Assessing the Environmental Impact of Anaerobic Digestion for Organic Waste in the Project Green Study Area

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June 28, 2010

Executive Summary

The School of Planning at the University of Waterloo (UW) was retained by the Toronto and Region Conservation Authority (TRCA) to conduct a study and prepare a report regarding the environmental impact of anaerobic digestion for organic waste in the Pearson Eco-Business Zone (PEBZ).

The scope of this project is outlined in "*Assessing the Environmental Impact of Anaerobic Digestion for Organic Waste in the Project Green Study Area (July 20, 2009)*" and an associated change of scope, entitled "*Assessing the Environmental Impact of Anaerobic Digestion for Organic Waste in the Project Green Study Area: Project Update (February 22, 2010)*". For the reader's reference these documents are attached in Appendix "A".

The following summarizes the original purpose and scope of the study:

- Identify the quantity and quality of organic waste generated in the PEBZ;
- Determine the environmental impacts of diverting the above waste for processing using anaerobic digestion within the PEBZ;
- Determine the economic impact of the diversion of organic waste and the associated energy generation; and
- Document project methodology and data, and provide recommendations in a report to the TRCA and the Partners in Project Green (PPG).

The study examined a survey completed by the researchers; information collected by Yield Energy; and in-depth interviews with two organic waste producers, one with a high quality organic waste, and the other with contamination in its organic waste stream.

The report identified a theoretical potential of 162,481 tonnes that could be diverted to anaerobic digestion. This number was determined by participants of the study and could vary significantly. This amount excluded all waste that is currently being sent to secondary markets. If the waste identified was managed through anaerobic digestion the following impacts could be observed:

- 346,659 GJ of energy generated or enough power for approximately 10,000 homes for one year;
- 9,051 tonnes of carbon equivalents destroyed or the equivalent of removing approximately 2600 cars from the road for one year; and
- 1001 tonnes of residual waste requiring disposal in a landfill.

This presents a significant environmental improvement over the current landfill or compost practices. The current waste management practices for the waste outlined above generate:

- 72,903 GJ of energy or enough power for approximately 2,100 homes for one year;
- 56,843 tonnes of carbon equivalents generated or the equivalent of adding approximately 16,000 cars to the road for one year; and
- 50,819 tonnes of residual waste.

In order to divert the identified waste to anaerobic digestion, there are several significant barriers that must be overcome:

- The producers of large volumes of high quality (i.e. non-contaminated) organic waste identified in this report are currently paid for their organic waste. This leaves an unpredictable stream of organic waste that may contain a significant level of contamination, making anaerobic digestion more difficult;
- Many of the respondents surveyed indicated that they would be unwilling to pay a premium for anaerobic digestion, even given its ability to accept co-mingled organic waste; and
- The Yield Energy report suggested that the tipping fees for anaerobic digestion would range between $60 and $130 per tonne. Much of the waste identified in this report is disposed of for less than these tipping fees. Therefore there is a need to reduce the tipping fees in order to divert waste to anaerobic digestion.

While anaerobic digestion may present a significant theoretical opportunity to reduce the environmental impacts, there are significant practical challenges associated with the diversion of organic waste to anaerobic digestion. In addition to these practical challenges the inability to achieve a significant survey participation rate makes it extremely difficult to reliably predict the quantity and quality of waste generated in an area such as that representative of the PEBZ.

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1.0 Introduction

The School of Planning at the University of Waterloo (UW) was retained by the Toronto and Region Conservation Authority (TRCA) to conduct a study and prepare a report regarding the environmental impact of anaerobic digestion for organic waste in the Pearson Eco-Business Zone (PEBZ).

1.1 Background

The TRCA and several partner associations, including the Greater Toronto Airport Authority (GTAA), are working together on an initiative (GTAA Partners in Project Green) to transform the area surrounding the Lester B. Pearson International Airport into an eco-business zone (GTAA Partners in Project Green 2010)

As part of this initiative the TRCA and GTAA Partners in Project Green (PPG) have formed the Resource Reutilization Committee. The committee's purpose is to more effectively manage the waste generated by various stakeholders in the study area. As part of this process, the committee has been examining the possibility of establishing a waste exchange and an anaerobic digester for processing organic wastes (GTAA Partners in Project Green 2010).

1.2 Scope of Project

The scope of this project is outlined in "*Assessing the Environmental Impact of Anaerobic Digestion for Organic Waste in the Project Green Study Area (July 20, 2009)*" and an associated change of scope, entitled "*Assessing the Environmental Impact of Anaerobic Digestion for Organic Waste in the Project Green Study Area: Project Update (February 22, 2010)*". For the reader's reference these documents are attached in Appendix "A".

The following summarizes the original purpose and scope of the study:

- Identify the quantity and quality of organic waste generated in the PEBZ;
- Determine the environmental impacts of diverting the above waste for processing using anaerobic digestion within the PEBZ;
- Determine the economic impact of the diversion of organic waste and the associated energy generation; and
- Document project methodology and data, and provide recommendations in a report to the TRCA and the PPG.

2.0 Methodology

The initial methodology for the project is outlined in the project scope and is outlined below in detail (a copy of the project scope is presented in Appendix "A")

Research for this project began in November 2009. Initial work consisted of calling each business as identified by the TRCA (a list of businesses is included in Appendix "B"). During the initial contact each business was informed about the nature of the project and ask to participate in an online survey. Individuals that expressed an interest in the study were sent an email with additional information and a link to the survey (a copy of the email and survey questions are included in Appendix "C").

Each potential participant identified by the TRCA was contacted up to three times, or until a response was received. Phone calls were made beginning in November 2009; follow up calls were made in December 2009 and January 2010. After the third attempt at contacting potential participants in January 2010, 25 potential participants had verbally expressed interest in the study. Of these, 5 completed the online survey. Several follow up emails were sent to those who had not completed the survey, but this had no effect on increasing the rate of participation.

After discussions with the TRCA in February 2010, it was agreed that the project methodology required adjustment. Both the TRCA and the researchers agreed that the information gained through the survey was insufficient. On February 22, 2010 a project update entitled "*Assessing the Environmental Impact of Anaerobic Digestion for Organic Waste in the Project Green Study Area: Project Update (February 22, 2010)*" was submitted to the TRCA for review and approval. Given the low survey response rate, the project update suggested that the report take a case study approach to the data. The following case studies would be used: the data provided through the surveys received as part of the original methodology; the organic waste data presented in Yield Energy's report; a waste hauler case study provided through the Yield Energy report; a high quality organic waste case study of a large bakery with multiple facilities in the study area (survey included in Appendix "C"); and a case study of co-mingled and/or contaminated organic waste provided by a large retail grocer.

Data collected was analyzed using the using the Integrated Waste Management Model (IWM). More information about the model can be found at www.iwm-model.uwaterloo.ca. In addition to the quantitative data collected through the surveys and interviews, qualitative insight will also be presented.

The most significant implication of the changes outlined in the project update, are the inability to conduct statistical analysis on the data, as a representative sample would not be achieved. However, the new approach would still provide insight into the environmental impact of organic waste diversion within the study area.

The TRCA provided approval of the project update on March 29, 2010.

2.1 Organic Waste Data Sets

Five distinct data sets were used to generate the analysis and findings for this report. These include; the results of the UW survey; organic waste producer data presented in the Yield Energy report; the waste hauler data presented in the Yield Energy report; an interview with a high quality organic waste generator; and an interview was a contaminated organic waste generator. Details about each data set are outlined in the following subsections, and Table 2.2-1 outlines the data sets.

Table 2.2-1: Data Sets

Data Set	Description
1	University of Waterloo Survey
2	Yield Energy Organic Waste Generators
3	Yield Energy Organic Waste Haulers
4	High Quality Organic Waste
5	Contaminated Organic Waste

2.1.1 UW Survey Data (Data Set 1)

This data set was generated through the survey responses received during the initial phase of the research. Unfortunately due to a low survey response rate the volume of waste identified in this data set in minimal. A copy of the survey questions is included in Appendix "C"

2.1.2 Yield Energy Organic Waste Generators (Data Set 2)

Yield Energy (YE) was retained by the TRCA to prepare a biogas feasibility study for the PEBZ. The report included an inventory of various organic waste producers in the Greater Toronto Area (GTA). A copy of the relevant data from the YE report is included in Appendix "D". This data was used to supplement the information collected in the UW Survey.

2.1.3 Yield Energy Organic Waste Haulers (Data Set 3)

Several attempts were made to conduct an interview with an organic waste hauler, without success. In order to provide information about the environmental impact of waste haulers, information collected in the YE report regarding waste haulers was used to create the case study. A copy of the relevant data from the YE report is included in Appendix "D"

2.1.4 High Quality Organic Waste Generator (Data Set 4)

Due to a low survey response rate, in-depth interviews were conducted. One of these interviews was with a large bakery operation in the PEBZ. This bakery represents an organic waste producer with low contamination (i.e. plastic) in their waste. Appendix "C" provides the questions used during the interview of the bakery. The interview provided both organic waste volume data and valuable insights from someone with tremendous experience in managing organic waste.

2.1.5 Contaminated Organic Waste Generator (Data Set 5)

A second in-depth interview was conducted with a large retail grocer operation that has several facilities in the PEBZ. This grocer represented an organic waste producer with higher contamination (i.e. plastic) in their waste. This level of contamination can present challenges to achieving an optimal waste management methodology and is generally considered a prime candidate for diversion to anaerobic digestion.. Appendix "C" includes a copy of the questions used during the interview.

2.2 IWM Analysis Methodology

All quantitative organic waste information collected during the research was analyzed using the Integrated Waste Management Model (IWM). The

IWM was calibrated to the Ontario energy mix. All results from the IWM are representative of the waste's life cycle. Three scenarios were used for each data set to illustrate the environmental impact of different waste management systems.

2.1.1 Baseline

Each data set was examined using their respective current waste management approaches to determine the current environment impacts of the system and to establish a baseline for comparison.

Waste data was entered into the IWM based on its current volume and management approach (compost, anaerobic digestion, and landfill). Any organic waste sent to secondary markets (animal feed and rendering) was considered diverted and excluded from analysis. When conducting the analysis with the IWM, no default settings were changed, as they are calibrated to the Canadian context.

2.2.2 Baseline to Anaerobic Digestion (AD1)

Each data set was then examined using a second scenario representative of diverting all waste accounted for in the baseline scenario to anaerobic digestion.

Waste data was entered into the IWM based on its current volume and assumed anaerobic digestion as the management approach. Any organic waste sent to secondary markets (animal feed and rendering) was considered diverted and excluded from analysis. When conducting the analysis with the IWM, no default settings were changed.

2.2.3 All Waste to Anaerobic Digestion (AD2)

The final scenario was used to determine the environmental impact of all waste, include organic material sent to secondary markets, in a data set being diverted to anaerobic digestion.

Waste data was entered into the IWM based on its current volume and assumed anaerobic digestion as the management approach. When conducting the analysis with the IWM, no default settings were changed, as they are calibrated to the Canadian context.

It should be noted that this scenario had the potential to significantly increase the waste compared to the baseline and baseline to anaerobic digestion scenarios. It should also be noted that organic waste currently sent to secondary markets should not be redirected to anaerobic digestion, as this would be a lower level diversion strategy. Reuse is considered the best waste management strategy as it reduces primary resource usage and therefore provides a net benefit.

2.2.4 Data Set Analysis

Table 2.2-2 outlines which analysis was used for each data set.

Table 2.2-2: Analysis Matrix

Data Set	Analysis
1	Was analyzed using all scenarios
2	Was analyzed using all scenarios
3	Was analyzed using two scenarios, the third sce-

	nario was excluded from analysis.
4	Was analyzed using all scenarios
5	Was analyzed using all scenarios

As indicated in the table the waste hauler data was only analyzed using two scenarios. This data set did not have any waste being sent to secondary markets and therefore both anaerobic digestion scenarios would have yielded the same results.

