Biosolids Management Master Plan

FINAL REPORT

Prepared for:

CITY OF GUELPH

Prepared by:

CH2MHILL

Responsible Solutions for a Sustainable Future™

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Notice of Draft Biosolids Management Master Plan Completion

The City of Guelph has prepared a Biosolids Management Master Plan (BMMP) to provide direction for biosolids management activities to the year 2025. The master plan study included a review of the City's current biosolids management program and an analysis of alternative management (processing, utilization, and disposal) options.

The Master Plan followed Phases 1 and 2 of the Municipal Class Environmental Assessment and incorporates comments received from the public and agencies during the course of the study. Two public information centres were held in February 2002 and in June 2005, and project information was made available on the City's website. While the plan addresses need and justification at a broad level, additional study under the Municipal Class EA will be required before implementation of strategy components can occur.

The Master Plan is available for review at the following locations until Monday November 6th, 2006:

- Library, Main Branch, 100 Norfolk Street, Guelph, ON N1H 4J6 Monday to Friday - 10:00 a.m. to 9: 00 p.m., Saturdays - 9: 00 a.m. to 5: 00 p.m. and Sundays - 1:00 p.m. to 5:00 p.m.
- City of Guelph, Environmental Services Department, Wastewater Services Division, 530 Wellington Street West, Monday to Friday - 8: 30 a.m. to 4: 30 p.m.
- City Clerk's office, City Hall, 59 Carden Street, Guelph, ON N1H 3A1, Monday to Friday - 8:30 a.m. to 4:30 p.m.
- Website – www.guelph.ca

Comments on the Master Plan should be forwarded by Monday November 6th, 2006 to:

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This Notice issued October 6th, 2006 and October 13th, 2006.

Executive Summary

The City of Guelph initiated a project to prepare a Biosolids Management Master Plan (BMMP) to provide direction for biosolids management activities to the year 2025. The goal of the project is to recommend a management strategy that is economically viable, meets regulatory requirements, can be maintained in the long term and is supported and endorsed by stakeholders and, ultimately by City Council.

Currently, the City uses the services of a contractor to remove Lystek-treated and dewatered biosolids from the wastewater treatment plant (WWpTP) and apply them to agricultural lands that have been pre-approved to accept these types of biosolids materials. Landowners and farmers receive this service at no cost. When land application is not available, the dewatered biosolids are blended with woodchips in the composting facility and disposed of at landfill.

Study Conclusions

The Guelph BMMP study included a review of the City's current biosolids management program and an analysis of alternative management (processing, disposal and utilization) options. The following represent the study conclusions generated:

1. **The existing method of management, that is, anaerobic digestion, dewatering, and land application of Lystek-treated, composted and dewatered biosolids, is the most economical for the City.** However, composting is infrequently used due to the age and unreliability of the system, as well as the regulators' difficulties with beneficial use. Due to the current lack of storage, landfilling of dewatered biosolids is utilized when required. Land application of liquid biosolids may be utilized for scheduled equipment shutdowns or during emergency situations.

   It was estimated that there will be sufficient agricultural land available to land apply biosolids over the long term. This conclusion assumes that there are no political or social barriers to this method of biosolids management. The City's procurement process and contract terms was also reviewed. It is recommended that the City will continue to contract with the private sector to manage its biosolids in an environmentally responsible and economical manner to the satisfaction of the City, its residents and the farming community.

2. **Process capacity and/or equipment upgrades are required for**:
   - **WAS thickening** – full scale facilities following demonstration
   - **Primary digestion** – two new primary digesters or equivalent
   - **Dewatering** – completion of replacement of presses 1 and 2 in 2006 followed by replacement of presses 3 and 4

   These facility improvements are required to provide the process ability to implement to management plan.

3. **The City needs to consider construction of storage facilities for Lystek-treated and other biosolids to be able to maximize beneficial use of biosolids, improve viability of the land application program and reduce dependency on landfilling.** Because the City currently

has no storage facilities, land application occurs at the rate of the process capacity of Lystek treatment and dewatering. Sites applications would be more economical if sufficient material were available to complete the application in a concise time period. Storage also allows some homogenization of the product, resulting in a more consistent material.

It is not recommended that the City invest in long-term storage facilities for dewatered cake, as the industry has not yet solved the problems with this technology for long-term storage. Rather, long-term storage facilities for the product that replaces composting should be provided. This storage could be used in the interim for dewatered cake. Storage for Lystek-treated biosolids is economical (compared to liquid biosolids storage) and the technologies are well-understood and proven reliable.

Maintaining a landfill contract is also recommended as an important part of the strategy, for contingency and emergency biosolids disposal.

4. **The City needs to <u>develop a plan for replacement of the composting facility</u> as soon as possible.** The City should continue to maintain a diversified biosolids management strategy; however, the current regulatory framework does not support unrestricted use of biosolids compost. Also, the City has determined that this composting equipment is at the end of its reliable service life and should be replaced (decommissioned) as soon as possible. Alternative treatment technologies, including heat drying and alkaline stabilization, produce a product, at similar cost, that may be federally registered as a fertilizer and is therefore a higher value product.

   The City should use the available time, prior to the first five-year BMMP review and update, to investigate partnering with other municipalities and private companies to determine if a suitable opportunity exists e.g. the N-Viro Niagara facility could be used to manage some of the biosolids to gain some experience with the product. This could be achieved by initiating discussions with potential partners (other municipalities or private companies) to develop co-operative initiatives and to establish networks for investigating new strategy alternatives. This method of management could reduce each partner’s costs. Municipalities will still have to proactively monitor programs that are contracted to the private sector to satisfy public concerns. The concept of municipalities partnering lends itself to management solutions that could provide benefits to all of the partners including adopting common best management practices and shared central facilities or contracting services effectively by utilizing contracts that fairly share risk between partners. The City should also initiate a pre-design study to determine the preferred replacement strategy.

   If the City determines that decommissioning of the compost facility and onsite replacement with another technology is preferred, this study concluded that heat drying or alkaline stabilization would currently be the preferred process. The City should commission a study to evaluate the market, regulatory trends and emerging technologies to confirm the analysis.

Implementation Plan

The study conclusions provided the basis for developing an Implementation Plan. The implementation plan identifies specific initiatives to maintain, improve and maximize the current land application program, to maintain the contingency disposal option, and to develop and plan for facility replacement. Accordingly, the Implementation Plan includes initiatives in three specific areas.

1. **Land Application Program – "Continuous Improvement"**

   The current land application program, with contingency landfill disposal, can be further supported and maintained into the future by implementing initiatives involving monitoring and quality control, communications, stakeholder involvement, improved procurement process, product market development, and appropriate storage capacity.

2. **Facility Replacement/Expansion Planning**

   To ensure a reliable, sustainable and diversified biosolids management program over the next 20+ years, the City must implement a number of initiatives. These include digestion and dewatering process improvements/expansion and compost processing replacement, as well as consideration of final markets, product quality enhancement and co-operative or Private, Public, Partnership (PPP) options. Contingency planning will be needed and can realistically be adjusted as options become available.

3. **Program Management**

   The management of risk is paramount as the City proceeds with the implementation of the biosolids management strategy. The City can reduce and manage potential liability associated with the biosolids management strategy by implementing the following initiatives:

   - Increase the awareness and understanding of City staff of the Ontario context for biosolids management through collaborative discussions with other municipalities and industry sector parties.
   - Implement a monitoring program to increase public assurance that the City's programs and activities are being carried out as contracted and according to regulatory protocols.
   - Consider adopting an EMS approach for its strategy implementation.
   - Take co-responsibility and co-ownership of land application site approval with the contractor.

Master Plan Development

The Guelph BMMP was developed following the Class Environmental Assessment (EA) requirements for a master plan. The two-phased process included the following key requirements:

- Understanding of the current program
- Examination of the alternative technologies, products, utilization, and disposal options
- Development of short-term actions and a long-term strategy to meet future requirements
- Documentation to provide clear and traceable decision-making
- Consultation with stakeholders throughout the decision-making process

Phase 1 activities included initial data gathering to determine the existing infrastructure conditions and future capacity requirements. This information was used to develop the "problem definition" or "needs statement" for the study.

Phase 2 activities included several component tasks focused on the screening of the long list of alternatives and a more detailed evaluation of a short list of seven alternative strategies including composting, heat drying and alkaline stabilization technologies as part of a diversified program.

The strategies were evaluated using an extensive set of criteria developed in consultation with public and agency stakeholders. The Master Plan strategy also included the development of an implementation plan, and recommendations for a risk management plan. Project information was available to the public at an Open House, Public Information Centre, via a project mailing list, and on the City's website.

The planning and decision-making process has been documented in the Master Plan report. All technical analyses and public correspondence are appended to the report. The Master Plan provides the basis for biosolids activities in the City to 2025 and must be reviewed and updated every five years.

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Glossary and Abbreviations

Glossary

***Beneficial use*:** A disposal process that takes advantage of at least one of the nutrient, soil conditioning, or fuel properties of sludge. Beneficial use practices include land application of biosolids as a soil amendment or fertilizer supplement and various procedures that derive energy from biosolids or convert them to useful products.

***Biochemical oxygen demand (BOD_5)*:** The amount of oxygen utilized during a 5-day incubation period for the biochemical degradation of organic material.

***Biosolids*:** Primarily organic solid product produced by wastewater treatment processes that are of a quality that can be beneficially used.

Market: The end use for the biosolids product or the utilization site(s).

***Pathogens*:** Disease-causing organisms found in wastewater and sludge.

***Sludge*:** Solids removed from wastewater by mechanical or biological means. Sludge and biosolids, as used in the text, mean the same when the sludge is processed to a biosolid quality.

***Wastewater*:** The spent or used water of a community or industry which contains dissolved or suspended matter. It is a general term for untreated discharged.

