4. Description of AD Facility Requirements:100,000 Tonne-per-Year Plant, Organics with up to 30% Unintentional Material; Wet, Mesophilic, Single-Stage Plant

4.1 Overview

This chapter presents a detailed outline of the proposed digestion plant to process 100,000 tonnes per year of organic material with up to 30% unintentional material. Chapters 5, 6 and 7 describe the proposed plants for each of the other three scenarios.

For planning purposes this waste stream is considered to be processed using the wet, mesophilic, single-stage AD technology, as developed in Chapter 2.

The proposed plant will be described in terms of the following:

- Description of Operations
- Plant Layout
- Process Flow and Mass Balance
- Cost Estimates

The Description of Operations text describes the proposed plant with sizing of key components.

The Plant Layout section shows a conceptual site plan, based on the 3.2 hectares of site space used as a screening criterion in Chapter 3.

The Process Flow and Mass Balance diagram shows the key process components and mass flows through the process. Due to the lack of operating data from North America, the mass balance is an estimate, based on the best available information from European technology vendors and current science.

Capital and O&M cost estimates are provided as the last section. These are also estimates based upon the best available information rather than documented costs from operating plants.

4.2 Description of Operations

The overall process flow consists of the following main components:

- Site Services (Entry Roads etc.)
- Waste Receiving;
- Front-End Processing, including Contaminant Removal and/or Waste Conditioning;

- Anaerobic Digestion Process;
- Separation of Solid and Liquid Products;
- Post-Digestion Curing of Digestate;
- Liquid Treatment;
- Biogas Handling; and
- Environmental Control

The basic elements of the plant are described below.

4.2.1 Site Services and Requirements

The facility will require basic services common to any waste management facility, including water and sewer, electrical grid connection, natural gas connections and access roads for entry to and exit from the plant. The locations of access roads are shown in the conceptual site plan. This layout is based on one-way, counter-clockwise truck traffic flow (best arrangement for large trucks) with road turning radii suitable for full size transfer trailers.

4.2.2 Waste Receiving

Similar to other waste management facilities, the anaerobic digestion plant would have an area for receiving solid waste. The waste reception system will include the following components:

Weigh Scale

Trucks would be weighed before and after unloading their cargo onto the tipping floor. The weigh scale would be sized and rated for the capacity expected from a full-length (16-17 m) transfer trailer carrying in excess of 30 tonnes.

Tipping Floor

The tipping floor must be enclosed inside the building, to minimize odour emissions from the waste being received. On the tipping floor, an operator will visually inspect the waste and remove large non-digestible items as well as other unacceptable items, such as household hazardous waste (HHW), before the waste is fed into the process. The tipping floor has been sized for two days storage, allowing for plant downtime and 4-day weeks. For the 100,000 tpy (400 tpd) plant capacity, daily variations in waste delivery truck quantities and capacities of 25% can be expected (i.e., +25% represents design case). Based on an on-floor material density for the 30% unintentional waste stream of approximately 250 –300 kg/m3 (275 kg/m3 average) and an average pile height of 4m, a total of 900 m^2 of tip floor storage is required. The tip floor has been set at twice this area (1800 m^2) to facilitate truck drive through and tipping, front-end-loader movement, rejects bin and main feed conveyor/bag breaker.

Liquid Waste Holding Tank

Liquid wastes from Industrial, Commercial and Institutional sources could comprise up to 25% of the waste input to the facility. Liquids would generally be brought in by vacuum trucks and would bypass the tipping floor. Liquid wastes would not need to go through the pre-processing system, and in most cases would be suitable for direct feed to the digesters (via the wet processing pulpers described below).

Holding capacity for incoming liquids would be required, which would consist of a tank that the wastes would be pumped into by the incoming tanker truck. Based on a daily waste input of 400 tonnes and a maximum liquid input of 25%, approximately 100 tonnes of liquid waste (or 100 m^3 at an estimated specific gravity of 1.0) could be expected daily. A 200 m^3 tank providing 2 days storage is proposed. This could be a concrete underground tank to conserve site space, however high water table concerns in the Portlands will likely dictate the need for an above-ground tank.

Pumping of liquids into the holding tank would be achieved using the pumps on the tanker trucks, but pumping capability will be required to convey liquids from the holding tank to the pulpers.

4.2.3 Front-End Pre-Processing

With the relatively high residue content of this waste stream and the presence of recyclable materials, significant front-end pre-processing will be required to both capture the recyclable materials and remove non-digestible contaminants so as to make the waste stream suitable for anaerobic digestion.

The front-end pre-processing system would be comparable to the front-end system installed at the City's Dufferin Transfer Station AD facility. For a 400 tpd facility, it is anticipated that a MRF having capacity of 15-20 tph (as is the case at the Dufferin facility) operating over 3 shifts would be required.

The key processing components of the MRF are described below.

Bag Breaker

Solid wastes would likely first pass through a bag breaker, a mechanical device that uses sharp edges to tear open plastic bags, releasing their contents. The need for a bag breaker will depend on the City's waste collection approach ultimately adopted and the ability of the downstream trommel screen to successfully open bags (the latter will be assessed at the City's Dufferin AD facility in the near future). Some of the plastic bags will stay on the bag breaker's knives, but the majority of plastic must be removed by a subsequent separation step (the trommel). The bag breaker would be installed on the main tip floor with waste fed directly to it using the front-end-loader.

Trommel Screen

A trommel screen is a large rotating drum containing openings of various sizes, normally installed at a slight decline to move material through the unit as it rotates. Trommel drums for waste screening are typically constructed of steel plate with holes drilled through the plate, while wire mesh style trommels are more typical for soil screening applications. Trommels for waste screening can be equipped with steel knives welded to the drum interior to assist in opening bags.

For this waste stream, a trommel with two opening sizes would be used to separate the material into "fines" (first opening size), "middles" (second opening size, set at larger than the first opening size) and "overs" (all remaining material). Anything that is smaller than the first opening size of the screen will fall through to a conveyor belt as fines. Objects larger than the first opening size will continue tumbling through the trommel and either fall through the next opening size as middles or be discharged off the end of the trommel as overs.

The opening size to separate fines would likely be from 40-50 mm. At this size, the fines will contain a high percentage of organic material suitable for digestion although grit and broken glass will also be present, which will be mostly removed in the pulper stage described below.

The opening size for the middles cut is typically 150-250 mm and is set to isolate the recyclable materials fraction (plastic containers, metal cans). This cut will subsequently be conveyed past manual picking and mechanical separation steps to capture the individual recyclable material streams.

Any remaining material in the trommel discharges off the end as the overs cut. This fraction typically contains paper, OCC, boxboard, textiles and plastic film, some of which is well suited for digestion. A subsequent picking station(s) is normally used on the overs conveyor to capture valuable materials or to remove materials that are unsuitable for the subsequent wet processing / digestion steps.

Ideally, the fines, middles and overs conveyors are recombined (after recyclable materials and unwanted materials are "negatively" sorted) so that all organics are directed to the digestion phase.

Picking Lines or Mechanical Removal of Glass and Plastic

The manual picking of waste is something that may eventually be phased out due to the health hazards of manual waste handling, but it remains the most effective method of recovering containers. Plastic containers such as PET and HDPE are the recyclable materials that are expected to be recovered by manual sorting of the middles stream. Only experience will demonstrate whether glass bottles can also be captured by this means. It is expected that a very high degree of glass breakage will have occurred by this point in the process, thus manual picking will not likely be practical. The downstream wet processing system must capture the majority of the broken glass.

If picking lines are not to be used because of human health issues, other mechanical means of sorting, such as flats-round separation, could be used for some recovery of containers. If picking lines are utilized, the picking stations would be housed within a controlled atmosphere enclosure.

Baler

Based on the anticipated recyclable materials quantity captured from this waste stream (see mass balance, Figure 4.2), a baler having capacity for some 35 bales per day will be required.

Magnetic Separation

The recovery of ferrous metals from the waste stream is achieved by means of a strong magnet suspended above the middles conveyor belt. Normally the conveyor containing the recombined fines, middles and overs streams is equipped with a magnetic head pulley to provide the plant with two-stage magnetic separation.

Eddy Current Separation

An eddy-current separator, located on the middles conveyor downstream of the magnetic separator, introduces eddy currents which cause a strong repelling force between the separator and aluminum. Aluminum is thus repelled off the middles conveyor to a storage bin while all other materials continue on to the recombining conveyor described above.

Wet Separation

The MRF components described above are all dry pre-processing steps that would be common to facilities employing either wet or dry AD technologies that are processing a high-residue waste stream. Wet separation, however, is unique to wet AD technologies as a pre-digestion step. Some dry technologies use a wet separation step after the material has been digested, which can reduce contaminants in the output product but does not protect digestion equipment and removes fewer contaminants than pre-digestion wet separation.

Different vendors supply different proprietary devices for wet separation. In general it involves mixing with water to produce a pumpable pulp, from which heavy non-digestibles (such as glass and grit) are removed by settling then flushing through a de-gritter and light non-digestibles (such as plastic film) are removed by raking off floatables from the pulp. The pulping device serves two other important functions, namely to defibre the material thus increasing its surface area and better preparing it for digestion and secondly, initiating the digestion process by using process water that already contains micro-organisms.

4.2.4 Anaerobic Digestion Process: Wet, Mesophilic, Single-stage

For the purposes of this report, a wet, mesophilic, single-stage anaerobic digestion process is assumed for the scenario of processing organics with up to 30% unintentional material. This is principally due to the inherent use of the wet separation step, which is effective at removing the high contaminant levels of plastic film as well as glass and grit.

The digester would be sized for approximately 15 days retention time. For the 100,000 tpy plant capacity, it is anticipated that three digesters, each of approximately 4500 m^3 capacity would be employed. The digesters would utilize a gas mixing system.

4.2.5 Solid-Liquid Separation

Following digestion, the digested solids would require dewatering before being sent to the final curing location. This dewatering would occur by means of screw presses and/or centrifuges. A polymer solution would be added prior to the presses to flocculate the solids and facilitate solids separation. Most of the water removed at this stage would be recycled to the pulping and wet separation stage of the front-end processing. The remainder would be wastewater, which may require some treatment for the reduction of nitrogen, phosphorus and suspended solids.

4.2.6 Post-Digestion Processing of Digestate

The dewatered solid digestate requires final aerobic curing, to ensure full stabilization and pathogen reduction, which occurs when the material self-heats to over 55^0 C. Due to the extensive space requirements involved in windrow composting, this step would be done offsite at another facility.

The digestate exiting from the pressing stage could be discharged directly into a waiting container (trailer, lugger or roll-off) or would require an intermediate storage area, from which it would be loaded onto trucks for hauling to the final composting site. For this waste stream, it is estimated that the digestate mass would be equal to approximately 49% of the mass of the total input to the plant, or 49,000 tonnes per year. This equates to a daily digestate output of approximately 200 tonnes or 100 tonnes per operating shift, based on a 2-shift hauling operation. It is proposed that a single transfer trailer bay be provided for the 100,000 tpy plant with two or three trailers having to be regularly shuttled each shift.

The material would be composted at a facility with the capacity for an input of 200 tonnes per day. The curing time required would be three to four weeks and possibly longer. Also, a bulking agent may be necessary to increase the pore space within the piles, absorb moisture, and add carbon to increase the C:N ratio. This could be chipped yard waste or another relatively inert organic material. It would be added to make up approximately 20% by mass of the composting material.

At a windrow height of 2.5 m and compost feedstock density of approximately 0.6 tonnes/m^3, with a curing time of 28 days it is estimated that approximately 1.3 ha would be required for curing of the digestate. Compost bulking and area requirement calculations can be found in Appendix A. It is noted that there are currently no operating facilities in the province with the capacity to process the required volume of material that would result from this plant.

4.2.7 Liquid Treatment

It is expected that the mass of liquid effluent generated at the plant which is not recycled and therefore needs to be treated and discharged could be equal to approximately 21% of the mass of the total input to the plant, or 21,000 tonnes per year. At a density of 1 tonne/m^3 and discharging six days a week, this equates to 67 m^3/ day of wastewater to be treated and sent to disposal.

The main parameters of concern would be suspended solids, nitrogen and phosphorus. A wastewater treatment process consisting of a clarifier and aeration tank could be installed if necessary. However, since the facility is in such close proximity to the Ashbridges Bay Treatment Plant, likely the effluent would be sent directly into the wastewater system without further treatment.

Table 4.1 presents a cost estimate for a wastewater treatment system for the reduction of nitrogen, phosphorus and suspended solids from a 100,000 tpy facility. The cost estimate is based on a wastewater maximum flow of 100 m^3 per day.

Table 4.1
Cost Estimate – Wastewater Treatment System

Capital Costs	**100,000 tpy facility**
Tankage (1 tank, 100 m2 @ $1500/m2)	150,000
Blower System	225,000
Aeration System	225,000
Alum System for P removal	100,000
Total Capital Cost:	**700,000**
Operating Costs	**100,000 tpy facility**
Chemical (Acetic Acid)	6,000
Chemical (Alum for P removal)	50,000
Power (50 kW @ 6c/kwh)	13,500
Maintenance (2% of Total Capital Investment)	14,000
Labour (1/2 time @ $50k/yr)	25,000
Waste Haulage (0.25 tonne/day registered waste @ $65/tonne)	6,000
Total Operating Cost per Year:	**114,500**

4.2.8 Biogas Collection & Refining

The biogas produced in the digester would be collected by piping and would need to be treated and pressurized for transport to the Boralex co-generation facility.

Biogas is produced from the digester at approximately 100% humidity. To reduce corrosion in piping and gas utilization equipment, moisture removal would be necessary. This would consist of a knockout device for condensate removal.

It may be necessary to remove hydrogen sulfide (H_2S) from the biogas. Sulfides would be removed by a chemical scrubber. The H_2S content of the gas out of the digester could be in the range of 200-2500 ppm.

The gas would come out of the digester at a pressure of less than 1 psi. A compressor would be used to compress the gas for digester mixing and pipeline delivery to the Boralex facility. The level of compression of the gas would be determined by the end use of the gas, as use in the Boralex co-gen unit requires a much higher pressure than use in the auxiliary boiler.

The transport and handling of biogas is described in Chapter 9.

4.2.9 Environmental Control Systems

The facility will include control measures for odour, noise and litter.

