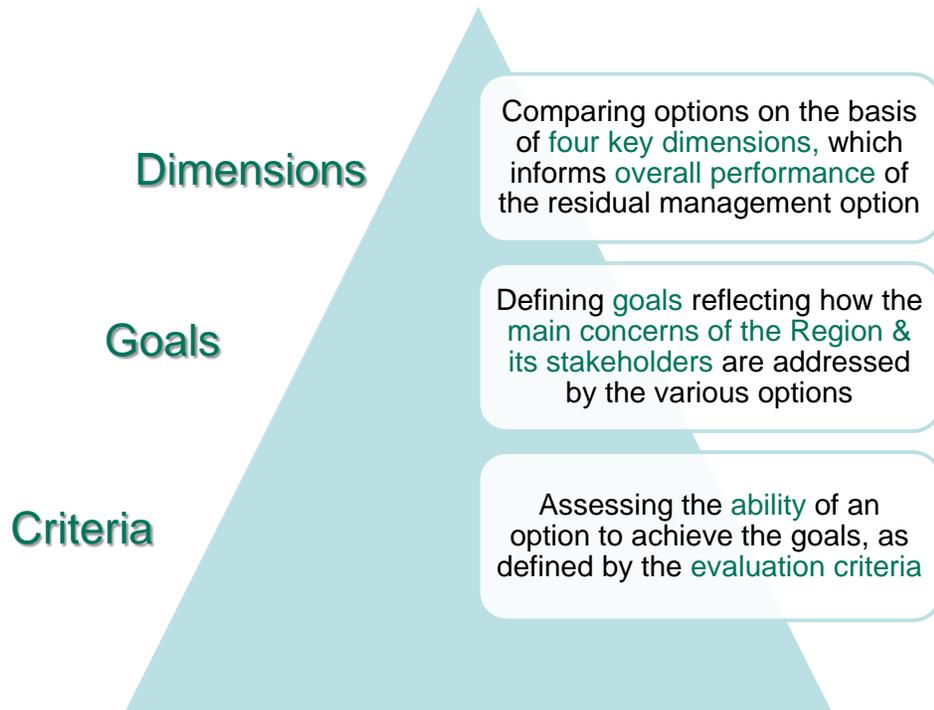


Figure 2: Proposed Hierarchic Structure for the Framework of Evaluation Criteria

Top layer – Dimensions

The organization of the framework into dimensions associated with the concept of sustainability provides a simple way of organizing the information and facilitating the communication of key issues, as shown in Figure 3. Each dimension has a specific purpose in assessing an option's performance.

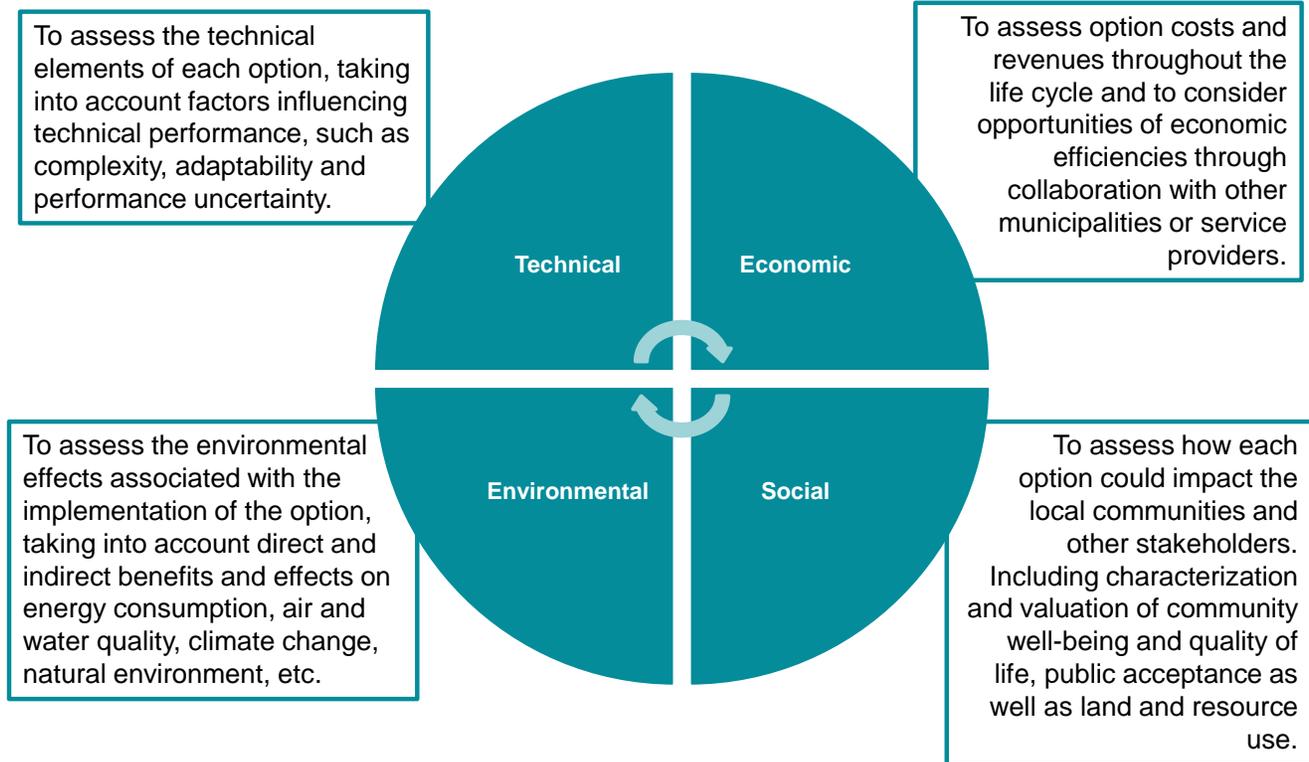


Figure 3: Dimensions Considered in Residual Waste Management MCDA.

Middle layer – Goals

The purpose of this intermediate step between dimension definition and evaluation criteria development is to identify the main drivers in each of the four dimensions.

Specific goals were identified for each dimension based on:

- The Region's Environmental Sustainability Strategy;
- The Region's Strategic Focus for 2001 – 2014;
- Golder's professional expertise in the waste management sector;
- Various workshops with the Region.

The final goals retained for the sustainability analysis are presented in Figure 4.



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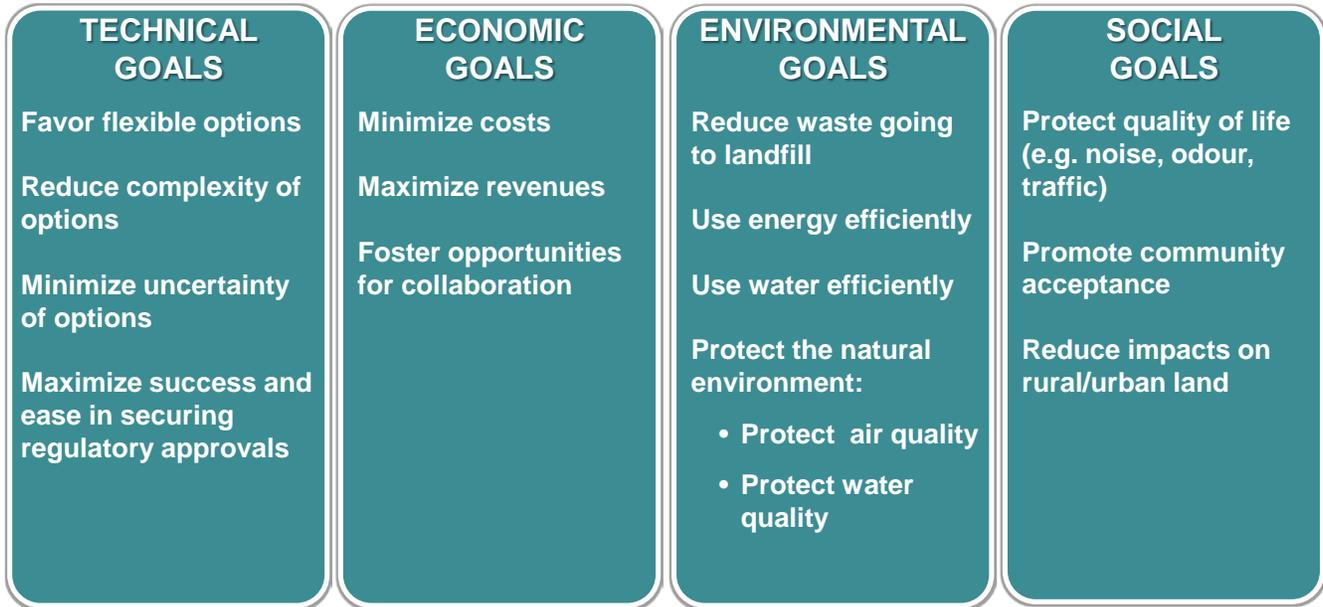


Figure 4: Goals Retained for the Sustainability Analysis

Bottom layer – Evaluation criteria

The multi-dimensional aspects of sustainability stemming from the goals must be translated into a set of measurable evaluation criteria to allow for meaningful analysis. Selecting evaluation criteria is therefore a critical step in developing a comprehensive MCDA analytical framework.

Evaluation criteria were selected to align with the Region-specific goals identified in each of the dimensions. These criteria were also concisely defined to achieve a common understanding of the issues they were meant to address, thus avoiding potential confusion and/or miscommunication.

Figure 5, Figure 6, Figure 7 and Figure 8 illustrate the evaluation criteria that were developed for the GoldSET analysis of the residual waste management options.

These evaluation criteria as well as their definitions are detailed in Section 3.2.