Abbreviations

°C	degrees Celsius
AMSA	Association of Metropolitan Sewerage Agencies
BFP	Belt filter press
BMMP	Biosolids Management Master Plan
C of A	Certificate of Approval issued by the MOE
CFIA	Canadian Food Inspection Agency
City	City of Guelph
D	day
dt	dry tonnes
EA	Environmental Assessment
EBR	Environmental Bill of Rights
EMS	Environmental Management Strategy
EU	European Union
GRCA	Grand River Conservation Authority
ha	hectare
HRT	Hydraulic retention time
kg	kilogram
L	litre
m	metre

m^3	cubic metre
mg	milligram
ML/d	megalitres per day
MLD	megalitres per day
MOE	Ontario Ministry of the Environment
MUA	Multi-attribute Utility Analysis
N	Nitrogen
NA	Not applicable
NACWA	Natural Association of Clean Water Agencies
NH_3	Ammonia
NM	Not measured
NMA	Nutrient Management Act
NMS	Nutrient management strategy
NO_3	Nitrate
NPV	Net Present Value
O&M	Operation and maintenance
OMAFRA	Ontario Ministry of Agriculture, Food and Rural Affairs
pH	non-dimensional measure of acidity or alkalinity of a fluid
PPP	Private, Public, Partnership
t	tonne (metric ton) or 1,000 kg
TKN	Total Kjeldahl Nitrogen
TM	Technical Memorandum
TWAS	Thickened waste activated sludge
USEPA	U.S. Environmental Protection Agency
WAS	Waste activated sludge
WEF	Water Environment Federation
wt	wet tonnes
WWTP	Wastewater treatment plant
y or yr	year

1. Introduction and Background

Project History

In response to growth pressures, the City of Guelph, in 1998, completed a Schedule C Class Environmental Assessment (EA) to identify a wastewater treatment strategy to serve the City's needs to the year 2016. The study considered the treatment requirements for the liquid portion of the wastewater stream and addressed issues associated with the management of the solids component of the wastewater stream. A two-stage liquid side expansion of the City's Wastewater Treatment Plant (WWTP) was recommended. The Stage 1 expansion, completed in 2002, increased the rated capacity of the WWTP from 54,000 to 64,000 m^3/d. The Stage 2 expansion will provide an additional increase in the rated capacity of the WWTP to 73,300 m^3/d.

The 1998 Class EA is currently being updated by the City of Guelph to review and select emerging treatment technologies for pilot testing and incorporation into the design of the Stage 2 expansion. This update is a result of a commitment included in the 1998 Class EA document to review technology options prior to the Stage 2 expansion.

The 1998 Class EA also recommended that biosolids management be further examined for the Stage 2 expansion to determine the most suitable approach for facility expansion and upgrade and for biosolids use or disposal. Since the Stage 1 expansion is complete and new legislation, including Ontario's Nutrient Management Act (NMA), was identified as potentially impacting the existing biosolids management approach, this Biosolids Management Master Plan (BMMP) was developed to address biosolids issues for the future.

The BMMP followed the Class Environmental Assessment planning and decision-making process identified for master plans.

The Class EA Update and the BMMP studies are related, as they both focus on activities and programs at the WWTP. The innovative technologies evaluated in the Class EA Update are focused on the liquid stream of the wastewater conveyed to the plant. The technology selection and implementation will generate biosolids with certain quality and quantity characteristics, depending on the technology selected for the Stage 2 expansion. This information is important to the BMMP decision-making process as it will determine the characteristics of the biosolids product and related feasible end uses and disposal options.

Report Organization

This report documents the BMMP. Section 1 provides a brief introduction and background to the study. The Master Planning process followed for this study is described in Section 2. The need and rationale for the BMMP is presented in Section 3. The assessment of compost utilization options and the examination of the existing compost facility are documented in Sections 4 and 5, respectively. Section 6 outlines the technology evaluation and strategy development. Section 7 provides an implementation plan for the recommended strategy. Reports on technical tasks are appended to this report, as are all correspondence and public consultation materials.

2. Master Planning Process

Class Environmental Assessment Process

This project followed the Municipal Engineer's Association Class Environmental Assessment (Class EA) (June 2000) process for master plans. Accordingly, Phases 1 and 2 of the Class EA decision-making process were completed including consultation with stakeholders and documentation of a Master Plan (Figure 2-1). For this project, the objective of the Master Plan was to develop a strategy for the management of biosolids generated at the Guelph WWTP in an environmentally sound, efficient, and cost-effective manner. The study included defining the need based on existing conditions and future wastewater treatment capacity, developing and assessing alternatives and identifying a preferred alternative, or set of alternatives, that will form a strategy for the long-term management of biosolids. This process included the participation of the community, whose input has influenced the development of the overall Master Plan components recommended in this plan. The Master Plan provides the basis and rationale for future Class EA studies prior to the design and construction of site-specific works recommended in the Master Plan.

Biosolids Master Plan Decision Tree

A decision process was developed for this study that incorporates the Class EA requirements. The preparation of the Master Plan involved the completion of six individual tasks that followed a logical, traceable and defensible sequence, serving as the foundation for a single decision-making process. The Decision Tree is presented in Figure 2-2. Tasks 1 and 2 (Master Plan definition and the determination of compost utilization opportunities) addressed Phase 1 of the Class EA requirements. Tasks 3 and 4 (the determination of compost optimization alternatives that provide cost savings and selection of a preferred biosolids management option to meet the City of Guelph's long-term needs) addressed Phase 2 of the Class EA requirements. Task 5 involved documenting the strategic activities of the BMMP, including recommended actions. The development and implementation of a stakeholder consultation plan to support and satisfy the Master Plan requirements under the Class EA process was completed as Task 6, and was undertaken concurrently with the other tasks.

Stakeholder Participation

Project Team

The project team for this study includes:

- City of Guelph
  - Management and operations staff of the WWTP

FIGURE 2-1
CITY OF GUELPH BIOSOLIDS MANAGEMENT ALTERNATIVES PLANNING

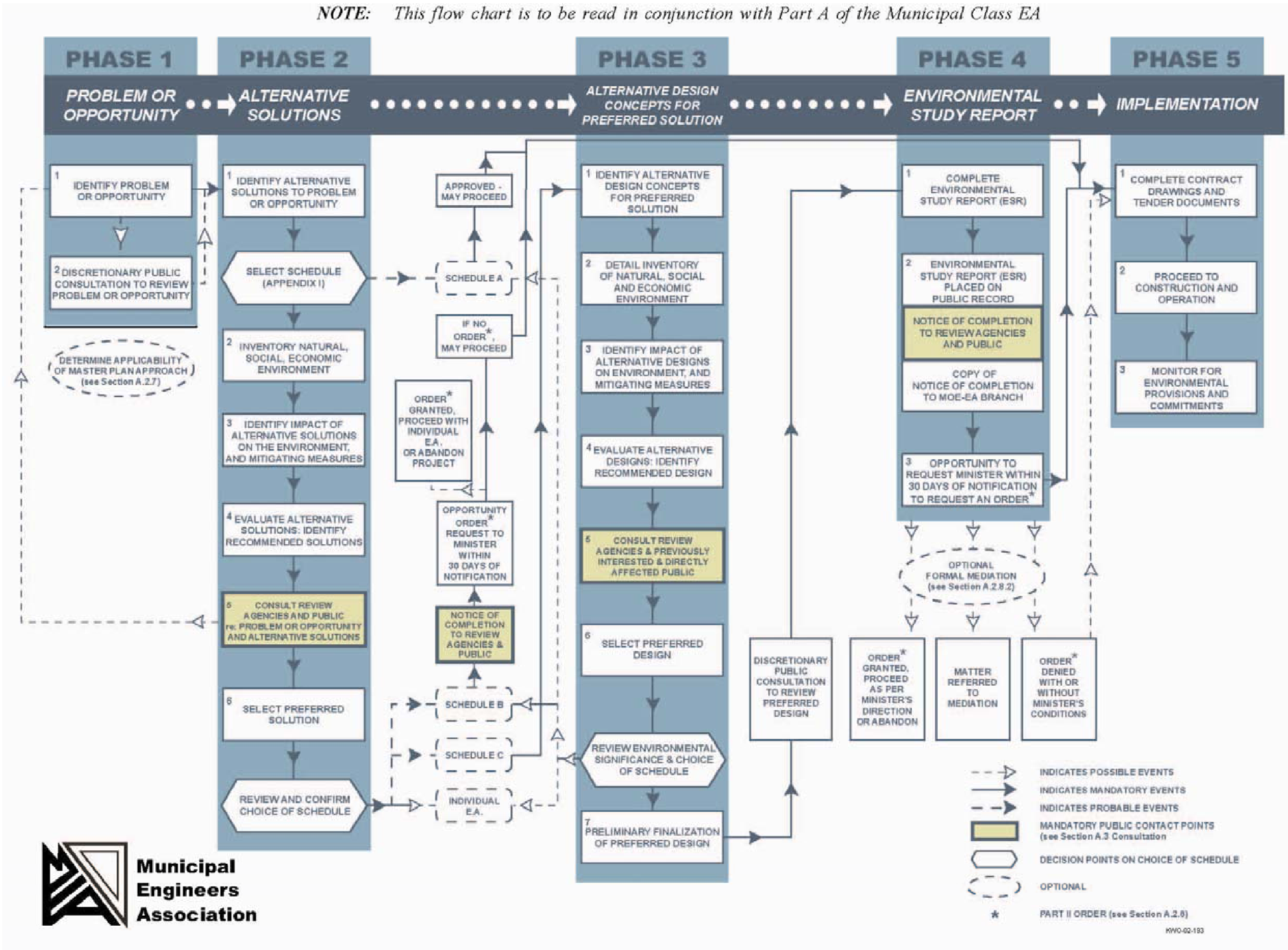
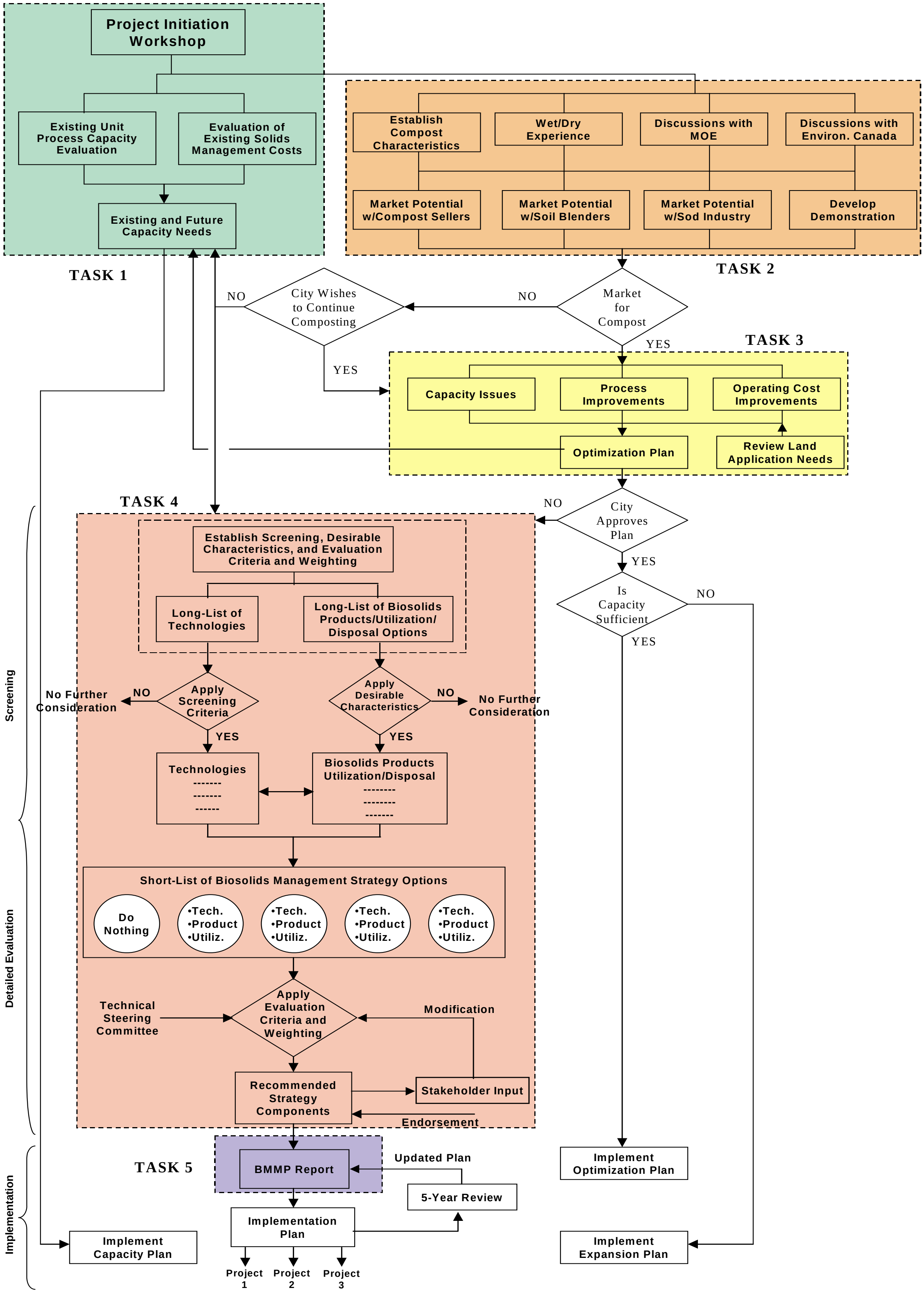