Odour would be addressed by a biofilter. All of the process buildings would be maintained under negative air pressure, and this air would be exhausted through a biofilter. In addition, certain equipment items containing high odour sources (for example; waste dissolver, bag breaker, trommel) would be directly vented to the odour control ducting network. The biofilter would be sized at approximately 75 m^3/hr per m^2 of biofilter surface area (at 200 mm pressure drop). This translates into a typical air change rate in the process buildings of about 3 air changes per hour, and also allows approximately 25% additional flow for direct venting of odorous equipment sources.

The biofilter would be equipped with a humidification system (both in the media bed and for the incoming air stream) and utilize a control system to monitor important operating parameters.

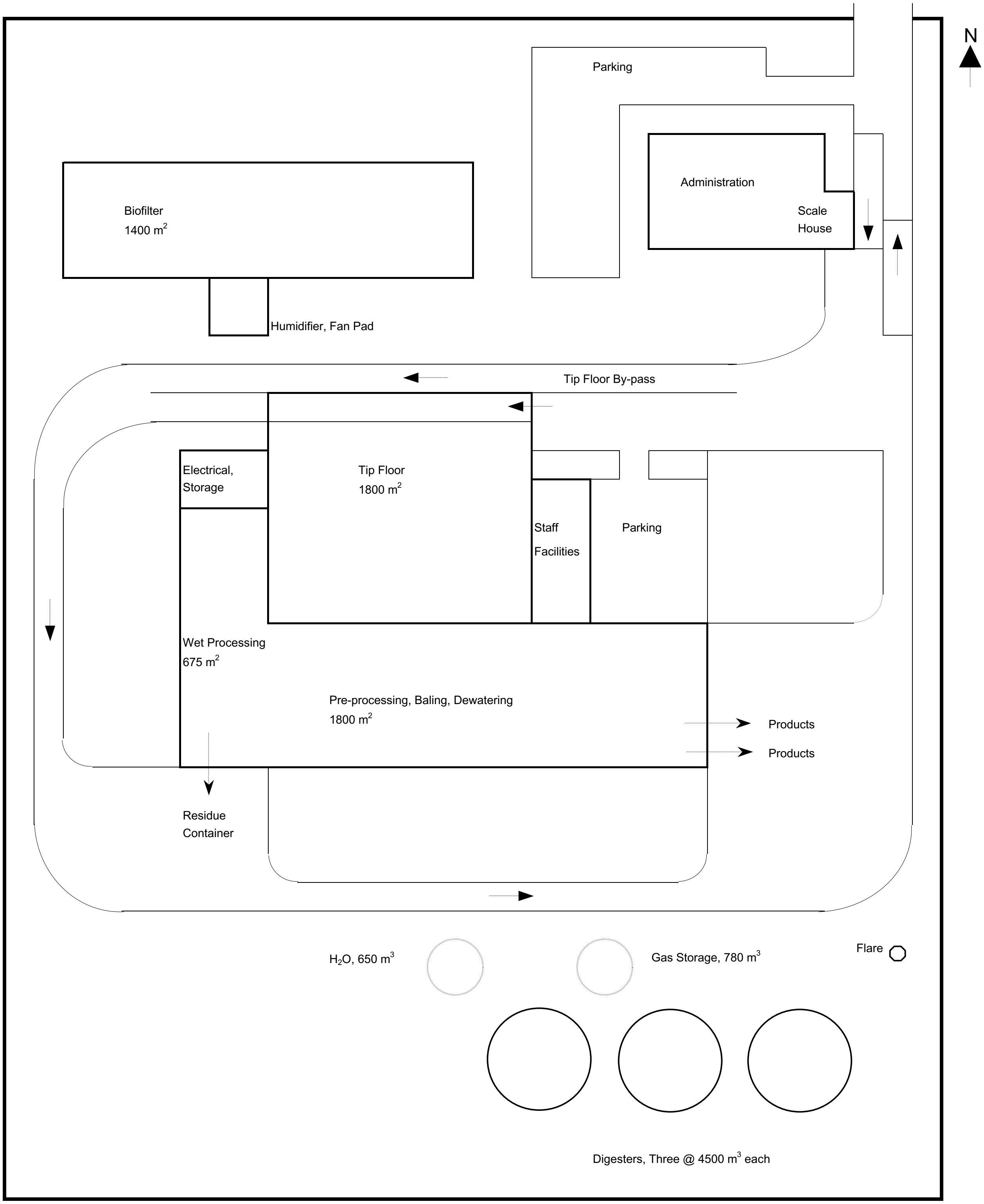
Noise control would primarily be achieved by ensuring process building doors are normally closed (which also addresses odour control) and utilizing enclosures for noisy equipment items if located outside (compressors for example). A drive-through tip floor, as proposed, with fast closing doors should mean that noise and odour escape is minimized. Berms and landscaping would also serve to mitigate noise to a certain extent.

The main areas with a potential for release of litter would be the tipping floor and the digestate loading area. Both of these would be enclosed inside the building. Fencing the site and conducting daily litter removal patrols would be typical of a facility of this nature.

4.3 Plant Layout

The layout of the plant is presented in Figure 4.1. This is a generalized layout for planning purposes, with some major components shown. The layout has been configured to readily allow for expansion to the 200,000 tpy capacity.

This site plan allows for expansion to a 200,000 tpy facility, which requires 3.2 hectares. If a smaller plant were developed and no expansion was planned for, then a correspondingly smaller site would be required.



100,000 TPY, Wet, Mesophilic, Single-Stage
(30% Unintentional Material)
Conceptual Site Plan - 3.2 Ha Site

Figure 4.1

Scale: 1:1000 (approx)

4.4 Process Flow and Mass Balance

Figure 4.2 shows the flow of materials through the process. The mass balance is approximate and can vary substantially with feedstock and technology, therefore the numbers given represent a range of about plus or minus 20%. Mass balance calculations on a total mass and dry solids basis are included in Appendix A.

It is estimated that 100,000 tonnes per year of source-separated organic waste with up to 30% unintentional material will yield approximately 8,960,000 m^3/yr of biogas, 49,000 tonnes/yr of digestate, and 21,000 m^3/yr of wastewater.

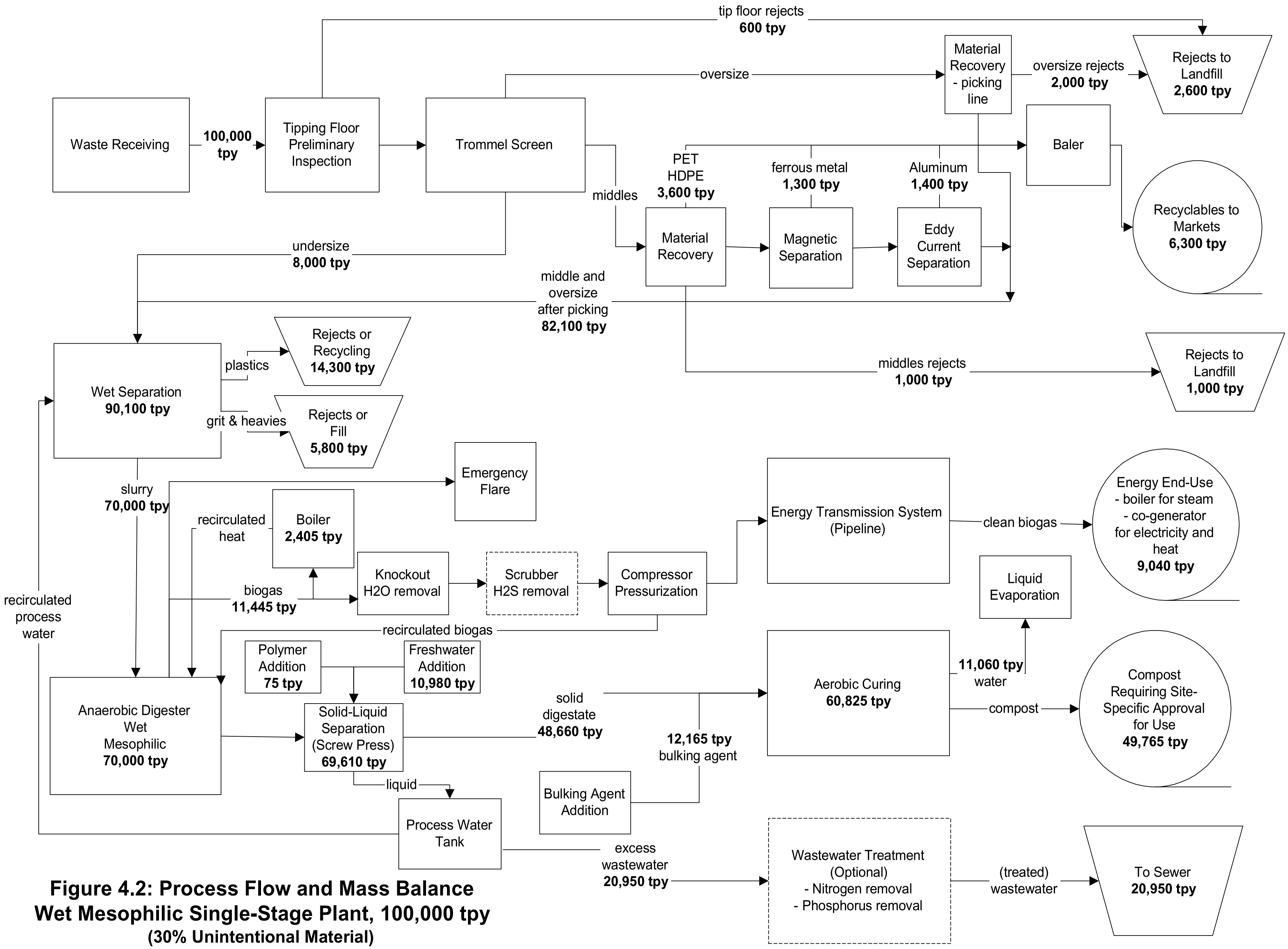


Figure 4.2: Process Flow and Mass Balance Wet Mesophilic Single-Stage Plant, 100,000 tpy
(30% Unintentional Material)

4.5 Cost Estimates

The capital and operating costs for a 100,000 tpy wet mesophilic plant are presented on the following pages. These are general estimates, scaled up from cost estimates for Toronto's pilot facility at the Dufferin transfer station, which is a wet, mesophilic plant.

It is estimated that a 100,000 tpy wet mesophilic plant would have a capital cost of approximately $36,385,000, and an operating cost of approximately $6,440,000 per year. This cost estimate does not include the costs of biogas utilization and transmission equipment, which are described in Chapter 9.

Table 4.2
Capital Cost Estimate - 100,000 tpy Wet, Mesophilic, Single-Stage
(30% Unintentional Material)

General Site Works		
Land costs		0
General (clearing, dewatering, signage, geotechnical investigations, etc.)		300,000
Roadways and parking lot paving (7,000 m2 x $40/m2)		280,000
Utility connections, lighting, buried piping (sewer, gas, water), existing utility relocations, etc.		400,000
	sub total:	**980,000**
Buildings		
Tip floor (1,800 m2 x $1,000/m2)		1,800,000
Pre-processing, Baling, Dewatering building (1,800 m2 x $1,200/m2)		2,160,000
Wet processing building (675 m2 x $1,200/m2)		810,000
Electrical, storage room building, staff facilities (400 m2 x $800/m2)		320,000
Administration area including laboratory, scale house (650 m2 x $1,000/m2)		650,000
Entry and exit scales (20 m scales in pit)		200,000
Miscellaneous (small structures, overhead truck doors, monorail hoist, sort platforms etc.)		400,000
	sub total:	**6,340,000**
Major Tankage		
Digesters (3 x 4,500 m3 glass lined steel)		5,460,000
Process water storage tank (650 m3)		250,000
Gas storage tank (780 m3)		275,000
Liquid (feedstock) storage tank (200 m3)		70,000
	sub total:	**6,055,000**
Pre-Processing Equipment (incl. electrical & instrumentation)		
Bag breaker, trommel screen		600,000
Conveyors, mag separator, eddy current separator		2,100,000
Baler and feed conveyor system		700,000
Miscellaneous (compactor, platforms, catwalks, hoppers, etc.)		500,000
	sub total:	**3,900,000**
Wet Processing Equipment (incl. electrical & instrumentation)		
Pulpers, tanks, degritters, conveyors, digester preheating, etc.		4,500,000
Screw presses (4)		3,300,000
Process piping, valves, pumps, small tanks		500,000
Miscellaneous (compressor, mixers, clarifier, platforms, catwalks, hoppers,etc.)		500,000
	sub total:	**8,800,000**
Odour Control		
Biofilter (concrete walls, media support, media, etc.)		300,000
Blowers, ducting, humidity control, other controls, etc.		200,000
	sub total:	**500,000**
Biogas Clean Up & Transmission System (See Table 6.4 for detailed estimate)		
		-
Miscellaneous		
Plumbing, fire protection, containers, inspections, etc.		250,000
	sub total:	**250,000**
	Total of above:	**26,825,000**
	Unforeseen and Estimating Allowance (20%):	5,370,000
	Engineering & Contract Administration (13%):	4,190,000
	Grand Total:	**36,385,000**

Table 4.3
Annual O&M Cost Estimate - 100,000 tpy Wet, Mesophilic, Single-Stage
(30% Unintentional Material)

Staff Requirements (based on 3 shift operation)		**$/yr**
1 Plant Manager (60k)		60,000
6 Process Control Operators (35 k)		210,000
2 Tip Floor Operators (30 k)		60,000
2 Maintenance Technicians (30 k)		60,000
2 Scale Operators (25 k)		50,000
1 Reception (25 k)		25,000
1 Marketing Mgr (35 k)		35,000
8 Sorters (21 k)		168,000
1 lab technician (30 k)		30,000
Sub total including 1.5 factor for O'head/benefits	sub total:	**1,047,000**
Utilities and Fuel (assumes no cogen unit on site)		
Fuel (2 vehicles x 10 l/hr x 20 hrs/d x 250 d/yr x $0.7/L)		70,000
Water (10,600 m3/yr x $1/m3)		10,600
Natural gas (not req'd, assumes biogas used to satisfy heat load)		0
Electricity (estimated 6.3 million kw.hr/yr)		378,000
	sub total:	**458,600**
Maintenance		
Pre-processing equipment (4% of capital)		156,000
Wet processing equipment (4% of capital)		352,000
Buildings & Site (0.5% of capital)		37,000
Tanks (0.5% of capital)		30,000
	sub total:	**575,000**
Other		
Property taxes		0
Rolling Equipment Lease		35,000
Flocculent (75 tpy x $3/kg)		225,000
Sewer Surcharges		20,000
Product hauling & tip fees to curing site, net compost revenues (approx. 49,000 tpy x $35/t)		1,715,000
Recyclable material revenues (approx. 6,300 tpy x $60/t)		(378,000)
Residue disposal (approx. 23,700 tpy @ $65/t)		1,540,500
Licensing Fees		50,000
Lab analysis costs		35,000
Service contracts		40,000
		3,282,500
	Total:	**5,360,000**
	Unforseen at 10%:	540,000
	Estimating Allowance at 10%:	540,000
	Grand Total (excludes land costs, property taxes):	**6,440,000**

5. Description of AD Facility Requirements: 200,000 Tonne-per-Year Plant, Organics with up to 30% Unintentional Material; Wet, Mesophilic, Single-Stage Plant

5.1 Overview

This chapter presents a detailed outline of the proposed digestion plant to process 200,000 tonnes per year of organic material with up to 30% unintentional material.