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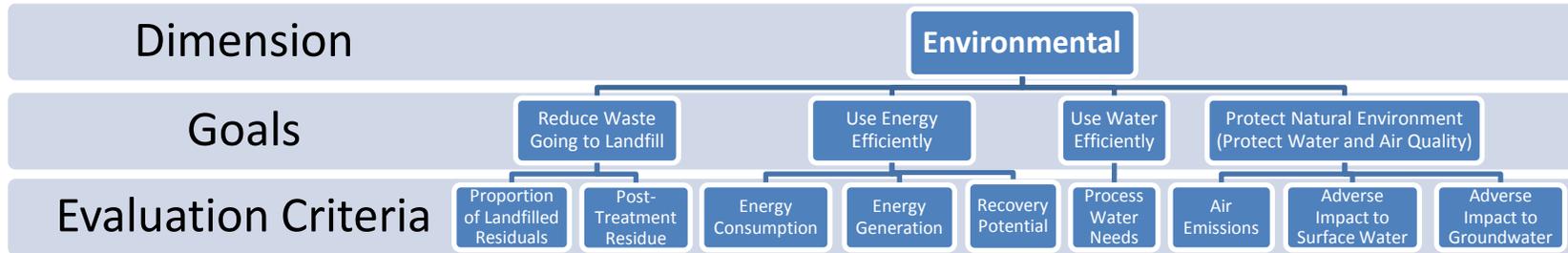


Figure 5: Goals and Evaluation Criteria for the Environmental Dimension

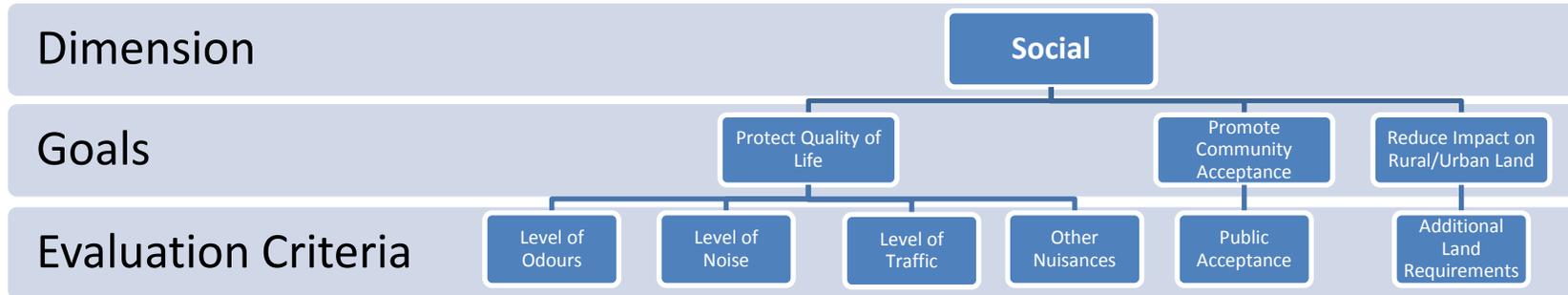


Figure 6: Goals and Evaluation Criteria for the Social Dimension



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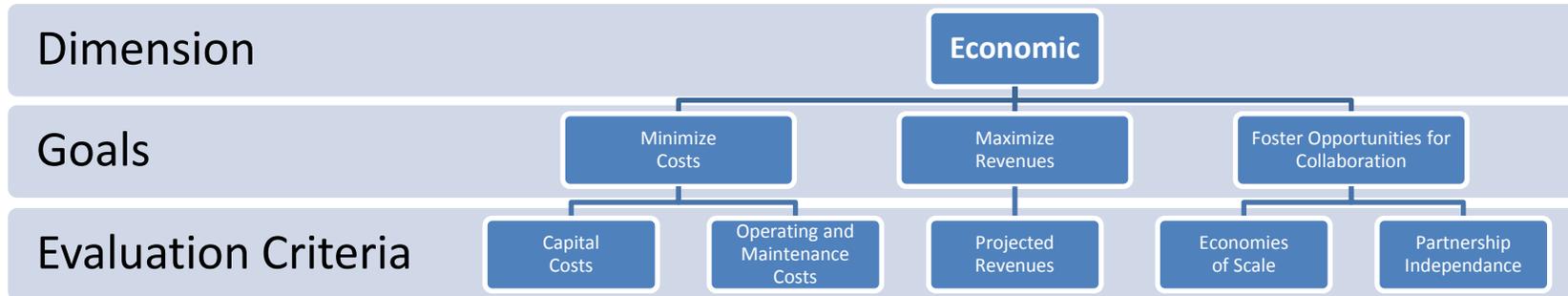


Figure 7: Goals and Evaluation Criteria for the Economic Dimension

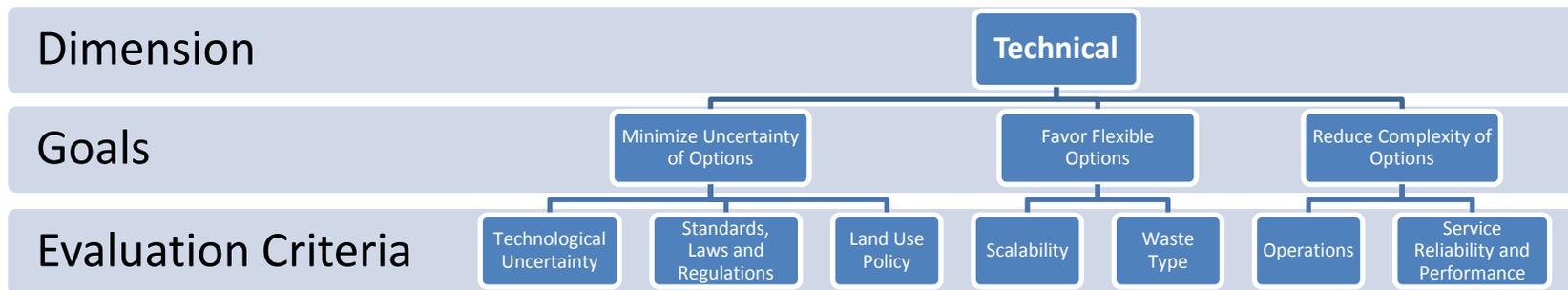


Figure 8: Goals and Evaluation Criteria for the Technical Dimension



2.5 Criteria Scoring

The scoring scheme is the means by which the performance of each option is normalized using a common scale for comparison purposes. The process assigns a numerical value to every evaluation criterion, usually on a scale from 0 to 100.

For this study, a scoring scheme was devised to ensure an effective comparison of the options. All qualitative and quantitative evaluation criteria were scored out of 100% and rolled-up into their respective goals and dimensions (environmental, social, economic and technical). For each dimension, the rolled-up scores range from 0% to 100%. The scoring scheme assigned the highest score (e.g. 100) to the best performing option with respect to the criteria, and the lowest score (e.g. 0) to the least performing option. Some options were evaluated in a pro-rated manner, using highest and lowest evaluations as score boundaries for a linear extrapolation between the best and the worst scores.

The list of final criteria as well as their respective scoring schemes can be found in Section 3.2.

2.6 Dimension Weighting

Weighting factors were assigned to each dimension. The weightings reflected the degree of importance of each dimension within the overall sustainability evaluation scheme.

The base case scenario weights each dimension equally with each a 25% weight.

Therefore, the weighting scheme for the base case scenario is as follows:

- Environmental: 25%
- Social: 25%
- Economic: 25%
- Technical: 25%

A sensitivity analysis was undertaken to verify the robustness of the evaluation results by changing the weights assigned to each of the dimensions. The results of this analysis are presented in Section 3.4.

2.7 Evaluation of Options

The options were scored on the basis of the criteria identified in Figure 5, Figure 6, Figure 7 and Figure 8. The qualitative and quantitative criteria were assigned and scored for each option through an in-depth literature review, input of industry experts and through various workshops with the Region. The scoring results were presented to the Region for validation. The feedback received provided the opportunity to revisit certain criteria, definitions, scoring schemes and scores.

The validated set of scores was then entered into the GoldSET waste management module for analysis and generation of overall scores and rankings.

2.8 Calculation of GoldSET Outputs

The GoldSET analysis provides a relative comparison of the performance of the residual waste management option(s) in terms of sustainability. The GoldSET module calculates a final score for each option as well as total



percentage scores for each of the four dimensions (environmental, social, economic and technical). GoldSET also presents the results in a graphical fashion that regroups the total percentages for each of the four dimensions in a single glance.

The higher the percentage score for a specific dimension, the more efficient the option is in terms of minimizing adverse impacts or maximizing positive impacts. The most sustainable options are presented as diamonds whose four axes are large and well balanced.

This evaluation resulted in single scores for each option, which established their relative ranking with respect to environmental, social, economic and technical aspects.

2.9 Sensitivity Analysis

Sensitivity analyses were carried out in order to assess the robustness of the option rankings. These analyses aimed to verify the influence of each dimension on the final ranking by varying the weight of each dimension. Section 3.4 presents these results.



3.0 EVALUATION AND RESULTS

3.1 Technology Options Retained for Sustainability Evaluation

The findings of the fatal flaw analysis, presented in detail in Interim Report No. 3, are summarized as follows:

- Landfill Mining, although a viable proven option would not provide for 20 years of waste disposal capacity.
- Mechanical Separation for Additional Recovery, although a viable proven option would not provide an additional 20 years of waste disposal capacity.
- Steam Classification has the potential to integrate with the Region's existing policies and infrastructure, to meet regulatory requirements in the province and to support additional recovery, however this option is not considered to be well established worldwide.

Since Landfill Mining, Mechanical Separation for Additional Recovery and Steam Classification did not meet the fatal flaw criteria, they have been eliminated from further consideration.

The remaining Residual Waste Management Technology Options for the sustainability evaluation are the following:

- Landfill Disposal (expansion or greenfield)
- Thermal Treatment (TT)
- Mechanical Biological Treatment (MBT)

3.2 Evaluation Criteria and Scoring Schemes

This section outlines the evaluation criteria, their detailed definitions and their respective scoring schemes. The complete evaluations matrix is attached as Appendix A.

3.2.1 Environmental Criteria and Scoring Schemes

Nine environmental criteria mirroring the four environmental goals were developed for the GoldSET sustainability evaluation. They are detailed together with their respective scoring schemes in Table 2.



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Table 2: Environmental Criteria and Scoring Schemes

ID code	Goal	Criteria	Criteria definition	Scoring scheme
ENV-1	Reduce waste going to landfill	Proportion of landfilled residuals	Proportion of inbound residual waste remaining after processing for final disposal (i.e. residue)	Pro-rated scoring on % landfilled
ENV-2		Post-treatment residue	Classification of any residues that remain following treatment of the residual waste by the option	0 = Remaining residue is typically classified as hazardous waste 33 = Remaining residue is non-hazardous and hazardous 66 = Remaining residue is non-hazardous and stabilized 100 = No residue remaining after treatment process
ENV-3	Use energy efficiently	Recovery potential	The potential for the option to recover resources (e.g. additional recyclables, energy, biofuel) from the residual waste stream	0 = No recovery potential 33 = Low recovery potential 66 = Moderate recovery potential 100 = High potential
ENV-4		Energy consumption	Estimated level of energy consumption	Pro-rated scoring on average energy consumption (kWh/tonne)
ENV-5		Energy generation	Estimated amount of energy generated by the option	Pro-rated scoring on average energy generated (kWh/tonne)
ENV-6	Protect the natural environment	Air emissions	The potential for the option to generate adverse air emissions	0 = High impact potential 33 = Moderate impact potential 66 = Low impact potential 100 = No impact potential
ENV-7		Adverse impact to groundwater	The potential for the option to adversely affect local groundwater	0 = High impact potential 33 = Moderate impact potential 66 = Low impact potential 100 = No impact potential
ENV-8		Adverse impact to surface water	The potential for the option to adversely affect local surface water	0 = High impact potential 33 = Moderate impact potential 66 = Low impact potential 100 = No impact potential
ENV-9	Use water efficiently	Process water needs	Dependency of the option on water for processing	0 = High quantity of water needed during process 50 = Moderate quantity of water needed during process 100 = No need for water during process



3.2.2 Social Criteria and Scoring Schemes

Six social criteria mirroring the three social goals were developed for the GoldSET sustainability evaluation. They are detailed together with their respective scoring schemes in Table 3.