FIGURE 2-2
CITY OF GUELPH BIOSOLIDS MANAGEMENT DECISION TREE



- CH2M HILL Canada Limited
  - Peter Burrowes, Project Manager
  - Multi-disciplinary team of engineers and planners

Review Agencies

The following agencies were consulted during the preparation of this BMMP:

- The Ontario Ministry of the Environment (MOE)
- The Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA)
- The Grand River Conservation Authority (GRCA)

Agency correspondence is presented in Appendix A.

Public Involvement

Project Initiation

The public involvement activities for this project were initiated at the outset of the study with an "Invitation to Participate" that was published in the Guelph Tribune, posted on the City of Guelph's web site and mailed to those listed on the City's project mailing list. At the same time a Fact Sheet was also made available. It included an overview of the study components and decision-making process and provided contact information.

Public Open House

A Public Open House was held on February 27, 2002. The purpose of the Open House was to provide an introduction of the study, including the study purpose, decision-making process and background information on the biosolids produced and managed at the WWTP. The event included a display of project information. An Information Brief and Comment Sheet were provided to attendees. City of Guelph staff and members of the consultant team were on hand to discuss the information and to respond to questions. The Open House received 11 visitors. No significant issues were identified as a result of the Open House.

Public Information Centre

A Public Information Centre (PIC) was held on June 21, 2005. This event was conducted as a joint PIC with the WWTP Class EA Update. The purpose of the PIC was to present the evaluated options for biosolids management, disposal and end use, and the recommended biosolids management strategy. The PIC received nine visitors. There were no specific issues raised on the BMMP recommendations.

The public notices, Public Open House and PIC materials, and study correspondence are presented in Appendix B.

Rationale for this Project

The need for this Master Plan was identified in the 1998 Wastewater Treatment Strategy Class EA. The trigger for starting the Master Plan was determined by the need to proceed with the Stage 2 liquid side expansion of the WWTP. Accordingly, the goal of this study is to develop a Master Plan for the management and end use of biosolids generated at the WWTP.

For this project, the objective of the Master Plan was to develop a strategy for the management of biosolids generated at the Guelph WWTP in an environmentally sound, efficient, and cost-effective manner.

The service area for this Master Plan is the existing service area of the Guelph WWTP.

Project Expectations and Critical Success Factors

Project Expectations

The expectations for this project were:

- To find a beneficial use for the biosolids compost
- To address current and future needs for biosolids and the City of Guelph
- To formulate a plan which meets the City of Guelph's biosolids issues whilst also meeting government standards and public scrutiny
- To use the wet/dry facility's experience as a resource

Critical Success Factors

The success of this project will be determined based on the following critical success factors:

- Value provided (Capital and Operation and Maintenance [O&M])
- Solutions are forward-looking
- Solutions are integrated with the WWTP processes
- Project is consistent with the community's values and environmental focus
- Regulatory requirements are met or exceeded
- Preferred strategy is endorsed by the public and stakeholders

3. Task 1: Management Plan Definition

Task Objective and Description

Task 1 was initiated in November 2000, and was completed in May 2001. The objective of Task 1 was to develop a framework for preparing the Master Plan. It included: analyzing the condition and capacities of existing equipment, estimating existing operational costs and determining existing and future solids processing capacity and potential equipment needs. This task provided a baseline for the subsequent study tasks and enabled the biosolids management alternatives planning to proceed.

The activities and recommendations developed in Task 1 are documented in the Task 1 Technical Memorandum (TM). TM1 is presented in Appendix C and the findings are summarized in this section of the report.

What are Biosolids?

The City of Guelph operates the WWTP, which produces treated biosolids as a by-product of the process used to treat the liquid component of the wastewater received at the plant. Biosolids are primarily organic and are of a sufficient quality that they can be beneficially used for their nutrient, soil conditioning, or fuel properties. Beneficial practices include land application of biosolids as a soil amendment or as a fertilizer supplement and a variety of procedures that derive energy from biosolids or convert them to useful products. Currently, the majority of biosolids produced at the WWTP are applied on agricultural land when the weather and field conditions permit, and disposed of at landfill during all other times.

Biosolids Management History

The following provides a chronological history of biosolids management at the WWTP. Biosolids management facilities at the Guelph WWTP are identified in Figure 3-1.

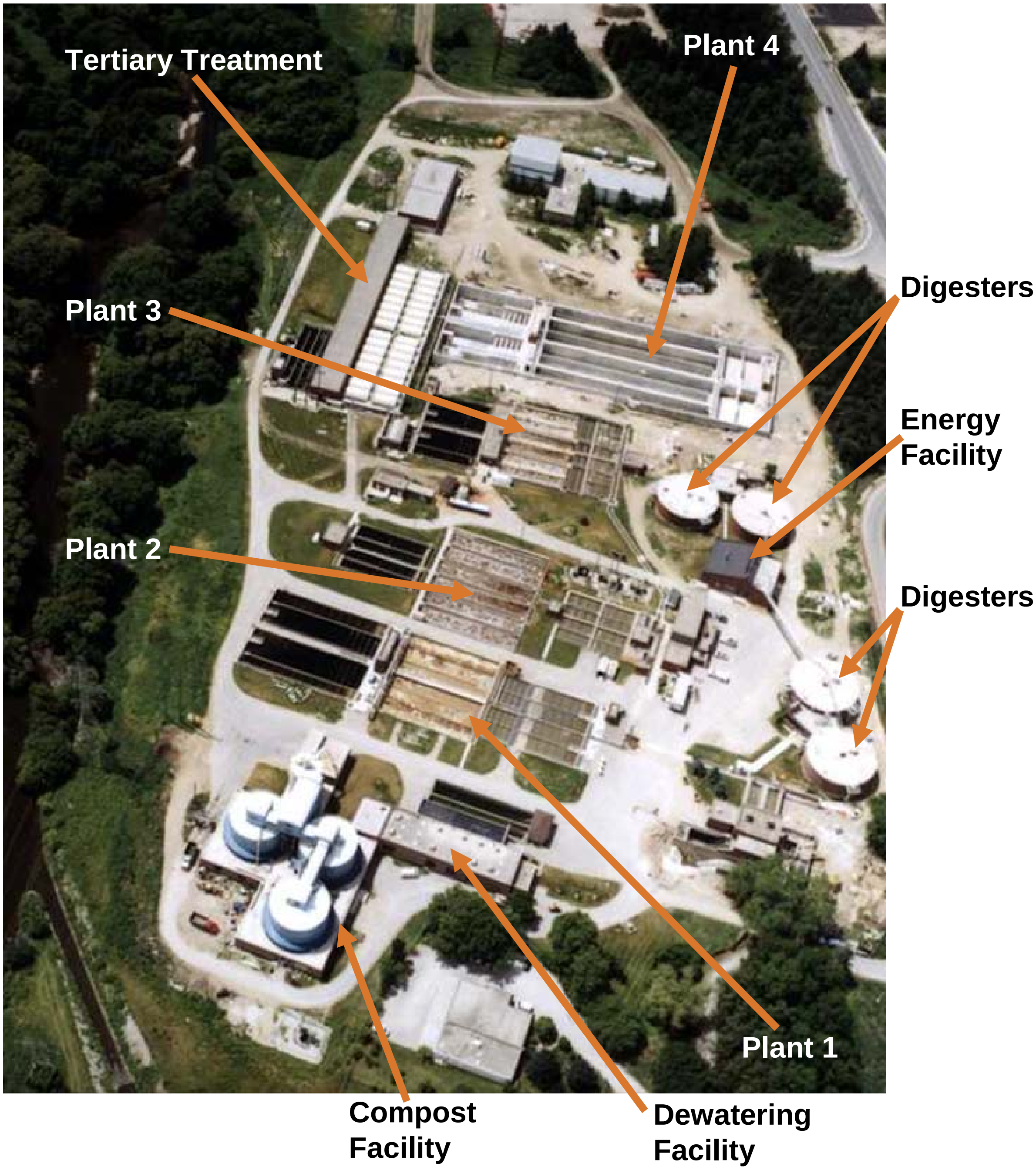
1950 -1980 – Digested (liquid) biosolids spread on land. Liquid biosolids were stored in lagoons located south of Plant 1. The lagoons were decommissioned and removed.