2.3 Transportation Sensitivity

During the collection of information for this study it became clear that companies did not have a concrete understanding of the travel distances associated with the disposal for their organic waste. This presented a challenge in determining the current baseline environmental impacts and associated changes under proposed scenarios. As such, a sensitivity analysis was done to determine the impact of travel on waste management systems. This sensitivity analysis assumed that 1000 tonnes of food waste were sent to compost at distances of 10, 100, 1,000, and 10,000Km. Each scenario consumed 163 GJ of energy and emitted 11 tonnes of carbon dioxide equivalents. Since all scenarios had the same environmental impact, the transport of waste can be excluded from the analysis without a significant impact on the results.

3.0 Observations & Analysis

3.1 UW Survey Data

Table 3.1-1 presents a summary of the organic waste generation by the participants in the UW Survey. The table includes a company ID (which corresponds to the full survey results in Appendix "E"), the annual organic waste generation, and current disposal method).

Table 3.1-1: UW Organic Waste Survey Summary

ID*	Tonnes/Year	Disposal
S1	7.5	Unknown
S2-1	300	Reuse
S2-2	30	Water Treatment
S3	3,000	Reuse
S4	--	--
S5	2.5	Landfill
S6	30	Reuse

See Appendix "E" Complete Yield Data associated with each ID

Table 3.1-2 provides a summary of disposal methods and associated waste volumes. These summary numbers were used to determine the baseline waste management scenario entered into the IWM.

Table 3.1-2: UW Organic Waste Survey Disposal Method Summary

Disposal Method	Tonnes/Year
Reuse	3,330
Anaerobic Digestion	0
Compost	0
Landfill	10
Water Treatment	30
Unknown	7.5

In addition to the information presented in the tables above, survey participants were asked "Would you be willing to pay a premium for organic waste disposal that re-utilizes the waste for energy generation?"; "What premium would your company be willing to pay?"; and "What support would be required to reduce barriers to an organics separation program in your company?". All respondents said they would not be willing to pay a premium for organic waste disposal, except one, who gave no response. All companies provided no response to the question regarding support needed to implement a source separated organics program.

3.1.1 Analysis of Information

The baseline scenario manages 40 (waste with an unknown management methodology is assumed to be landfilled) tonnes of organic waste, while producing 19 GJ of energy and 50 tonnes of carbon dioxide equivalents. The baseline scenario also generates 40 tonnes of residual waste.

Sending all the waste examined in the baseline scenario to anaerobic digestion results in the generation of 86 GJ of energy and the destruction of 2 tonnes of carbon dioxide equivalents while managing the same volume of waste. This scenario also generates 0 tonnes of residual waste.

The third scenario examined the environmental impacts if all waste (including that currently sent for reuse) was sent to anaerobic digestion. Under this scenario 7,244 GJ were generated, and 189 tonnes of carbon dioxide equivalents were destroyed while leaving 21 tonnes of residual waste. It is important to note that this scenario managed 3,370 tonnes of organic waste, an 8,425% increase from the baseline scenario. The full IWM are presented in Appendix "F".

3.2 Yield Energy Organic Waste Generators

Table 3.2-1 presents a summary of the organic waste information collected by YE. The table includes a company ID (which corresponds to the table presented in Appendix "D"), the annual organic waste generation, and current disposal method (AD is short for Anaerobic Digestion).

Table 3.2-1: Yield Energy Organic Waste Generation Summary

ID*	Tonnes/Year	Disposal
Y1	80	Compost
Y2	300	Compost
Y3	516	Reuse
Y4	51,100	Reuse
Y5	118/790	AD /Reuse
Y6	23	Compost
Y7	313	Compost
Y8	8	Compost
Y9	500	Compost/Landfill
Y10	11,000	Reuse
Y11	540	Compost
Y13	300	Compost/Landfill
Y14	6,000	Landfill
Y15	32	Compost
Y16	12	Landfill
Y17	NA	Alcohol Recovery

****See Appendix "D" Complete Yield Data associated with each ID***

Table 3.2-2 provides a summary of disposal methods and associated volumes. These summary numbers were used to determine the baseline waste management scenario entered into the IWM.

Table 3.2-2: YE Organic Waste Disposal Summary

Disposal Method	Tonnes/Year
Reuse	63,306
Anaerobic Digestion	118
Compost	3,296
Landfill	6,012

3.2.1 Analysis of Information

The baseline scenario manages 9,426 tonnes of organic waste, while producing 2,568 GJ of energy and 7,496 tonnes of carbon dioxide equivalents. The baseline scenario also generates 6,178 tonnes of residual waste.

Sending all the waste examined in the baseline scenario to anaerobic digestion results in the generation of 20,262 GJ of energy and the destruction of 529 tonnes of carbon dioxide equivalents while managing the same volume of waste. This scenario also generates 59 tonnes of residual waste.

The third scenario examined the environmental impacts if all waste (including that currently sent for reuse) was sent to anaerobic digestion. Under this scenario, 156,347 GJ were generated and 4,082 tonnes of carbon dioxide equivalents were destroyed while leaving 451 tonnes of residual waste. It is important to note that this scenario managed 72,732 tonnes of organic waste, a 771% increase from the baseline scenario. The full IWM inputs and outputs are presented in Appendices "F".

3.3 Yield Energy Organic Waste Haulers

In addition to surveying businesses in the PEBZ, the YE report (*"PEBZ Biogas Feasibility Study"*) also examined the organic waste collected by various waste haulers. This information was used as the basis for a waste hauler case study.

Table 3.3-1 presents a summary of waste hauler information collected by YE. The table includes a company ID (which corresponds to the table presented in Appendix "D"), the annual organic waste collection, and current disposal method (AD is short for Anaerobic Digestion).

Table 3.3-1: Waste Hauler Summary

ID*	Tonnes/Year	Disposal
WH1	30,000	Compost/AD
WH2	5,200	Unknown
WH3	10,000	Unknown
WH4	8,000	Unknown
WH5	4,000	Unknown
WH6	35,000	Compost
WH7	30,000	Unknown
WH8	--	--
WH9	5,200	Unknown

****See Appendix "D" Complete Yield Data associated with each ID***

Table 3.3-2 provides a summary of disposal methods and associated volumes. These summary numbers were used to determine the baseline waste management scenario entered into the IWM.

Table 3.3-2: Waste Hauler Disposal Method Summary

Disposal Method	Tonnes/Year
Reuse	0
Anaerobic Digestion	30,000
Compost	65,000
Landfill	0
Unknown	32,000

3.3.1 Analysis of Information

The baseline scenario manages 127,400 tonnes of organic waste (it is assumed that waste with an unknown management methodology is landfilled), while producing 69,238 GJ of energy and 39,256 tonnes of carbon dioxide equivalents. The baseline scenario also generates 35,836 tonnes of residual waste.

Sending all the waste examined in the baseline scenario to anaerobic digestion results in the generation of 273,862 GJ of energy, and the destruction of 7,151 tonnes of carbon dioxide equivalents while managing the same volume of waste. This scenario also generates 791 tonnes of residual waste. The full IWM inputs and outputs are presented in Appendix "F".

3.4 High Quality Organic Waste

3.4.1 Summary of Interview

On April 29, 2010 an interview was conducted with a representative of a large bakery with facilities in the study area. The interview asked questions regarding the following themes: size of operation; organic waste generation; organic waste revenue stream; organic waste markets; seasonal variability in organic waste; and contamination of organic waste. The themes were selected as they provide insight into the feasibility of anaerobic digestion for IC&I sector organic waste. The following sections summarize the results of the interview:

1. Size of Operation

The bakery operates three plants within the PEBZ. These include: (1) a pie and cookie plant, (2) a Mexican food plant, and (3) an artisan bread plant. The sizes of these operations are: (1) 150,000 square feet and 210 employees, (2) 60,000 square feet and 100 employees, and (3) 100,000 square feet and 120 employees.

2. Organic Waste Generation

All three facilities produce food grade organic waste. Plant (1) produces 76 tonnes of solid waste sent to landfill, and 250 tonnes of diverted waste (mostly organic). Plant (1) has a diversion rate of 77%, the lowest of the three plants examined. This is due to two factors including: high sugar content in the organic waste, and the packaging used at the facility.

Plant (2) produces 5 tonnes of solid waste, 230 tonnes of diverted waste, and has a diversion rate of 98%. Plant (3) produces 24 tonnes of solid waste, 404 tonnes of diverted waste, and has a diversion rate of 95%.

3. Organic Waste Revenue Stream

The bakery considers its organic waste a revenue stream. The bakery sells its high quality food grade organic waste to U-Pak, a waste hauler. U-Pak then processes this waste, which is sold to the animal feed industry. The majority of the bakery's organic waste is used in pig and cattle feed. The bakery's income from organic waste is approximately 5% of the sale value of a unit of finished product. The bakery views their organic waste as "… a revenue stream which reduces the negativity of operating the plant."

In order for the bakery to be interested in biogas operations for their dry organic waste (the waste sold for animal feed applications), the tipping rate would have to improve significantly. However, the bakery is interested in biogas if it were to be cost neutral, but the tradeoff would be at least partial ownership of carbon credits generated through the biogas production. The bakery would also benefit significantly from the publicity of good sustainability practices associated with a biogas application.

4. Organic Waste Market

The representative for the bakery indicated that the secondary market for organic waste used in animal feed applications is saturated. While the bakery has not had difficulty in selling their own organic waste, the price has continually been lowered through the influx of more organic waste. The bakery provides a steady and predicable amount of organic waste and is at little risk of losing their contract with U-Pak. However, smaller operations could see their organic waste declined.

It should also be noted that contamination of organic waste (through a pathogen) would likely close the secondary market for organic waste.

The bakery believes that the "first biogas plant will be a pressure release value for the food waste industry."

5. Seasonal Variability

The bakery experiences seasonal variation in their organic waste generation. For example, during the summer there is a significant drop in bread sales, but an associated increase in hamburger and hot dog buns, and vice versa for the winter. Seasons are not the only factor that impacts organic waste generation. The cancellation of the 2009 Canada Day celebrations in Toronto decreased the annual sale of hamburger and hot dog buns by 4-5%. The baseload of the plants (90% of production) stays steady, but the variable component (10% of production) can vary by 30-40%.

6. Contaminated Organic Waste

Contaminated organic waste cannot go to the animal food industry and is therefore sent to landfill for disposal. There are various criteria that determine if the contamination is significant enough to exclude it from use as animal feed. The bakery noted that it would much prefer to send this to biogas.

Contaminated organic waste represents approximately 1% of the diverted organic waste. The bakery wants to divert that waste for both the increased diversion rates and the stewardship credit.

3.4.2 Summary of Data for IWM

Table 3.4-1 presents a summary of bakery's organic waste. The table includes a plant ID, the annual organic waste generation, and current disposal method.

Table 3.4-1: Bakery Organic Waste Summary

Plant ID	Tonnes/Year	Disposal
1	250 (diverted) 2.5 (Contaminated)	Reuse Landfill
2	230 (diverted) 2.3 (Contaminated)	Reuse Landfill
3	404 (diverted) 4.04 (Contaminated)	Reuse Landfill

Table 3.4-2 provides a summary of disposal methods and associated volumes. These summary numbers were used to determine the baseline waste management scenario, and were entered into the IWM.

Table 3.4-2: Bakery Organic Waste Disposal Method Summary

Disposal Method	Tonnes/Year
Reuse	884
Landfill	9

3.4.3 Analysis of Information

The baseline scenario manages 9 tonnes of organic waste, while producing 4 GJ of energy and 11 tonnes of carbon dioxide equivalents. The baseline scenario also generates 9 tonnes of residual waste.