For planning purposes this waste stream is considered to be processed using the wet, mesophilic, single-stage AD technology, as developed in Chapter 2.

The proposed plant will be described in terms of the following:

- Description of Operations
- Plant Layout
- Process Flow and Mass Balance
- Cost Estimates

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The Plant Layout section shows a conceptual site plan, based on the 3.2 hectares of site space used as a screening criterion in Chapter 3.

The Process Flow and Mass Balance diagram shows the key process components and mass flows through the process. Due to the lack of operating data from North America, the mass balance is an estimate, based on the best available information from European technology vendors and current science.

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- Separation of Solid and Liquid Products;
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- Liquid Treatment;
- Biogas Handling; and
- Environmental Control

The basic elements of the plant are described below.

5.2.1 Site Services and Requirements

The facility will require basic services common to any waste management facility, including water and sewer, electrical grid connection, natural gas connections and access roads for entry to and exit from the plant. The locations of access roads are shown in the conceptual site plan. This layout is based on one-way, counter-clockwise truck traffic flow (best arrangement for large trucks) with road turning radii suitable for full size transfer trailers.

5.2.2 Waste Receiving

Similar to other waste management facilities, the anaerobic digestion plant would have an area for receiving solid waste. The waste reception system will include the following components:

Weigh Scale

Trucks would be weighed before and after unloading their cargo onto the tipping floor. The weigh scale would be sized and rated for the capacity expected from a full-length (16-17 m) transfer trailer carrying in excess of 30 tonnes.

Tipping Floor

The tipping floor must be enclosed inside the building, to minimize odour emissions from the waste being received. On the tipping floor, an operator will visually inspect the waste and remove large non-digestible items as well as other unacceptable items, such as household hazardous waste (HHW), before the waste is fed into the process. The tipping floor has been sized for two days storage, allowing for plant downtime and 4-day weeks. For the 200,000 tpy (800 tpd) plant capacity, daily variations in waste delivery truck quantities and capacities of 25% can be expected (i.e., +25% represents design case). Based on an on-floor material density for the 30% unintentional waste stream of approximately 250 –300 kg/m3 (275 kg/m3 average) and an average pile height of 4m, a total of 1800 m^2 of tip floor storage is required. An additional 1200 m^2 of floor space was added to facilitate truck drive through and tipping, front-end-loader movement, rejects bin and main feed conveyor/bag breaker, for a total of 3000 m^2.

Liquid Waste Holding Tank

Liquid wastes from Industrial, Commercial and Institutional sources could comprise up to 25% of the waste input to the facility. Liquids would generally be brought in by vacuum trucks and would bypass the tipping floor. Liquid wastes would not need to go through the pre-processing system, and in most cases would be suitable for direct feed to the digesters (via the wet processing pulpers described below).

Holding capacity for incoming liquids would be required, which would consist of a tank that the wastes would be pumped into by the incoming tanker truck. Based on a daily waste input of 800 tonnes and a maximum liquid input of 25%, approximately 200 tonnes of liquid waste (or 200 m^3 at an estimated specific gravity of 1.0) could be expected daily. A 400 m^3 tank providing 2 days storage is proposed. This could be a concrete underground tank to conserve site space, however high water table concerns in the Portlands will likely dictate the need for an above-ground tank.

Pumping of liquids into the holding tank would be achieved using the pumps on the tanker trucks, but pumping capability will be required to convey liquids from the holding tank to the pulpers.

5.2.3 Front-End Pre-Processing

With the relatively high residue content of this waste stream and the presence of recyclable materials, significant front-end pre-processing will be required to both capture the recyclable materials and remove non-digestible contaminants so as to make the waste stream suitable for anaerobic digestion.

The front-end pre-processing system would be comparable to the front-end system installed at the City's Dufferin Transfer Station AD facility. For an 800 tpd facility, it is anticipated that a MRF having capacity of 30-40 tph operating over 3 shifts would be required.

The key processing components of the MRF are described below.

Bag Breaker

Solid wastes would likely first pass through a bag breaker, a mechanical device that uses sharp edges to tear open plastic bags, releasing their contents. The need for a bag breaker will depend on the City's waste collection approach ultimately adopted and the ability of the downstream trommel screen to successfully open bags (the latter will be assessed at the City's Dufferin AD facility in the near future). Some of the plastic bags will stay on the bag breaker's knives, but the majority of plastic must be removed by a subsequent separation step (the trommel). The bag breaker would be installed on the main tip floor with waste fed directly to it using the front-end-loader.

Trommel Screen

A trommel screen is a large rotating drum containing openings of various sizes, normally installed at a slight decline to move material through the unit as it rotates. Trommel drums for waste screening are typically constructed of steel plate with holes drilled through the plate, while wire mesh style trommels are more typical for soil screening applications. Trommels for waste screening can be equipped with steel knives welded to the drum interior to assist in opening bags.

For this waste stream, a trommel with two opening sizes would be used to separate the material into "fines" (first opening size), "middles" (second opening size, set at larger than the first opening size) and "overs" (all remaining material). Anything that is smaller than the first opening size of the screen will fall through to a conveyor belt as fines. Objects larger than the first opening size will continue tumbling through the trommel and either fall through the next opening size as middles or be discharged off the end of the trommel as overs.

The opening size to separate fines would likely be from 40-50 mm. At this size, the fines will contain a high percentage of organic material suitable for digestion although grit and broken glass will also be present, which will be mostly removed in the pulper stage described below.

The opening size for the middles cut is typically 150-250 mm and is set to isolate the recyclable materials fraction (plastic containers, metal cans). This cut will subsequently be conveyed past manual picking and mechanical separation steps to capture the individual recyclable material streams.

Any remaining material in the trommel discharges off the end as the overs cut. This fraction typically contains paper, OCC, boxboard, textiles and plastic film, some of which is well suited for digestion. A subsequent picking station(s) is normally used on the overs conveyor to capture valuable materials or to remove materials that are unsuitable for the subsequent wet processing / digestion steps.

Ideally, the fines, middles and overs conveyors are recombined (after recyclable materials and unwanted materials are "negatively" sorted) so that all organics are directed to the digestion phase.

Picking Lines or Mechanical Removal of Glass and Plastic

The manual picking of waste is something that may eventually be phased out due to the health hazards of manual waste handling, but it remains the most effective method of recovering containers. Plastic containers such as PET and HDPE are the recyclable materials that are expected to be recovered by manual sorting of the middles stream. Only experience will demonstrate whether glass bottles can also be captured by this means. It is expected that a very high degree of glass breakage will have occurred by this point in the process, thus manual picking will not likely be practical. The downstream wet processing system must capture the majority of the broken glass.

If picking lines are not to be used because of human health issues, other mechanical means of sorting, such as flats-round separation, could be used for some recovery of containers. If picking lines are utilized, the picking stations would be housed within a controlled atmosphere enclosure.

Baler

Based on the anticipated recyclable materials quantity captured from this waste stream (see mass balance, Figure 5.2), two balers, each with a capacity for some 35 bales per day will be required.

Magnetic Separation

The recovery of ferrous metals from the waste stream is achieved by means of a strong magnet suspended above the middles conveyor belt. Normally the conveyor containing the recombined fines, middles and overs streams is equipped with a magnetic head pulley to provide the plant with two-stage magnetic separation.

Eddy Current Separation

An eddy-current separator, located on the middles conveyor downstream of the magnetic separator, introduces eddy currents which cause a strong repelling force between the separator and aluminum. Aluminum is thus repelled off the middles conveyor to a storage bin while all other materials continue on to the recombining conveyor described above.

Wet Separation

The MRF components described above are all dry pre-processing steps that would be common to facilities employing either wet or dry AD technologies that are processing a high-residue waste stream. Wet separation, however, is unique to wet AD technologies as a pre-digestion step. Some dry technologies use a wet separation step after the material has been digested, which can reduce contaminants in the output product but does not protect digestion equipment and removes fewer contaminants than pre-digestion wet separation.

Different vendors supply different proprietary devices for wet separation. In general it involves mixing with water to produce a pumpable pulp, from which heavy non-digestibles (such as glass and grit) are removed by settling then flushing through a de-gritter and light non-digestibles (such as plastic film) are removed by raking off floatables from the pulp. The pulping device serves two other important functions, namely to defibre the material thus increasing its surface area and better preparing it for digestion and secondly, initiating the digestion process by using process water that already contains micro-organisms.

5.2.4 Anaerobic Digestion Process: Wet, Mesophilic, Single-stage

For the purposes of this report, a wet, mesophilic, single-stage anaerobic digestion process is assumed for the scenario of processing organics with up to 30% unintentional material. This is principally due to the inherent use of the wet separation step, which is effective at removing the high contaminant levels of plastic film as well as glass and grit.

The digester would be sized for approximately 15 days retention time. For the 200,000 tpy plant capacity, it is anticipated that six digesters, each of approximately 4500 m^3 capacity would be employed. The digesters would utilize a gas mixing system.

5.2.5 Solid-Liquid Separation

Following digestion, the digested solids would require dewatering before being sent to the final curing location. This dewatering would occur by means of screw presses and/or centrifuges. A polymer solution would be added prior to the presses to flocculate the solids and facilitate solids separation. Most of the water removed at this stage would be recycled to the pulping and wet separation stage of the front-end processing. The remainder would be wastewater, which may require some treatment for the reduction of nitrogen, phosphorus and suspended solids. The number of screw presses would be twice that of the 100,000 tpy facility.

5.2.6 Post-Digestion Processing of Digestate

The dewatered solid digestate requires final aerobic curing, to ensure full stabilization and pathogen reduction, which occurs when the material self-heats to over 55^0 C. Due to the extensive space requirements involved in windrow composting, this curing step would be done offsite at another facility.

The digestate exiting from the pressing stage could be discharged directly into a waiting container (trailer, lugger or roll-off) or would require an intermediate storage area, from which it would be loaded onto trucks for hauling to the final composting site. For this waste stream, it is estimated that the digestate mass would be equal to approximately 49% of the mass of the total input to the plant, or 97,000 tonnes per year. This equates to a daily digestate output of approximately 400 tonnes or 200 tonnes per operating shift, based on a 2-shift hauling operation. It is proposed that a single transfer trailer bay be provided for the 200,000 tpy plant with four to six trailers having to be regularly shuttled each shift.

The material would be composted at a facility with the capacity for an input of 400 tonnes per day. The curing time required would be three to four weeks and possibly longer. Also, a bulking agent may be necessary to increase the pore space within the piles and absorb moisture. This could be chipped yard waste or sawdust, or another relatively inert organic material. It would be added to make up approximately 20% by mass of the composting material.

At a windrow height of 2.5 m and compost feedstock density of approximately 0.6 tonnes/m^3, with a curing time of 28 days it is estimated that approximately 2.6 ha would be required for curing of the digestate. Compost bulking and area requirement calculations can be found in Appendix A. It is noted that there are currently no operating facilities in the province with the capacity to process the required volume of material that would result from this plant.

5.2.7 Liquid Treatment

It is expected that the mass of liquid effluent generated at the plant which is not recycled and therefore needs to be treated and discharged could be equal to approximately 21% of the mass of the total input to the plant, or 42,000 tonnes per year. At a density of 1 tonne/m^3 and discharging six days a week, this equates to 135 m^3/ day of wastewater to be treated and sent to disposal.

The main parameters of concern would be suspended solids, nitrogen and phosphorus. A wastewater treatment process consisting of a clarifier and aeration tank could be installed if necessary. However, since the facility is in such close proximity to the Ashbridges Bay Treatment Plant, likely the effluent would be sent directly into the wastewater system without further treatment.

Table 5.1 presents a cost estimate for a wastewater treatment system for the reduction of nitrogen, phosphorus and suspended solids from a 200,000 tpy facility. The cost estimate is based on a wastewater maximum flow of 200 m^3 per day.

Table 5.1
Cost Estimate – Wastewater Treatment System

Capital Costs	**200,000 tpy facility**
Tankage (2 tanks, 100 m2 each @ $1500/m2)	300,000
Blower System	450,000
Aeration System	450,000
Alum System for P removal	200,000
Total Capital Cost:	**1,400,000**
Operating Costs	**200,000 tpy facility**
Chemical (Acetic Acid)	12,000
Chemical (Alum for P removal)	100,000
Power (50 kW @ 6c/kwh)	27,000
Maintenance (2% of Total Capital Investment)	28,000
Labour (1/2 time @ $50k/yr)	25,000
Waste Haulage (0.5 tonne/day registered waste @ $65/tonne)	12,000
Total Operating Cost per Year:	**204,000**

5.2.8 Biogas Collection & Refining

The biogas produced in the digester would be collected by piping and would need to be treated and pressurized for transport to the Boralex co-generation facility.

Biogas is produced from the digester at approximately 100% humidity. To reduce corrosion in piping and gas utilization equipment, moisture removal would be necessary. This would consist of a knockout device for condensate removal.

It may be necessary to remove hydrogen sulfide (H_2S) from the biogas. Sulfides would be removed by a chemical scrubber. The H_2S content of the gas out of the digester could be in the range of 200-2500 ppm.

The gas would come out of the digester at a pressure of less than 1 psi. A compressor would be used to compress the gas for digester mixing and pipeline delivery to the Boralex facility. The level of compression of the gas would be determined by the end use of the gas, as use in the Boralex co-gen unit requires a much higher pressure than use in the auxiliary boiler.

The transport and handling of biogas is described in Chapter 9.

5.2.9 Environmental Control Systems

The facility will include control measures for odour, noise and litter.