1980 – 1984 – The biosolids quality characteristics included a high heavy metal concentration, relative to the MOE guidelines for land application. The City of Guelph had difficulty locating sufficient agricultural lands to apply the biosolids product. This resulted in the decision to implement additional biosolids processing, including dewatering and air drying, followed by landfill disposal.

1984 – The additional processing resulted in problems with odours associated with air dried biosolids. There were also operational problems encountered at the landfill with the management of the dewatered product.

Late 1980s – The City of Guelph instituted composting and thermal drying pilot trials to find a solution to the operational and odour problems.

FIGURE 3-1
GUELPH WWTP BIOSOLIDS MANAGEMENT FACILITIES



1990 – 1995 – Biosolids Composting was selected as a preferred method to resolve the problems associated with the management of dewatered biosolids and a compost facility was constructed at the WWTP. The compost product was intended to be used as landfill cover at the City of Guelph's Eastview Landfill facility.

1995 – 1998 – All the biosolids material was digested, dewatered, composted and used as landfill cover.

1998 – In addition to composting, the City of Guelph applied digested (liquid) and dewatered biosolids on agricultural land. This allowed the City to reduce operating costs and carry out maintenance on the composting system.

2001 – City of Guelph commences work on the BMMP

2002 – Eastview Landfill is closed. Composting system used to blend dewatered biosolids with woodchips to satisfy requirements for disposal at Green Lane Landfill. Biosolids are land applied and landfilled.

2003 – City of Guelph completes Lystek demonstration trial. The Lystek process, which treats dewatered cake, produces a material that is approximately 14 to 15 percent solids, but has viscous properties similar to liquid biosolids, and can be manipulated to produce a "Class A" (under U.S. Environmental Protection Agency [USEPA] Part 503 definition) biosolids product. This process results in a reduction in the biosolids volume, compared to a traditional liquid product. Odour potential is also reduced. This results in reduced storage and transportation requirements. The product can be stored and land applied, similar to a liquid product.

2004-2005 – City of Guelph installs full-scale Lystek process and initiated waste activated sludge (WAS) thickening pilot testing. Lystek biosolids are applied to agricultural land, along with liquid (digested) and dewatered biosolids. Dewatered biosolids blended with woodchips are landfilled when land application is not available.

2005 – Due to age, the two oldest belt filter presses (BFPs) in the dewatering facility require replacement. A tender was issued and equipment selected for installation in 2006. A demonstration rotary drum thickener for waste activated sludge (WAS) was purchased. The unit will be operational in 2006 and will thicken WAS from Plants 1, 2 and 3.

Existing Biosolids Treatment System

With the compost system fully operational (1995–2000) the Guelph WWTP generated about 54 m^3/d (20,000 m^3/yr) of unscreened compost. The unit processes that comprise the solids treatment system at the WWTP include digestion, dewatering, Lystek treatment, and composting. Each process is summarized below.

Anaerobic Digestion

High rate mesophylic anaerobic digestion is the most commonly used biosolids stabilization process in Canada and the U.S. Biological organisms decompose organic matter in the absence of oxygen and at temperatures of 30°C to 38°C, which produces methane, carbon dioxide, water, and partly degraded organics. The MOE recommends a minimum 15-day hydraulic retention time (HRT) as a design guideline for this process to provide sufficient stabilization of organic material. The current facilities are operating at capacity. Additional digestion capacity is required to provide redundancy for maintenance and for future solids processing needs, to maintain a minimum 15-day HRT in the primary digesters. In 2000, digestion cost was approximately $31 per dry tonne produced.

Dewatering

BFPs are commonly used for dewatering biosolids. Liquid is removed by squeezing the biosolids between two porous belts. The existing facilities include four presses and can provide the dewatering capacity required for Stage 2 expansion to 73,300 m^3/d, assuming that the facility can be operated for a longer period of time each day. However, two BFPs require replacement in 2006 due to age and deteriorated condition. It is anticipated that the remaining two BFPs will require replacement due to age in approximately 2010. In 2000, the dewatering cost was $139 per dry tonne cake produced.

Lystek™

A proprietary process, Lystek treatment uses temperature and pH adjustment to promote cell lysis of dewatered biosolids. By breaking down cell walls in the batch process, a product with fluid-like properties is generated. This “high solids fluid”, with about 14 percent solids, is suitable for agricultural land application, with the benefit of reduced volume compared to traditional liquid biosolids, and easier storage and land application operation than dewatered biosolids. The demonstration trials in 2003 were successful and continued with land application of the Lystek-treated biosolids in 2004. Installation of the full-scale reactor was completed in 2006, with the ability to process a maximum of 6 dry tones (dt)/d.

Composting

Composting is a biological stabilization process for organic matter. An in-vessel (enclosed) system is used at the Guelph WWTP producing compost from a mixture of woodchips and dewatered biosolids. The compost facility was designed to process 15,100 dry kilograms of biosolids per operating day, dewatered to 20 percent total solids with an allowable range of 17 to 20 percent solids. The facility was designed as a three-vessel reactor system (two in operation with one for additional curing) with an estimated combined retention time of 26.5 days. Normally the system is forced to operate as a one- or two-vessel system due to scheduled and unscheduled reactor shutdowns. This results in a compost product that contains approximately five percent greater moisture content than design specifications due the decreased material resident time. In 2000, the cost of composting was $353 per tonne. The facility required a significant amount of unscheduled maintenance due in part to the increasing age of equipment and processing problems caused by metal, stones and oversized material mixed into the amendment material.

Task 1 Conclusions

The Task 1 conclusions are as follows:

- The Guelph WWTP solids management systems are sufficient to process the projected residuals, at current average influent concentration conditions, until the 73,300 m^3/d plant capacity has been reached, with required process unit replacements due to age. An increase in digestion capacity is required to meet the MOE 15-day HRT guideline.

- Industrial wastewater loadings may have a significant impact on solids production at the WWTP. Current maximum and City of Guelph by-law compliance loadings were estimated for predicted future industrial wastewater flows. This showed that if industries produce wastewater at current maximum loadings and predicted flow rates, the estimated WWTP solids production will be approximately 40 percent greater than industrial wastewater at by-law compliance loadings and predicted flow rates.
- The resulting solids contribution from industrial loading decreases the available capacity in the existing process units and would advance the requirement for additional unit process capacity in the solids management train. As the contribution loading of major industries is largely soluble in nature it may impact the secondary treatment system of the WWTP and increase the volume of WAS produced. Without WAS thickening, additional WAS would decrease the settleability of solids co-settled in the primary tanks, resulting in larger volumes of sludge, due to a decreased solids concentration and a greater mass of solids.
- The estimated operational costs provide a baseline to which future costs and costs of alternative management systems can be compared.
- Composting capacity is estimated to be sufficient to the capacity planning horizon, assuming that raw wastewater influent loadings remain stable or are reduced and a three-vessel system can be maintained. However, the degree of product stability required will depend on the ultimate end use or disposal of the compost product. Additional retention time in the reactor vessels can be obtained through a drier dewatered biosolids feedstock and additional stability can be obtained through additional curing of the material, by outdoor storage, if required. Retrofitting of the drive system of the outfeed device and other work is required to improve the reliability of the composting facility.

4. Task 2: Compost Utilization Assessment

Task Objective and Description

The objective of Task 2 was to determine if there are viable end uses for the composted biosolids product currently produced a the WWTP and to identify the required product quality. Subtasks included:

- *A Composting Market Survey* – Development and execution of a market survey to identify potential end users (companies and organizations) and uses for the composted biosolids product.
- *A Regulatory Review* – Identification of regulatory (quality) requirements for various composted biosolids end uses.
- *Utilization Demonstration Program Plan* – Development of demonstration program for selected composted biosolids end uses using the biosolids product currently produced at the WWTP.

The activities and recommendations developed in Task 2 are documented in the Task 2 TM. TM2 is presented in Appendix D and summarized in this section of the report.