Sending all the waste examined in the baseline scenario to anaerobic digestion results in the generation of 19 GJ of energy and 0 tonnes of carbon dioxide equivalents while managing the same volume of waste. This scenario also generates 0 tonnes of residual waste.

The third scenario examined the environmental impacts if all waste (including that currently sent for reuse) was sent to anaerobic digestion. Under this scenario 1,919 GJ were generated, and 50 tonnes of carbon dioxide equivalents were destroyed while leaving 6 tonnes of residual waste. It is important to note that this scenario managed 893 tonnes of organic waste, a 9,922% increase from the baseline scenario. The full IWM inputs and outputs are presented in Appendices "F".

In addition to these scenarios it should be noted that the pie and cookie plant (Plant #1) currently diverts 77% of the waste generated. Some of the non-diverted waste includes organic waste with either high sugar content or contamination (in the form of packaging) and cannot be used as animal feed. It was difficult to determine the actual quantity of this organic waste and therefore it was excluded from the analysis. However, this waste could represent up to 76 tonnes of material that could be diverted to anaerobic digestion.

3.5 Contaminated Organic Waste

3.5.1 Summary of Interview

On May 20, 2010 a survey was received from a representative of a large retail grocery provider with operations in the PEBZ. The survey asked questions in the following areas: size of operation; organic waste generation; organic waste revenue stream; organic waste markets; seasonal variability in organic waste; and contamination of organic waste. The areas were selected as they provide insight into the feasibility of anaerobic digestion for IC&I sector organic waste. The following sections summarize the results of the interview:

1. Size of Operation

The grocer has approximately 23 corporate stores in the PEBZ. These average 85,000 square feet each and are all retail grocery establishments.

2. Organic Waste Generation

These stores generate produce trimmings, bakery waste (unsold goods), hot deli food waste (prep and unsold goods), sushi waste (prep and unsold goods), raw meat, bones, fat trimmings, hot deli grease or 'yellow grease', grease trap waste or 'brown grease', reclamation waste (from damaged grocery items), and some dairy waste from damaged or expired goods. Table 3.5-1 details the 2009 organic waste volumes generated by the grocer surveyed. The grocer's representative estimated 5-10% of the grocer's garbage could be diverted as organic waste if packaging was not an issue.

Table 3.5-1: Grocer Waste Summary

Type of Waste	Tonnes/Year
Organic	16,457
Rendering	1,315
Yellow Grease	414
Brown Grease	6,136

Garbage	33,980

3. Organic Waste Revenue Stream
The grocer receives revenue from their rendering and 'yellow grease' waste. All other organic waste streams are currently a cost to the grocer. In 2009, the grocer generated approximately $14,000.00, mainly from 'yellow grease'. The grocer also pays for all hauling costs.

4. Organic Waste Market
The grocer currently sends organic waste to animal feed processors, composting, and anaerobic digestion. There has never been a time when secondary markets have not accepted the grocer's waste.

5. Seasonal Variability
The grocer has noticed higher volumes during the local produce season (June to October) and during holiday times (Thanksgiving and Christmas). The seasonal lows are noticed after New Years' Day.

6. Contaminated Organic Waste
The grocer has some packaged waste (such as lunchmeats) that is disposed of with contamination (the packaging). The material contaminating the organic waste includes: plastics, elastics, twist ties, and onion bags, mostly from the produce department. It is too laborious to open every package to create source separated organic waste. This waste is sent to landfill near St. Catherine's, Ontario.
Disposal costs for the grocer's organic waste can range from $70 to $120 per tonne, depending on the geographical region and the distance from landfill.

3.5.2 Contaminated Organic Waste: Summary of Data for IWM

Based on the interview, Table 3.4-2 provides a summary of disposal methods and associated volumes. These summary numbers were used to determine the baseline waste management scenario entered into the IWM.

Table 3.5-2: Contaminated Organic Waste Disposal Summary

Disposal Method	Tonnes/Year
Reuse	1,729
Compost	16,457
Landfill	7,934

3.5.3 Analysis of Information

The baseline scenario manages 24, 391 tonnes of organic waste, while producing 1,074 GJ of energy and 10,030 tonnes of carbon dioxide equivalents. The baseline scenario also generates 8,756 tonnes of residual waste.

Sending all the waste examined in the baseline scenario to anaerobic digestion results in the generation of 52,430 GJ of energy and the destruction 1,369 tonnes of carbon dioxide equivalents while managing the same volume of waste. This scenario also generates 151 tonnes of residual waste.

The third scenario examined the environmental impacts if all waste (including that current sent for reuse) was sent to anaerobic digestion. Under this scenario 56,146 GJ were generated, and 1,466 tonnes of carbon dioxide equivalents were destroyed while leaving 162 tonnes of residual waste. It is important to note that this scenario managed 26,119 tonnes of organic waste. The full IWM inputs and outputs are presented in Appendix "F".

4.0 Discussion

Despite best efforts and the employment of various data collection methodologies it proved extremely difficult to achieve the desired participation rates in the study. Of particular note is the survey conducted as part of the research. Approximately 150 businesses were contacted, but only 5 were willing to share information about their organic waste generation. Without meaningful and statistically significant data it is extremely difficult to accurately provide organic waste data for the purpose of a feasibility study. Further it appears both based on the literature and the Yield Energy report that others have encountered the same difficulty producing results that can be relied upon.

This lack of rigorous data provides a significant barrier to diverting waste to anaerobic digestion. If a reliable stream of organic waste of a sufficient quality cannot be demonstrated, it would be inherently risky to move forward with the construction of an anaerobic digester. The following text provides a detailed explanation of the data.

4.1 Yield Energy Report

In the YE Report *"PEBZ Biogas Feasibility Study,"* 16 generators of organic waste were identified and surveyed for information. The following provides a summary of the results:

- Collectively they had an annual organic waste generation of approximately 75,000 tonnes of organic waste;
- 15 of the 16 producers already utilize some form of diversion, and 5 of the 16 producers send their organic waste for reuse (animal feed, rendering, alcohol recovery);
- The producers are paying tipping fees ranging from -$10 to $1000/tonne;
- The average tipping fee is $176/tonne. Excluding the $1000/tonne tipping fee (considered an outliner because it is an order of magnitude larger than other tipping fees) reduces the average to $121;
- 4 of the 16 organic waste producers would be willing to pay a premium to dispose of co-mingled organics;
- Of the 75,000 tonnes of organic waste identified in the report, 51,000 tonnes belongs to Molsons and is sent to animal feed, generating a $10/tonne income;
- Approximately 74,700 tonnes of the organic waste identified in the report are disposed of for less $130/tonne (the highest tipping rate identified for anaerobic digestion in the YE report); and
- Approximately 63,000 tonnes are disposed of for less than $60/tonne (the lowest tipping rate identified for anaerobic digestion in the YE report). The $60/tonne tipping fee requires that the anaerobic digester

receives a $46/tonne credit for GHG reduction.

In order to realistically achieve the 50,000 tonnes of organic waste needed to operate the proposed anaerobic digester, the tipping fee would need to be significantly below $60 per tonne. Given the waste identified by YE in their report, the anaerobic digester would likely need to pay approximately $10 per tonne to achieve a minimum of 50,000 tonnes of organic waste.

It should also be noted that organic waste producers paying greater than $60 per tonne in tipping fees had smaller volumes of organic waste that could potentially create an unpredictable supply for an anaerobic digester.

4.2 University of Waterloo Survey

During the process of collecting survey results, as outlined in the proposal, some interesting observations were made. These are outlined below:

- Approximately 150 business were contacted according to the methodology outlined is Section 2.1. During this process, 26 companies expressed an interest in the study and verbally committed to completing the survey. Only 6 surveys were actually completed;

- Observations made during the contact process suggests that many of the 150 business are small, with few employees and little knowledge regarding their waste management practices;

- The tipping fee identified in the survey ranged from $0 to greater than $175. However, the large producers of organic waste were paid for their organic waste, as noted in the additional comment section of their surveys. The larger tipping fees were for smaller producers of organic waste, or highly contaminated (i.e. from cleaning processes) organic waste; and

- Of the six companies that did respond to the survey, five said they would be unwilling to pay a premium for organic waste disposal that re-utilizes the waste for energy generation, and the other did not respond.

As with the waste identified by the YE report, large producers of organic waste identified in the UW survey have found ways of being paid for their high quality organic waste. The remainder of the waste is of low volume and quality and could not be reliably depended on for the operation of an anaerobic digester.

4.3 Waste Hauler Observations

The following observations were made about the waste hauler data presented in the Yield Energy report:

- 127,400 tonnes of organic waste collected by waste haulers in the study area were identified;

- 95,000 tonnes of this waste is currently being sent to other anaerobic digesters or compost;

- Only one company provided a price per tonne ($45); and

- Very few details regarding the quality and consistency of the waste were collected.

The data provided in the waste hauler section of the YE energy report was limited in nature. This did not allow for analysis based on tipping fees or current disposal methods. Given the difficultly experienced in recruiting a waste hauler for inclusion as an interview participant, this seems to be the nature of the industry.

4.4 High Quality Organic Waste

While interviewing a representative from the bakery operation, many qualitative insights were gained; these are outlined below:

- The bakeries in the study area produce a significant quantity of uncontaminated organic waste. Due to disposal costs associated with organic waste, the bakery has found animal feed producers willing to pay for the waste;
- The representative from the bakery noted that the animal feed industry is saturated with organic waste, which has pushed prices down;
- It was also noted that anaerobic digestion may prove a much needed "pressure release value" for organic waste disposal;
- However, the bakery generates a sufficient quantity and quality of waste that it is unlikely that it will ever be rejected from the animal feed market;
- One of the bakery's plants in the study area generates organic waste with high sugar content, approximately 76 tones per year. This waste is not acceptable to the animal feed industry and therefore the waste is currently not diverted; and
- The bakery representative also noted that it would be interested in a cost neutral disposal method, which would provide them with carbon dioxide destruction credits.

The bakery also generates small volumes of lower quality organic waste that it could dispose of in anaerobic digestion. However, these represent less than 100 tonnes per year and do not generate a consistent supply.

4.5 Contaminated Organic Waste

The finial organization interviewed during the research for this report was a large retail grocer with several locations within the study area. The following highlights the insights gained:

- The grocer generates various types of organic waste, as outlined in Section 3.5.1;
- Their current diversion rate is 67.7%;
- The grocer's non-diverted waste includes approximately 5-10%, or between 1,700 and 3,400 tonnes, of organic material;
- The organic material not diverted by the grocer is heavily packaged;

- The grocer receives income from their "yellow grease" and rendering disposal methods;

- The grocer notices significant peak organic waste volumes from June to October and holidays, and there is a significant reduction in organic waste during the winter months; and

- Disposal costs organic wastes range from $70 to $120 per tonne.

The grocer presents the best opportunity for diversion of organic waste to anaerobic digestion. The grocer produces approximately 26,000 tonnes annually of organic waste suitable for anaerobic digestion and pays between $70 and $120 per tonne for disposal. Approximately 3,400 tonnes of this is contaminated and would require pretreatment.

4.0 Conclusions

The School of Planning at the University of Waterloo (UW) was retained by the Toronto and Region Conservation Authority (TRCA) to conduct a study and prepare a report regarding the environmental impact of anaerobic digestion for organic waste in the Pearson Eco-Business Zone (PEBZ).

The study examined a survey completed by the researchers; information collected by Yield Energy; and in-depth interviews with two organic waste producers, one with a high quality organic waste, and the other with contamination in its organic waste stream.