Odour would be addressed by a biofilter. All of the process buildings would be maintained under negative air pressure, and this air would be exhausted through a biofilter. In addition, certain equipment items containing high odour sources (for example: waste dissolver, bag breaker, trommel) would be directly vented to the odour control ducting network. The biofilter would be sized at approximately 75 m^3/hr per m^2 of biofilter surface area (at 200 mm pressure drop). This translates into a typical air change rate in the process buildings of about 3 air changes per hour, and also allows approximately 25% additional flow for direct venting of odorous equipment sources.

The biofilter would be equipped with a humidification system (both in the media bed and for the incoming air stream) and utilize a control system to monitor important operating parameters.

Noise control would primarily be achieved by ensuring process building doors are normally closed (which also addresses odour control) and utilizing enclosures for noisy equipment items if located outside (compressors for example). A drive-through tip floor, as proposed, with fast closing doors should mean that noise and odour escape is minimized. Berms and landscaping would also serve to mitigate noise to a certain extent.

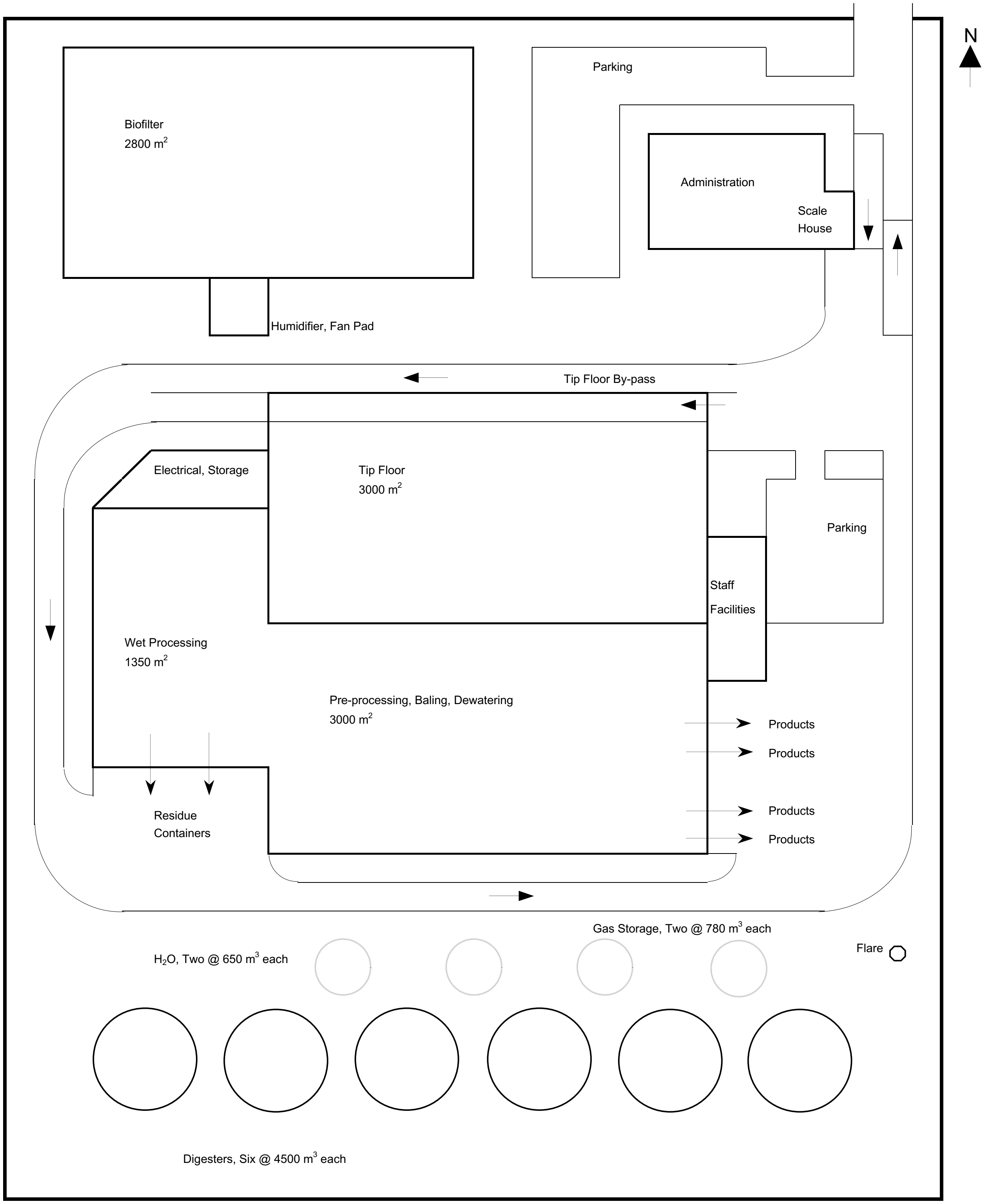
The main areas with a potential for release of litter would be the tipping floor and the digestate loading area. Both of these would be enclosed inside the building. Fencing the site and conducting daily litter removal patrols would be typical of a facility of this nature.

5.3 Plant Layout

The layout of the plant is presented in Figure 5.1. This is a generalized layout for planning purposes, with some major components shown.

The site plan is based on the 3.2 hectares of space required for a 200,000 tpy plant.

This plant would have all the same processing components as the 100,000 tpy wet mesophilic plant, sized for twice the throughput. The layout for the 100,000 tpy facility was designed such that all areas could be expanded to the 200,000 tpy facility size without moving any major structures, except for the staff building.



200,000 TPY, Wet, Mesophilic, Single-Stage
(30% Unintentional Material)
Conceptual Site Plan - 3.2 Ha Site

Figure 5.1

Scale: 1:1000 (approx)

5.4 Process Flow and Mass Balance

Figure 5.2 shows the flow of materials through the process. The mass balance is approximate and can vary substantially with feedstock and technology, therefore the numbers given represent a range of about plus or minus 20%. Mass balance calculations on a total mass and dry solids basis are included in Appendix A.

It is estimated that 100,000 tonnes per year of source-separated organic waste with up to 30% unintentional material will yield approximately 17,920,000 m^3/yr of biogas, 97,000 tonnes/yr of digestate, and 42,000 m^3/yr of wastewater.

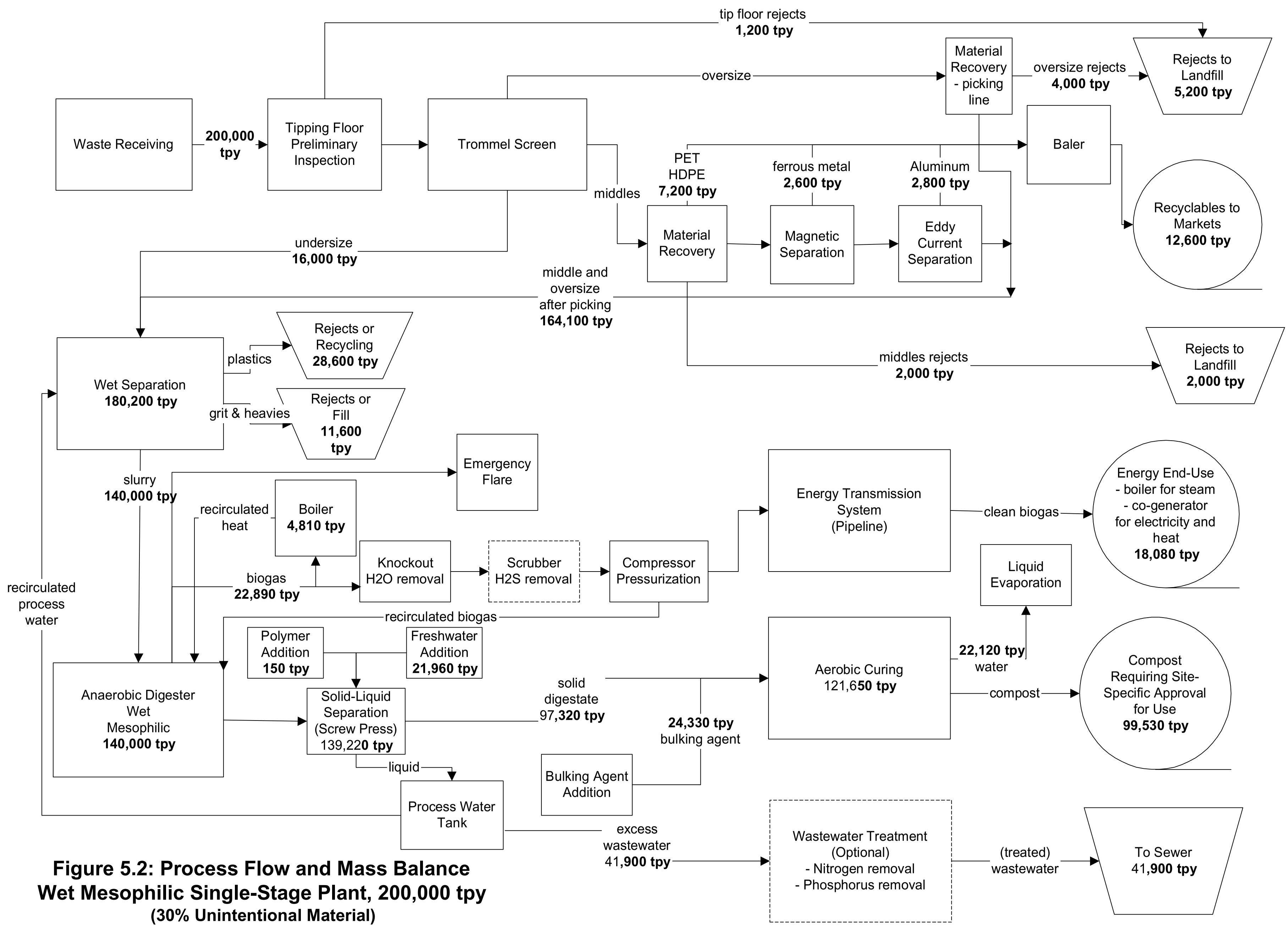


Figure 5.2: Process Flow and Mass Balance
Wet Mesophilic Single-Stage Plant, 200,000 tpy
(30% Unintentional Material)

5.5 Cost Estimates

The capital and operating costs for a 200,000 tpy wet mesophilic plant are presented on the following pages. These are general estimates, scaled up from cost estimates for Toronto's pilot facility at the Dufferin transfer station, which is a wet, mesophilic plant.

It is estimated that a 200,000 tpy wet mesophilic plant would have a capital cost of approximately $66,200,000, and an operating cost of approximately $11,500,000 per year. This cost estimate does not include the costs of biogas utilization and transmission equipment, which are described in Chapter 9.

Table 5.2
Capital Cost Estimate - 200,000 tpy Wet, Mesophilic, Single-Stage
(30% Unintentional Material)

General Site Works		
Land costs		0
General (clearing, dewatering, signage, geotechnical investigations, etc.)		300,000
Roadways and parking lot paving (7,000 m2 x $40/m2)		280,000
Utility connections, lighting, buried piping (sewer, gas, water), existing utility relocations, etc.		400,000
	sub total:	**980,000**
Buildings		
Tip floor (3,000 m2 x $1,000/m2)		3,000,000
Pre-processing, Baling, Dewatering building (3,000 m2 x $1,200/m2)		3,600,000
Wet processing building (1,350 m2 x $1,200/m2)		1,620,000
Electrical, storage room building, staff facilities (500 m2 x $800/m2)		400,000
Administration area including laboratory, scale house (650 m2 x $1,000/m2)		650,000
Entry and exit scales (20 m scales in pit)		200,000
Miscellaneous (small structures, overhead truck doors, monorail hoist, sort platforms etc.)		500,000
	sub total:	**9,970,000**
Major Tankage		
Digesters (6 x 4,500 m3 glass lined steel)		10,920,000
Process water storage tank (2 x 650 m3)		500,000
Gas storage tank (2 x 780 m3)		550,000
Liquid (feedstock) storage tank (400 m3)		100,000
	sub total:	**12,070,000**
Pre-Processing Equipment (incl. electrical & instrumentation)		
Bag breaker, trommel screen		1,200,000
Conveyors, mag separator, eddy current separator		4,200,000
Baler and feed conveyor system		1,000,000
Miscellaneous (compactor, platforms, catwalks, hoppers, etc.)		800,000
	sub total:	**7,200,000**
Wet Processing Equipment (incl. electrical & instrumentation)		
Pulpers, tanks, degritters, conveyors, digester preheating, etc.		9,000,000
Screw presses (8)		6,600,000
Process piping, valves, pumps, small tanks		800,000
Miscellaneous (compressor, mixers, clarifier, platforms, catwalks, hoppers,etc.)		800,000
	sub total:	**17,200,000**
Odour Control		
Biofilter (concrete walls, media support, media, etc.)		500,000
Blowers, ducting, humidity control, other controls, etc.		400,000
	sub total:	**900,000**
Biogas Clean Up & Transmission System (See Table 6.4 for detailed estimate)		
		-
Miscellaneous		
Plumbing, fire protection, containers, inspections, etc.		500,000
	sub total:	**500,000**
	Total of above:	**48,820,000**
	Unforeseen and Estimating Allowance (20%):	9,760,000
	Engineering & Contract Administration (13%):	7,620,000
	Grand Total:	**66,200,000**

Table 5.3
Annual O&M Cost Estimate - 200,000 tpy Wet, Mesophilic, Single-Stage
(30% Unintentional Material)

Staff Requirements (based on 3 shift operation)		**$/yr**
1 Plant Manager (60k)		60,000
6 Process Control Operators (35 k)		210,000
4 Tip Floor Operators (30 k)		120,000
2 Maintenance Technician (30 k)		60,000
2 Scale Operators (25 k)		50,000
1 Reception (25 k)		25,000
1 Marketting Mgr (35 k)		35,000
16 Sorters (21 k)		336,000
1 lab technician (30 k)		30,000
Sub total including 1.5 factor for O'head/benefits	sub total:	**1,389,000**
Utilities and Fuel		
Fuel (4 vehicles x 10 l/hr x 20 hrs/d x 250 d/yr x $0.7/L)		140,000
Water (21,200 m3/yr x $1/m3)		21,200
Natural gas (not req'd, assumes biogas used to satisfy heat load)		0
Electricity (estimated 12 million kw.hr/yr)		720,000
	sub total:	**881,200**
Maintenance		
Pre-processing equipment (3% of capital)		216,000
Wet processing equipment (3% of capital)		516,000
Buildings & Site (0.5% of capital)		55,000
Tanks (0.5% of capital)		60,000
	sub total:	**847,000**
Other		
Property taxes		0
Rolling Equipment Lease		70,000
Flocculent (150 tpy x $3/kg)		450,000
Sewer Surcharges		40,000
Product hauling & tip fees to curing site, net compost revenues (approx. 98,000 tpy x $35/t)		3,430,000
Recyclable material revenues (approx. 12,600 tpy x $60/t)		(756,000)
Residue disposal (approx. 47,400 tpy @ $65/t)		3,081,000
Licensing Fees		50,000
Lab analysis costs		35,000
Service contracts		60,000
		6,460,000
	Total:	**9,580,000**
	Unforeseen at 10%:	960,000
	Estimating Allowance at 10%:	960,000
	Grand Total:	**11,500,000**

6. Description of AD Facility Requirements: 100,000 Tonne-per-Year Plant, Organics with up to 10% Unintentional Material; Dry, Thermophilic, Single-Stage Plant

6.1 Overview

This chapter presents a detailed outline of the proposed digestion plant to process 100,000 tonnes per year of source-separated organic material with up to 10% unintentional material.