Composting Market Survey

A telephone market survey was conducted in 2001–2002 to identify potential end uses and end users for the composted biosolids produced at the WWTP. The survey was designed to collect information on the following:

- Types of uses for the compost
- Potential demand for compost
- Potential revenues from the sale of compost
- Regulatory issues
- Compost quality issues

The end users surveyed included:

- Regulatory agencies including Ontario Ministry of Agriculture, Food and Rural Affairs (OMFRA), and the Ontario Ministry of the Environment (Guelph District and Approvals Branch)
- A landfill operation
- City of Guelph Public Works Department
- Landscape Companies
- Top Soil Blending Companies
- Sod Farm Operators
- Golf Course Operators

The results of the survey contributed, in part, to the determination of the future viability of the existing compost system at the WWTP and its potential contribution as a component of an overall biosolids management strategy.

Potential End Uses

The potential end uses identified through the market survey include:

- Agricultural land application, including:
  - Low nitrogen crops
  - Tree farms
  - Sod farms
- Recreational sites, including:
  - Golf courses
  - Ball parks
- Topsoil market
- Soil conditioner – where biosolids are blended with poor quality topsoil to improve fertility, including:
  - Bulk sales from the WWTP to the public and /or brokers and blenders
  - Bagging/Sales
- Landfill cover material
- Land reclamation operations, including:
  - Quarries
  - Mines
  - Aggregate extraction areas

Potential End Users and Demand

The market survey identified several viable end use markets for the composted biosolids produced at the WWTP. End users potentially include landscapers, topsoil blenders and distributors, landfill operators, mining and quarry operators, sod farm operations, and golf courses. The City of Guelph Municipal Works Department and provincial works operations were also identified as potential end users.

Based on the maximum potential capacity of the composting facility, the City of Guelph could produce about 27,000 m^3/yr of composted biosolids. The potential demand for compost within approximately 40 km of the City and the associated revenue is presented in Table 4.1.

TABLE 4.1
POTENTIAL DEMAND AND REVENUE FROM THE SALE OF COMPOST

Compost Market	Potential Demand and Revenues for Compost: Demand (m^3/yr)	Revenue ($/$m^3$)	Revenue ($/yr)
Landscapers	26,000[1]		
Topsoil blenders and distributors	40,000[2]	$10	$400,000[3,9]
Landfill operators	0[4]	-[5]	-
Mining and Quarry Operators		-[5]	-
Agricultural (sod farms)	40,000[6]	-[5,7]	-[5,7]
Golf Courses	-[8]	-	-
Public Works	1,000	-	-
Total	**107,000**	**$0 – $10**	**$0 – $400,000**

Notes:
[1] Landscapers assumed to utilize 65 percent of topsoil from distributors
[2] Surveyed topsoil distributors assumed to represent 30 percent of local topsoil market
[3] Concerned with composted biosolids quality
[4] Sufficient construction soil wastes and topsoil available onsite
[5] Users would take compost at no cost
[6] Generator would pay for transportation costs to the site
[7] At 20 tonnes (33 m^3) per hectare (ha) per year
[8] No interest due to quality concerns
[9] If all of Guelph's compost utilized, $270,000 potential revenue

The survey results show that maximum potential market demand is estimated to be 107,000 m^3/yr. The largest market demand is potentially from the sale of compost to topsoil blenders and distributors, and sod farm operations. The majority of this demand is of a seasonal nature, with peak demand identified in the spring period.

Potential Revenue and Market Issues

Through the survey it was determined that potential revenues from the sale of composted biosolids are estimated to be about $270,000 per year. Regulatory and biosolids quality characteristics must be demonstrated before potential users would consider purchasing the material.

Compost quality, public perception of product safety, and government approval requirements were identified as potential obstacles to the use of composted biosolids in the marketplace. Specific issues identified in the survey include:

- The impacts associated with metal, pathogens and toxic organics that are present in the compost product
- The uncertainty that sufficient monitoring and quality control practices are in place
- The lack of experience with using composted biosolids in the market place
- The public perception and the stigma associated with biosolids and potential impacts on business operations
- The concern with safety risks and public contact

Task 2 Recommendations

Based on the results of the market survey, the following recommendations were developed:

- **Recommendation #1** – Complete demonstrations with topsoil blenders, sod farms, and land reclamation activities in partnership with regulatory agencies. The purpose of the demonstrations is to:
  - Demonstrate operations and quality control practices to produce a safe consistent product for end use
  - Demonstrate the product with willing end users identified through the survey
  - Complete additional monitoring and identify further processing requirements if needed (i.e. screening, curing), depending on end use needs.
  - Develop new markets for the use of the composted biosolids

  Implementation of the demonstration projects must include the following components:

  - Defined demonstration objectives
  - Approval requirements
  - Demonstration project description, including application rates, methods, equipment requirements, area requirements, etc.
  - Implementation plan including costs
  - Schedule and logistics
  - Demonstration program participation
- **Recommendation #2** – Construct a storage facility for the storage and curing of composted biosolids
- **Recommendation #3** – Monitor the composted biosolids for bulk density and soluble salts parameters
- **Recommendation #4** – Combine marketing efforts with the City of Guelph's wet/dry composting operations as a means to address common issues
- **Recommendation #5** – Develop public education materials to improve public perception of the composted biosolids material and end uses
- **Recommendation #6** – In conjunction with demonstration projects, the City of Guelph should initiate discussions with the MOE and the Canadian Food Inspection Agency (CFIA) to develop support for the beneficial utilization of composted biosolids and to establish regulatory requirements and approaches to meet regulations. The City should continue to develop and compile analytical data on the composted biosolids to support these efforts.

Demonstration Project Recommendations

Based on the market survey, the following demonstration projects were identified:

- Sod Farm operations
- Land Reclamation activities
- Topsoil Production

The purpose of the demonstration projects is to develop new markets for the use of the compost product. Implementation of the demonstration project must include the following components:

- Defined demonstration objectives
- Approval requirements
- Demonstration project description, including application rates, methods, equipment requirements, area requirements, etc.
- Implementation plan including costs
- Schedule and logistics
- Demonstration program participation

At the time this report was prepared, the City of Guelph had been unable to carry out composting demonstration projects due to equipment and processing issues at the WWTP. Due to the processing issues, and a restricted regulatory environment, the City stated its wishes to proceed with the evaluation of other biosolids management alternatives. Accordingly, the study moved to the identification and evaluation of an expanded list of management alternatives. The composting alternative continued to be evaluated as a feasible option for the remainder of the operational life cycle of the existing compost processing facilities.

5. Task 3: Compost Process

The purpose of Task 3 was to investigate the alternatives for optimizing the existing composting operations. This task involved using the cost information generated in Task 1 and the composted biosolids quality requirements developed in Task 2 to identify recommendations for operational optimization that would result in both cost savings and process improvements. The activities and recommendations developed in Task 3 are documented in a Task 3 TM3. TM3 is presented in Appendix E and summarized in this section of the report.

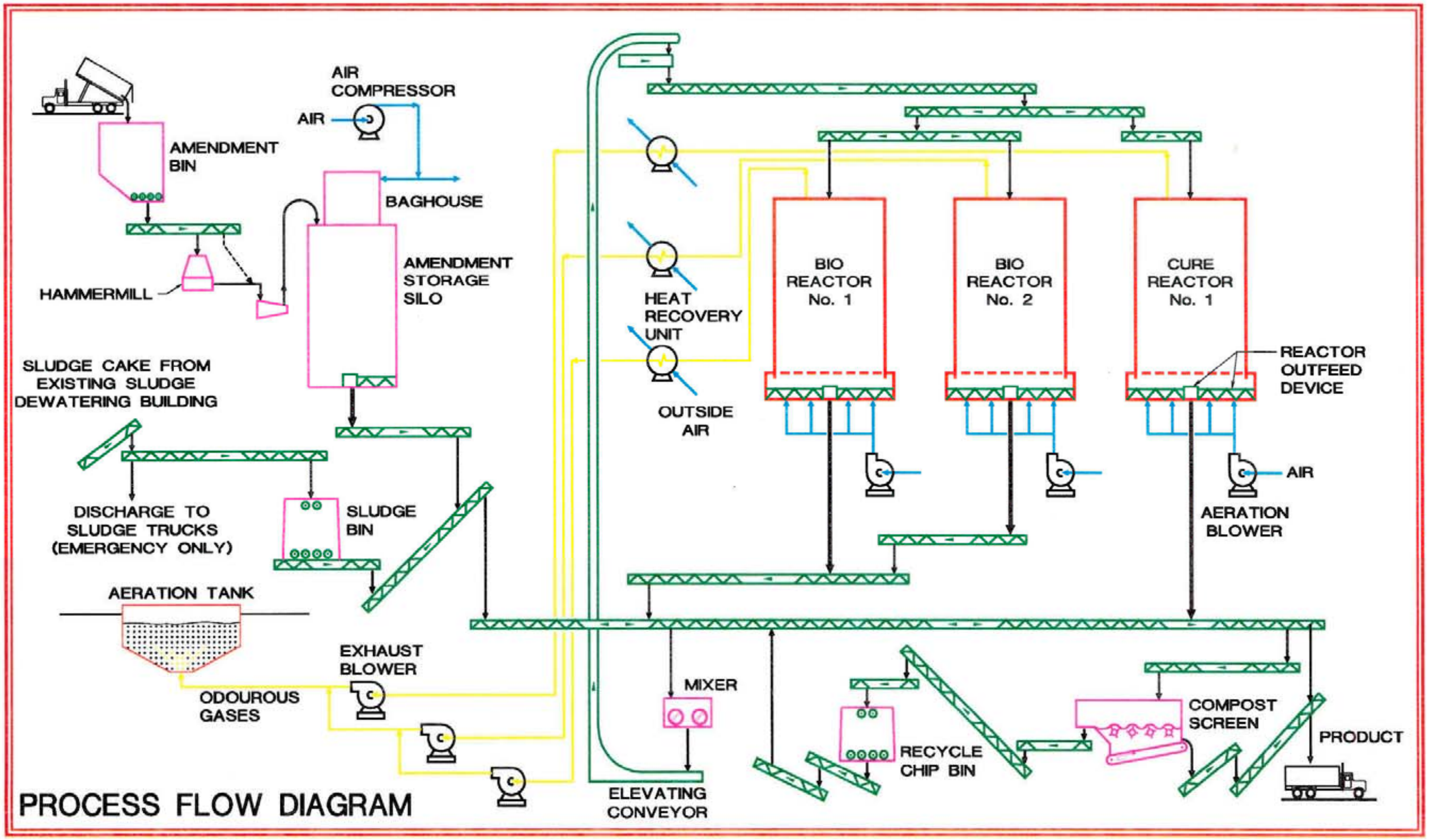
Major Equipment Components

The compost system includes the following major equipment components:

Major Equipment Component	*Function*
Amendment Receiving/Storage	Receives and stores amendment material (woodchips) in a large silo
Sludge Storage	Completely enclosed bin that receives dewatered biosolids cake.
Mixer	Blends the dewatered biosolids, wood chips, and recycled compost. Also homogenizes the compost product during the transfer from the bioreactor to the cure reactor.
Transport systems	A series of screw conveyors and sandwich-belt conveyors that move raw materials and intermediate and finished compost through the processing facility.
Bioreactors	Vessels where the composting occurs. Material is loaded at the top of the reactor. Composting occurs as the material moves down through various zone environments.
Loading	Conveys compost from the bioreactor to the cure reactor in batches
Aeration system	Provides a continuous flow of compressed air to each reactor through a system of perforated pipe together with a coarse gravel bed which provides for a comprehensive distribution of air. The reactors are kept under a very small negative pressure to prevent compost exhaust from escaping. Compost exhaust is collected, passed through air-to-air heat exchangers and discharged to the aeration tanks.
Instrumentation and Controls	A SCADA system provides automatic system controls based on a selection of operating conditions.

Figure 5-1 presents the Process Flow Diagram of the composting facility.

FIGURE 5-1
COMPOST SYSTEM PROCESS FLOW DIAGRAM SCHEMATIC



The maintenance history of the facility was reviewed, as were the compost system processes and operating costs. A benchmark assessment was conducted to gauge the performance of the compost facility relative to other similar facilities in operation. Task 3 concluded with a summary of issues related to the operation of the facility and recommendations for optimizing operations and reducing costs. As the facility continues to age, the potential for major equipment repair increases as a result of failure.

Primary TM3 recommended actions for operating equipment (as of June 2002) are shown in Table 5.1.

TABLE 5.1
TASK 3 RECOMMENDED ACTIONS FOR OPERATING EQUIPMENT

Item	Comment	Potential Reliability/ Operations Improvement	Action
Amendment Receiving	Good condition; equipment may fail if amendment quality is poor	Amendment source control Ability to screen incoming amendment	Issue RFP for amendment Have contract with amendment supplier(s) with penalties for non-performance
Hammermill	Takes 3.5 to 4 hours to unload one truck of amendment through hammermill	If required for daily operation dry storage facility may be necessary	Cost/benefit analysis of dry storage area and hammermill use
Amendment storage silo	Under extreme cold weather conditions, amendment freezes in ring around the silo, can cause blockages if frozen lumps are knocked to bottom of silo	Insulate silo Heat silo	Insulate silo Heat silo
Sludge (day) bin	Capacity not compatible with current operations – dewatering operates 16 hours per day and composting 8 hours per day	Increase operations time of composting facility, requires more staff	Cost/benefit analysis of increased day bin capacity
Mixer and Controls	Top access hatch doors too big and heavy, hinges don't work	Replace doors with removable light weight covers, replace hinges	Replace doors with removable light weight covers, replace hinges
	Mixer paddles 'fling' material onto far side of funnel feeding belt and stick to side, eventually plugging funnel; must be cleaned out two to three times per day (10 – 45 mins per clean)	Line interior of funnel with HDMWPE coating system Remove last few paddles and replace with short screw	Assess efficiency of HDMWPE coating – take equipment off line and coat, before retrofitting with short screw
Slide plates	Material builds up in grooves and eventually slide gate cannot close properly; difficult to clean; results in blowers overworking and tripping out	Redesign for self-cleaning (preferred) or manual cleaning	Redesign and maintain scheduled inspections and maintenance

TABLE 5.1
TASK 3 RECOMMENDED ACTIONS FOR OPERATING EQUIPMENT

Item	Comment	Potential Reliability/ Operations Improvement	Action
Bioreactors and Cure Infeed	A shadow is cast by the distributor supports and the feed mix is unevenly distributed Spinner plate difficult to adjust, at slow speeds does not work well	Need better adjustment for spinner plate Control for spinner plate direction through PLC from SCADA Redesign spinner plate as cone-shaped and improve attachment to vessel	Design and obtain budget quotation for new spinner plate and pilot test in one reactor
	Access to reactors difficult	Need cage for each reactor Need better way to put access cage into reactor – beam and power hoist preferred	Conceptually design and obtain budget quotation for cage and beam and pilot test in one reactor
Bioreactors and Cure Outfeed	Poor reliability due to excessive bearings wear and clutch breakdown (must be replaced every 2 months) and 6- to 10-week wait for replacement parts	Test different operating scenarios	Run outfeed devices at slower rate for longer periods; ensure Taulman operating instructions are reviewed (e.g. run outfeeds at same time as filling)
		Replace outfeed device	Contact other composting facilities in US to determine preferred outfeed device alternatives Visit US facilities Request proposals for preferred new outfeed devices
Aeration blower	Air flow rate may be limiting.	Adjustable output may be beneficial	Install VFDs
Heat recovery	Does not work effectively; difficult to clean, high maintenance – if filter plugs, ducting collapses Condensate presents problems (more prevalent in winter) in the heat exchanger units themselves	Install vacuum relief valve Install ability to bypass Determine efficiency of equipment Install condensate traps	Design and install vacuum relief valve, ability to bypass and condensate traps Request proposal by manufacturer to overhaul or retrofit to improve efficiency
Ventilation	Heat relief and ventilation poor; in summer 2001, 4 large fans were purchased to reduce temperature Some exhaust fan motors have failed to be accessed for maintenance	Place exhaust fan on building exterior Provide (fixed) safe access to motors Ensure louvre screens are clean	Assess building HVAC and air flow to determine best location of exterior fan and any necessary ducting retrofits Design and request budget quotations for access ladders to motors Maintain scheduled inspections and maintenance
Instrumentation	SCADA computer outdated	Update SCADA computer	Update to windows based system compatible with WWTP operating system Implement new logic and SCADA screens during computer upgrade

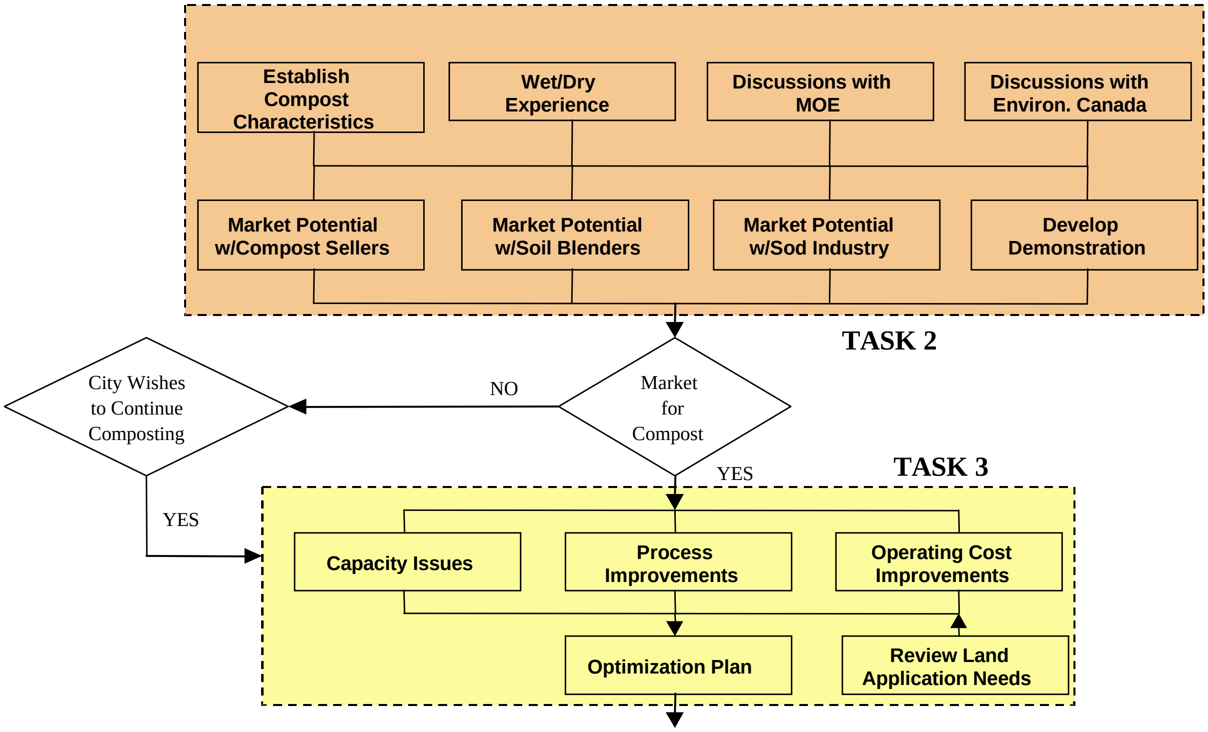
TABLE 5.1
TASK 3 RECOMMENDED ACTIONS FOR OPERATING EQUIPMENT

Item	Comment	Potential Reliability/ Operations Improvement	Action
Conveyors			
351	Requires replacement	Replacement is scheduled	Maintain scheduled inspections and maintenance
552 B	Requires replacement	Replacement to be scheduled	
550	Requires new endplate	Endplate replacement to be scheduled	
553 (final discharge)	Requires replacement	Replacement is scheduled	
554	Safety cages and rollers on doors require redesign and replacement	Redesign and replacement to be scheduled	
562	Requires new endplate	Endplate replacement is scheduled	
Feed mix	C:N ratio may not be optimum Moisture content difficult to control and maintain with one reactor system	Measure mix C:N of feed and moisture regularly Use Taulman 'recipe' as guideline	Discuss with other facilities any scientific approaches used
Level and temperature monitoring	1 level sensor per reactor system ineffective with current infeed distribution problems	Retrofit additional level sensors Mount IR camera, radar or ultrasonic sensor to show profile of top	Determine preferred alternative Obtain budget quotation Install in one reactor to pilot test
	Three temperature probes per reactor are insufficient to provide an accurate reactor profile	Retrofit additional 2 or 3 temperature probes at each level	
Maintenance Scheduling	Emergency maintenance predominant	Work towards preventative maintenance Correct continuous outfeed device problems	Employ dedicated maintenance worker(s)
Annual Costs	Amendment	Screen and recycle	Review effectiveness of screening, hammermill, etc.
		Issue amendment contract RFP to maintain competitiveness of suppliers	Produce amendment RFP for competitiveness of suppliers Review costs and benefits of amendment types and suppliers
	Operations overtime	Employ maintenance and cleaning staff	Employ dedicated maintenance worker(s) and cleaners/ labourers