Table 3: Social Criteria and Scoring Schemes

ID code	Goal	Criteria	Criteria definition	Scoring scheme
SOC-1	Protect quality of life	Level of odours	The potential for odours (post-construction)	0 = Significant potential for odours 33 = Moderate potential for odours 66 = Low potential for odours 100 = Negligible potential for odours
SOC-2		Level of noise	The potential for noise (post-construction)	0 = Significant potential for noise 50 = Moderate potential for noise 100 = Negligible potential for noise
SOC-3		Level of traffic	The potential for traffic impacts on local/regional roads (post-construction)	0 = Significant potential for traffic impacts 50 = Moderate potential for traffic impacts 100 = Negligible potential for traffic impacts
SOC-4		Other nuisances	The potential for nuisances during operations (e.g. dust, weeds, vectors, vermin, smoke)	0 = High potential for nuisances 50 = Moderate potential for nuisances 100 = Low potential for nuisances
SOC-5	Promote community acceptance	Public acceptance	The community's known or anticipated perception towards the option (considers input captured during consultation to date)	0 = Majority of the community is, or is anticipated to be, opposed to the option 50 = Option is, or is anticipated to be, controversial (supported by most, but with organized opposition) 100 = Broad community support of option is anticipated
SOC-6	Reduce impact on rural/urban land	Additional land requirements	Approximate area required to site the option, including buffer zone requirements	0 = Greater than 10 ha of land required 50 = 5 to 10 ha of land required 100 = 0 to 5 ha of land required

3.2.3 Economic Criteria and Scoring Schemes

Five economic criteria mirroring the three economic goals were developed for the GoldSET sustainability evaluation. They are detailed together with their respective scoring schemes in Table 4.



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Table 4: Economic Criteria and Scoring Schemes

ID code	Goal	Criteria	Criteria definition	Scoring scheme
ECO-1	Minimize costs	Capital costs	Estimated capital costs	Pro-rated scoring on costs per tonne (\$/tonne)
ECO-2		Operating and maintenance costs	Estimated operating and maintenance costs	Pro-rated scoring on costs per tonne (\$/tonne)
ECO-3	Maximize revenues	Projected revenues	Estimated energy and resource recovery revenue	Pro-rated scoring on revenue per tonne (\$/tonne)
ECO-4	Foster opportunities for collaboration	Economies of scale	Potential for public or private partnerships for co-treatment and/or disposal to achieve economies of scale	0= Low potential for partnership 50 = Medium potential for partnership 100 = High potential for partnership
ECO-5		Partnership independence	Degree to which the option is viable without requiring a partnership	0 = Option needs partnership for optimal efficiency 50 = Option may need partnership to attain optimal efficiency, though not required 100 = Option does not need partnership in order to attain optimal efficiency

3.2.4 Technical Criteria and Scoring Schemes

Seven technical criteria mirroring the three technical goals were developed for the GoldSET sustainability evaluation. They are detailed together with their respective scoring schemes in Table 5.

Table 5: Technical Criteria and Scoring Schemes

ID code	Goal	Criteria	Criteria definition	Scoring scheme
TEC-1	Favor flexible options	Scalability	The ability of the option to manage changing residual waste quantities over time	0 = No flexibility 33 = Low flexibility 66 = Moderate flexibility 100 = High flexibility
TEC-2		Waste type	The ability of the option to manage changing residual waste composition over time	0 = No flexibility 33 = Low flexibility 66 = Moderate flexibility 100 = High flexibility
TEC-3	Reduce complexity of options	Operations	The complexity of the operating requirements throughout the option life cycle	0 = High complexity 33 = Moderate complexity 66 = Low complexity 100 = No complexity



**REGION OF WATERLOO WMMP
SUSTAINABILITY EVALUATION OF RESIDUAL WASTE
MANAGEMENT OPTIONS**

ID code	Goal	Criteria	Criteria definition	Scoring scheme
TEC-4		Service reliability and performance	The likelihood of service and/or operational disruptions or delays	0 = Potential for severe disruptions 33 = Potential for moderate disruptions 66 = Potential for minor disruptions 100 = No anticipated disruptions
TEC-5		Technological uncertainty	The level of technological uncertainty associated with the option in achieving the overall objectives (e.g. the management of residual waste)	0 = 1 full-scale commercial operation with a minimum of 1 year operating experience managing municipal solid waste 33 = 2 to 5 full-scale commercial operations with up to 5 years cumulative operating experience managing municipal solid waste 66 = Generally widespread, some variation between technologies within the prescribed options category 100 = Widespread application (i.e. >5 full-scale commercial operations) with >5 years cumulative experience managing municipal solid waste
TEC-6	Minimize uncertainty of options	Standards, laws and regulations	The complexity and duration of obtaining all necessary regulatory approvals for the option	0 = Potential for complex and lengthy approvals process (e.g. pilot project and/or Individual Environmental Assessment process anticipated) 33 = Approvals process anticipated to be of moderate complexity and duration 66 = Well-established environmental approvals process for the option, demonstrated in the past to be completed in a timely manner 100 = No regulatory approvals process required
TEC-7		Land use policy	The compatibility of the option with existing Regional and Municipal land use policies	0 = The option may be compatible with existing land use policies, subject to amendment(s) 100 = The option is compatible with existing land use policies



3.3 Results and Option Rankings

The results obtained from the evaluation of the options are presented in Figure 9. The evaluation reveals the following information:

- Thermal Treatment is the best performing option with the highest single score. It also has by far the highest environmental and social scores of all three options. However, it is less performing in terms of economic and technical dimensions. It has the highest capital, operating and maintenance costs, but has the all round best performance in terms of energy and resource recovery revenue. The fact that this option needs to partner for optimal efficiency can also explain the option's low economic performance. Technically, Thermal Treatment can be compared to Mechanical Biological Treatment (MBT) but its approval process is slightly more complex and lengthy than for MBT.
- Mechanical Biological Treatment is well balanced throughout the four dimensions, but has all round lower scores compared to Thermal Treatment. This option's scores are slightly above the ones for Landfill, except for its technical performance that is hindered by the fact that MBT is slightly less flexible and more complex than Landfill.
- Landfill has the same overall single score as MBT. However, it has the lowest environmental and social results of all three options. On the other hand, it scores the highest technical score out of the three.
- In terms of environmental performance, the best performing option is Thermal Treatment.
- In terms of social performance, the best performing option is Thermal Treatment.
- In terms of economic performance, the best performing option is Mechanical Biological Treatment.
- In terms of technical performance, the best performing option is Landfill.



REGION OF WATERLOO WMMP SUSTAINABILITY EVALUATION OF RESIDUAL WASTE MANAGEMENT OPTIONS

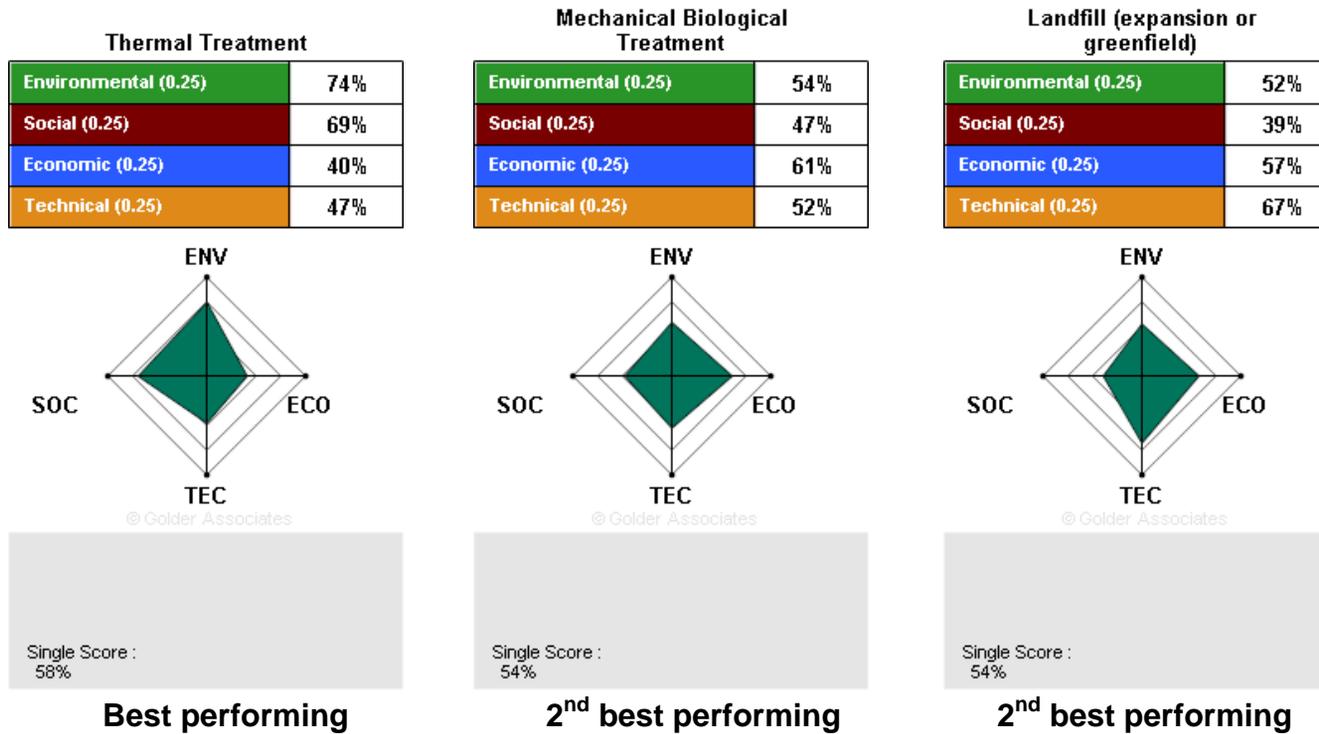


Figure 9: GoldSET Results



3.4 Results of the Sensitivity Analysis

The sensitivity analysis aims to determine the influence of each dimension in the final scores and in the overall ranking of options. This analysis serves to emphasize a dimension by changing its weight in the overall scoring scheme, allowing for an analysis of each dimension’s influence. The analysis also represents an opportunity to test the robustness of the base case scenario’s results.

Four sensitivity analyses were conducted. Table 6 presents the parameters used for these sensitivity analyses.

Table 6: Sensitivity Analysis Parameters

	Environmental	Social	Economic	Technical
Base case scenario	25%	25%	25%	25%
Sensitivity analysis 1 – Emphasis on the environmental dimension	40%	20%	20%	20%
Sensitivity analysis 2 – Emphasis on the social dimension	20%	40%	20%	20%
Sensitivity analysis 3 – Emphasis on the economic dimension	20%	20%	40%	20%
Sensitivity analysis 4 – Emphasis on the technical dimension	20%	20%	20%	40%

The results obtained from the sensitivity analyses are presented in Table 7. These analyses reveal the following information:

- Thermal Treatment (TT) generally has the highest performance of all except when economic and technical dimensions are emphasized. It is then relegated to second place in terms of performance.
- Mechanical Biological Treatment (MBT) consistently scores as second highest performing option. It becomes the best performing option when the economic dimension is emphasized and it becomes the least performing one when the emphasis is brought on the technical dimension.
- Landfill is generally tied as the second best performing option with MBT but it is the least performing option of all when environmental and social dimensions are emphasized. Landfill becomes the best performing option only when emphasis is made on the technical dimension.