The report identified a theoretical potential of 162,481 tonnes that could be diverted to anaerobic digestion. This number was determined by participants of the study and could vary significantly. This amount excluded all waste that is currently being sent to secondary markets. If the waste identified was managed through anaerobic digestion the following impacts could be observed:

- 346,659 GJ of energy generated or enough power for approximately 10,000 homes for one year;

- 9,051 tonnes of carbon equivalents destroyed or the equivalent of removing approximately 2600 cars from the road for one year; and

- 1001 tonnes of residual waste requiring disposal in a landfill.

This presents a significant environmental improvement over the current landfill or compost practices. The current waste management practices for the waste outlined above generate:

- 72,903 GJ of energy or enough power for approximately 2,100 homes for one year;

- 56,843 tonnes of carbon equivalents generated or the equivalent of adding approximately 16,000 cars to the road for one year; and

- 50,819 tonnes of residual waste.

In order to divert the identified waste to anaerobic digestion, there are several significant barriers that must be overcome:

- The producers of large volumes of high quality (i.e. non-contaminated) organic waste identified in this report are currently paid for their organic waste. This leaves an unpredictable stream of organic waste that may contain a significant level of contamination, making anaerobic digestion more difficult;

- Many of the respondents surveyed indicated that they would be unwilling to pay a premium for anaerobic digestion, even given its ability to accept co-mingled organic waste; and

- The Yield Energy report suggested that the tipping fees for anaerobic digestion would range between $60 and $130 per tonne. Much of the waste identified in this report is disposed of for less than these tipping fees. Therefore there is a need to reduce the tipping fees in order to divert waste to anaerobic digestion.

While anaerobic digestion may present a significant theoretical opportunity to reduce the environmental impacts, there are significant practical challenges associated with the diversion of organic waste to anaerobic digestion. In addition to these practical challenges the inability to achieve a significant survey participation rate makes it extremely difficult to reliably predict the quantity and quality of waste generated in an area such as that representative of the PEBZ.

5.0 References

GTAA Partners in Project Green (2010). "Partners in Project Green - Resource Reutilization Team." Retrieved April 30, 2010, from http://www.partnersinprojectgreen.com/background/project-teams/resource-reutilization-team.

GTAA Partners in Project Green (2010). "Partners in Project Green - What is Partners in Project Green?". Retrieved April 30, 2010, from http://www.partnersinprojectgreen.com/background/what-is.

Yield Energy (2009). PEBZ Biogas Feasibility Study.

Appendix "A": Project Scope

UNIVERSITY OF
Waterloo

Assessing the Environmental Impact of Anaerobic Digestion for Organic Waste in the Project Green Study Area

Prepared by:
Murray Haight, PhD, RPP, MCIP
Aaron Stauch, BES

Prepared for:
Chris Rickett
Toronto and Region Conservation Authority

July 20, 2009

Background

GTAA Partners in Project Green (PPG) are in the process of establishing an eco-industrial park (EIP) in the area surrounding the Lester B. Pearson International Airport (LPIA). This area is currently used for various industrial purposes; these include several food processing businesses and retail food establishments. A chart outlining these establishments is presented in Appendix “A”.

The management of waste produced by the region is a major component of establishing the EIP. One option being examined by Yield Energy is establishing an anaerobic digester (AD) for the processing of organic food waste generated by businesses in the EIP. As part of this process Yield Energy has developed a business case for the use of AD. However, the environmental impacts have not been determined.

In support of the above undertaking, the following proposal seeks to establish a project with the Toronto and Area Region Conservation Authority (TRCA) to meet the following objectives:

1. Identify the quantity and quality of organic waste generated in the proposed EIP;
2. Determine the environmental impacts of diverting the above waste for processing using anaerobic digestion within the EIP;
3. Determine the economic impact of the diversion of organic waste and the associated energy generation;
4. Document project methodology and data, and provide recommendations in a report to the TRCA and PPG.

Methodology

In order to meet the objectives outlined above, the following must be undertaken:

1. Survey companies outlined in Appendix “A” regarding organic waste generation and size of operation (a draft survey is provided in Appendix “B”). Where possible use information already collected by Yield Energy to avoid contacting businesses repeatedly. Waste haulers in the area will also be surveyed regarding the approximate amount of waste they haul and to determine any complementary waste streams that could be brought in from the surrounding area.
2. Determine organic waste generation by industry type and size;
3. Develop an estimate of regional organic waste generation for the EIP;
4. Use the Integrated Waste Management Model (IWMM, http://www.iwm-model.uwaterloo.ca/) to determine the current environmental impacts of disposal for organic waste. Run a second scenario with the IWMM assuming that organic waste was processed using AD;
5. Determine the cost of disposal for organic waste using the current model. Ascertain the capital cost for AD, the cost of organic waste disposal with AD, and the value of energy generated with AD. Use these to evaluate the approximate re-

turn on investment for AD and determine the cost or benefit associated with the use of AD;
6. Provide a report to the TRAC and PPG regarding the findings of the study.

Timeline
The timeline of the project outlined above will greatly depend on the timely response by survey respondents. Assuming a reasonable response rate is reached by late Fall 2009, a completed report regarding results and recommendation could be provided to TRAC and PPG by April 2010.

Costs
In order to provide funding for this project TRCA and the University of Waterloo will explore funding opportunities with Yield Energy and funding agencies such as MITACS (http://www.mitacsaccelerate.ca). In this funding opportunity an industry partner (Yield Energy) contributes $7,500 and the funding agency matches this amount (this can be repeated for up to 3 four-month internships. This level of funding would cover: survey administration, mileage, and student funding.

Significance
This project will provide valuable information regarding the environmental and economic impacts of using anaerobic digestion in a municipal solid waste (MSW) situation and for use in greening projects such as EIPs. AD (in industrial settings) and regional waste assessments are underrepresented in the literature. As such this project provides an opportunity to provide needed justification for pursuing AD as a greening project (both environmentally and economically) and to establish PPG as a leader in the waste management-planning field.

Limitations
The project will not involve the independent assessment of waste generated by the companies outlined in Appendix “A”. Rather, it will rely on the information provided to develop a proof of concept for anaerobic digestion.

Appendix "A"

Company Name	NAICS Code	Company Name	NAICS Code
A D M Cocoa Canada Ltd.	3113	Dainty Foods Inc.	3112
A-One Cakes & Pastries Inc.	3118	DEALERS INGREDIENTS INC.	311940
A-One Catering	3118	Double Pastry	3118
Akuna Health Products Inc.	3119	Dr. Oetker Ltd.	3119
Arctic Glacier Inc.	3121	EMBASSY FLAVOURS LTD.	311940
Asian Flair Foods Inc.	3119	English Bay Batter (Toronto) Inc.	3112
BACARDI CANADA INC.	312140	EUROPEAN QUALITY MEATS & SAUSAGES	311614
Barilo's Fine Sausages Ltd.	3116	F O N A International Canada	3119
Benny Bully's	3111	FEATURE FOODS INC	311710
Bistro Alsace Gourmet Foods Inc.	3114	FERRARA CANDY CO. LTD.	311990
Bowsers Pet Products	3111	Ferrara Candy Co. Ltd.	3113
BRAMPTON POULTRY PRIDE LTD.	311615	Flavour Essence Product Inc.	3119
Brazilian Canadian Coffee Co. Ltd.	311920	Food Source	3119
Bread Works	3118	Freshway Products Inc.	3119
Breadko National Baking Ltd.	3118	Furlani's Food Corp.	3115
BREW-BY-U	312120	Gateau Swiss	3118
Burnbrae Farms	3119	Gateaux Galore Inc.	3118
CAN RELY INC	311990	Gay Lea Foods Co-operative Ltd.	3115
Can-Pan Candy Inc.	3113	GIRAFFE FOOD & BEVERAGE	311930
CANADA BREAD BRAMPTON DISTRUBUTION	311814	Givaudan Canada Co.	3119
Canada Supply Inc.	3121	Griffin, Harold T. Inc.	3117
Cardinal Meat Specialists Limited	3116	Hans Dairy Inc.	311511
Carefree Coffee Co. Inc.	3121	Hansco Distributors Inc.	3112
Central Canada Foods Corp.	3116	HOSTESS FRITO LAY	311919
CEYLON TEA COMPANY LTD.	311920	HUBBERTS INDUSTRIES	311225
CHELSEA (A DIVISION OF 1247078 ONTARIO INC.)	311710	Imperial Flavours Inc.	3115
China Brand Food Products Inc	311940	INNOVATIVE FOOD BRANDS	311410
COBS BREAD	311811	Innovative Foods Corporation	3112
COCA-COLA BOTTLING COMPANY LTD.	312110	Italian Home Bakery Limited	311814
Cott Beverages Canada Inc.	3121	ITALPASTA LTD.	311823
CREATE A TREAT LTD./ ALAR FOODS	311990	ITALPASTA LTD.	311823
Croissant Tree, The	3118	JAKO FISH INC.	311710
D' ANGELO BRANDS LTD.	311615	Janes Family Foods	3114
D'Angelo Brands Ltd.	3119	K D Canners Inc.	3114

Company Name	NAICS Code	Company Name	NAICS Code
Kasseler Food Products Inc.	3119	Power Packaging Co.	3121
KERRY CANADA	311930	PRIVATE RECIPES LTD.	311990
KUTCO INTERNATIONAL INC.	311615	Produce Counter, The	3114
Laura Secord	3113	Puddy Brothers Ltd.	3116
Linda Foods	3119	Puratos Canada Inc.	3118
M L G Enterprises	3119	Puretap Water Distillers Ltd.	3121
Maple Leaf Consumer Foods	3116	Rang Foods Inc.	3118
Maple Leaf Meats Ltd.	3116	Red Club	3119
MAPLE LEAF POULTRY COMPANY	311615	ROTHMANS BENSON & HEDGES INC.	312210
MAPLEHURST BAKERIES INC.	311811	S J T Canada Inc.	3113
Master Delight Inc.	3113	Savoury Snack Products Inc.	3119
Matheson Sweets & Catering Ltd.	3119	SKILCOR FOOD PRODUCTS INC	311615
MATTHEW MCAVAN ENTERPRISES LTD.	311911	Skjodt-Barrett Foods	3119
MAYWAH FOODS INC.	311940	Smithville Meat Wholesalers Ltd.	3116
McCain Foods Canada	3114	SOFINA FOODS INC.	311614
McCormick Canada Inc.	3119	Sol Cuisine	3114
Meaty Meats Inc.	3116	SONS BAKERY	311811
MIMAC GLAZE LTD.	311822	Starr Culinary Delights Inc.	3118
Minute Maid Company of Canada	3114	SUN PAC FOODS LTD.	311420
Mississauga Sweets & Catering Ltd.	3119	SUN RICH FRESH FOODS INC.	311420
NAFTA FOODS & PACKAGING	311340	SUN VALLEY FOODS	311410
NATURE'S WAY BAKERY	311821	Super-Pufft Snacks Corp.	3113
Niagara Smoked Fish Ltd.	3117	Supreme Pierogies Inc.	3114
OCEANFRESH PACKERS INC.	311710	SWEET PALACE	311811
OLDE YORK POTATO CHIPS	311919	T W I Foods Inc.	3118
Olive It & More	3119	THE WINE & BEER FACTORY	312120
OLYMEL L.P.	311615	TORBRAM JHAT KA MEATS	311615
Only Halal Inc.	3116	TREAT SHOPPE	311340
Orange Crate Inc.	3119	Triple A Cheese Co. Ltd.	3115
ORGANIC OVEN (A DIVISION OF 1518418 ONTARIO LIMITED)	311990	Trophy Foods Inc.	3119
PARMALAT CANADA	312110	UNILEVER CANADA	312110
Parmalat Canada	3115	UWG-UNITED WE GROW	311990
Pasta Corner Inc.	3118	Vidhya Foods Inc.	3119
Pasta International	3118	Vincor International Inc.	3121
PENINSULA CAKE HOUSE	311811	VINTNER'S CELLAR	312130
POPULAR PIZZA	311990	Wray & Nephew Canada Ltd.	3121
POTATOLAND COMPANY	311420		

Summary of NAICS Codes

3111	Animal Food Manufacturing
3112	Flour / Rice / Corn Milling
3113	Sugar Cane / Beet Sugar / Coco Processing
3114	Frozen Fruit / Veg Manufacturing, Fruit/Veg Canning
3115	Dairy Manufacturing
3116	Meat Slaughtering / Rendering / Processing
3117	Seafood Canning / Processing
3118	Bakeries / Frozen Pastries Manufacturing / Pasta
3119	Nuts, Peanut Butter, Coffee, Tea, Flavoring Syrup, Mayonnaise Dressing, Spice, Extract, Perishable Prepared Food
3121	Soft Drink, Bottled Water, Breweries, Wineries, Distilleries
3122	Tobacco Products

Appendix "B" – Sample Survey Questions

Company Name:
Contact Name and Information:

Describe, in general terms, the type of business you operate.