Decision Process Triggers

The decision process for this Master Planning exercise was defined in Task 1. Tasks 2 and 3 were completed and, accordingly, the next steps in the planning process were determined through a decision triggered by the outcomes of Tasks 2 and 3. The triggers are explained below and illustrated in Figure 5-2.

FIGURE 5-2
TRIGGERS FOR DECISIONS



- **If Tasks 2 and 3** determined that the existing compost facility at the WWTP **has** reliable capacity for the solids produced at 73.3 megalitres per day (MLD) (the long-term planning period requirement) **and** reliable end use options (for the composted biosolids that are produced) **then no further evaluation would be required.** The Master Plan document would be prepared and the proposed activities would be implemented.
- **If Tasks 2 and 3** determined that the existing compost facility **has** reliable capacity **for less than** 73.3 MLD **and** reliable end use options **then** an evaluation of treatment and processing options would be required to identify a solution to provide the additional capacity requirement.
- **If Tasks 2 and 3** determined that the existing compost facility **does not have** reliable capacity for the future **or** there are no reliable end-use options **then** a comprehensive evaluation would required to determine a long-term solution to provide full biosolids production capacity and reliable end uses.

It was determined through Tasks 2 and 3 that the WWTP biosolids management treatment processes have or could have, with recommended upgrades, sufficient capacity to manage the anticipated biosolids volumes that are expected to be generated by the Stage 2 liquid side treatment capacity expansion to 73.3 ML/d. However, it was found that the compost system requires ongoing maintenance due to equipment and processing issues. Additionally, it was determined the composted biosolids product would likely not gain regulatory acceptance as a stand alone material for sale and that it would require demonstration, regulatory acceptance and effort to develop a suitable market for the composted biosolids. Accordingly, the City of Guelph decided to proceed with a comprehensive evaluation of biosolids management options to develop a long-term strategy for biosolids treatment capacity and end use. This decision initiated Task 4 of the Master Planning process.

Since initiating Task 4, the City has determined that the resources required to upgrade and keep the composting facility operational have and will impact its ability to keep the rest of the plant operating reliably. Therefore, the City has elected to operate the compost facility as little as possible and replace it as soon as is practically possible.

6. Task 4: Biosolids Management Strategy Development

The purpose of Task 4 was to develop a biosolids management strategy. The management strategy development included a two-staged evaluation process. Stage 1 included an initial screening of a long list of technologies, products and end uses (presented in TM4 Part I). The resulting short list of technologies, products and end uses were then combined to form management strategies (TM4 Part II). In stage 2, the strategies were then developed to determine the conceptual design requirements (TM4 Part IIIA) and evaluated using detailed evaluation criteria to rank strategies and to provide the basis for decisions on the long-term plan (TM4 Part IIIB). The activities and recommendations developed in Task 4 are documented in these TMs which are presented in Appendix F and summarized in this section of the report.

Developing the Long List

In order to determine which of the many technology alternatives available for biosolids management were feasible for the City of Guelph, the project team first reviewed all the possible end uses for biosolids based on defined priorities. Once feasible end uses had been identified, the products required for these end uses were then established. Finally, the technologies available to make these products, that met the defined priorities, were determined.

Stage 1 – Screening the Long List

In Stage 1, a set of screening or “must have” criteria were developed to screen the long list of alternative treatment technologies and end-use options (utilization and disposal). Those options that did not meet all criteria were eliminated from further evaluation. The screening resulted in a shortlist of desirable technology options and end use options. The options were then combined to produce biosolids management strategies that were further evaluated in more detail. The screening criteria are presented in Table 6.1.

Summary of Screening of Biosolids End Uses

For this study, six end uses were identified. From this set of end uses, three were found to meet the priorities defined for end use alternatives. The screening results are presented in Table 6.2.

TABLE 6.1
STAGE 1 – SCREENING CRITERIA

Screening Criteria	Considerations
Priorities for End-Uses	**Integration:** Opportunity to take advantage of existing infrastructure; the absence of major obstacles to implementation; end-uses must be within the City of Guelph's capability to implement (technically, financially, regulatory) **Sustainability:** End-uses should endure over time in an environmentally-safe manner; the long-term strategy must provide the capacity to manage all the biosolids produced at the WWTP **Reliability:** End-uses should meet or exceed Ontario's regulatory requirements and standards; the overall biosolids management strategy must be reliable, meet public scrutiny, and be enforceable within the City of Guelph's current framework **Flexibility**: Overall biosolids management strategy should include a variety of treatment and end-use options that should be adaptable under different circumstances
Priorities for Treatment Technologies	**Reliability**: Technologies should be proven to maintain uninterrupted options; treatment must be proven to demonstrate reliability; at least three years implementation at a similar size facility

TABLE 6.2
SUMMARY OF SCREENING EXERCISE FOR END USES

End Use Option	Must-Have Criteria				Remarks
	Community Health & Safety	Reliability	Sustainability	Flexibility	
Agricultural Land	Pass	Pass	Pass	Pass	
Forested Land	Pass	Pass	Fail	Pass	Sufficient area of forested land is not available
Land Reclamation	Pass	Pass	Pass	Pass	
Landfill Disposal*	Pass	Pass	Fail	Pass	No operating landfill in Guelph area
Public Contact	Pass	Pass	Pass	Pass	
Industrial Use	Pass	Pass	Fail	Pass	No market potential

Notes: * Landfilling could be maintained as a back-up end-use, utilizing facilities outside of the Guelph area.
The shaded End Use Options pass all must-have criteria

Three of the options failed the screening. Biosolids application to forested land does not meet the requirement for sustainability due to the limited area of forested land accessible to Guelph, at the present. As there is no active landfill in the Guelph area, this was not considered a sustainable option for the long term, but could be utilized as a back-up contingency. There is no identified market potential for industrial use of biosolids at this time in the Guelph area.

While land reclamation passes all the must-have criteria, as there is potential for quarry reclamation close to the WWTP, this market would have to be developed.

Should the markets for end use alternatives change in the future, the technology alternatives selected should allow for flexibility to adapt to these opportunities under the guidance of the subsequent updates of this BMMP.

Summary of Screening Long List of Process Technologies

Six categories of process technologies were screened using the defined priority (reliability) for technologies. For each process category a minimum of six technologies was evaluated against the Must-Have Criteria. The results of the screening are presented in Table 6.3.

TABLE 6.3
SUMMARY OF SCREENING LONG LIST OF PROCESS TECHNOLOGIES

Technology Category	Number of Technologies Evaluated	Number of Technologies that Met Defined Priorities	Technologies Passed
Conditioning/Optimization	19	1	• Polymer
Thickening	7	4	• Centrifuge • Gravity belt thickener • Rotary drum thickener • Dissolved air floatation
Stabilization – Liquid	22	3	• Conventional anaerobic digestion • Thermophilic anaerobic digestion • Lime stabilization (liquid)
Dewatering	14	2	• Centrifuge • Belt filter press
Stabilization – Post-Dewatering	24	3	• Thermal drying • Alkaline stabilization (AASSAD, Biodry, Envessel, Pasteurization, Biofix) • LystekTM
High Temperature Combustion/ Oxidation Processes	17	0	

Only one technology for conditioning/optimization, polymer, passed the screening exercise. The majority of WWTPs in North America utilize polymer for conditioning/optimization, and this practice is currently used at the Guelph WWTP.

Four thickening technologies (centrifuge, gravity belt thickener, rotary drum thickener and dissolved air floatation) met the must-have criteria.

The three liquid stabilization technologies that passed the screening exercise were conventional anaerobic digestion, thermophilic anaerobic digestion, and liquid lime stabilization. All these technologies are used in North America for liquid biosolids stabilization, and the Guelph WWTP currently uses conventional anaerobic digestion.