Table 7: Sensitivity Analysis Results

Performance	Base case scenario	Sensitivity analysis No. 1 (<i>environmental emphasis</i>)	Sensitivity analysis No. 2 (<i>social emphasis</i>)	Sensitivity analysis No. 3 (<i>economic emphasis</i>)	Sensitivity analysis No. 4 (<i>technical emphasis</i>)
Best performing	TT	TT	TT	MBT	Landfill
2nd best performing	MBT / Landfill	MBT	MBT	TT / Landfill	TT
Least performing		Landfill	Landfill		MBT



REGION OF WATERLOO WMMP SUSTAINABILITY EVALUATION OF RESIDUAL WASTE MANAGEMENT OPTIONS

Globally, the sensitivity analysis shows that the sustainability analysis results are robust. Thermal Treatment generally has the best performing results and never becomes the least performing option. Mechanical Biological Treatment is generally the second best performing option and sometimes shares its second place with Landfill in the base case scenario and when there is focus on the economic dimension. Landfill is generally the second or least performing option, becoming the best performing option only when the technical dimension is emphasized.

This shows that, in terms of sustainability, Thermal Treatment (TT) and Mechanical Biological Treatment (MBT) are the most balanced options. Their positions in the general ranking have not changed much during the sensitivity analysis because they generally perform well in all four dimensions.

The next step in the study evaluation process is to complete a life cycle analysis (LCA) for each of the three options to determine the environmental footprint of each option. This information will further aid in informing the decision-making process for the preferred option(s) for the Region's Waste Management Master Plan. The results of the LCA will be presented in a separate report.



4.0 STUDY LIMITATIONS

This report has been prepared for the exclusive use of the Region of Waterloo. The factual information, interpretations, comments and recommendations contained herein are specific to the project described in this report and do not apply to any other project. This report must be read in its entirety as some sections could be falsely interpreted when taken individually or out of context. As well, the text of the final version of this report supersedes any other text, opinion or preliminary version produced by Golder Associates Ltd. (Golder).

Unless otherwise specified, the interpretations, comments and recommendations presented in this report have been formulated as per the scope of work and the assumptions that have been described in the report.

As with many semi-quantitative evaluation methods, the outcome of the assessment performed with GoldSET[®] may depend on those conducting the evaluation. Golder shall not be held responsible for any damages and losses resulting from the use of the information and/or output from GoldSET.



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Report Signature Page

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APPENDIX A

Detailed Criteria Evaluations

INDICATOR EVALUATION

Code	Theme	Indicator	Indicator Definition	Unit	Scoring Scheme	Landfill (expansion or greenfield)	Mechanical Separation for additional Material	Thermal Treatment	Mechanical Biological Treatment
Environment									
ENV-1	Proportion of Landfilled Residuals	Proportion of Landfilled Residuals	Proportion of inbound residual waste remaining after processing for final disposal (i.e. residue)	%	Pro-rated scoring on % landfilled	100	90	20	35
ENV-2	Post-Treatment Residue	Post-Treatment Residue	Classification of any residues that may remain following treatment of the residual waste by the option	-	0 = Remaining residue is typically classified as hazardous waste 33 = Remaining residue is non-hazardous and hazardous 66 = Remaining residue is non-hazardous and stabilized 100 = No residue remaining after treatment process	33	66	33	66
ENV-3	Energy	Recovery Potential	The potential for the option to recover resources (e.g. additional recyclables, energy, biofuel) from the residual waste stream	-	0 = No potential 33 = low potential 66 = Moderate potential 100 = High potential	66	33	100	66
ENV-4	Energy	Energy Consumption	Estimated level of energy consumption	kWh/tonne	Pro-rated scoring on average energy consumption (kWh/tonne)	10	80	75	85
ENV-5	Energy	Energy Generation	Estimated amount of energy generated by the option	kWh/tonne	Pro-rated scoring on average energy generated (kWh/tonne)	5	0	675	150
ENV-6	Air	Air Emissions	The potential for the option to generate adverse air emissions.	-	0 = High impact potential 33 = Moderate impact potential 66 = Low impact potential 100 = No impact potential	33	100	66	66
ENV-7	Water	Adverse Impact to Groundwater	The potential for the option to adversely affect local groundwater	-	0 = High impact potential 33 = Moderate impact potential 66 = Low impact potential 100 = No impact potential	66	100	100	66
ENV-8	Water	Adverse Impact to Surface Water	The potential for the option to adversely affect local surface water	-	0 = High impact potential 33 = Moderate impact potential 66 = Low impact potential 100 = No impact potential	66	100	100	66
ENV-9	Water	Process Water Needs	Dependency of the option on water for processing	-	0 = High quantity of water needed during process 50 = Moderate quantity of water needed during process 100 = No need for water during process	100	100	50	50

INDICATOR EVALUATION

Code	Theme	Indicator	Indicator Definition	Unit	Scoring Scheme	Landfill (expansion or greenfield)	Mechanical Separation for additional Material	Thermal Treatment	Mechanical Biological Treatment
Social									
SOC-1	Quality of Life	Level of odours	The potential for odours (post-construction)	-	0 = Significant potential for odours 33 = Moderate potential for odours 66 = Low potential for odours 100 = Negligible potential for odours	33	66	66	33
SOC-2	Quality of Life	Level of noise	The potential for noise (post-construction)	-	0 = Significant potential for noise 50 = Moderate potential for noise 100 = Negligible potential for noise	50	50	50	50
SOC-3	Quality of Life	Level of traffic	The potential for traffic impacts on local/regional roads (post-construction)	-	0 = Significant potential for traffic impacts 50 = Moderate potential for traffic impacts 100 = Negligible potential for traffic impacts	100	50	50	50
SOC-4	Quality of Life	Other nuisances	The potential for public disruptions during operations (dust, weeds, vectors, vermin, smoke, etc.)	-	0 = High potential 50 = Moderate potential 100 = Low potential	50	100	100	50
SOC-5	Community acceptance	Public Acceptance	The community's known or anticipated perception towards the option (Considers input captured during consultation to date)	-	0 = Majority of the community is, or is anticipated to be, opposed to the option. 50 = Option is, or is anticipated to be, controversial (supported by most, but with organized opposition). 100 = Broad community support of option is anticipated.	0	100	50	50
SOC-6	Land impact	Additional Land Requirements	Approximate area required to site the option, including buffer zone requirements.	-	0 = Greater than 10 ha of land required 50 = 5 to 10 ha of land required 100 = 0 to 5 ha of land required	0	50	100	50
Economics									
ECO-1	Minimize Costs	Capital Costs	Estimated capital costs (\$ per tonne)	\$/tonne	Pro-rated scoring on costs per tonne	30	100	825	620
ECO-2	Minimize Costs	Operating and Maintenance Costs	Estimated operating and maintenance costs (\$ per tonne)	\$/tonne	Pro-rated scoring on costs per tonne	70	35	95	65
ECO-3	Maximize revenues	Projected Revenues	Estimated energy and resource recovery revenue (\$ per tonne)	\$/tonne	Pro-rated scoring on revenue per tonne	5	10	55	20
ECO-4	Partnership	Economies of Scale	Potential for public or private partnerships for co-treatment and/or disposal to achieve economies of scale	-	0= Low potential 50 = Medium potential 100= High potential	0	100	100	100
ECO-5	Partnership	Partnership Independence	Degree to which the option is viable without requiring a partnership	-	0 = Option needs to partnership for optimal efficiency 50 = Option may need partnership to attain optimal efficiency, though not required 100 = Option does not need partnership in order to attain optimal efficiency	100	50	0	50

INDICATOR EVALUATION

Code	Theme	Indicator	Indicator Definition	Unit	Scoring Scheme	Landfill (expansion or greenfield)	Mechanical Separation for additional Material	Thermal Treatment	Mechanical Biological Treatment
Technical									
TEC-1	Flexibility	Scalability	The ability of the option to manage changing residual waste quantities over time	-	0 = No flexibility 33 = Low flexibility 66 = Moderate flexibility 100 = High flexibility	100	66	66	66
TEC-2	Flexibility	Waste Type	The ability of the option to manage changing residual waste composition over time	-	0 = No flexibility 33 = Low flexibility 66 = Moderate flexibility 100 = High flexibility	100	66	66	66
TEC-3	Complexity	Operations	The complexity of the operating requirements throughout the option lifecycle	-	0 = High complexity 33 = Moderate complexity 66 = Low complexity 100 = No complexity	66	66	33	33
TEC-4	Complexity	Service Reliability and Performance	The likelihood of service and/or operational disruptions or delays	-	0 = Potential for severe disruptions 33 = Potential for moderate disruptions 66 = Potential for minor disruptions 100 = No anticipated disruptions	100	66	66	66
TEC-5	Uncertainty	Technological Uncertainty	The level of technological uncertainty associated with the option in achieving the overall objectives (i.e. the management of residual waste)	-	0 = 1 full scale commercial operation with a minimum of 1 year operating experience managing MSW 33 = 2 to 5 full scale commercial operations with up to 5 years cumulative operating experience managing municipal solid waste 66 = Generally widespread, some variation between technologies within the prescribed options category 100 = Widespread application (i.e. >5 full scale commercial operations) with >5 years cumulative experience managing municipal solid waste	100	100	66	66
TEC-6	Uncertainty	Standards, Laws and Regulations	The complexity and duration of obtaining all necessary regulatory approvals for the option	-	0 = Potential for complex and lengthy approvals process (e.g. pilot project and/or Individual Environmental Assessment process anticipated) 33 = Approvals process anticipated to be of moderate complexity and duration 66 = Well established environmental approvals process for the option, demonstrated in the past to be completed in a timely manner 100 = No regulatory approvals process required	0	66	33	66
TEC-7	Uncertainty	Land Use Policy	The compatibility of the option with existing Regional and Municipal land use policies	-	0 = The option may be compatible with existing land use policies, subject to amendment(s) 100 = The option is compatible with existing land use policies	0	0	0	0