How much organic waste, and of what type, do you generate per year? Please provide as much detail about the types and quantity of waste as possible.

What are your current disposal practices for organic waste?

(a) What is the frequency of trash collection?

(b) What type of bin/dumpster is currently be used for disposal?

(c) Is waste disposed of in a plastic bag or directly into the bin?

(d) If waste is not source segregated, what is the destination of waste?

(e) Would there be enough physical space to double the number of trash bins/dumpster you are currently utilizing?

Would you be interested in participating in anaerobic digestion (link to a description of the project) if it were prove to be environmentally and economically effective?

Would you be interested in participating in an AD co-op?

What are your current disposal costs for organic waste?

Do you currently use any green energy sources?

What do you currently pay for energy?

Is there seasonal variability in your organic waste generation?

What support would be required to reduce barriers to an organics separation program in your company?

Assessing the Environmental Impact of Anaerobic Digestion for Organic Waste in the Project Green Study Area

Project Update
February 22, 2010

The following presents an amendment to the proposal entitled *"Assessing the Environmental Impact of Anaerobic Digestion for Organic Waste in the Project Green Study Area (July 20. 2009)".*

Work Completed to Date:
Work towards the scope presented in the original proposal began in November of 2009. The following summarizes work completed to date:

- Phone calls to organic waste producers in the Pearson Eco-Business Zone were originally made in November 2009;
- Follow-up phone calls were made in December 2009 and January 2010 (each business was contacted three times, or until a negative or positive response was achieved);
- Approximately 150 businesses were contacted through this process;
- The majority of the phone calls resulted in voice messages (with contact information) being left for the potential participant;
- 25 potential participants provided contact information and agreed to potentially participate in the survey;
- Of these, five have completed a survey; and
- A follow-up email has been sent to those of the 25 that have not yet completed a survey, and an additional follow-up email will be sent this week.

Proposed Change:
Give the low survey response rate, it is suggested that the report take a case study approach to the data. The following case studies would be used to show the environmental impact of organic waste diverted through anaerobic digestion:

- The organic waste data presented in Yield Energy's report;
- Data provided through the surveys received;
- A waste hauler case study provided through a survey of Waste Management (draft survey attached);
- A high quality organic waste case study provided through a survey of Weston Bakeries (draft survey attached); and
- A case study of co-mingled and/or contaminated organic waste provided by a company to be identified (possibilities include Loblaws).

The data collected through each case study would still be processed through the Integrated Waste Management Model. Further, contextual data will be added to the surveys to provide more depth to the analysis.

Rationale:
This change is necessary to provide the desired product. The low survey response rate has not allowed for meaningful data to be collected.

Implications:
The most significant implication of this change is an inability to conduct statistical analysis on the data, as a representative sample will not be achieved. However, the new approach will still be able to provide insight into the environmental impact of organic waste diversion in the study area.

Appendix "B": University of Waterloo Survey Contacts

Akuna Health Products Inc.
A-One Catering
BRAMPTON POULTRY PRIDE LTD.
Brazilian Canadian Coffee Co. Ltd.
Breadko National Baking Ltd.
Burnbrae Farms
Can-Pan Candy Inc.
CANADA BREAD BRAMPTON DISTRUBUTION DEPOT
Cardinal Meat Specialists Limited
Central Canada Foods Corp.
China Brand Food Products Inc
COCA-COLA BOTTLING COMPANY LTD.
Cott Beverages Canada Inc.
Double Pastry
Dr. Oetker Ltd.
EMBASSY FLAVOURS LTD.
EUROPEAN QUALITY MEATS & SAUSAGES
F O N A International Canada
Food Source
HOSTESS FRITO LAY
Gateau Swiss
GIRAFFE FOOD & BEVERAGE
Givaudan Canada Co.
Hans Dairy Inc.
Hansco Distributors Inc.
HUBBERTS INDUSTRIES
INNOVATIVE FOOD BRANDS
Innovative Foods Corporation
Italian Home Bakery Limited
JAKO FISH INC.
Janes Family Foods
Kasseler Food Products Inc.
K D Canners Inc.
KUTCO INTERNATIONAL INC.
Linda Foods
UNILEVER CANADA
Maple Leaf Meats Ltd.
MAPLE LEAF POULTRY COMPANY
MAPLEHURST BAKERIES INC.
Master Delight Inc.
Freshway Products Inc.
McCormick Canada Inc.
MIMAC GLAZE LTD.
Mississauga Sweets & Catering Ltd.
NAFTA FOODS & PACKAGING
OLDE YORK POTATO CHIPS

Olive It & More
OLYMEL L.P.
PARMALAT CANADA
Pasta International
Power Packaging Co.
PRIVATE RECIPES LTD.
Puddy Brothers Ltd.
Puretap Water Distillers Ltd.
Savoury Snack Products Inc.
Maple Leaf Consumer Foods
Skjodt-Barrett Foods
Sol Cuisine
Triple A Cheese Co. Ltd.
Trophy Foods Inc.
Vincor International Inc.
SONS BAKERY
SUN RICH FRESH FOODS INC.
D' ANGELO BRANDS LTD.
MATTHEW MCAVAN ENTERPRISES LTD.
VINTNER'S CELLAR
FERRARA CANDY CO. LTD.
OCEANFRESH PACKERS INC.
PENINSULA CAKE HOUSE
ROTHMANS BENSON & HEDGES INC.
ORGANIC OVEN (A DIVISION OF 1518418 ONTARIO LIMITED)
KERRY CANADA
ITALPASTA LTD.
SUN VALLEY FOODS
BREW-BY-U
POTATOLAND COMPANY
BACARDI CANADA INC.
THE WINE & BEER FACTORY
TORBRAM JHAT KA MEATS
CAN RELY INC
CHELSEA (A DIVISION OF 1247078 ONTARIO INC.)
SUN PAC FOODS LTD.
CEYLON TEA COMPANY LTD.
TREAT SHOPPE
D'Angelo Brands Ltd.
English Bay Batter (Toronto) Inc.
Furlani's Food Corp.
Gay Lea Foods Co-operative Ltd.
Imperial Flavours Inc.
McCain Foods Canada
Minute Maid Company of Canada
Parmalat Canada
Produce Counter, The
Starr Culinary Delights Inc.

Super-Pufft Snacks Corp.
ITALPASTA LTD.
Red Club
SOFINA FOODS INC.
COBS BREAD
CREATE A TREAT LTD./ ALAR FOODS
DEALERS INGREDIENTS INC.
FEATURE FOODS INC
MAYWAH FOODS INC.
NATURE'S WAY BAKERY
POPULAR PIZZA
SKILCOR FOOD PRODUCTS INC
SWEET PALACE
UWG-UNITED WE GROW
Bowsers Pet Products
Supreme Pierogies Inc.
Benny Bully's
Rang Foods Inc.
Orange Crate Inc.
Griffin, Harold T. Inc.
Vidhya Foods Inc.
A-One Cakes & Pastries Inc.
Carefree Coffee Co. Inc.
M L G Enterprises
A D M Cocoa Canada Ltd.
Croissant Tree, The
Niagara Smoked Fish Ltd.
Pasta Corner Inc.
Wray & Nephew Canada Ltd.
Bistro Alsace Gourmet Foods Inc.
Meaty Meats Inc.
Puratos Canada Inc.
Dainty Foods Inc.
Smithville Meat Wholesalers Ltd.
S J T Canada Inc.
Matheson Sweets & Catering Ltd.
Only Halal Inc.
Laura Secord
Flavour Essence Product Inc.
Ferrara Candy Co. Ltd.
Barilo's Fine Sausages Ltd.
Canada Supply Inc.
Bread Works
T W I Foods Inc.
Asian Flair Foods Inc.
Gateaux Galore Inc.
Arctic Glacier Inc.

Appendix “C”: University of Waterloo Survey Materials

Material Used for Online Surveys

Introduction Letter

Dear Participant,
You are invited to participate in a research study conducted by Aaron Stauch, under the supervision of Murray Haight, School of Planning at the University of Waterloo.

The objectives of the research study are to determine the types and quantities of organic waste generated by industries/manufacturers located within the Pearson Eco-Business Zone and to determine the environmental impacts of using this organic waste in anaerobic digestion for energy generation. The study is being completed for fulfillment of a Master in Environmental of Studies and is being funded in cooperation with the Toronto and Region Conservation Authority (TRCA), Yield Energy, and MITACS Accelerate Canada.

Partners in Project Green is a growing community of businesses working together to green their bottom line by creating an internationally-recognized 'eco-business zone' around Toronto Pearson. Through new forms of business-to-business collaboration, Partners in Project Green delivers programming that helps businesses reduce energy and resource costs, uncover new business opportunities, and address everyday operational challenges in a green and cost-effective manner.

If you wish to participate or receive more information regarding the study, please visit our website at www.uw-ad.ca. If you prefer not to submit your data through the online interface, please contact one of the researchers so that we can arrange for you to participate using an alternative method such as through an email, a paper-based questionnaire or if you prefer through a telephone survey.

It is important for you to know that any information that you provide will be confidential. The website is programmed to collect only your responses and does not collect any information, including machine identifiers that could potentially identify you. The researchers are also willing to enter into non-disclosure agreements regarding any information provided.

Should you have any questions about the study, please contact either Aaron Stauch (amstauch@uwaterloo.ca) or Murray Haight (mehaight@uwaterloo.ca). Further, if you would like to receive a copy of the results of this study, please contact either investigator.

Thank you for participating in this important study.

Online Survey Questions

Section 1 – General Company Information

1. What is your company name and contact information?
2. Describe, in general terms, the type of business you operate?
3. What North American Industry Classification System code best describes your business?
4. Describe the size of your business?

Section 2 – Description of Waste Generation & Collection

1. How much organic waste, and of what type, does your company generate per year? (the categories provided are intended for waste generated through business processes, such as a slaughter house would have significant amounts of meat waste)
2. What are your current disposal costs for organic waste (per tonne)?
3. When is most of your organic waste generated?
4. Is your organic waste source segregated?
5. What is the frequency of your organic waste collection?
6. How far is your organic waste shipped for disposal?
7. What type of bins/dumpsters are currently used for organic waste disposal?
8. How does your company internally dispose of organic waste?
9. What is the destination of your organic waste?
10. Would there be enough physical space to double the number of trash bins/dumpster you are currently utilizing?

Section 3 – Adoption of an Organics Re-utilization Program

1. Would you be willing to pay a premium for organic waste disposal that re-utilizes the waste for energy generation?
2. What premium would your company be willing to pay?
3. What support would be required to reduce barriers to an organics separation program in your company?