For planning purposes this waste stream is proposed to be processed using the dry, thermophilic, single-stage AD technology, as developed in Chapter 2.

The proposed plant will be described in terms of the following:

- Description of Operations
- Plant Layout
- Process Flow and Mass Balance
- Cost Estimates

The Description of Operations text describes the proposed plant with sizing of key components.

The Plant Layout section shows a conceptual site plan, based on the 3.2 hectares of site space used as a screening criterion in Chapter 3.

The Process Flow and Mass Balance diagram shows the key process components and mass flows through the process. Due to the lack of operating data from North America, the mass balance is an estimate, based on the best available information from European technology vendors and current science.

Capital and O&M cost estimates are provided as the last section. These are also estimates based upon the best available information rather than documented costs from operating plants.

6.2 Description of Operations

The overall process flow consists of the following main components:

- Site Services (Entry Roads etc.)
- Waste Receiving;
- Front-End Processing, including Contaminant Removal and/or Waste Conditioning;
- Anaerobic Digestion Process;

- Separation of Solid and Liquid Products;
- Post-Digestion Curing of Digestate;
- Liquid Treatment;
- Biogas Handling; and
- Environmental Control

The basic elements of the plant are described below.

6.2.1 Site Services and Requirements

The facility will require basic services common to any waste management facility, including water and sewer, electrical grid connection, natural gas connections and access roads for entry to and exit from the plant. The locations of access roads are shown in the conceptual site plan. This layout is based on one-way, counter-clockwise truck traffic flow (best arrangement for large trucks) with road turning radii suitable for full size transfer trailers.

6.2.2 Waste Receiving

Similar to other waste management facilities, the anaerobic digestion plant would have an area for receiving solid waste. The waste reception system will include the following components:

Weigh Scale

Trucks would be weighed before and after unloading their cargo onto the tipping floor. The weigh scale would be sized and rated for the capacity expected from a full-length (16-17 m) transfer trailer carrying in excess of 30 tonnes.

Tipping Floor

The tipping floor must be enclosed inside the building, to minimize odour emissions from the waste being received. On the tipping floor, an operator will visually inspect the waste and remove large non-digestible items as well as other unacceptable items, such as household hazardous waste (HHW), before the waste is fed into the process. The tipping floor has been sized for two days storage, allowing for plant downtime and 4-day weeks. For the 100,000 tpy (400 tpd) plant capacity, daily variations in waste delivery truck quantities and capacities of 25% can be expected (i.e., +25% represents design case). Based on an on-floor material density for the 10% unintentional waste stream of approximately 300 –350 kg/m3 (325 kg/m3 average) and an average pile height of 4m, a total of about 800 m^2 of tip floor storage is required. An additional 1000 m^2 of tip floor space was added to facilitate truck drive through and tipping, front-end-loader movement, rejects bin and main feed conveyor/bag breaker, for a total of 1800 m^2.

Liquid Waste Holding Tank

Liquid wastes from Industrial, Commercial and Institutional sources could comprise up to 25% of the waste input to the facility. Liquids would generally be brought in by vacuum trucks and would bypass the tipping floor. Liquid wastes would not need to go through the pre-processing system, and in most cases would be suitable for direct feed to the digesters (via the wet processing pulpers described below).

Holding capacity for incoming liquids would be required, which would consist of a tank that the wastes would be pumped into by the incoming tanker truck. Based on a daily waste input of 400 tonnes and a maximum liquid input of 25%, approximately 100 tonnes of liquid waste (or 100 m^3 at an estimated specific gravity of 1.0) could be expected daily. A 200 m^3 tank providing 2 days storage is proposed. This could be a concrete underground tank to conserve site space, however high water table concerns in the Portlands will likely dictate the need for an above-ground tank.

Pumping of liquids into the holding tank would be achieved using the pumps on the tanker trucks, but pumping capability will be required to convey liquids from the holding tank to the pulpers.

6.2.3 Front-End Pre-Processing

Due to the fact that this plant would be processing a cleaner waste stream than the facility described in Chapters 4 and 5, a less extensive front-end pre-processing system would be required. The only manual removal of contaminants would be the tipping floor removal of large objects by the loader operator, and only ferrous metals (and possibly aluminum) would be recovered from the waste as recyclable. Rather than contaminant removal, size reduction is the main waste conditioning step for the dry technology.

The key pre-processing components are described below.

Bag Breaker

Solid wastes would likely first pass through a bag breaker, a mechanical device that uses sharp edges to tear open plastic bags, releasing their contents. The need for a bag breaker will depend on the City's waste collection approach ultimately adopted and the ability of the downstream trommel screen to successfully open bags (the latter will be assessed at the City's Dufferin AD facility in the near future). Some of the plastic bags will stay on the bag breaker's knives, but the majority of plastic must be removed by a subsequent separation step (the trommel). The bag breaker would be installed on the main tip floor with waste fed directly to it using the front-end-loader.

Comminuting Drum

The first step in the dry thermophilic process is size reduction of the waste, by a device such as a comminuting drum. This is a rotating drum, in which the softer organic material would break down to smaller particles while inert materials such as plastic, textiles and metals would not break apart. Any glass bottles in the waste stream would also likely be broken in this step.

There is an average retention time in the drum of 1.5 hours, after which the material is sent through the trommel screen.

Trommel Screen

A trommel screen is a large rotating drum containing openings of various sizes, normally installed at a slight decline to move material through the unit as it rotates. Trommel drums for waste screening are typically constructed of steel plate with holes drilled through the plate, while wire mesh style trommels are more typical for soil screening applications. Trommels for waste screening can be equipped with steel knives welded to the drum interior to assist in opening bags.

For this waste stream, a trommel with one opening size would be used to separate the material into "fines" (objects less than 40-50 mm), and "overs" (all remaining material).

The fines will contain a high percentage of organic material suitable for digestion although grit and broken glass will also be present.

The overs fraction from the trommel, containing occasional plastic and metal containers as well as paper, cardboard, textiles and plastic film, would be directed to disposal.

Baler

A baler for the baling of ferrous metal and possibly aluminum would be required. Based on the anticipated recyclable materials quantity captured from this waste stream (see mass balance, Figure 6.2), a baler having capacity for 3 bales per day will be required.

Magnetic Separation

The recovery of ferrous metals from the waste stream is achieved by means of a strong magnet suspended above the fines conveyor belt. The conveyor directing the overs stream to residue could be equipped with a magnetic head pulley to provide the plant with a second magnetic separation step.

Eddy Current Separation

An eddy-current separator introduces eddy currents which cause a strong repelling force between the separator and aluminum. Aluminum is thus repelled off the conveyor to a storage bin while all other materials continue on to the recombining conveyor described above.

The economics of including an eddy current separator will depend on the quantities of aluminum expected in the waste stream (which will be better known after commencement of the source-separated organics collection pilot program).

6.2.4 Anaerobic Digestion Process: Dry, Thermophilic, Single-stage

For the purposes of this report, a dry, thermophilic, single-stage anaerobic digestion process is assumed for the scenario of processing source-separated organics with up to 10% unintentional material. This is principally because of the higher gas production and lower operational complexity of dry thermophilic digestion of this feedstock, which does not have the high levels of contaminants found in the first waste stream. The components of the dry digestion process are described below.

Mixing Unit

In the mixing unit, incoming waste from the pre-processing steps is mixed with some recirculated waste from the digester, which acts as an inoculant and minimizes process disruptions due to nutrient spikes. Low-pressure steam is injected here to heat the waste to a temperature of between 48 and 55^0 C.

Feed Pump

The mixing unit feeds to the feed pump, which is designed to pump high-solids slurries. The feed pump moves the material, which is at 20-40% solids, into the digester.

Digester

Most dry technologies use a plug-flow design with a vertical cylindrical digester. Mixing can occur by recirculation of the waste in a continuous loop. The feed pump moves the waste through a pipe up to the top of the tank, from which it make its way down to the bottom to pass through an outlet back to the pump. This cycle happens a number of times over a retention time of 15-18 days.

Alternately, the waste may pass through the digester only once, but the inside configuration of the walls and a central baffle prevent short-circuiting of the path from the inlet to the outlet, ensuring the standard retention time of 15-18 days. There are no moving parts inside a high-solids digester.

For the 100,000 tpy plant capacity, it is anticipated that two digesters, each of approximately 2790 m^3 capacity would be employed. Note that the digestion volume for the dry technology is significantly less than that for the wet process described in Chapters 4 and 5; this is due to the fact that dry technologies do not carry excess process water as the wet technologies do, and therefore need less digester volume.

6.2.5 Solid-Liquid Separation

Following digestion, the digested solids would require dewatering before being sent to the final curing location. This dewatering would occur by means of screw presses and/or centrifuges. A polymer solution would be added prior to the presses to flocculate the solids and facilitate solids separation. Most of the water removed at this stage would be recycled to the pulping and wet separation stage of the front-end processing. The remainder would be wastewater, which may require some treatment for the reduction of nitrogen, phosphorus and suspended solids.

6.2.6 Post-Digestion Processing of Digestate

The dewatered solid digestate requires final aerobic curing, to ensure full stabilization and pathogen reduction, which occurs when the material self-heats to over 55^0 C. Due to the extensive space requirements involved in windrow composting, this curing step would be done offsite at another facility.

The digestate exiting from the pressing stage could be discharged directly into a waiting container (trailer, lugger or roll-off) or would require an intermediate storage area, from which it would be loaded onto trucks for hauling to the final composting site. For this waste stream, it is estimated that the digestate mass would be equal to approximately 56% of the mass of the total input to the plant, or 56,000 tonnes per year. This equates to a daily digestate output of approximately 220 tonnes or 110 tonnes per operating shift, based on a 2-shift hauling operation. It is proposed that a single transfer trailer bay be provided for the 100,000 tpy plant with two or three trailers having to be regularly shuttled each shift.

The material would be composted at a facility with the capacity for an input of 220 tonnes per day. The curing time required would be three to four weeks and possibly longer. Also, a bulking agent may be necessary to increase the pore space within the piles and absorb moisture. This could be chipped yard waste or sawdust, or another relatively inert organic material. It would be added to make up approximately 20% by mass of the composting material.

At a windrow height of 2.5 m and compost feedstock density of approximately 0.6 tonnes/m^3, with a curing time of 28 days it is estimated that approximately 1.5 ha would be required for curing of the digestate. Compost bulking and area requirement calculations can be found in Appendix A. It is noted that there are currently no operating facilities in the province with the capacity to process the required volume of material that would result from this plant.

6.2.7 Liquid Treatment

It is expected that the mass of liquid effluent generated at the plant which is not recycled and therefore needs to be treated and discharged could be equal to approximately 33% of the mass of the total input to the plant, or 33,000 tonnes per year. At a density of 1 tonne/m^3 and discharging six days a week, this equates to 105 m^3/ day of wastewater to be treated and disposed of.

The main parameters of concern would be suspended solids, nitrogen and phosphorus. A wastewater treatment process consisting of a clarifier and aeration tank could be installed if necessary. However, since the facility is in such close proximity to the Ashbridges Bay Treatment Plant, likely the effluent would be sent directly into the wastewater system without further treatment.

Table 6.1 presents a cost estimate for a wastewater treatment system for the reduction of nitrogen, phosphorus and suspended solids from a 100,000 tpy facility. The cost estimate is based on a wastewater maximum flow of 100 m^3 per day.

Table 6.1
Cost Estimate – Wastewater Treatment System

Capital Costs	**100,000 tpy facility**
Tankage (1 tank, 100 m2 @ $1500/m2)	150,000
Blower System	225,000
Aeration System	225,000
Alum System for P removal	100,000
Total Capital Cost:	**700,000**
Operating Costs	**100,000 tpy facility**
Chemical (Acetic Acid)	6,000
Chemical (Alum for P removal)	50,000
Power (50 kW @ 6c/kwh)	13,500
Maintenance (2% of Total Capital Investment)	14,000
Labour (1/2 time @ $50k/yr)	25,000
Waste Haulage (0.25 tonne/day registered waste @ $65/tonne)	6,000
Total Operating Cost per Year:	**114,500**

6.2.8 Biogas Collection & Refining

The biogas produced in the digester would be collected by piping and would need to be treated and pressurized for transport to the Boralex co-generation facility.

Biogas is produced from the digester at approximately 100% humidity. To reduce corrosion in piping and gas utilization equipment, moisture removal would be necessary. This would consist of a knockout device for condensate removal.

It may be necessary to remove hydrogen sulfide (H_2S) from the biogas. Sulfides would be removed by a chemical scrubber. The H_2S content of the gas out of the digester could be in the range of 200-2500 ppm.

The gas would come out of the digester at a pressure of less than 1 psi. A compressor would be used to compress the gas for digester mixing and pipeline delivery to the Boralex facility. The level of compression of the gas would be determined by the end use of the gas, as use in the Boralex co-gen unit requires a much higher pressure than use in the auxiliary boiler.

The transport and handling of biogas are described in Chapter 9.

6.2.9 Environmental Control Systems

The facility will include control measures for odour, noise and litter.

Odour would be addressed by a biofilter. All of the process buildings would be maintained under negative air pressure, and this air would be exhausted through a biofilter. In addition, certain equipment items containing high odour sources (for example: waste dissolver, bag breaker, trommel) would be directly vented to the odour control ducting network. The biofilter would be sized at approximately 75 m^3/hr per m^2 of biofilter surface area (at 200 mm pressure drop). This translates into a typical air change rate in the process buildings of about 3 air changes per hour, and also allows approximately 25% additional flow for direct venting of odorous equipment sources.

The biofilter would be equipped with a humidification system (both in the media bed and for the incoming air stream) and utilize a control system to monitor important operating parameters.