**Environmental Dimension
Landfill/Landfill Expansion**

Goal	Indicator No.	Indicator	Description	Scoring Scheme	Indicator Evaluation	Justification	Assumption	Reference
Waste Reduction	ENV-1	Proportion of Landfilled Residuals	Proportion of inbound residual waste remaining after processing for final disposal (i.e. residue)	Pro-rated scoring on % landfilled	100	Option assumes 100% disposal of residual waste at landfill, therefore no recovery potential.	NA	NA
Waste Reduction	ENV-2	Post-Treatment Residue	Classification of any residues that may remain following treatment of the residual waste by the option	0 = Remaining residue is typically classified as hazardous waste 33 = Remaining residue is non-hazardous and hazardous 66 = Remaining residue is non-hazardous and stabilized 100 = No residue remaining after treatment process	33	Assumes all incoming residual wastes is landfilled and therefore minimal to no residue would remain.	NA	NA
Energy	ENV-3	Recovery Potential	The potential for the option to recover resources (e.g. additional recyclables, energy, biofuel) from the residual waste stream	0 = No potential 33 = low potential 66 = Moderate potential 100 = High potential	66	Every million tonnes of municipal solid waste in a landfill is estimated to be able to produce approximately 432,000 cod of LFG, which can be utilised and converted to power to thermal energy (heat).	Assumes landfill with a LFG utilisation facility. Because only LFG (energy) is recovered - assume moderate potential.	US EPA. (2010). LFG Energy Project Development Handbook.
Energy	ENV-4	Energy Consumption	Estimated level of energy consumption	Pro-rated scoring on average energy consumption (kWh/tonne)	10	An estimated 11.1 kwh/tonne (see assumption tab)	It is assumed that 1.8 Kg of diesel is used per tonne to operate a landfill (only operational fuel usage - excludes gas utilisation plant). Assuming 1 kg of diesel = 1 L 1.8 L of diesel. Assumes 1 liter of diesel = 40MJ = 11.1kWh (average values).	Golder Associates. (2005). Life Cycle Assessment Landfill Emissions. Staffordshire University. (2011). A Beginner's Guide to Energy and Power.
Energy	ENV-5	Energy Generation	Estimated amount of energy generated by the option	Pro-rated scoring on average energy generated (kWh/tonne)	5	Estimated at 63 KWh/tonne of waste in-place	Assumes that 5 million tonnes (200000 * 25yrs operation) landfilled and a 1MWe gas engine generates a total of 208,000 MWeH. Converting total energy generation to a per tonne basis by dividing by 5million is equal to 63kwh per tonne. It should be noted that energy continues to be generated post-closure and energy captured can vary significantly based on waste composition, collection efficiencies, etc.	Golder Associates. (2005). Life Cycle Assessment Landfill Emissions.
Air	ENV-6	Air Emissions	The potential for the option to generate adverse air emissions.	0 = High impact potential 33 = Moderate impact potential 66 = Low impact potential 100 = No impact potential	33	New landfill in Ontario, and auxiliary corresponding facilities (i.e. Gas Utilisation Facility) will be required to comply with applicable environmental regulations (i.e. A7 Air guidelines). Air emissions are more prolonged from a landfill as it continues post-closure, and typically any excess is flared. It is therefore assumed moderate impact potential.	Assumes an engineered landfill with a landfill gas collection system, and gas utilisation facility. Any excess gas is assumed to be flared.	NA
Water	ENV-7	Adverse Impact to Groundwater	The potential for the option to adversely affect local groundwater	0 = High impact potential 33 = Moderate impact potential 66 = Low impact potential 100 = No impact potential	66	Liquid containment within a modern landfill results from a combination of the liner and the leachate collection system performing complementary functions to minimise groundwater contamination potential. Liners prevent leachate and gas migration out of the landfill while directing liquids to the leachate collection system - assume low impact potential.	Assumes a lined landfill with a leachate collection system Assumes sensitive receptor not in close proximity.	Northern Ireland Environmental Agency (2009). River Basin Management Plans – Groundwater Classification, Landfill.
Water	ENV-8	Adverse Impact to Surface Water	The potential for the option to adversely affect local surface water	0 = High impact potential 33 = Moderate impact potential 66 = Low impact potential 100 = No impact potential	66	The scale of impact on surface waters and ecosystems from landfill sites is generally considered to be low in a well designed and engineered landfill site, except where there are sensitive receptors (e.g. wetlands, springs, abstractions) in close proximity to a particular site) - as such it is assumed low.	Assumes a lined landfill with a leachate collection system and storm water management system. Assumes sensitive receptor not in close proximity.	Northern Ireland Environmental Agency (2009). River Basin Management Plans – Groundwater Classification, Landfill.
Water	ENV-9	Process Water Needs	Dependency of the option on water for processing	0 = High quantity of water needed during process 50 = Moderate quantity of water needed during process 100 = No need for water during process	100	Minimal amounts of water will be required at the landfill site, mainly to wash equipment and for administration/scale house uses.	NA	NA

**Social Dimension
Landfill/Landfill Expansion**

Goal	Indicator No.	Indicator	Description	Scoring Scheme	Indicator Evaluation	Justifications	Assumptions	Reference
Quality of Life	SOC-1	Level of Odours	The potential for odours (post-construction)	0 = Significant potential for odours 33 = Moderate potential for odours 66 = Low potential for odours 100 = Negligible potential for odours	33	Odour emission from landfill areas has a high potential to cause significant annoyance to people living in their surroundings. However odour can be controlled via a landfill gas control system (as demonstrated at the Waterloo Landfill Site) and proper site management - therefore potential assumed moderate.	Assumes an engineered landfill site with a landfill gas control system.	Waterloo Landfill Site and Brighton Landfill Environmental Assessment.
Quality of Life	SOC-2	Level of Noise	The potential for noise (post-construction)	0 = Significant potential for noise 50 = Moderate potential for noise 100 = Negligible potential for noise	50	Noise is an issue that will be controlled by regulations. Noise levels at nearby sensitive receptors can be limited by conditions listed in an environmental permit. The main contributors to noise associated with a landfill site are likely to be: Vehicle movements / manoeuvring, landfill packer and excavator (landfill filling activities), drum roller, grader, pump/leachate system, and landfill utilisation plant (e.g. turbines, ventilators, etc.).	NA	Brighton Landfill Environmental Assessment.
Quality of Life	SOC-3	Traffic	The potential for traffic impacts on local/regional roads (post-construction)	0 = Significant potential for traffic impacts 50 = Moderate potential for traffic impacts 100 = Negligible potential for traffic	100	Landfill sites will most likely be served by large numbers of trucks with a potential impact on local roads, however this will depend on site location and therefore assumed low.	NA	NA
Quality of Life	SOC-4	Other nuisances	The potential for public disruptions during operations (dust, weeds, vectors, vermin, smoke, etc.)	0 = High potential 50 = Moderate potential 100 = Low potential	50	Good housekeeping and on site management can minimize the risk of public disruption, however given the odour nature of landfill sites vectors, pests and weeds will likely be an issue.	NA	NA
Community acceptance	SOC-5	Public Acceptance	The community's known or anticipated perception towards the option (Considers input captured during consultation to date)	0 = Majority of the community is, or is anticipated to be, opposed to the option. 50 = Option is, or is anticipated to be, controversial (supported by most, but with organized opposition). 100 = Broad community support of option is anticipated.	0	Landfill sites will most likely result in public opposition.	NA	NA
Land Impact	SOC-6	Additional Land Requirements	Approximate area required to site the option, including buffer zone requirements.	0 = Greater than 10 ha of land required 50 = 5 to 10 ha of land required 100 = 0 to 5 ha of land required	0	Using the Waterloo Landfill and Cambridge landfill sites as references it is anticipated that an area of land plus buffer to be greater than 10 ha.	Number based on the current Waterloo Landfill Site. Assumes 200000 tpa X 25 yrs landfill life = 5,000,000 tonne landfill capacity.	NA

**Economic Dimension
Landfill/Landfill Expansion**

Goal	Indicator No.	Indicator	Description	Scoring Scheme	Indicator Evaluation	Justification	Assumption	Reference
Minimize Costs	ECO-1	Capital Costs	Estimated capital costs (\$ per tonne)	Pro-rated scoring on costs per tonne	30	Engineering landfill cells for liner and leachate collection system, excavation estimated at \$30 per tonne.	Assumes landfill cell, including clearing, excavation and liner/leachate collection system is about \$1 million dollars per hectare, excludes cost of landfill gas utilisation plant. Assumes a 15 ha for a 5 million tonne landfill (i.e. 200,000 X 25 yrs).	
Minimize Costs	ECO-2	Operating and Maintenance Costs	Estimated operating and maintenance costs (\$ per tonne)	Pro-rated scoring on costs per tonne	70	Opex estimated at \$65-70/tonne derived using data from the City of Barrie.	Based on the Barrie Landfill Site (i.e. 2.6 million dollars per annum for 41,440 tonnes per annum)	Barrie Lanfill Site
Maximize Revenues	ECO-3	Projected Revenues	Estimated energy and resource recovery revenue (\$ per tonne)	Pro-rated scoring on revenue per tonne	5	See environmental dimension (ENV 5) 63 Kwh/tonne at 8 cents per KWh = \$5 per tonne	NA	NA
Partnership	ECO-4	Economies of Scale	Potential for public or private partnerships for co-treatment and/or disposal to achieve economies of scale	0= Low potential 50 = Medium potential 100= High potential	0	Landfill sites can indeed benefit from considerable economies of scale, however given the regulatory environment of landfill sites is complex and the public opposition, they are likely not to increase in size. Additionally, competition from private landfill sites in Ontario can hamper potential for economies of scale - assume medium potential.	NA	NA
Partnership	ECO-5	Partnership Independence	Degree to which the option is viable without requiring a partnership	0 = Option needs to partnership for optimal efficiency 50 = Option <u>may</u> need partnership to attain optimal efficiency, though not required 100 = Option does not need partnership in order to attain optimal efficiency	100	Option does not need partnership for optimal efficiency, given that landfill sites can be scaled accordingly, and have in the past (i.e. Waterloo and Cambridge Landfill Sites) have been built to serve municipalities.	NA	NA