Material Used for High Quality Organic Waste Producer

Dear [redacted]

You are invited to participate in a research study conducted by Aaron Stauch under the supervision of Murray Haight, in the School of Planning at the University of Waterloo. The objectives of this research study are to determine the types and quantities of organic waste generated by industries and manufacturers located within the Pearson Eco-Business Zone, and to determine the environmental impacts of using this organic waste in anaerobic digestion for energy generation. The study is being completed for fulfillment of a Master's degree in Environmental Studies and is being funded in cooperation with the Toronto and Region Conservation Authority (TRCA), Yield Energy, and MITACS Accelerate Canada.

Partners in Project Green is a growing community of businesses working together to green their bottom line by creating an internationally-recognized 'eco-business zone' around Toronto-Pearson. Through new forms of business-to-business collaboration, Partners in Project Green delivers programming that helps businesses reduce energy and resource costs, uncover new business opportunities, and address everyday operational challenges in a green and cost-effective manner.

If you decide to volunteer, you will be asked to complete a 20-minute interview (questions attached). You may decline to respond to any questions that you do not wish to answer and you can withdraw your participation at any time. There are no known or anticipated risks from participating in this study.

It is important for you to know that any information that you provide will be confidential. The researchers are also willing to enter into non-disclosure agreements regarding any information provided.

The data collected from this study will be maintained on a password-protected computer database in a restricted access area of the university. As well, the data will be electronically archived after completion of the study, maintained for two years, and then erased.

Should you have any questions about the study, please contact either Aaron Stauch (amstauch@uwaterloo.ca) or Murray Haight (mehaight@uwaterloo.ca). Further, if you would like to receive a copy of the results of this study, please contact either investigator.

I would like to assure you that this study has been reviewed by and received ethics clearance through the Office of Research Ethics at the University of Waterloo. However, the final decision about participation is yours. If you have any comments or concerns regarding your participation in this study, please feel free to contact Dr.

Susan Sykes, Director, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or by email at ssykes@uwaterloo.ca.

Thank you for considering participation in this study,

1. Please describe the size (ie revenue, square footage, employees, amount of product generated) and nature of the [redacted] operation in the Pearson Eco-Business Zone.

2. What quantities and types of organic waste does [redacted] generate within the Pearson Eco-Business Zone?

3a. Are any of [redacted] organic wastes used as a revenue stream (i.e. sold for animal feed or other secondary uses)?

b. How much revenue is earned through the waste discussed in question 3a?

c. How is this waste transported to the secondary user? How far is it shipped? Does [redacted] or the secondary user pay for the shipping costs?

4. Is there variability in the market for the secondary use of [redacted] organic waste? Is there ever a time when Weston has trouble selling its organic waste? If so, what is done during these periods?

5. Has [redacted] noticed any seasonality in its organic waste generation? When do you generate the most waste? When do you generate the less? How much is generated during these periods?

6a. Does [redacted] generate any organic waste that is not marketed as a secondary product? If so, how much do you generate?
b. How does [redacted] dispose of the organic waste discussed in 6.a.?
c. What are [redacted] disposal costs for the waste discussed in 6.a.?
d. Does [redacted] source segregate the wastes discussed in 6.a.?
e. What is the frequency of waste collection for the wastes discussed in 6.a.?
f. How far is the organic waste shipped for the disposal of 6.a.?
g. Would it be possible to dispose of the waste discussed in 6.a. through a local anaerobic digestion facility? If not, what are the barriers to this?

7. Do you have other contacts in the area that could provide me information regarding their company's waste?

Material Used for Low Quality Organic Waste Producer

Good afternoon [redacted],

I am a graduate student in the School of Planning at the University of Waterloo. I am currently completing research regarding organic waste generation and diversion in Ontario. I recently met with [redacted] and he suggested that I contact you regarding [redacted] organic waste management practices.

The objectives of this research study are to determine the types and quantities of organic waste generated by companies located within and around the Pearson Eco-Business Zone, and to determine the environmental impacts of using this organic waste in anaerobic digestion for energy generation. The study is being completed for fulfillment of a Master's degree in Environmental Studies and is being funded in cooperation with the Toronto and Region Conservation Authority (TRCA), Yield Energy, and MITACS Accelerate Canada. If you decide to volunteer, you will be asked to complete a 20-minute interview (questions attached). You may decline to respond to any questions that you do not wish to answer and you can withdraw your participation at any time. There are no known or anticipated risks from participating in this study. It is important for you to know that any information that you provide will be confidential. The researchers are also willing to enter into non-disclosure agreements regarding any information provided.

The following are questions I am looking to answer:

1. Please describe the size (i.e. revenue, square footage, employees, amount of product generated) and nature of the [redacted] operation in and around the Pearson Eco-Business Zone.

2. What quantities and types of organic waste does [redacted] generate within and around the Pearson Eco-Business Zone?

3a. Are any of [redacted] organic wastes used as a revenue stream (i.e. sold for animal feed or other secondary uses)?

b. How much revenue is earned through the waste discussed in question 3a?

c. How is this waste transported to the secondary user? How far is it shipped? Does [redacted] or the secondary user pay for the shipping costs?

4. Is there variability in the market for the secondary use of [redacted] organic waste? Is there ever a time when [redacted] has trouble selling its organic waste? If so, what is done during these periods?

5. Has [redacted] noticed any seasonality in its organic waste generation? When do you generate the most waste? When do you generate the least? How much is generated during these periods?

6a. Does [redacted] generate any organic waste that is not marketed as a secondary product? If so, how much do you generate?

b. How does [redacted] dispose of the organic waste discussed in 6.a.?

c. What are [redacted] disposal costs for the waste discussed in 6.a.?

d. Does [redacted] source segregate the wastes discussed in 6.a.?

e. What types and quantities of contamination are present in the waste identified in 6.a.?

f. What is the frequency of waste collection for the wastes discussed in 6.a.?

g. How far is the organic waste shipped for the disposal of 6.a.?

h. Would it be possible to dispose of the waste discussed in 6.a. through a local anaerobic digestion facility? If not, what are the barriers to this?

Thank you for taking time to consider this request. I look forward to discussing my research with you.

Aaron

Appendix "D": PEBZ Biogas Feasibility Study

YIELD
renewable energy producers

Exhibit #6 – PEBZ Waste Survey – Companies and Institutions

	YIELD Companies & Institutions	Organic Waste Characterization	Pre-Processing Requirements	Qty/ year in Tonnes	Current Destination	Current Fees (Net/Net)	Premium for Co-mingled Organics	Barriers to Expand
1	Credit Valley Hospital	In-patient meal & Kitchen waste	Separation & Pasteurization	80	Composting	$9/65 gal tote = $166/tonne	Yes, expand program & save of de-packaging labour	Increased labour costs,Need commitment from Food Vendors, Odour/cleanliness, storage
2	York University	Packaged & Non-packaged Cafeteria food	Separation & Pasteurization	300	Composting	$6/tote= $100/tonne	Possibly	Cost
3	Gaylea Foods	Waste Milk solids	None	516	Animal Feed	$95/tonne	No	None
4	Molson	Spent grain & yeast	Extrusion	51,000	Sold for Animal feed	Paid ~$10/tonne	No	None
5	Nestle	FOGs - ORMI, Batter Waste & Dry Chocolate/ biscuit - U-Pak	De-Water - FOGS	FOGS - 118 Solid - 790	FOGS - Farm AD, Solids - Pig Food	FOGS - $380/tonne , Solids - $50/tonne	No	Currently in discussions with a biogas company, need to show cost savings
6	Sick Kids Hospital	In-patient meal & Kitchen waste	Separation & Pasteurization	23	Composting	$14/ tote = $185/tonne	No	Cost & Resources
7	Woodbine Race Track	Non-packaged Food Waste	Separation & Pasteurization	313	Composting	$223/tonne	Yes, but overall costs should go down	Cost & labour savings
8	International Centre	Kitchen Food Waste, Public food waste not separated	Separation & Pasteurization	8	Composting	$14/tote - $185/tonne	No	Education & marketing to increase public awareness for separation
9	Cara Foods	Restaurant	Separation & Pasteurization	~50 /location 500 total	Compost /Landfill	$60/tonne	No	Don't believe it is cost effective to collect
10	Maple Leaf	Slaughterhouse		11,000	Rendering	~$40/tonne	No	None
11	GTAA	Restaurant	Separation & Pasteurization	540	Composting	$67/tonne	No	Labour and cost
13	Costco	Grocery Food waste	Separation & Pasteurization	300 /Store - 5 stores	Compost/ Landfill	$12- $13.50/95 gal. Tote	No	Storage Space in coolers/freezers w/o bugs, rodents
14	Walmart	Grocery Food waste	Separation & Pasteurization	300-500 /store - 20 stores in GTA	U-Pak & Turtle Island - Landfill	~$65/tonne	No	Few cost comparable environmental alternatives
15	McDonald's	Restaurant	Separation & Pasteurization	One - 95 gal* tote /day = 32.4 tonnes/ year	BFI /Composting	$100/mos - ~$5/tote	No	Need customer to separate
16	Embassy Flavours	Food Processor	Clean	12 tonnes	Landfill	$1000/tonne	Yes	Lack of Service
17	Bacardi Rum	Distillers Grain	Clean	NA	3rd Party for alcohol recovery	Just pay shipping	NA	Time & People
		Sub-Total		~75,000	tonnes per year			
	* 90 gal tote=90kgs							

PEBZ Biogas Feasibility Study Page 39 of 43

YIELD
renewable energy producers

Exhibit #7 – PEBZ Waste Survey – ICI Waste Haulers

	YIELD	Organic Waste Characterization	Pre-Processing Requirements	Qty/ year in Tonnes	Current Destination	Current Fees (Net/Net)	Premium for Co-mingled Organics	Barriers to Expand	Current Hauler
1	**Turtle Island Recycling**	Mixed organics	Separation & Pasteurization	30,000	Compost/ NewMarket AD	$45/tonne	Yes, if they could charge more	Cost effective separation of organics from non-organics,	Self
2	**Waste Co**	Grocery, Restaurants, Food Processors	Separation & Pasteurization	5,200	N/A	N/A	N/A	N/A	Self
3	**MegaCity Waste**	Grocery, Restaurants, Food Processors	Separation & Pasteurization	10,000	N/A	N/A	N/A	N/A	Self
4	**Metro Waste**	Food Processors	Extrusion	8,000	N/A	N/A	N/A	N/A	Self
5	**Mamone Waste**	Food Processors	Extrusions	4,000	N/A	N/A	N/A	N/A	Self
6	**U-Pak Disposal**	Grocery, Restaurants, Food Processors	Separation & Pasteurization	35,000	Composter	N/A	N/A	N/A	Self
7	**ORMI**	FOGS	Filter / De-watered	30,000	Farm Based Ads	N/A	N/A	Not enough end-point	Self
8	**Waste Management**								
9	**York Disposal**	Grocery, Restaurants, Food Processors	Separation & Pasteurization	5,200	N/A	N/A	N/A	N/A	Self
		Total		**127,400**	**tonnes per year**				