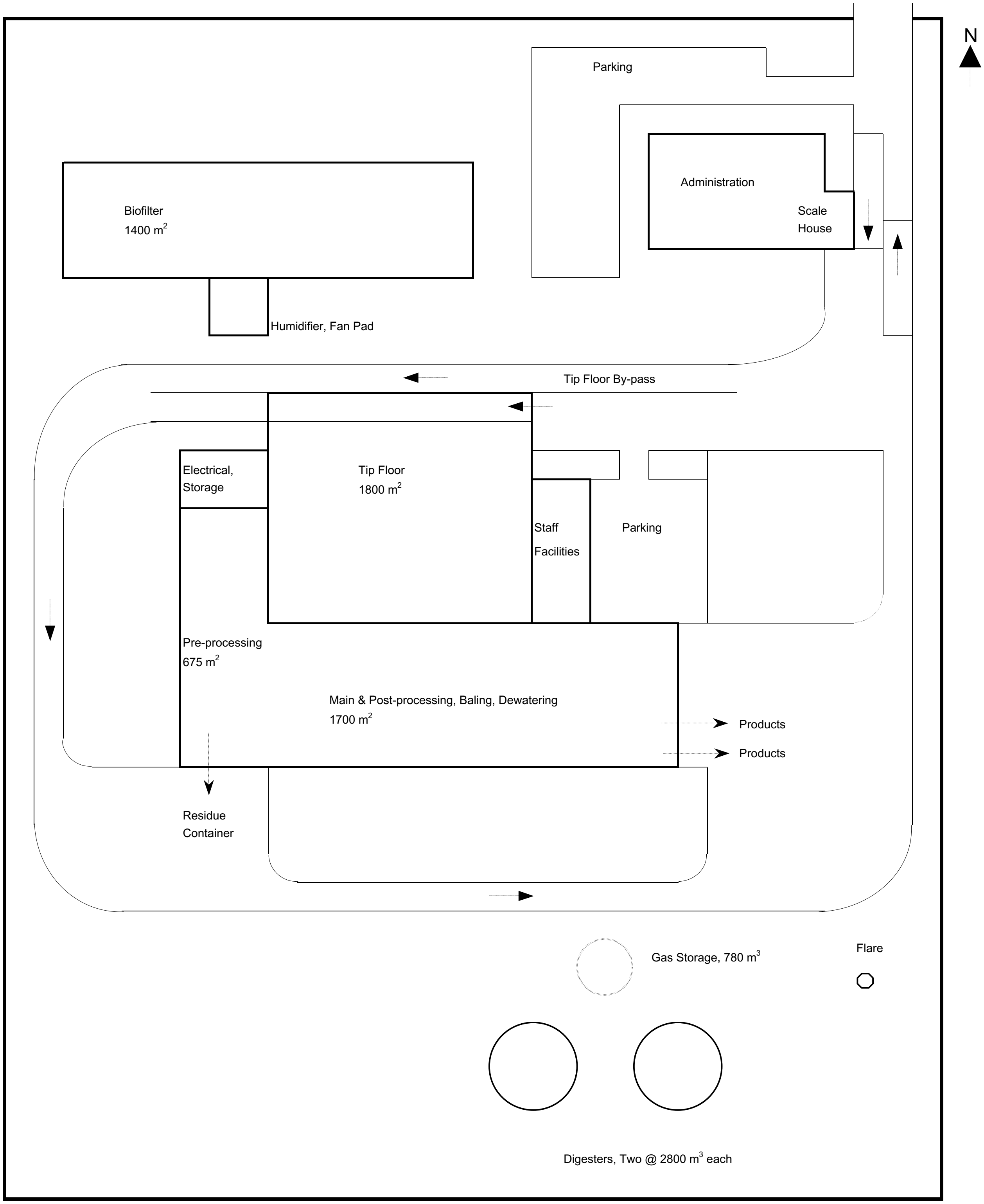
Noise control would primarily be achieved by ensuring process building doors are normally closed (which also addresses odour control) and utilizing enclosures for noisy equipment items if located outside (compressors for example). A drive-through tip floor, as proposed, with fast closing doors should mean that noise and odour escape is minimized. Berms and landscaping would also serve to mitigate noise to a certain extent.

The main areas with a potential for release of litter would be the tipping floor and the digestate loading area. Both of these would be enclosed inside the building. Fencing the site and conducting daily litter removal patrols would be typical of a facility of this nature.

6.3 Plant Layout

The layout of the plant is presented in Figure 6.1. This is a generalized layout for planning purposes, with some major components shown. The layout has been configured to readily allow for expansion to the 200,000 tpy capacity.

This site plan allows for expansion to a 200,000 tpy facility, which requires 3.2 hectares. If a smaller plant were developed and no expansion was planned for, then a correspondingly smaller site would be required.



100,000 TPY, Dry, Thermophilic, Single-Stage
(10% Unintentional Material)
Conceptual Site Plan - 3.2 Ha Site

Figure 6.1

Scale: 1:1000 (approx)

6.4 Process Flow and Mass Balance

Figure 6.2 shows the flow of materials through the process. The mass balance is approximate and can vary substantially with feedstock and technology, therefore the numbers given represent a range of about plus or minus 20%. Mass balance calculations on a total mass and dry solids basis are included in Appendix A.

It is estimated that 100,000 tonnes per year of source-separated organic waste with up to 10% unintentional material will yield approximately 9,620,000 m^3/yr of biogas, 56,000 tonnes/yr of digestate, and 33,000 m^3/yr of wastewater.

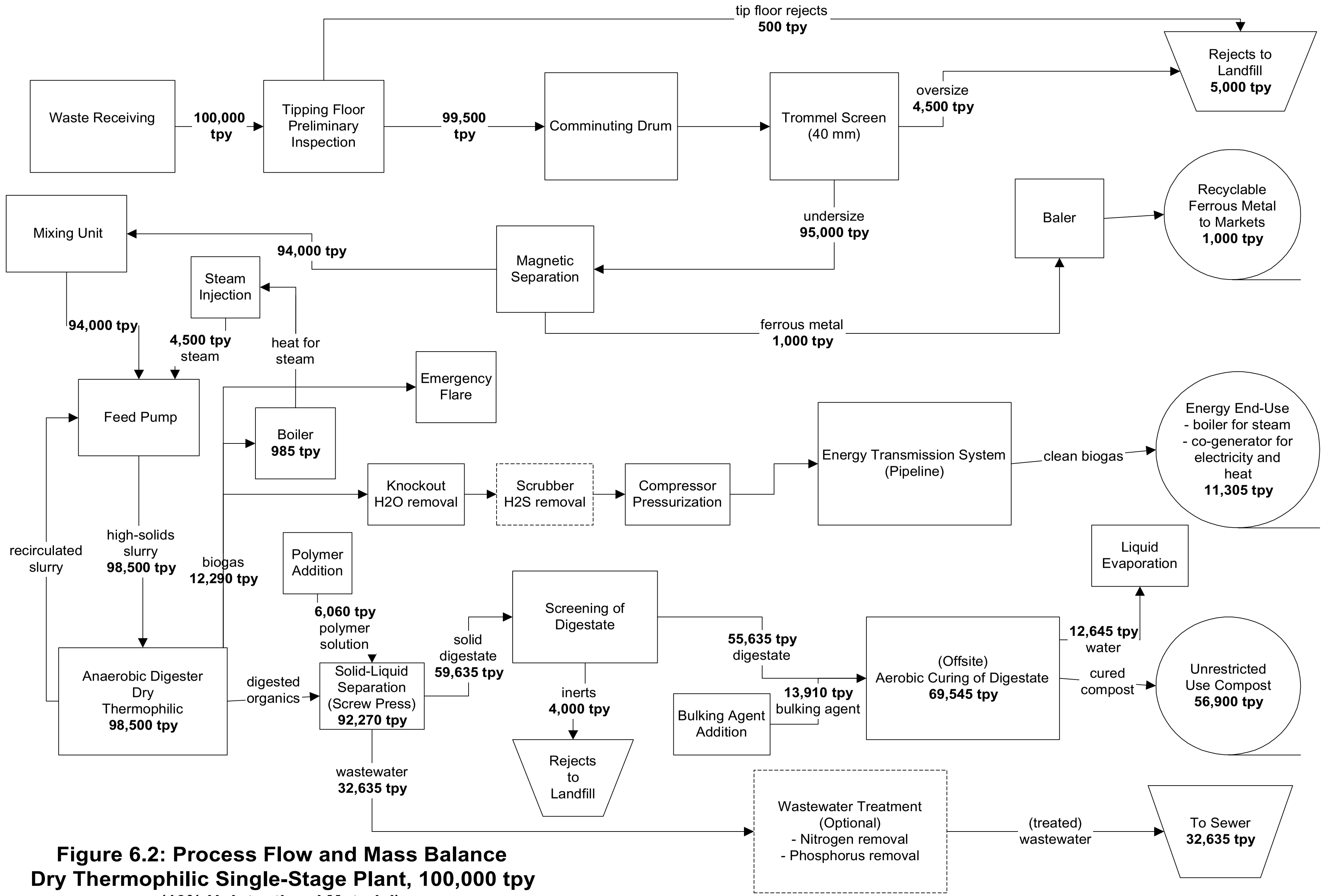


Figure 6.2: Process Flow and Mass Balance
Dry Thermophilic Single-Stage Plant, 100,000 tpy
(10% Unintentional Material)

6.5 Cost Estimates

The capital and operating costs for a 100,000 tpy dry thermophilic plant are presented on the following pages. These are general estimates, obtained from European technology vendors, with some costs (those independent of the type of digestion process used) estimated from the costs of Toronto's pilot facility at the Dufferin transfer station.

It is estimated that a 100,000 tpy dry thermophilic plant would have a capital cost of approximately $32,420,000, and an operating cost of approximately $5,470,000 per year. The cost estimate for this proposed plant is lower than that for the wet mesophilic plant in part because this plant would be processing a cleaner feedstock, and therefore capital and operating costs associated with front-end processing are reduced. Also, the process is simpler and requires less energy. This cost estimate does not include the costs of biogas utilization and transmission equipment, which are described in Chapter 9.

Table 6.2
Capital Cost Estimate - 100,000 tpy Dry, Thermophilic, Single-Stage
(10% Unintentional Material)

General Site Works		
Land costs		0
General (clearing, dewatering, signage, geotechnical investigations, etc.)		300,000
Roadways and parking lot paving (7,000 m2 x $40/m2)		280,000
Utility connections, lighting, buried piping (sewer, gas, water), existing utility relocations, etc.		400,000
	sub total:	**980,000**
Buildings		
Tip floor (1,800 m2 x $1,000/m2)		1,800,000
Pre-processing, building (675 m2 x $1,200/m2)		810,000
Main and post-processing building (1,700 m2 x $1,200/m2)		2,040,000
Electrical, storage room building, staff facilities (400 m2 x $800/m2)		320,000
Administration area including laboratory, scale house (650 m2 x $1,000/m2)		650,000
Entry and exit scales (20 m scales in pit)		200,000
Miscellaneous (small structures, overhead truck doors, monorail hoist, sort platforms etc.)		400,000
	sub total:	**6,220,000**
Major Tankage		
Digesters (2 x 2,800 m3)		3,640,000
Process water tank		100,000
Gas storage tank (780 m3)		275,000
Liquid (feedstock) storage tank (200 m3)		70,000
	sub total:	**4,085,000**
Pre-Processing Equipment (incl. electrical & instrumentation)		
Comminuting drums (4), trommel screen		2,000,000
Conveyors, mag separator		500,000
Baler and feed conveyor system		300,000
Miscellaneous (compactor, platforms, catwalks, hoppers, etc.)		300,000
	sub total:	**3,100,000**
Main and Post-Processing Equipment (incl. electrical & instrumentation)		
Feed pumps, mixing unit, conveyors, digester preheating, etc.		4,500,000
Screw presses (2), centrifuge		2,970,000
Vibrating Screen		300,000
Other process piping, valves, pumps, small tanks		500,000
Miscellaneous (compressor, mixers, clarifier, platforms, catwalks, hoppers,etc.)		500,000
	sub total:	**8,770,000**
Odour Control		
Biofilter (concrete walls, media support, media, etc.)		300,000
Blowers, ducting, humidity control, other controls, etc.		200,000
	sub total:	**500,000**
Biogas Clean Up & Transmission System (See Table 6.4 for detailed estimate)		
		-
Miscellaneous		
Plumbing, fire protection, containers, inspections, etc.		250,000
	sub total:	**250,000**
	Total of above:	**23,910,000**
	Unforeseen and Estimating Allowance (20%):	4,780,000
	Engineering & Contract Administration (13%):	3,730,000
	Grand Total:	**32,420,000**

Table 6.3
Annual O&M Cost Estimate - 100,000 tpy Dry, Thermophilic, Single-Stage
(10% Unintentional Material)

Staff Requirements (based on 3 shift operation)		**$/yr**
1 Plant Manager (60k)		60,000
6 Process Control Operators (35 k)		210,000
2 Tip Floor Operators (30 k)		60,000
2 Maintenance Technician (30 k)		60,000
2 Scale Operators (25 k)		50,000
1 Reception (25 k)		25,000
1 Marketing Mgr (35 k)		35,000
4 Sorters (21 k)		84,000
1 lab technician (30 k)		30,000
Sub total including 1.5 factor for O'head/benefits	sub total:	**921,000**
Utilities and Fuel (assumes no cogen unit on site)		
Fuel (2 vehicles x 10 l/hr x 20 hrs/d x 250 d/yr x $0.7/L)		70,000
Water (10,600 m3/yr x $1/m3)		10,600
Natural gas (not req'd, assumes biogas used to satisfy heat load)		0
Electricity (estimated 5.9 million kw.hr/yr)		354,000
	sub total:	**434,600**
Maintenance		
Pre-processing equipment (4% of capital)		124,000
Main and post- processing equipment (4% of capital)		351,000
Buildings & Site (0.5% of capital)		36,000
Tanks (0.5% of capital)		20,000
	sub total:	**531,000**
Other		
Property taxes		0
Rolling Equipment Lease		35,000
Flocculent (85 tpy x $3/kg)		255,000
Sewer Surcharges		20,000
Product hauling & tip fees to curing site, net compost revenues (approx. 56,000 tpy x $30/t)		1,680,000
Recyclable material revenues (approx. 1,000 tpy x $40/t)		(40,000)
Residue disposal (approx. 9,000 tpy @ $65/t)		585,000
Licensing Fees		50,000
Lab analysis costs		35,000
Service contracts		40,000
		2,660,000
	Total:	**4,550,000**
	Unforseen at 10%:	460,000
	Estimating Allowance at 10%:	460,000
	Grand Total:	**5,470,000**

7. Description of AD Facility Requirements: 200,000 Tonne-per-Year Plant, Organics with up to 10% Unintentional Material; Dry, Thermophilic, Single-Stage Plant

7.1 Overview

This chapter presents a detailed outline of the proposed digestion plant to process 200,000 tonnes per year of source-separated organic material with up to 10% unintentional material.