**Technical Dimension
Landfill/Landfill Expansion**

Goal	Indicator No.	Indicator	Description	Scoring Scheme	Indicator evaluation	Justification	Assumption	Reference
Flexibility	TECH-1	Scalability	The ability of the option to manage changing residual waste quantities over time	0 = No flexibility 33 = Low flexibility 66 = Moderate flexibility 100 = High flexibility	100	Landfills can be designed to accept various quantities of wastes; however expansion of a existing landfill site to accept larger quantities of waste will result in a complex regulatory process and may be restricted by land requirements. The landfill site can however accept a larger quantities of waste per annum, however given the finite capacity, this will lower the site life. Assume low flexibility based on above factors.	NA	Interim Rpt 3 Universal List Review
Flexibility	TECH-2	Waste Type	The ability of the option to manage changing residual waste composition over time	0 = No flexibility 33 = Low flexibility 66 = Moderate flexibility 100 = High flexibility	100	Landfill accepts all types of municipal non-hazardous residual wastes.	Assumes no ban (i.e. organics) is in place of specific types of municipal solid waste.	Interim Rpt 3 Universal List Review
Complexity	TECH-3	Operations	The complexity of the operating requirements throughout the option lifecycle	0 = High complexity 33 = Moderate complexity 66 = Low complexity 100 = No complexity	66	Specialized labour services not obligatory to successfully operate a landfill site, though technicians and scientists should be available to monitor the site (e.g. environmental monitoring, proper functioning of gas utilisation facility and leachate collection system).	NA	NA
Complexity	TECH-4	Service Reliability and Performance	The likelihood of service and/or operational disruptions or delays	0 = Potential for severe disruptions 33 = Potential for moderate disruptions 66 = Potential for minor disruptions 100 = No anticipated disruptions	100	Option is well established and reliable. Disruptions unlikely once operational.	Assumes waste feedstock guaranteed.	NA
Uncertainty	TECH-5	Technological Uncertainty	The level of technological uncertainty associated with the option in achieving the overall objectives (i.e. the management of residual waste)	0 = 1 full scale commercial operation with a minimum of 1 year operating experience managing MSW 33 = 2 to 5 full scale commercial operations with up to 5 years cumulative operating experience managing municipal solid waste 66 = Generally widespread, some variation between technologies within the prescribed options category 100 = Widespread application (i.e. >5 full scale commercial operations) with >5 years cumulative experience managing municipal solid waste	100	Landfill sites are a traditional method used for waste disposal, as such they are widespread in Canada and globally.	NA	Interim Rpt 3 Universal List Review
Uncertainty	TECH-6	Standards, Laws and Regulations	The complexity and duration of obtaining all necessary regulatory approvals for the option	0 = Potential for complex and lengthy approvals process (e.g. pilot project and/or Individual Environmental Assessment process anticipated) 33 = Approvals process anticipated to be of moderate complexity and duration 66 = Well established environmental approvals process for the option, demonstrated in the past to be completed in a timely manner 100 = No regulatory approvals process required	0	In Ontario, an individual EA is anticipated for a new or expansion of existing landfill site. Though proven successful in the past, process is complex and lengthy.	NA	NA
Uncertainty	TECH-7	Land Use Policy	The compatibility of the option with existing Regional and Municipal land use policies	0 = The option may be compatible with existing land use policies, subject to amendment(s) 100 = The option is compatible with existing land use policies	0	Land-use and zoning amendments will be required for a new landfill site.	NA	NA

Environmental Dimension
Thermal Treatment

Goal	Indicator No.	Indicator	Description	Scoring Scheme	Indicator Evaluation	Justification	Assumption	Reference
Waste Reduction	ENV-1	Proportion of Landfilled Residuals	Proportion of inbound residual waste remaining after processing for final disposal (i.e. residue)	Pro-rated scoring on % landfilled	20	Mass Burn: Up to 20 to 25% by weight Gasification: 10% to 20% by weight Average combined: 15% to 22.5%	Assumes average of estimate max and min of residue landfilled for gasification and mass burn. Assumes no market for ash recovered.	Stantec. (2010). Waste-To-Energy A Technical Review of Municipal Solid Waste Thermal Treatment Practices.
Waste Reduction	ENV-2	Post-Treatment Residue	Classification of any residues that may remain following treatment of the residual waste by the option	0 = Remaining residue is typically classified as hazardous waste 33 = Remaining residue is non-hazardous and hazardous 66 = Remaining residue is non-hazardous and stabilized 100 = No residue remaining after treatment process	33	Residue consists of fly and bottom ash which is hazardous and non-hazardous respectively.	NA	NA
Energy	ENV-3	Recovery Potential	The potential for the option to recover resources (e.g. additional recyclables, energy, biofuel) from the residual waste stream	0 = No potential 33 = low potential 66 = Moderate potential 100 = High potential	100	High potential for recovery because both energy, metals, and dry recyclables are front-end can be recovered.	NA	NA
Energy	ENV-4	Energy Consumption	Estimated level of energy consumption	Pro-rated scoring on average energy consumption (kWh/tonne)	75	The electrical consumption, of an incineration plant is typically between 60 and 190kWh/tonne, averaging at 75 kWhr/tonne.	Assumes 200,000 tonne per annum mass burn facility The costs of consumable (i.e. electrical consumption) are understood to be on the same basis as for a mass burn and gasification system.	Mayor of London. (2008). Cost of Incineration and non-Incineration Energy-from-Waste Technologies.
Energy	ENV-5	Energy Generation	Estimated amount of energy generated by the option	Pro-rated scoring on average energy generated (kWh/tonne)	675	Electricity production rates assumed between 500 to 850 kWh/tonne.	Assumes 200,000 tonne per annum facility (gasification and mass burn average)	Mayor of London. (2008) Cost of Incineration and non-Incineration Energy-from-Waste Technologies.
Air	ENV-6	Air Emissions	The potential for the option to generate adverse air emissions.	0 = High impact potential 33 = Moderate impact potential 66 = Low impact potential 100 = No impact potential	66	Thermal treatment will generate adverse air emissions but are equipped with an air pollution control system to meet applicable emission guidelines.	Assumes that any thermal treatment facility will require to comply with the Ontario Ministry of Environment A-7 Air Guidelines, as such impact potential assumed at low.	NA
Water	ENV-7	Adverse Impact to Groundwater	The potential for the option to adversely affect local groundwater	0 = High impact potential 33 = Moderate impact potential 66 = Low impact potential 100 = No impact potential	100	Thermal treatment facilities are enclosed, and therefore impact on groundwater systems assumed none to low.	Assumes facilities will comply with Environmental Protection Act.	NA
Water	ENV-8	Adverse Impact to Surface Water	The potential for the option to adversely affect local surface water	0 = High impact potential 33 = Moderate impact potential 66 = Low impact potential 100 = No impact potential	100	Thermal treatment facilities are enclosed and equipped with storm water management systems, and therefore impact assumed at none to low.	Assumes that any thermal treatment facility will require to comply with the Ontario Ministry of Environment Sotrmwater Management guidelines.	NA
Water	ENV-9	Process Water Needs	Dependency of the option on water for processing	0 = High quantity of water needed during process 50 = Moderate quantity of water needed during process 100 = No need for water during process	50	The water consumption can range from about 0.1 to 0.4 m3/tonne of waste	Water consumption varies by technology employed, and it is assumed that 1 cubic meter of water per tonne of waste to be high quantity of water. Sample Facility Example: a 200,000 tpa facility in Germany consumes 51,200 cubic meter per annum of water.	World Bank. (1999) Municipal Solid Waste Incineration technical guide.

**Social Dimension
Thermal Treatment**

Goal	Indicator No.	Indicator	Description	Scoring Scheme	Indicator Evaluation	Justifications	Assumptions	Reference
Quality of Life	SOC-1	Level of Odours	The potential for odours (post-construction)	0 = Significant potential for odours 33 = Moderate potential for odours 66 = Low potential for odours 100 = Negligible potential for odours	66	Any waste management operations can give rise to odours. These can be minimized by building design, performing operations under controlled conditions indoors and good working practices. Additionally, incineration processes normally use the air from combustion process to operate the working areas under negative pressure. Therefore if controls in place, potential for odour should be low to moderate.	NA	Department for Environment Food and Rural Affairs UK. (2007). Incineration of Municipal Solid Waste.
Quality of Life	SOC-2	Level of Noise	The potential for noise (post-construction)	0 = Significant potential for noise 50 = Moderate potential for noise 100 = Negligible potential for noise	50	Noise is an issue that will be controlled by regulations and noise levels at nearby sensitive receptors can be limited by conditions listed in an environmental permit. The main contributors to noise associated with incineration are likely to be: Traffic; Mechanical processing such as waste preparation; Air extraction fans and ventilation systems; Steam turbine units; and Air cooled condenser units.	NA	Department for Environment Food and Rural Affairs UK. (2007). Incineration of Municipal Solid Waste.
Quality of Life	SOC-3	Traffic	The potential for traffic impacts on local/regional roads (post-construction)	0 = Significant potential for traffic impacts 50 = Moderate potential for traffic impacts 100 = Negligible potential for traffic impacts	50	Moderate traffic impacts anticipated resulting from hauling wastes to the facility, and residue out of the facility. Impact can vary depending on site location and road/highway access.	NA	NA
Quality of Life	SOC-4	Other nuisances	The potential for public disruptions during operations (dust, weeds, vectors, vermin, smoke, etc.)	0 = High potential 50 = Moderate potential 100 = Low potential	100	The enclosed nature of waste incineration operations will limit the potential to attract vermin and birds. Additionally, good housekeeping and on site management of tipping and storage areas is can minimize the risk of public disruption.	NA	Department for Environment Food and Rural Affairs UK. (2007). Incineration of Municipal Solid Waste.
Community acceptance	SOC-5	Public Acceptance	The community's known or anticipated perception towards the option (Considers input captured during consultation to date)	0 = Majority of the community is, or is anticipated to be, opposed to the option. 50 = Option is, or is anticipated to be, controversial (supported by most, but with organized opposition). 100 = Broad community support of option is anticipated.	50	Public opposition anticipated, however through consultation activities and other public awareness activities, this could reduce opposition. Organized opposition anticipated.	NA	NA
Land Impact	SOC-6	Additional Land Requirements	Approximate area required to site the option, including buffer zone requirements.	0 = Greater than 10 ha of land required 50 = 5 to 10 ha of land required 100 = 0 to 5 ha of land required	100	Average of 3 facility sized scaled to 200,000 tpa is 4.3 ha	For a 90,000 tpa facility, an estimated 1.7 ha of land required. For a 250,000 tpa facility an estimated 4 ha of land required. For a 400,000 tpa facility an estimated 12 ha of land required. Using ratio calculation, it assumed that 3.7, 3.2, 6 ha required respectively for a 200,000 tpa facility This is just an estimate and can vary	Department for Environment Food and Rural Affairs UK. (2007). Incineration of Municipal Solid Waste.