PEBZ Biogas Feasibility Study Page 40 of 43

Appendix “E”: University of Waterloo Survey Results

ID	NAICS	Description	Employees	Square Feet	Annual Revenue	Product Generated	Organic Waste Generated	Tonnes / Year	Peak Seasons	Disposal Costs Per Tonne	SSO	Frequency of Collection	Distance for Disposal	Type of Bin/Dumpster	Organic waste disposed	Destination	Space to Double	Would you pay a premium	What premium	What support would help
S1	3111	Manufacturing and packing dog and cat treats	5	2000	$2,000,000	--	Meat & seafood	5-10,	No Peak Season	$0-$25	Yes	Monthly	0-5km	None	Directly into the bin	--	No	No	0%	NR
S2	3118	Wholesale bakery for food services	34	40,000	--	--	Baked good, liquid effluent from cleaning equipment	100-500, 10-50	No Peak Season	>$175	Yes	Bi-Weekly	10-50Km	Solid waste is shipped in compactor dumpster, liquid is carried by bulk tanker	Directly into the bin	Animal feed and water treatment facility	No	No	NR	NR
S3	3118	Bakery	300	130,000	$50,000,000	--	Baked good	1000-5000,	No Peak Season	$0-$25	Yes	Weekly	0-5km	10 Ton Units	Directly into the bin	Agri feed industry	No	No	0%	None
S4	--	Dry spice blending for the meat, poultry, and snack seasoning industry	45	55,000	--	5.6 Million KG	--	--	NR	NA	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
S5	3115	Dairy manufacturing	20	22,000	$10,000,00	2 Million KG	Dairy	0-5,	No Peak Season	$75-$100	Yes	Weekly	10-50km	NR	Directly into the bin	Landfill	No	No	0%	NR
S6	3117	Bottlers of pickled fish products, manufacture horseradish and other sauces	40	30,000		--	Meat & seafood	10-50,	Winter 30-40%, Spring 20-30%, Summer 10-20%, Fall 30-40%	$125-$150	No	Weekly	NR	NR	Directly into the bin	Rederer	Yes	No	NR	NR

Appendix “F”: Integrated Waste Management Model Outputs

Table G-1: Complete IWMM Results for Yield Energy Report

	Composting			AD			Landfill			Total WM System			Net Life Cycle Inventory		
	Baseline	*AD1*	*AD2*	*Baseline*	*AD1*	*AD2*	*Baseline*	*AD1*	*AD2*	*Baseline*	*AD1*	*AD2*	*Baseline*	*AD1*	*AD2*
Tonnes Managed (***)	3296	0	0	118	9426	72732	6012	0	0	9426	9426	72732			
Energy Consumed (GJ)	535	0	0	-254	-20262	-156347	-2849	0	0	-2568	-20262	-156347	-2568	-20262	-156347
Greenhouse Gases															
CO2 (tonnes)	18	0	0	0	0	0	-84	0	0	-66	0	0	-66	0	0
CH4 + Nox(tonnes)	0.12	0.00	0.00	-0.05	-4.36	-33.68	349.05	0.00	0.00	349.12	-4.36	-33.68	349.12	-4.36	-33.68
CO2 Equivalents (tonnes)	35	0	0	-7	-529	-4082	7468	0	0	7496	-529	-4082	7496	-529	-4082
Acid Gases															
Nox (tonnes)	0.049	0.000	0.000	-0.021	-1.697	-13.095	0.768	0.000	0.000	0.796	-1.697	-13.095	0.796	-1.697	-13.095
Sox (tonnes)	0.063	0.000	0.000	-0.027	-2.178	-16.809	-0.296	0.000	0.000	-0.261	-2.178	-16.809	-0.261	-2.178	-16.809
HCI (tonnes)	0.004	0.000	0.000	-0.002	-0.137	-1.061	-0.003	0.000	0.000	-0.001	-0.137	-1.061	-0.001	-0.137	-1.061
Smog Precursors															
Nox (tonnes)	0.049	0.000	0.000	-0.021	-1.697	-13.095	0.768	0.000	0.000	0.796	-1.697	-13.095	0.796	-1.697	-13.095
PM (tonnes)	0.579	0.000	0.000	-0.012	-0.940	-7.256	1.669	0.000	0.000	2.236	-0.940	-7.256	2.236	-0.940	-7.256
VOCs (tonnes)	0.083	0.000	0.000	0.000	-0.004	-0.030	0.543	0.000	0.000	0.626	-0.004	-0.030	0.626	-0.004	-0.030
Heavy Metals & Organics															
Air															
Pb (kg)	0.003	0.000	0.000	-0.001	-0.113	-0.868	-0.014	0.000	0.000	-0.013	-0.113	-0.868	-0.013	-0.113	-0.868
Hg (kg)	0.001	0.000	0.000	0.000	-0.021	-0.165	-0.003	0.000	0.000	-0.003	-0.021	-0.165	-0.003	-0.021	-0.165
Cd (kg)	0.000	0.000	0.000	0.000	-0.003	-0.027	0.001	0.000	0.000	0.001	-0.003	-0.027	0.001	-0.003	-0.027
Dioxins (TEQ)(g)	0.000	0.000	0.000	0.000	0.001	0.009	0.000	0.000	0.000	0.000	0.001	0.009	0.000	0.001	0.009
Water															
Pb (kg)	0.092	0.000	0.000	-0.040	-3.227	-24.898	-0.458	0.000	0.000	-0.406	-3.227	-24.898	-0.406	-3.227	-24.898
Hg (kg)	0.000	0.000	0.000	0.000	0.000	-0.003	0.000	0.000	0.000	0.000	0.000	-0.003	0.000	0.000	-0.003
Cd (kg)	0.001	0.000	0.000	0.000	-0.023	-0.177	-0.004	0.000	0.000	-0.004	-0.023	-0.177	-0.004	-0.023	-0.177
BOD (kg)	0.004	0.000	0.000	0.037	2.949	22.755	-0.014	0.000	0.000	0.027	2.949	22.755	0.027	2.949	22.755
Dioxins (TEQ) (g)	n/a	n/a	n/a	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Residual Waste (Tonnes	165	0	0	1	59	451	6012	0	0	6178	59	451	6178	59	451

*** Tonnes Managed may not display exactly as entered due to rounding errors (+/- 17 tonnes); The "Baseline" scenario provides the environmental impact of the current waste management system, excluding waste that is reused; AD1 assumes that all waste outlined in the base-line scenario is diverted to anaerobic digestion; AD2 assumes that all waste (include waste that is currently reused) is sent to anaerobic digestion; GJ = gigajoule; CO2 = Carbon Dioxide; CH4 = methane; NOx = Nitrous oxide; SOx = Sulfur Oxide; HCI = Hydrogen Chloride; PM = Particulate Material; VOC = Volatile Organic Compounds; Pb = Lead; Hg = Mercury; Cd = Cadmium; DOB = Biochemical Oxygen Demand; kg = Kilograms; g = Grams; TEQ = ????; Bold Numbers represent the list impact on the environment

Table G-2: Complete IWMM Results for University of Waterloo Survey

	Composting			AD			Landfill			Total WM System			Net Life Cycle Inventory		
	Baseline	*AD1*	*AD2*	*Baseline*	*AD1*	*AD2*	*Baseline*	*AD1*	*AD2*	*Baseline*	*AD1*	*AD2*	*Baseline*	*AD1*	*AD2*
Tonnes Managed (***)	0	0	0	0	40	3370	40	0	0	40	40	3370			
Energy Consumed (GJ)	0	0	0	0	-86	-7244	-19	0	0	-19	-86	-7244	-19	-86	-7244
Greenhouse Gases															
CO2 (tonnes)	0	0	0	0	0	0	-1	0	0	-1	0	0	-1	0	0
CH4 + Nox(tonnes)	0.00	0.00	0.00	0.00	-0.02	-1.56	2.32	0.00	0.00	2.32	-0.02	-1.56	2.32	-0.02	-1.56
CO2 Equivalents (tonnes)	0	0	0	0	-2	-189	50	0	0	50	-2	-189	50	-2	-189
Acid Gases															
Nox (tonnes)	0.000	0.000	0.000	0.000	-0.007	-0.607	0.005	0.000	0.000	0.005	-0.007	-0.607	0.005	-0.007	-0.607
Sox (tonnes)	0.000	0.000	0.000	0.000	-0.009	-0.779	-0.002	0.000	0.000	-0.002	-0.009	-0.779	-0.002	-0.009	-0.779
HCl (tonnes)	0.000	0.000	0.000	0.000	-0.001	-0.049	0.000	0.000	0.000	0.000	-0.001	-0.049	0.000	-0.001	-0.049
Smog Precursors															
Nox (tonnes)	0.000	0.000	0.000	0.000	-0.007	-0.607	0.005	0.000	0.000	0.005	-0.007	-0.607	0.005	-0.007	-0.607
PM (tonnes)	0.000	0.000	0.000	0.000	-0.004	-0.336	0.011	0.000	0.000	0.011	-0.004	-0.336	0.011	-0.004	-0.336
VOCs (tonnes)	0.000	0.000	0.000	0.000	0.000	-0.001	0.004	0.000	0.000	0.004	0.000	-0.001	0.004	0.000	-0.001
Heavy Metals & Organics															
Air															
Pb (kg)	0.000	0.000	0.000	0.000	0.000	-0.040	0.000	0.000	0.000	0.000	0.000	-0.040	0.000	0.000	-0.040
Hg (kg)	0.000	0.000	0.000	0.000	0.000	-0.008	0.000	0.000	0.000	0.000	0.000	-0.008	0.000	0.000	-0.008
Cd (kg)	0.000	0.000	0.000	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	-0.001	0.000	0.000	-0.001
Dioxins (TEQ)(g)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Water															
Pb (kg)	0.000	0.000	0.000	0.000	-0.014	-1.154	-0.003	0.000	0.000	-0.003	-0.014	-1.154	-0.003	-0.014	-1.154
Hg (kg)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cd (kg)	0.000	0.000	0.000	0.000	0.000	-0.008	0.000	0.000	0.000	0.000	0.000	-0.008	0.000	0.000	-0.008
BOD (kg)	0.000	0.000	0.000	0.000	0.013	1.054	0.000	0.000	0.000	0.000	0.013	1.054	0.000	0.013	1.054
Dioxins (TEQ) (g)	n/a	n/a	n/a	n/a	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Residual Waste (Tonnes	0	0	0	0	0	21	40	0	0	40	0	21	40	0	21

*** Tonnes Managed may not display exactly as entered due to rounding errors (+/- 17 tonnes); The "Baseline" scenario provides the environmental impact of the current waste management system, excluding waste that is reused; AD1 assumes that all waste outlined in the baseline scenario is diverted to anaerobic digestion; AD2 assumes that all waste (include waste that is currently reused) is sent to anaerobic digestion; GJ = gigajoule; CO2 = Carbon Dioxide; CH4 = methane; NOx = Nitrous oxide; SOx = Sulfur Oxide; HCl = Hydrogen Chloride; PM = Particulate Material; VOC = Volatile Organic Compounds; Pb = Lead; Hg = Mercury; Cd = Cadmium; DOB = Biochemical Oxygen Demand; kg = Kilograms; g = Grams; TEQ = ????; Bold Numbers represent the list impact on the environment