For planning purposes this waste stream is considered to be processed using the dry, thermophilic, single-stage AD technology, as developed in Chapter 2.

The proposed plant will be described in terms of the following:

- Description of Operations
- Plant Layout
- Process Flow and Mass Balance
- Cost Estimates

The Description of Operations text describes the proposed plant with sizing of key components.

The Plant Layout section shows a conceptual site plan, based on the 3.2 hectares of site space used as a screening criterion in Chapter 3.

The Process Flow and Mass Balance diagram shows the key process components and mass flows through the process. Due to the lack of operating data from North America, the mass balance is an estimate, based on the best available information from European technology vendors and current science.

Capital and O&M cost estimates are provided as the last section. These are also estimates based upon the best available information rather than documented costs from operating plants.

7.2 Description of Operations

The overall process flow consists of the following main components:

- Site Services (Entry Roads etc.)
- Waste Receiving;
- Front-End Processing, including Contaminant Removal and/or Waste Conditioning;
- Anaerobic Digestion Process;

- Separation of Solid and Liquid Products;
- Post-Digestion Curing of Digestate;
- Liquid Treatment;
- Biogas Handling; and
- Environmental Control

The basic elements of the plant are described below.

7.2.1 Site Services and Requirements

The facility will require basic services common to any waste management facility, including water and sewer, electrical grid connection, natural gas connections and access roads for entry to and exit from the plant. The locations of access roads are shown in the conceptual site plan. This layout is based on one-way, counter-clockwise truck traffic flow (best arrangement for large trucks) with road turning radii suitable for full size transfer trailers.

7.2.2 Waste Receiving

Similar to other waste management facilities, the anaerobic digestion plant would have an area for receiving solid waste. The waste reception system will include the following components:

Weigh Scale

Trucks would be weighed before and after unloading their cargo onto the tipping floor. The weigh scale would be sized and rated for the capacity expected from a full-length (16-17 m) transfer trailer carrying in excess of 30 tonnes.

Tipping Floor

The tipping floor must be enclosed inside the building, to minimize odour emissions from the waste being received. On the tipping floor, an operator will visually inspect the waste and remove large non-digestible items as well as other unacceptable items, such as household hazardous waste (HHW), before the waste is fed into the process. The tipping floor has been sized for two days storage, allowing for plant downtime and 4-day weeks. For the 200,000 tpy (800 tpd) plant capacity, daily variations in waste delivery truck quantities and capacities of 25% can be expected (i.e., +25% represents design case). Based on an on-floor material density for the 10% unintentional waste stream of approximately 300 –350 kg/m3 (325 kg/m3 average) and an average pile height of 4m, a total of about 1600 m^2 of tip floor storage is required. An additional 1200 m^2 was added to the floor space to facilitate truck drive through and tipping, front-end-loader movement, rejects bin and main feed conveyor/bag breaker, for a total 2800 m^2.

Liquid Waste Holding Tank

Liquid wastes from Industrial, Commercial and Institutional sources could comprise up to 25% of the waste input to the facility. Liquids would generally be brought in by vacuum trucks and would bypass the tipping floor. Liquid wastes would not need to go through the pre-processing system, and in most cases would be suitable for direct feed to the digesters (via the wet processing pulpers described below).

Holding capacity for incoming liquids would be required, which would consist of a tank that the wastes would be pumped into by the incoming tanker truck. Based on a daily waste input of 800 tonnes and a maximum liquid input of 25%, approximately 200 tonnes of liquid waste (or 200 m^3 at an estimated specific gravity of 1.0) could be expected daily. A 400 m^3 tank providing 2 days storage is proposed. This could be a concrete underground tank to conserve site space, however high water table concerns in the Portlands will likely dictate the need for an above-ground tank.

Pumping of liquids into the holding tank would be achieved using the pumps on the tanker trucks, but pumping capability will be required to convey liquids from the holding tank to the pulpers.

7.2.3 Front-End Pre-Processing

Due to the fact that this plant would be processing a cleaner waste stream than the facility described in Chapters 4 and 5, a less extensive front-end pre-processing system would be required. The only manual removal of contaminants would be the tipping floor removal of large objects by the loader operator, and only ferrous metals (and possibly aluminum) would be recovered from the waste as recyclable. Rather than contaminant removal, size reduction is the main waste conditioning step for the dry technology.

The key pre-processing components are described below.

Bag Breaker

Solid wastes would likely first pass through a bag breaker, a mechanical device that uses sharp edges to tear open plastic bags, releasing their contents. The need for a bag breaker will depend on the City’s waste collection approach ultimately adopted and the ability of the downstream trommel screen to successfully open bags (the latter will be assessed at the City’s Dufferin AD facility in the near future). Some of the plastic bags will stay on the bag breaker’s knives, but the majority of plastic must be removed by a subsequent separation step (the trommel). The bag breaker would be installed on the main tip floor with waste fed directly to it using the front-end-loader.

Comminuting Drum

The first step in the dry thermophilic process is size reduction of the waste, by a device such as a comminuting drum. This is a rotating drum, in which the softer organic material would break down to smaller particles while inert materials such as plastic, textiles and metals would not break apart. Any glass bottles in the waste stream would also likely be broken in this step.

There is an average retention time in the drum of 1.5 hours, after which the material is sent through the trommel screen.

Trommel Screen

A trommel screen is a large rotating drum containing openings of various sizes, normally installed at a slight decline to move material through the unit as it rotates. Trommel drums for waste screening are typically constructed of steel plate with holes drilled through the plate, while wire mesh style trommels are more typical for soil screening applications. Trommels for waste screening can be equipped with steel knives welded to the drum interior to assist in opening bags.

For this waste stream, a trommel with one opening size would be used to separate the material into “fines” (objects less than 40-50 mm), and “overs” (all remaining material).

The fines will contain a high percentage of organic material suitable for digestion although grit and broken glass will also be present.

The overs fraction from the trommel, containing occasional plastic and metal containers as well as paper, cardboard, textiles and plastic film, would be directed to disposal.

Baler

A baler for the baling of ferrous metal and possibly aluminum would be required. Based on the anticipated recyclable materials quantity captured from this waste stream (see mass balance, Figure 7.2), a baler having capacity for 6 bales per day will be required.

Magnetic Separation

The recovery of ferrous metals from the waste stream is achieved by means of a strong magnet suspended above the fines conveyor belt. The conveyor directing the overs stream to residue could be equipped with a magnetic head pulley to provide the plant with a second magnetic separation step.

Eddy Current Separation

An eddy-current separator introduces eddy currents which cause a strong repelling force between the separator and aluminum. Aluminum is thus repelled off the conveyor to a storage bin while all other materials continue on to the recombining conveyor described above.

The economics of including an eddy current separator will depend on the quantities of aluminum expected in the waste stream (which will be better known after commencement of the source-separated organics collection pilot program).

7.2.4 Anaerobic Digestion Process: Dry, Thermophilic, Single-stage

For the purposes of this report, a dry, thermophilic, single-stage anaerobic digestion process is assumed for the scenario of processing source-separated organics with up to 10% unintentional material. This is principally because of the higher gas production and lower operational complexity of dry thermophilic digestion of this feedstock, which does not have the high levels of contaminants found in the first waste stream. The components of the dry digestion process are described below.

Mixing Unit

In the mixing unit, incoming waste from the pre-processing steps is mixed with some recirculated waste from the digester, which acts as an inoculant and minimizes process disruptions due to nutrient spikes. Low-pressure steam is injected here to heat the waste to a temperature of between 48 and 55^0 C.

Feed Pump

The mixing unit feeds to the feed pump, which is designed to pump high-solids slurries. The feed pump moves the material, which is at 20-40% solids, into the digester.

Digester

Most dry technologies use a plug-flow design with a vertical cylindrical digester. Mixing can occur by recirculation of the waste in a continuous loop. The feed pump moves the waste through a pipe up to the top of the tank, from which it make its way down to the bottom to pass through an outlet back to the pump. This cycle happens a number of times over a retention time of 15-18 days.

Alternately, the waste may pass through the digester only once, but the inside configuration of the walls and a central baffle prevent short-circuiting of the path from the inlet to the outlet, ensuring the standard retention time of 15-18 days. There are no moving parts inside a high-solids digester.

For the 200,000 tpy plant capacity, it is anticipated that four digesters, each of approximately 2790 m^3 capacity would be employed. Note that the digestion volume for the dry technology is significantly less than that for the wet process described in Chapters 4 and 5; this is due to the fact that dry technologies do not carry excess process water as the wet technologies do, and therefore need less digester volume.

7.2.5 Solid-Liquid Separation

Following digestion, the digested solids would require dewatering before being sent to the final curing location. This dewatering would occur by means of screw presses and/or centrifuges. A polymer solution would be added prior to the presses to flocculate the solids and facilitate solids separation. Most of the water removed at this stage would be recycled to the pulping and wet separation stage of the front-end processing. The remainder would be wastewater, which may require some treatment for the reduction of nitrogen, phosphorus and suspended solids.

7.2.6 Post-Digestion Processing of Digestate

The dewatered solid digestate requires final aerobic curing, to ensure full stabilization and pathogen reduction, which occurs when the material self-heats to over 55^0 C. Due to the extensive space requirements involved in windrow composting, this curing step would be done offsite at another facility.

The digestate exiting from the pressing stage could be discharged directly into a waiting container (trailer, lugger or roll-off) or would require an intermediate storage area, from which it would be loaded onto trucks for hauling to the final composting site. For this waste stream, it is estimated that the digestate mass would be equal to approximately 56% of the mass of the total input to the plant, or 112,000 tonnes per year. This equates to a daily digestate output of approximately 450 tonnes or 225 tonnes per operating shift, based on a 2-shift hauling operation. It is proposed that a single transfer trailer bay be provided for the 200,000 tpy plant with four to six trailers having to be regularly shuttled each shift.

The material would be composted at a facility with the capacity for an input of 450 tonnes per day. The curing time required would be three to four weeks and possibly longer. Also, a bulking agent may be necessary to increase the pore space within the piles, absorb moisture, and add carbon to raise the C:N ratio. This could be chipped yard waste or another relatively inert organic material. It would be added to make up approximately 20% by mass of the composting material.

At a windrow height of 2.5 m and compost feedstock density of approximately 0.6 tonnes/m^3, with a curing time of 28 days it is estimated that approximately 3.0 ha would be required for curing of the digestate. It is noted that there are currently no operating facilities in the province with the capacity to process the required volume of material that would result from this plant.

7.2.7 Liquid Treatment

It is expected that the mass of liquid effluent generated at the plant which is not recycled and therefore needs to be treated and discharged could be equal to approximately 33% of the mass of the total input to the plant, or 66,000 tonnes per year. At a density of 1 tonne/m^3 and discharging six days a week, this equates to 212 m^3/ day of wastewater to be treated and disposed of.

The main parameters of concern would be suspended solids, nitrogen and phosphorus. A wastewater treatment process consisting of a clarifier and aeration tank could be installed if necessary. However, since the facility is in such close proximity to the Ashbridges Bay Treatment Plant, likely the effluent would be sent directly into the wastewater system without further treatment.

Table 7.1 presents a cost estimate for a wastewater treatment system for the reduction of nitrogen, phosphorus and suspended solids from a 200,000 tpy facility. The cost estimate is based on a wastewater maximum flow of 200 m^3 per day.

Table 7.1
Cost Estimate – Wastewater Treatment System

Capital Costs	**200,000 tpy facility**
Tankage (2 tanks, 100 m2 each @ $1500/m2)	300,000
Air Blower System	450,000
Clarifier System	450,000
Alum System for P removal	200,000
Total Capital Cost:	**1,400,000**
Operating Costs	**200,000 tpy facility**
Chemical (Acetic Acid)	12,000
Chemical (Alum for P removal)	100,000
Power (50 kW @ 6c/kwh)	27,000
Maintenance (2% of Total Capital Investment)	28,000
Labour (1/2 time @ $50k/yr)	25,000
Waste Haulage (0.5 tonne/day registered waste @ $65/tonne)	12,000
Total Operating Cost per Year:	**204,000**

7.2.8 Biogas Collection & Refining

The biogas produced in the digester would be collected by piping and would need to be treated and pressurized for transport to the Boralex co-generation facility.

Biogas is produced from the digester at approximately 100% humidity. To reduce corrosion in piping and gas utilization equipment, moisture removal would be necessary. This would consist of a knockout device for condensate removal.

It may be necessary to remove hydrogen sulfide (H_2S) from the biogas. Sulfides would be removed by a chemical scrubber. The H_2S content of the gas out of the digester could be in the range of 200-2500 ppm.

The gas would come out of the digester at a pressure of less than 1 psi. A compressor would be used to compress the gas for digester mixing and pipeline delivery to the Boralex facility. The level of compression of the gas would be determined by the end use of the gas, as use in the Boralex co-gen unit requires a much higher pressure than use in the auxiliary boiler.

The transport and handling of biogas are described in Chapter 9.

7.2.9 Environmental Control Systems

The facility will include control measures for odour, noise and litter.

Odour would be addressed by a biofilter. All of the process buildings would be maintained under negative air pressure, and this air would be exhausted through a biofilter. In addition, certain equipment items containing high odour sources (for example; waste dissolver, bag breaker, trommel) would be directly vented to the odour control ducting network. The biofilter would be sized at approximately 75 m^3/hr per m^2 of biofilter surface area (at 200 mm pressure drop). This translates into a typical air change rate in the process buildings of about 3 air changes per hour, and also allows approximately 25% additional flow for direct venting of odorous equipment sources.

The biofilter would be equipped with a humidification system (both in the media bed and for the incoming air stream) and utilize a control system to monitor important operating parameters.

Noise control would primarily be achieved by ensuring process building doors are normally closed (which also addresses odour control) and utilizing enclosures for noisy equipment items if located outside (compressors for example). A drive-through tip floor, as proposed, with fast closing doors should mean that noise and odour escape is minimized. Berms and landscaping would also serve to mitigate noise to a certain extent.