**Economic Dimension
Thermal Treatment**

Goal	Indicator No.	Indicator	Description	Scoring Scheme	Indicator Evaluation	Justification	Assumption/Rational	Reference
Minimize Costs	ECO-1	Capital Costs	Estimated capital costs (\$ per tonne)	Pro-rated scoring on costs per tonne	825	<p>Mass Burn: \$640 to \$960/design tonne</p> <p>Gasification: \$640 to \$1067 /design tonne</p> <p>Thermal Treatment Average: \$640 to \$1013/design tonne</p>	<p>(1) Assumes a facility size of 200,000 tpa.</p> <p>(2) Cost estimates provided in GBP (2008), assumes a 2.0 exchange rate to Canadian dollars, cost escalated using annual Canadian inflation to represent 2012 value</p> <p>(3) Capex for pyrolysis assumed to be similar to that of gasification, and cost for plasma gasification has been excluded as it represents a small segment of thermal treatment technologies and would skew the results.</p> <p>(4) The average capex maximum for mass burn and gasification was combined to reflect a general thermal technology cost per tonne maximum. The same applies to the minimum.</p>	Mayor of London. (2008) Cost of Incineration and non-Incineration Energy-from-Waste Technologies.
Minimize Costs	ECO-2	Operating and Maintenance Costs	Estimated operating and maintenance costs (\$ per tonne)	Pro-rated scoring on costs per tonne	95	<p>Mass Burn: \$85 to \$96/tonne/annum</p> <p>Gasification: \$85 to \$117/tonne/annum</p> <p>Thermal Treatment Average: \$85 to \$107/tonne/annum</p>	<p>(1) Assumes a facility size of 200,000 tpa.</p> <p>(2) Cost estimates provided in GBP (2008), assumes a 2.0 exchange rate to Canadian dollars, cost escalated using annual Canadian inflation to represent 2012 value</p> <p>(3) Opex for pyrolysis assumed to be similar to that of gasification, and cost for plasma gasification has been excluded as it represents a small segment of thermal treatment technologies and would skew the results.</p> <p>(4) The average opex maximum for mass burn and gasification was combined to reflect a general thermal technology cost per tonne maximum. The same applies to the minimum.</p>	Mayor of London. (2008) Cost of Incineration and non-Incineration Energy-from-Waste Technologies.
Maximize Revenues	ECO-3	Projected Revenues	Estimated energy and resource recovery revenue (\$ per tonne)	Pro-rated scoring on revenue per tonne	55	<p>Electricity production rates of between 465 to 825 kWh/annual tonne at 8 cents/kwh equals \$37 to 66/tonne</p> <p>2 percent of 200,000 tpa at \$277 per tonne = \$1,108,000 per annum (or \$5.5/ annual tonne)</p> <p>Range (Energy + Metals) = \$42 to \$71/annual tonne</p>	<p>(1) Assumes net electricity production for gasification of 430 to 800 kwh/tonne, and 500 to 850 kwh/tonne for mass burn. For the purpose of this evaluation, net electrical production were averaged to reflect a general value for thermal treatment technologies.</p> <p>(2) Exclude revenue generated from heat because it is dependent on site location and if a company down the road would need this heat</p> <p>(3) Assume 2% by weight metals recovered, revenue calculated using the 2012 Ontario Price Sheet (yearly average)</p> <p>(4) \$ per KWh based on rate used at the Durham York Energy Centre (8 cents/kwh)</p> <p>(5) For comparison purposes, revenue from converting syngas to a liquid fuel has been excluded. It has been assumed that syngas will be used to generate electricity/power through a turbine generator.</p>	Durham York Energy Centre Power Purchase agreement Ontario Price Sheet (2012 yearly average) Stantec. (2010)Waste-To-Energy A Technical Review of Municipal Solid Waste Thermal Treatment Practices.
Partnership	ECO-4	Economies of Scale	Potential for public or private partnerships for co-treatment and/or disposal to achieve economies of scale	0= Low potential 50 = Medium potential 100= High potential	100	<p>Option has high potential for economies of scales, as reflected in capital cost for a mass burn facility:</p> <p>100,000 tpa facility = \$747 to 1067/tonne 150,000 tpa facility = \$711 to 1024/tonne 200,000 tpa facility = \$640 to 960/tonne</p> <p>OPEX economies also anticipated.</p>	NA	Mayor of London. (2008) Cost of Incineration and non-Incineration Energy-from-Waste Technologies.
Partnership	ECO-5	Partnership Independence	Degree to which the option is viable without requiring a partnership	0 = Option needs to partnership for optimal efficiency 50 = Option <u>may</u> need partnership to attain optimal efficiency, though not required 100 = Option does not need partnership in order to attain optimal efficiency	0	<p>Partnership assumed to be necessary for optimal efficiency of a thermal treatment facility, because the Region only disposes 92000 tonnes per annum (2011) of residential residual waste. Higher capacities through partnership may be more efficient and feasible from an economical and energy generation standpoint.</p>	NA	

**Technical Dimension
Thermal Treatment**

Goal	Indicator No.	Indicator	Description	Scoring Scheme	Indicator evaluation	Justification	Assumption	Reference
Flexibility	TECH-1	Scalability	The ability of the option to manage changing residual waste quantities over time	0 = No flexibility 33 = Low flexibility 66 = Moderate flexibility 100 = High flexibility	66	Thermal treatment facilities are typically modular, and there fore can be designed to manage various waste processing capacities. Typically each module can range from 40,000 to 300,000 tonnes per year.	Assumes most thermal treatment technologies are modular and can accommodate various scales.	Interim Rpt 3 Universal List Review
Flexibility	TECH-2	Waste Type	The ability of the option to manage changing residual waste composition over time	0 = No flexibility 33 = Low flexibility 66 = Moderate flexibility 100 = High flexibility	66	Mass burn thermal treatment facilities can treat feedstock of varying composition; however operational efficiencies are typically realized with a dryer feedstock. Gasification and pyrolysis require homogeneous feedstock, and therefore have lower flexibility.	Assumes moderate flexibility to take into account the variability between the various thermal treatment technologies (i.e. gasification vs. mass burn).	Interim Rpt 3 Universal List Review
Complexity	TECH-3	Operations	The complexity of the operating requirements throughout the option lifecycle	0 = High complexity 33 = Moderate complexity 66 = Low complexity 100 = No complexity	33	Specialized labour services (e.g. Engineers and technicians) are required to successfully operate thermal treatment facilities.	NA	NA
Complexity	TECH-4	Service Reliability and Performance	The likelihood of service and/or operational disruptions or delays	0 = Potential for severe disruptions 33 = Potential for moderate disruptions 66 = Potential for minor disruptions 100 = No anticipated disruptions	66	Option is well established and reliable. Minor annual disruptions likely for maintenance, however not anticipated to halt operation because its typical to maintain 'one module' at a time.	Assumes most common form of Thermal Treatment Technologies - Mass Burn Incineration Assumes waste feedstock guaranteed. Some technologies have issues with reliability (i.e. pyrolysis and plasma gasification)	NA
Uncertainty	TECH-5	Technological Uncertainty	The level of technological uncertainty associated with the option in achieving the overall objectives (i.e. the management of residual waste)	0 = 1 full scale commercial operation with a minimum of 1 year operating experience managing MSW 33 = 2 to 5 full scale commercial operations with up to 5 years cumulative operating experience managing municipal solid waste 66 = Generally widespread, some variation between technologies within the prescribed options category 100 = Widespread application (i.e. >5 full scale commercial operations) with >5 years cumulative experience managing municipal solid waste	66	There are 90 operating thermal treatment facilities in North America, and over 400 facilities in Europe, the majority of which employ a conventional thermal technology system. Conventional thermal treatment have a long track record of reliability.	Assumes most common form of Thermal Treatment Technologies - Mass Burn Incineration If evaluating pyrolysis and plasma gasification exclusively, the score/rank may likely be lower.	Interim Rpt 3 Universal List Review
Uncertainty	TECH-6	Standards, Laws and Regulations	The complexity and duration of obtaining all necessary regulatory approvals for the option	0 = Potential for complex and lengthy approvals process (e.g. pilot project and/or Individual Environmental Assessment process anticipated) 33 = Approvals process anticipated to be of moderate complexity and duration 66 = Well established environmental approvals process for the option, demonstrated in the past to be completed in a timely manner 100 = No regulatory approvals process required	33	In Ontario, an Individual EA is typically not anticipated for a thermal treatment facility. Approvals process considered to be moderately complex, though demonstrated in the past to be achievable (i.e. Durham York Energy Centre).	NA	NA
Uncertainty	TECH-7	Land Use Policy	The compatibility of the option with existing Regional and Municipal land use policies	0 = The option may be compatible with existing land use policies, subject to amendment(s) 100 = The option is compatible with existing land use policies	0	Land-use and zoning amendments likely to be required, though is dependent on site location.	NA	NA

**Environmental Dimension
MBT**

Goal	Indicator No.	Indicator	Description	Scoring Scheme	Indicator Evaluation	Justification	Assumption	Reference
Waste Reduction	ENV-1	Proportion of Landfilled Residuals	Proportion of inbound residual waste remaining after processing for final disposal (i.e. residue)	Pro-rated scoring on % landfilled	35	MBT - AD: 39% sent to landfill MBT - Aerobic: 32% sent to landfill	Assumes recovery potential for CLO and therefore not landfilled. Includes residue during mechanical and biological stage.	City of Toronto (2009). Mixed Waste Planning Study.
Waste Reduction	ENV-2	Post-Treatment Residue	Classification of any residues that may remain following treatment of the residual waste by the option	0 = Remaining residue is typically classified as hazardous waste 33 = Remaining residue is non-hazardous and hazardous 66 = Remaining residue is non-hazardous and stabilized 100 = No residue remaining after treatment process	66	Non-hazardous residue generated from MBT facilities.	CLO and other residues are non-hazardous, though additional stabilization/maturation may be required.	NA
Energy	ENV-3	Recovery Potential	The potential for the option to recover resources (e.g. additional recyclables, energy, biofuel) from the residual waste stream	0 = No potential 33 = low potential 66 = Moderate potential 100 = High potential	66	Moderate potential because materials in the residual stream are typically contaminated, and market for CLO is not developed. Additionally, depending on which MBT process system is used, biogas can be recovered.	NA	NA
Energy	ENV-4	Energy Consumption	Estimated level of energy consumption	Pro-rated scoring on average energy consumption (kWh/tonne)	85	The electrical consumption, of an MBT-AD is estimated at 110 to 150 kWh/tonne, and the electrical consumption of an MBT-Aerobic is estimated at 25 to 60 kWh/tonne.	Energy consumption can vary based on building design, operation efficiencies, and technology used.	City of Toronto (2009). Mixed Waste Planning Study. City of Toronto (2012). Business Case for an MBT-AD.
Energy	ENV-5	Energy Generation	Estimated amount of energy generated by the option	Pro-rated scoring on average energy generated (kWh/tonne)	150	Biogas electricity production per tonne of waste can range from 75 to 225 kWh, varying according to the feedstock composition, biogas production rates and electrical generation equipment.	Assumes an MBT with AD which used CHP system to generate electricity. Aerobic composting can not generate electricity and therefore excluded from this indicator as it would skew the result.	DEFRA. (2007). Mechanical Biological Treatment of Municipal Solid Waste.
Air	ENV-6	Air Emissions	The potential for the option to generate adverse air emissions.	0 = High impact potential 33 = Moderate impact potential 66 = Low impact potential 100 = No impact potential	66	MBT-AD can generate adverse air emissions but are equipped with an air pollution control system to meet applicable emission guidelines.	Assumes that any thermal treatment facility will require to comply with the Ontario Ministry of Environment A-7 Air Guidelines, as such impact potential assumed at low.	NA
Water	ENV-7	Adverse Impact to Groundwater	The potential for the option to adversely affect local groundwater	0 = High impact potential 33 = Moderate impact potential 66 = Low impact potential 100 = No impact potential	66	MBT facilities are typically enclosed, and therefore impact on groundwater systems assumed low.	Assumes facilities will comply with Environmental Protection Act.	NA
Water	ENV-8	Adverse Impact to Surface Water	The potential for the option to adversely affect local surface water	0 = High impact potential 33 = Moderate impact potential 66 = Low impact potential 100 = No impact potential	66	MBT facilities are enclosed and equipped with stormwater management systems, and therefore impact assumed at low.	Assumes that any MBT facility will require to comply with the Ontario Ministry of Environment Stormwater Management guidelines.	NA
Water	ENV-9	Process Water Needs	Dependency of the option on water for processing	0 = High quantity of water needed during process 50 = Moderate quantity of water needed during process 100 = No need for water during process	50	Assume moderate quantity of water needed.	The level of water usage will be specific to the technology and therefore it is not possible to provide detail consumption needs. One example, a MBT with AD 250,000 tpa consumes an estimated 13000 cubic meters of water per year. Additionally it should be noted that MBT AD process generates excess process water.	City of Toronto (2009). Mixed Waste Processing Facility.