Table G-3: Complete IWMM Results for Waste Haulers

	Composting		AD		Landfill		Total WM System		Net LCI	
	Baseline	*AD1*	*Baseline*	*AD1*	*Baseline*	*AD1*	*Baseline*	*AD1*	*Baseline*	*AD1*
Tonnes Managed (***)	65000	0	30000	127400	32400	0	127400	127400		
Energy Consumed (GJ)	10543	0	-64489	-273862	-15292	0	-69238	-273862	-69238	-273862
Greenhouse Gases										
CO2 (tonnes)	351	0	0	0	-447	0	-96	0	-96	0
CH4 + Nox(tonnes)	2.46	0.00	-13.89	-58.99	1881.11	0.00	1869.68	-58.99	1869.68	-58.99
CO2 Equivalents (tonnes)	682	0	-1684	-7151	40258	0	39256	-7151	39256	-7151
Acid Gases										
Nox (tonnes)	0.966	0.000	-5.401	-22.937	4.160	0.000	-0.275	-22.937	-0.275	-22.937
Sox (tonnes)	1.238	0.000	-6.933	-29.443	-1.586	0.000	-7.281	-29.443	-7.281	-29.443
HCI (tonnes)	0.087	0.000	-0.437	-1.858	-0.017	0.000	-0.368	-1.858	-0.368	-1.858
Smog Precursors										
Nox (tonnes)	0.966	0.000	-5.401	-22.937	4.160	0.000	-0.275	-22.937	-0.275	-22.937
PM (tonnes)	11.413	0.000	-2.993	-12.710	9.638	0.000	18.058	-12.710	18.058	-12.710
VOCs (tonnes)	1.633	0.000	-0.013	-0.053	2.933	0.000	4.554	-0.053	4.554	-0.053
Heavy Metals & Organics										
Air										
Pb (kg)	0.063	0.000	-0.358	-1.521	-0.078	0.000	-0.373	-1.521	-0.373	-1.521
Hg (kg)	0.012	0.000	-0.068	-0.288	-0.016	0.000	-0.072	-0.288	-0.072	-0.288
Cd (kg)	0.002	0.000	-0.011	-0.047	0.005	0.000	-0.004	-0.047	-0.004	-0.047
Dioxins (TEQ)(g)	0.000	0.000	0.004	0.015	0.001	0.000	0.005	0.015	0.005	0.015
Water										
Pb (kg)	1.816	0.000	-10.270	-43.612	-2.459	0.000	-10.913	-43.612	-10.913	-43.612
Hg (kg)	0.001	0.000	-0.001	-0.006	-0.001	0.000	-0.001	-0.006	-0.001	-0.006
Cd (kg)	0.017	0.000	-0.073	-0.310	-0.022	0.000	-0.079	-0.310	-0.079	-0.310
BOD (kg)	0.079	0.000	9.386	39.859	-0.073	0.000	9.392	39.859	9.392	39.859
Dioxins (TEQ) (g)	n/a	n/a	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Residual Waste (Tonnes	3250	0	186	791	32400	0	35836	791	35836	791

*** Tonnes Managed may not display exactly as entered due to rounding errors (+/- 17 tonnes); The "Baseline" scenario provides the environmental impact of the current waste management system, excluding waste that is reused; AD1 assumes that all waste outlined in the baseline scenario is diverted to anaerobic digestion; AD2 assumes that all waste (include waste that is currently reused) is sent to anaerobic digestion; GJ = gigajoule; CO2 = Carbon Dioxide; CH4 = methane; NOx = Nitrous oxide; SOx = Sulfur Oxide; HCI = Hydrogen Chloride; PM = Particulate Material; VOC = Volatile Organic Compounds; Pb = Lead; Hg = Mercury; Cd = Cadmium; DOB = Biochemical Oxygen Demand; kg = Kilograms; g = Grams; TEQ = ????; Bold Numbers represent the list impact on the environment

Table G-4: Complete IWMM Results for Bakery Operation

	Composting			AD			Landfill			Total WM System			Net Life Cycle Inventory		
	Baseline	*AD1*	*AD2*	*Baseline*	*AD1*	*AD2*	*Baseline*	*AD1*	*AD2*	*Baseline*	*AD1*	*AD2*	*Baseline*	*AD1*	*AD2*
Tonnes Managed (***)	0	0	0	0	9	893	9	0	0	9	9	893			
Energy Consumed (GJ)	0	0	0	0	-19	-1919	-4	0	0	-4	-19	-1919	-4	-19	-1919
Greenhouse Gases															
CO2 (tonnes)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4 + Nox(tonnes)	0.00	0.00	0.00	0.00	0.00	-0.41	0.51	0.00	0.00	0.51	0.00	-0.41	0.51	0.00	-0.41
CO2 Equivalents (tonnes)	0	0	0	0	0	-50	11	0	0	11	0	-50	11	0	-50
Acid Gases															
Nox (tonnes)	0.000	0.000	0.000	0.000	-0.002	-0.161	0.001	0.000	0.000	0.001	-0.002	-0.161	0.001	-0.002	-0.161
Sox (tonnes)	0.000	0.000	0.000	0.000	-0.002	-0.206	0.000	0.000	0.000	0.000	-0.002	-0.206	0.000	-0.002	-0.206
HCl (tonnes)	0.000	0.000	0.000	0.000	0.000	-0.013	0.000	0.000	0.000	0.000	0.000	-0.013	0.000	0.000	-0.013
Smog Precursors															
Nox (tonnes)	0.000	0.000	0.000	0.000	-0.002	-0.161	0.001	0.000	0.000	0.001	-0.002	-0.161	0.001	-0.002	-0.161
PM (tonnes)	0.000	0.000	0.000	0.000	-0.001	-0.089	0.002	0.000	0.000	0.002	-0.001	-0.089	0.002	-0.001	-0.089
VOCs (tonnes)	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000
Heavy Metals & Organics															
Air															
Pb (kg)	0.000	0.000	0.000	0.000	0.000	-0.011	0.000	0.000	0.000	0.000	0.000	-0.011	0.000	0.000	-0.011
Hg (kg)	0.000	0.000	0.000	0.000	0.000	-0.002	0.000	0.000	0.000	0.000	0.000	-0.002	0.000	0.000	-0.002
Cd (kg)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Dioxins (TEQ)(g)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Water															
Pb (kg)	0.000	0.000	0.000	0.000	-0.003	-0.306	-0.001	0.000	0.000	-0.001	-0.003	-0.306	-0.001	-0.003	-0.306
Hg (kg)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cd (kg)	0.000	0.000	0.000	0.000	0.000	-0.002	0.000	0.000	0.000	0.000	0.000	-0.002	0.000	0.000	-0.002
BOD (kg)	0.000	0.000	0.000	0.000	0.003	0.279	0.000	0.000	0.000	0.000	0.003	0.279	0.000	0.003	0.279
Dioxins (TEQ) (g)	n/a	n/a	n/a	n/a	0.000	0.000	0.000	n/a	n/a	0.000	0.000	0.000	0.000	0.000	0.000
Residual Waste (Tonnes	0	0	0	0	0	6	9	0	0	9	0	6	9	0	6

*** Tonnes Managed may not display exactly as entered due to rounding errors (+/- 17 tonnes); The "Baseline" scenario provides the environmental impact of the current waste management system, excluding waste that is reused; AD1 assumes that all waste outlined in the base-line scenario is diverted to anaerobic digestion; AD2 assumes that all waste (include waste that is currently reused) is sent to anaerobic digestion; GJ = gigajoule; CO2 = Carbon Dioxide; CH4 = methane; NOx = Nitrous oxide; SOx = Sulfur Oxide; HCI = Hydrogen Chloride; PM = Particulate Material; VOC = Volatile Organic Compounds; Pb = Lead; Hg = Mercury; Cd = Cadmium; DOB = Biochemical Oxygen Demand; kg = Kilograms; g = Grams; TEQ = ????; Bold Numbers represent the list impact on the environment

Table G-5: Complete IWMM Results for Large Retail Grocer

	Composting			AD			Landfill			Total WM System			Net Life Cycle Inventory		
	Baseline	*AD1*	*AD2*	*Baseline*	*AD1*	*AD2*	*Baseline*	*AD1*	*AD2*	*Baseline*	*AD1*	*AD2*	*Baseline*	*AD1*	*AD2*
Tonnes Managed (***)	16457	0	0	0	24390	26119	7934	0	0	24391	24390	26119			
Energy Consumed (GJ)	2669	0	0	0	-52430	-56146	-3744	0	0	-1074	-52430	-56146	-1074	-52430	-56146
Greenhouse Gases															
CO2 (tonnes)	89	0	0	0	0	0	-109	0	0	-21	0	0	-21	0	0
CH4 + Nox(tonnes)	0.62	0.00	0.00	0.00	-11.29	-12.09	460.61	0.00	0.00	461.24	-11.29	-12.09	461.24	-11.29	-12.09
CO2 Equivalents (tonnes)	173	0	0	0	-1369	-1466	9858	0	0	10030	-1369	-1466	10030	-1369	-1466
Acid Gases															
Nox (tonnes)	0.245	0.000	0.000	0.000	-4.391	-4.703	1.019	0.000	0.000	1.264	-4.391	-4.703	1.264	-4.391	-4.703
Sox (tonnes)	0.313	0.000	0.000	0.000	-5.637	-6.036	-0.388	0.000	0.000	-0.075	-5.637	-6.036	-0.075	-5.637	-6.036
HCl (tonnes)	0.022	0.000	0.000	0.000	-0.356	-0.381	-0.004	0.000	0.000	0.018	-0.356	-0.381	0.018	-0.356	-0.381
Smog Precursors															
Nox (tonnes)	0.245	0.000	0.000	0.000	-4.391	-4.703	1.019	0.000	0.000	1.264	-4.391	-4.703	1.264	-4.391	-4.703
PM (tonnes)	2.890	0.000	0.000	0.000	-2.433	-2.606	2.367	0.000	0.000	5.257	-2.433	-2.606	5.257	-2.433	-2.606
VOCs (tonnes)	0.414	0.000	0.000	0.000	-0.010	-0.011	0.718	0.000	0.000	1.132	-0.010	-0.011	1.132	-0.010	-0.011
Heavy Metals & Organics															
Air															
Pb (kg)	0.016	0.000	0.000	0.000	-0.291	-0.312	-0.019	0.000	0.000	-0.003	-0.291	-0.312	-0.003	-0.291	-0.312
Hg (kg)	0.003	0.000	0.000	0.000	-0.055	-0.059	-0.004	0.000	0.000	-0.001	-0.055	-0.059	-0.001	-0.055	-0.059
Cd (kg)	0.000	0.000	0.000	0.000	-0.009	-0.010	0.001	0.000	0.000	0.002	-0.009	-0.010	0.002	-0.009	-0.010
Dioxins (TEQ)(g)	0.000	0.000	0.000	0.000	0.003	0.003	0.000	0.000	0.000	0.000	0.003	0.003	0.000	0.003	0.003
Water															
Pb (kg)	0.460	0.000	0.000	0.000	-8.349	-8.941	-0.602	0.000	0.000	-0.142	-8.349	-8.941	-0.142	-8.349	-8.941
Hg (kg)	0.000	0.000	0.000	0.000	-0.001	-0.001	0.000	0.000	0.000	0.000	-0.001	-0.001	0.000	-0.001	-0.001
Cd (kg)	0.004	0.000	0.000	0.000	-0.059	-0.064	-0.005	0.000	0.000	-0.001	-0.059	-0.064	-0.001	-0.059	-0.064
BOD (kg)	0.020	0.000	0.000	0.000	7.631	8.172	-0.018	0.000	0.000	0.002	7.631	8.172	0.002	7.631	8.172
Dioxins (TEQ) (g)	n/a	n/a	n/a	n/a	0.000	0.000	0.000	n/a	n/a	0.000	0.000	0.000	0.000	0.000	0.000
Residual Waste (Tonnes)	823	0	0	0	151	162	7934	0	0	8756	151	162	8756	151	162

*** Tonnes Managed may not display exactly as entered due to rounding errors (+/- 17 tonnes); The "Baseline" scenario provides the environmental impact of the current waste management system, excluding waste that is reused; AD1 assumes that all waste outlined in the baseline scenario is diverted to anaerobic digestion; AD2 assumes that all waste (include waste that is currently reused) is sent to anaerobic digestion; GJ = gigajoule; CO2 = Carbon Dioxide; CH4 = methane; NOx = Nitrous oxide; SOx = Sulfur Oxide; HCI = Hydrogen Chloride; PM = Particulate Material; VOC = Volatile Organic Compounds; Pb = Lead; Hg = Mercury; Cd = Cadmium; DOB = Biochemical Oxygen Demand; kg = Kilograms; g = Grams; TEQ = ????; Bold Numbers represent the list impact on the environment