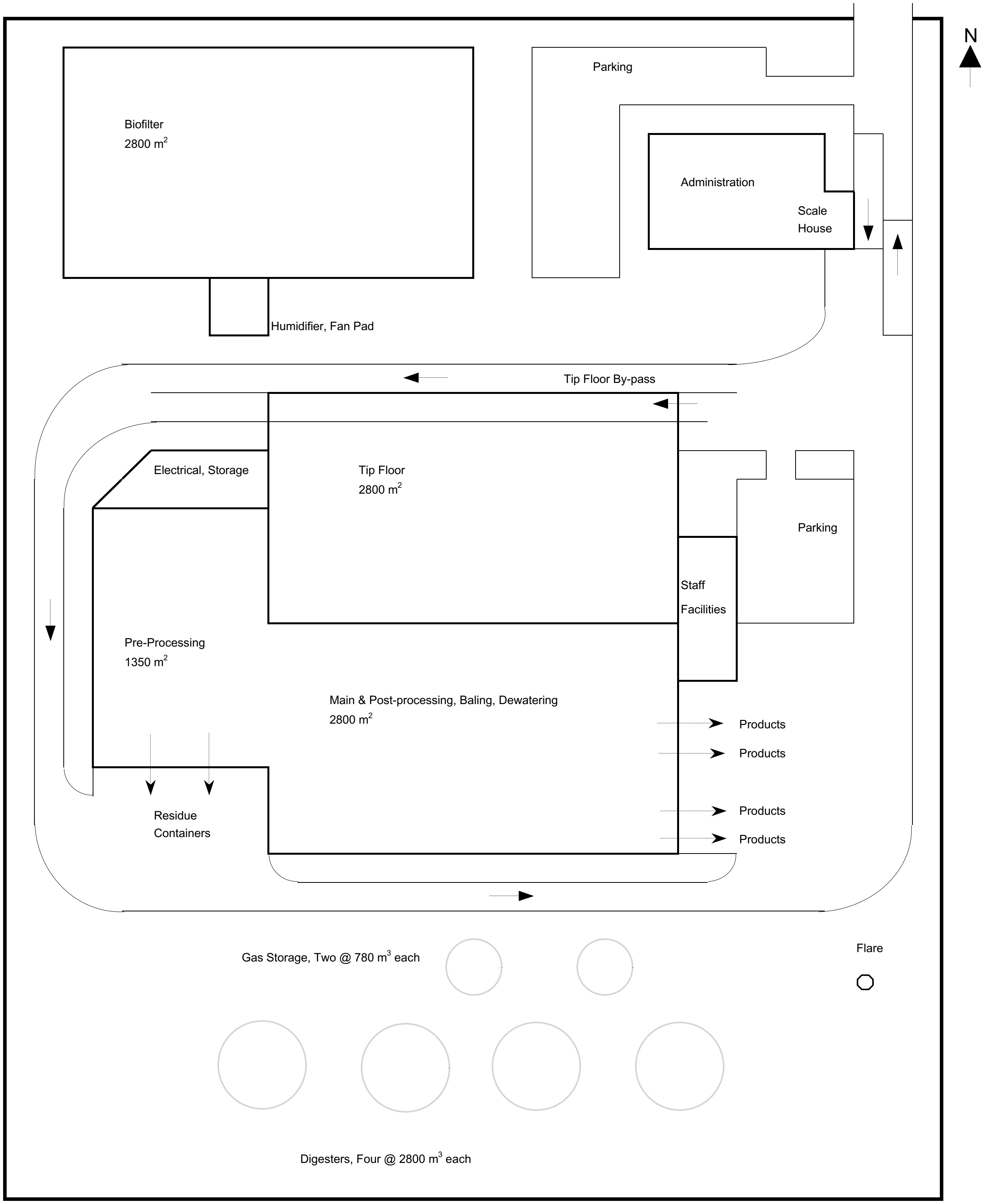
The main areas with a potential for release of litter would be the tipping floor and the digestate loading area. Both of these would be enclosed inside the building. Fencing the site and conducting daily litter removal patrols would be typical of a facility of this nature.

7.3 Plant Layout

The layout of the plant is presented in Figure 7.1. This is a generalized layout for planning purposes, with some major components shown.

The site plan is based on the 3.2 hectares of space required for a 200,000 tpy plant.

This plant would have all the same processing components as the 100,000 tpy dry thermophilic plant, sized for twice the throughput. The layout for the 100,000 tpy facility was designed such that all areas could be expanded to the 200,000 tpy facility size without moving any major structures, except for the staff building.



200,000 TPY, Dry, Thermophilic, Single-Stage
(10% Unintentional Material)
Conceptual Site Plan - 3.2 Ha Site

Figure 7.1

Scale: 1:1000 (approx)

7.4 Process Flow and Mass Balance

Figure 7.2 shows the flow of materials through the process. The mass balance is approximate and can vary substantially with feedstock and technology, therefore the numbers given represent a range of about plus or minus 20%. Mass balance calculations on a total mass and dry solids basis are included in Appendix A.

It is estimated that 200,000 tonnes per year of source-separated organic waste with up to 10% unintentional material will yield approximately 19,240,000 m^3/yr of biogas, 112,000 tonnes/yr of digestate, and 66,000 m^3/yr of wastewater.

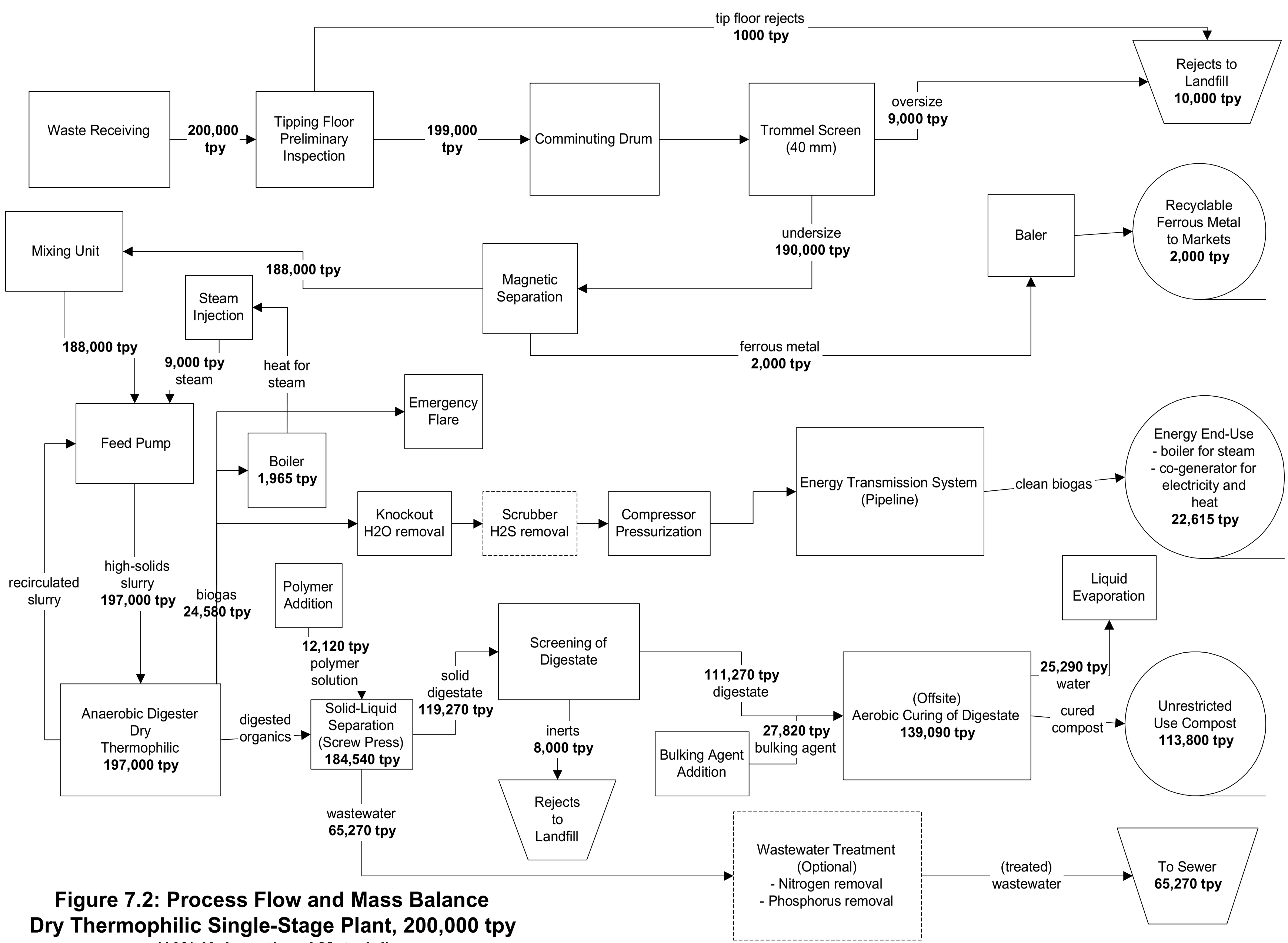


Figure 7.2: Process Flow and Mass Balance
Dry Thermophilic Single-Stage Plant, 200,000 tpy
(10% Unintentional Material)

7.5 Cost Estimates

The capital and operating costs for a 200,000 tpy dry thermophilic plant are presented on the following pages. These are general estimates, obtained from European technology vendors, with some costs (those independent of the type of digestion process used) estimated from the costs of Toronto's pilot facility at the Dufferin transfer station.

It is estimated that a 200,000 tpy dry thermophilic plant would have a capital cost of approximately $58,690,000, and an operating cost of approximately $9,580,000 per year. The cost estimate for this proposed plant is lower than that for the wet mesophilic plant in part because this plant would be processing a cleaner feedstock, and therefore capital and operating costs associated with front-end processing are reduced. Also, the process is simpler and requires less energy. This cost estimate does not include the costs of biogas utilization and transmission equipment, which are described in Chapter 9.

Table 7.2
Capital Cost Estimate - 200,000 tpy Dry, Thermophilic, Single-Stage
(10% Unintentional Material)

General Site Works		
Land costs		0
General (clearing, dewatering, signage, geotechnical investigations, etc.)		300,000
Roadways and parking lot paving (7,000 m2 x $40/m2)		280,000
Utility connections, lighting, buried piping (sewer, gas, water), existing utility relocations, etc.		400,000
	sub total:	**980,000**
Buildings		
Tip floor (2,800 m2 x $1,000/m2)		2,800,000
Pre-processing building (1,350 m2 x $1,200/m2)		1,620,000
Main and post-processing building (2,800 m2 x $1,200/m2)		3,360,000
Electrical, storage room building, staff facilities (500 m2 x $800/m2)		400,000
Administration area including laboratory, scale house (650 m2 x $1,000/m2)		650,000
Entry and exit scales (20 m scales in pit)		200,000
Miscellaneous (small structures, overhead truck doors, monorail hoist, sort platforms etc.)		500,000
	sub total:	**9,530,000**
Major Tankage		
Digesters (4 x 2,800 m3)		7,280,000
Process water tank		200,000
Gas storage tank (2 x 780 m3)		550,000
Liquid (feedstock) storage tank (400 m3)		100,000
	sub total:	**8,130,000**
Pre-Processing Equipment (incl. electrical & instrumentation)		
Comminuting drums (8), trommel screen (2)		4,000,000
Conveyors, mag separator		1,000,000
Baler and feed conveyor system		500,000
Miscellaneous (compactor, platforms, catwalks, hoppers, etc.)		600,000
	sub total:	**6,100,000**
Main and Post-Processing Equipment (incl. electrical & instrumentation)		
Feed pumps, mixing unit, conveyors, digester preheating, etc.		9,000,000
Screw presses (4), centrifuges (2)		5,940,000
Vibrating screens (2)		600,000
Process piping, valves, pumps, small tanks		800,000
Miscellaneous (compressor, mixers, clarifier, platforms, catwalks, hoppers,etc.)		800,000
	sub total:	**17,140,000**
Odour Control		
Biofilter (concrete walls, media support, media, etc.)		500,000
Blowers, ducting, humidity control, other controls, etc.		400,000
	sub total:	**900,000**
Biogas Clean Up & Transmission System (See Table 6.4 for detailed estimate)		
		-
Miscellaneous		
Plumbing, fire protection, containers, inspections, etc.		500,000
	sub total:	**500,000**
	Total of above:	**43,280,000**
	Unforeseen and Estimating Allowance (20%):	8,660,000
	Engineering & Contract Administration (13%):	6,750,000
	Grand Total:	**58,690,000**

Table 7.3
Annual O&M Cost Estimate - 200,000 tpy Dry, Thermophilic, Single-Stage
(10% Unintentional Material)

Staff Requirements (based on 3 shift operation)		**$/yr**
1 Plant Manager (60k)		60,000
6 Process Control Operators (35 k)		210,000
4 Tip Floor Operators (30 k)		120,000
2 Maintenance Technician (30 k)		60,000
2 Scale Operators (25 k)		50,000
1 Reception (25 k)		25,000
1 Marketing Mgr (35 k)		35,000
8 Sorters (21 k)		168,000
1 lab technician (30 k)		30,000
Sub total including 1.5 factor for O'head/benefits	sub total:	**1,137,000**
Utilities and Fuel		
Fuel (4 vehicles x 10 l/hr x 20 hrs/d x 250 d/yr x $0.7/L)		140,000
Water (21,200 m3/yr x $1/m3)		21,200
Natural gas (not req'd, assumes biogas used to satisfy heat load)		0
Electricity (estimated 11.2 million kw.hr/yr)		672,000
	sub total:	**833,200**
Maintenance		
Pre-processing equipment (3% of capital)		183,000
Wet processing equipment (3% of capital)		514,200
Buildings & Site (0.5% of capital)		53,000
Tanks (0.5% of capital)		41,000
	sub total:	**791,200**
Other		
Property taxes		0
Rolling Equipment Lease		70,000
Flocculent (170 tpy x $3/kg)		510,000
Sewer Surcharges		40,000
Product hauling & tip fees to curing site, net compost revenues (approx.112,000 tpy x $30/t)		3,360,000
Recyclable material revenues (approx. 2,000 tpy x $40/t)		(80,000)
Residue disposal (approximately 18,000 tpy @ $65/t)		1,170,000
Licensing Fees		50,000
Lab analysis costs		35,000
Service contracts		60,000
		5,215,000
	Total:	**7,980,000**
	Unforseen at 10%:	800,000
	Estimating Allowance at 10%:	800,000
	Grand Total:	**9,580,000**