**Social Dimension
MBT**

Goal	Indicator No.	Indicator	Description	Scoring Scheme	Indicator Evaluation	Justifications	Assumptions	Reference
Quality of Life	SOC-1	Level of Odours	The potential for odours (post-construction)	0 = Significant potential for odours 33 = Moderate potential for odours 66 = Low potential for odours 100 = Negligible potential for odours	33	The control of odour at MBT facilities needs careful consideration. Because MBT facilities are located within an enclosed building, potential odour emissions can normally be controlled through the building ventilation system. MBT process require movement of waste during the various steps, in addition to CLO maturation using windrows, therefore potential for odour is assumed as moderate.	NA	Department for Environment Food and Rural Affairs UK. (2007). MBT.
Quality of Life	SOC-2	Level of Noise	The potential for noise (post-construction)	0 = Significant potential for noise 50 = Moderate potential for noise 100 = Negligible potential for noise	50	Noise is an issue that will be controlled by regulations and noise levels at nearby sensitive receptors can be limited by conditions listed in an environmental permit. The main contributors to noise associated with incineration are likely to be: vehicle movements / manoeuvring. traffic noise on the local road networks; mechanical processing such as shredders, screens, trommels and ball mills; and air extraction fans and ventilation systems.	NA	Department for Environment Food and Rural Affairs UK. (2007). MBT.
Quality of Life	SOC-3	Traffic	The potential for traffic impacts on local/regional roads (post-construction)	0 = Significant potential for traffic impacts 50 = Moderate potential for traffic impacts 100 = Negligible potential for traffic	50	MBT facilities will most likely be served by large numbers of trucks with a potential impact on local roads and the amenity of local residents.		Department for Environment Food and Rural Affairs UK. (2007). MBT.
Quality of Life	SOC-4	Other nuisances	The potential for public disruptions during operations (dust, weeds, vectors, vermin, smoke, etc.)	0 = High potential 50 = Moderate potential 100 = Low potential	50	MBT facilities can be designed in enclosed structures, and therefore can limit the potential to attract vermin and birds. Additionally, good housekeeping and on site management of tipping and storage areas is can minimize the risk of public disruption. However, because there are multiple stages to an MBT facility, the potential for nuisance is assumed at moderate.	NA	Department for Environment Food and Rural Affairs UK. (2007). MBT.
Community acceptance	SOC-5	Public Acceptance	The community's known or anticipated perception towards the option (Considers input captured during consultation to date)	0 = Majority of the community is, or is anticipated to be, opposed to the option. 50 = Option is, or is anticipated to be, controversial (supported by most, but with organized opposition). 100 = Broad community support of option is anticipated.	50			
Land Impact	SOC-6	Additional Land Requirements	Approximate area required to site the option, including buffer zone requirements.	0 = Greater than 10 ha of land required 50 = 5 to 10 ha of land required 100 = 0 to 5 ha of land required	50	An estimated range between 8.7 to 10.1 ha for 200,000 tpa facility. Average of range is calculated at 9.4 ha.	Assumes onsite maturation of CLO, and assumes an MBT-AD system. Land requirements may vary based on site design, technology selected, and buffer land required, etc.	City of Toronto (2012). Business Case for an MBT-AD.

Economic Dimension
MBT

Goal	Indicator No.	Indicator	Description	Scoring Scheme	Indicator Evaluation	Justification	Assumption	Reference
Minimize Costs	ECO-1	Capital Costs	Estimated capital costs (\$ per tonne)	Pro-rated scoring on costs per tonne	620	MBT AD \$631 to \$825per design tonne MBT with Aerobic \$432 to \$585/tonne per annum Combined: \$532 to \$705/tonne	(1) Assumes a facility size of 200,000 tpa. (2) Capex estimates based on detailed costing developed for a MBT with AD (Electricity Recovery) for the City of Toronto in 2012. (3) Capex estimates for MBT Aerobic Composting are based on a 2009 study undertaken for the City of Toronto. Costs were escalated to 2012 using inflation 2012, and costing assume in-vessel tunnelling aerobic composting system. (4) Cost excludes price of land and connection to grid, as it is site specific and can vary significantly. Additionally, MBT with RDF Production have been excluded from this as it represents a smaller segment MBT system and depending on availability of RDF market. (5) The average capex maximum for MBT AD and MBT Aerobic was combined to reflect a general MBT cost per tonne maximum. The same applies to the minimum.	City of Toronto Business Case for an MBT-AD Facility (2012)
Minimize Costs	ECO-2	Operating and Maintenance Costs	Estimated operating and maintenance costs (\$ per tonne)	Pro-rated scoring on costs per tonne	65	MBT with AD \$55 to \$75/tonne per annum MBT with Aerobic \$49 to 74/tonne per annum Combined: \$52 to \$75/tonne	(1) Assumes a facility size of 200,000 tpa. (2) Opex estimates based on detailed costing developed for a MBT with AD (Electricity Recovery) for the City of Toronto in 2012. (3) Opex estimates for MBT Aerobic Composting are based on a 2009 study undertaken for the City of Toronto. Costs were escalated to 2012 using inflation 2012, and costing assume in-vessel tunnelling aerobic composting system. (4) Excludes revenue from dry recyclables or energy. (5) The average opex maximum for MBT AD and MBT Aerobic was combined to reflect a general MBT cost per tonne maximum. The same applies to the minimum.	City of Toronto Business Case for an MBT-AD Facility (2012) City of Toronto. Mixed Waste Planning Study (2009)
Maximize Revenues	ECO-3	Projected Revenues	Estimated energy and resource recovery revenue (\$ per tonne)	Pro-rated scoring on revenue per tonne	20	MBT AD: \$20 in revenue per tonne of incoming waste. MBT Aerobic: \$9/tonne	(1) Assumes MBT-AD Facility with Electricity Recovery. Revenue for MBT-AD calculated using the Toronto Business Case as a reference. (2) Excludes revenue generated form heat because it is dependent on site location and if a company down the road would need this heat and assumes no revenue from CLO. (4) Revenue for MBT with an aerobic system is based on the following mass balance (0.7% N-Fe, 2.0% Fe, 1.8% plastics, and 1.5% Paper/cardboard). Revenue was derived using the 2012 Ontario Price Sheet yearly average (50% of price sheet value because of contamination risk since it is the residual waste stream).	City of Toronto Business Case for an MBT-AD Facility (2012). 2012 Ontario Price Sheet, yearly average.
Partnership	ECO-4	Economies of Scale	Potential for public or private partnerships for co-treatment and/or disposal to achieve economies of scale	0= Low potential 50 = Medium potential 100= High potential	100	Option has high potential for economies of scales, as reflected in capital cost two facility sizes: 150,000 tpa facility = \$638 to 821/tonne (CAPEX), \$50 to \$90/tonne (OPEX) 240,000 tpa facility = \$605 to 764/tonne (CAPEX), \$47 to \$81/tonne (OPEX)	NA	City of Toronto Business Case for an MBT-AD Facility (2012).
Partnership	ECO-5	Partnership Independence	Degree to which the option is viable without requiring a partnership	0 = Option needs to partnership for optimal efficiency 50 = Option <u>may</u> need partnership to attain optimal efficiency, though not required 100 = Option does not need partnership in order to attain optimal efficiency	50	Option does not need partnership for optimal efficiency, given that MBT technologies are modular and can be scaled accordingly.	NA	NA

**Technical Dimension
MBT**

Goal	Indicator No.	Indicator	Description	Scoring Scheme	Indicator Evaluation	Justification	Assumption	Reference
Flexibility	TECH-1	Scalability	The ability of the option to manage changing residual waste quantities over time	0 = No flexibility 33 = Low flexibility 66 = Moderate flexibility 100 = High flexibility	66	MBT systems are modular and can therefore be scaled accordingly. The majority of MBT plants have been built at a scale between 20,000 to 100,000 tonnes per year, though MBT plants with capacities greater than 200,000 tonnes per year exist, therefore a moderate flexibility is assumed.	NA	Interim Rpt 3 Universal List Review
Flexibility	TECH-2	Waste Type	The ability of the option to manage changing residual waste composition over time	0 = No flexibility 33 = Low flexibility 66 = Moderate flexibility 100 = High flexibility	66	MBT facilities can treat feedstock of varying composition; however higher organic proportions (i.e. kitchen waste) can result in larger biogas outputs in AD systems.	NA	Interim Rpt 3 Universal List Review
Complexity	TECH-3	Operations	The complexity of the operating requirements throughout the option lifecycle	0 = High complexity 33 = Moderate complexity 66 = Low complexity 100 = No complexity	33	Specialized labour services (e.g. engineers and technicians) are required to successfully operate MBT facilities.	NA	NA
Complexity	TECH-4	Service Reliability and Performance	The likelihood of service and/or operational disruptions or delays	0 = Potential for severe disruptions 33 = Potential for moderate disruptions 66 = Potential for minor disruptions 100 = No anticipated disruptions	66	Option is well established and reliable. Minor annual disruptions likely for maintenance, however not anticipated to halt operation.	Assumes waste feedstock guaranteed.	NA
Uncertainty	TECH-5	Technological Uncertainty	The level of technological uncertainty associated with the option in achieving the overall objectives (i.e. the management of residual waste)	0 = 1 full scale commercial operation with a minimum of 1 year operating experience managing MSW 33 = 2 to 5 full scale commercial operations with up to 5 years cumulative operating experience managing municipal solid waste 66 = Generally widespread, some variation between technologies within the prescribed options category 100 = Widespread application (i.e. >5 full scale commercial operations) with >5 years cumulative experience managing municipal solid waste	66	MBT systems have been processing biodegradable waste fractions for over 20 years, and therefore this concept is not new. Globally there are more than 123 MBT plants in operation, with European countries leading in number of facilities and operational experience.	NA	Interim Rpt 3 Universal List Review
Uncertainty	TECH-6	Standards, Laws and Regulations	The complexity and duration of obtaining all necessary regulatory approvals for the option	0 = Potential for complex and lengthy approvals process (e.g. pilot project and/or Individual Environmental Assessment process anticipated) 33 = Approvals process anticipated to be of moderate complexity and duration 66 = Well established environmental approvals process for the option, demonstrated in the past to be completed in a timely manner 100 = No regulatory approvals process required	66	In Ontario, an Individual EA is not anticipated for a MBT. Approvals process considered to be moderately complex, though various individual components of the MBT system have been permitted in the past (i.e. MRF, AD, Aerobic Composting Facility, etc.)	NA	NA
Uncertainty	TECH-7	Land Use Policy	The compatibility of the option with existing Regional and Municipal land use policies	0 = The option may be compatible with existing land use policies, subject to amendment(s) 100 = The option is compatible with existing land use policies	0	Land-use and zoning amendments likely to be required, though is dependent is site location.	NA	NA

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