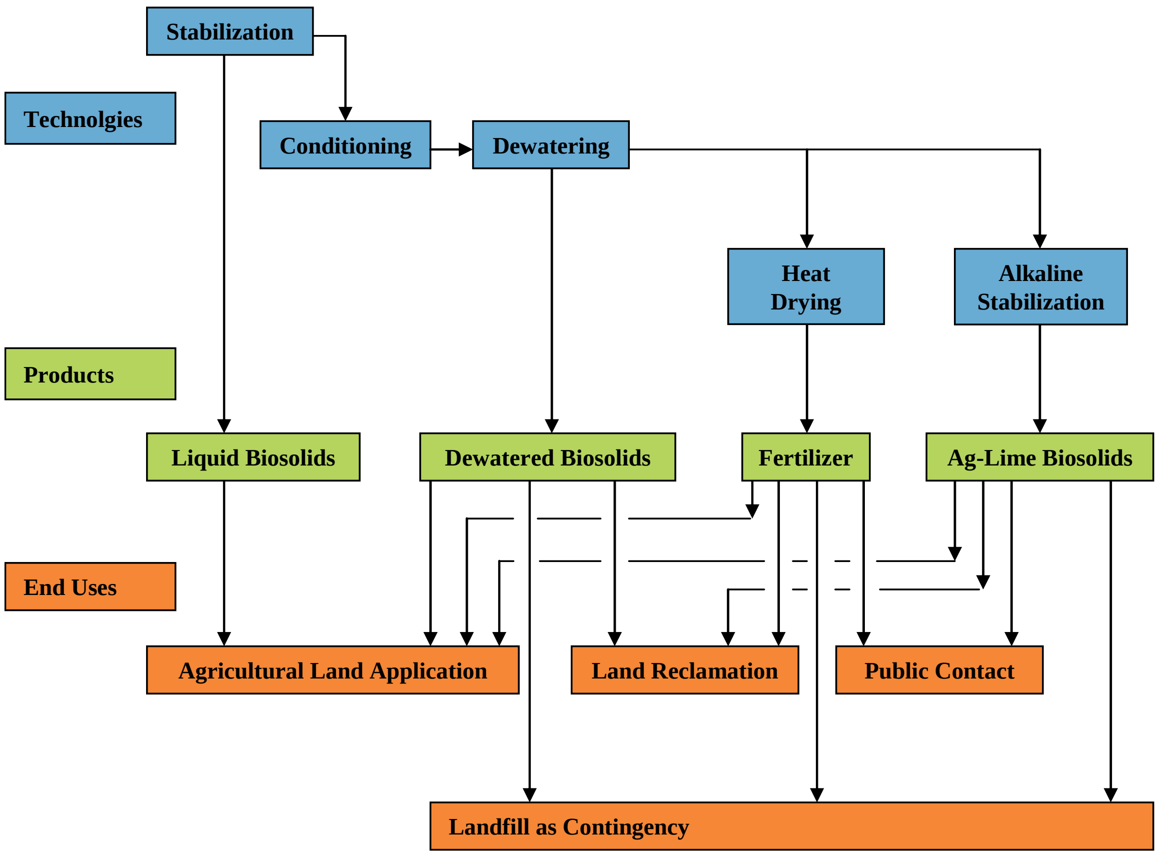
Of the 14 dewatering processes screened, two (centrifuge and belt press) technologies passed the exercise. BFPs are currently utilized at the Guelph WWTP, and the City of Guelph has recently tendered for replacement of the two oldest BFP with new BFPs.

Thermal drying, alkaline stabilization and Lystek treatment were the only post-dewatering technologies that passed the "must-have" criteria for technologies and subsequent product end uses. The other technologies listed in this group failed either due to the lack of sustainability related to final product use or as they are not proven technologies.

Summary of Stage 1 Screening

Figure 6-1 presents the results of the screening exercise and shows the process flow from the technologies which passed the screening exercise, through the products determined to be acceptable in the screening exercise, to the end uses which passed the must-have criteria, and the possible interactions between these component, thereby defining alternative biosolids management strategy options.

FIGURE 6-1
SUMMARY OF SCREENED ALTERNATIVES



Stage 2 – Detailed Evaluation of Biosolids Strategy Options

In the second stage, the biosolids management strategies were developed and evaluated using detailed evaluation criteria to provide an assessment of options relative to the potential impact on technical, natural environment, social, and economic criteria.

Stage 2 Evaluation Methodology

The biosolids management strategy options were evaluated using a Multi-Attribute Utility Analysis (MUA) methodology. This methodology involves a structured evaluation of the risks and benefits of a decision compared to the costs.

Steps in the MUA methodology include:

- Developing selection criteria for which project alternatives will be judged – for this project the selection criteria was developed with the consultant team and the City of

Guelph. The criteria includes technical, natural environment, social, and economic considerations, consistent with the intent of EA planning and decision-making

- Weighting the importance of the chosen criteria
- Development of performance measures associated with evaluation criteria
- Consultation with stakeholders
- Scoring of Alternatives
- Evaluation of costs and risks of potential project alternatives
- Ranking the potential project alternatives in relation to value to cost relationships

Evaluation Criteria

The set of evaluation criteria used to assess the short list of combined treatment, utilization, and disposal (strategy) options that resulted from the screening exercise are presented in Table 6.4.

TABLE 6.4
EVALUATION OBJECTIVES, CRITERIA, AND MEASURE

Objective	Evaluation Criteria	Criteria Measure
Technical Environment	**Technical Performance** – The ability of an alternative to satisfactorily perform its intended functions (treatment, utilization method, disposal options)	The alternative is very reliable, consistently meets or exceeds performance criteria and product quality – 10 The alternative is moderately reliable, meets performance criteria and product quality with regular O&M – 5 The alternative is not very reliable and requires high levels of O&M to meet performance and product quality – 0
	Energy Requirements – The energy, water, and other utilities requirements for the product produced by the alternative are comparable relative to the existing treatment system and other alternatives.	The alternative is very energy efficient; re-use and recycle options are possible – 10 The alternative is somewhat energy efficient – 5 The alternative is not very energy efficient; uses significant amounts of energy/utilities – 0
	Long-term Sustainability – The ability of an alternative (treatment, utilization/disposal) to adapt to changing conditions (technologies, regulations, market factors)	The alternative can easily be adapted to changing conditions to meet long term needs – 10 The alternative is somewhat flexible to meet long term needs (some constraints) – 5 The alternative is not very flexible; difficult to meet needs in the long term – 0
	Ease of Implementation – The alternative can be easily implemented on a technical, regulatory and practical basis (land availability, operational aspects, administrative requirements, etc.)	The alternative is very easy to implement with respect to approvals and construction – 10 The alternative is somewhat easy to implement (some constraints) – 5 The alternative has many difficulties with respect to implementation – 0

TABLE 6.4
EVALUATION OBJECTIVES, CRITERIA, AND MEASURE

Objective	Evaluation Criteria	Criteria Measure
	Compatibility – The alternative is compatible with current processing units and can be installed and integrated into the current plant operations with minimal impact to current operations	The alternative is very compatible and compliments current processing units and can be integrated into current plant operations with minimal impact – 10 The alternative is somewhat compatible and complimentary to current processing units and can be integrated with minimal impact – 5 The alternative is not compatible or complimentary to current processing units and integration may be difficult – 0
	Complexity – The alternative does not add complexity to current operations and can be operated and maintained by current level of licensed operators with appropriate training	The alternative is not complicated and can be operated and maintained by current staff competencies – 10 The alternative is somewhat complicated and can be operated and maintained with minimal staff training – 5 The alternative is complicated and significant staff training and development is necessary for O&M – 0
	Regulatory Acceptance/ Approvals – Regulatory approvals are not complicated, both processing and product utilization/disposal are approvable	The alternative is an accepted regulatory practice and approvals are not expected to be difficult – 10 The alternative is unique and expected to receive regulatory acceptance and approval with some effort – 5 The alternative is very unique and regulatory acceptance and approval may take significant effort – 0
Social/Cultural Consideration	**Odour** – The potential for alternative to minimize odour events	The alternative has little or no potential to produce odour – 10 The alternative has moderate potential to produce odour, odour control measures may be needed to prevent migration offsite – 5 The alternative has high potential to produce odour; significant mitigation needed to control migration offsite – 0
	Agricultural Practices – The potential for the alternative to be compatible with current (and developing) agricultural practices over the long term	The alternative is very compatible with current practices and developing practices – 10 The alternative is somewhat compatible with current and developing practices – 5 The alternative is not compatible with existing and developing practices; may require significant modifications to increase compatibility – 0
	Visual Character – The potential for the alternative to maintain the visual character of an area	The alternative is discreet and will have no impact on the visual character of an area ; existing visual character will be maintained – 10 Components of the alternative may have a minor impact on the visual character of an area: visual character may be modified somewhat – 5 The alternative will have a significant impact on the visual character of an area; existing character will be altered to a great degree – 0
	Transportation – The potential for the alternative to avoid increased demands on the transportation systems (patterns, volumes, and infrastructure requirements)	The alternative will not place additional demands on transportation system – 10 The alternative may place minor additional demands on the transportation system – 5 The alternative may place major demands on the transportation system – 0

TABLE 6.4
EVALUATION OBJECTIVES, CRITERIA, AND MEASURE

Objective	Evaluation Criteria	Criteria Measure
	Noise – The potential for the alternative to minimize the production of noise during normal operations	The alternative has little or no potential to produce noise – 10 The alternative has moderate potential to produce noise, noise control measures may be needed to prevent migration offsite – 5 The alternative has high potential to produce noise; significant mitigation needed to control migration offsite – 0
	Occupational Health & Safety (In-Plant) – Potential risk or liability to staff health and safety from exposure to: • Explosions • Processing chemicals • Gaseous emissions • Toxic organics	The alternative will result in very little potential risk to staff health and safety compared to other alternatives – 10 The alternative will result in a moderate potential risk to staff health and safety are compared with other alternatives – 5 The alternative will result in a high potential risk to staff health and safety compared to other alternatives (without substantial mitigation) – 0
	Occupational Health & Safety (Offsite) – Potential risk or liability to community health and safety from exposure to: • Explosions • Traffic accidents • Gaseous emissions • Toxic organics • Heavy metals • Flooding of watercourses (Speed/Grand River)	The alternative will result in very little potential risk to community health and safety compared to other alternatives – 10 The alternative will result in a moderate potential risk to community health and safety are compared with other alternatives – 5 The alternative will result in a high potential risk to community health and safety compared to other alternatives (without substantial mitigation) – 0
	Public Acceptability – The potential of the alternative to receive public support and acceptance based on: • Projects of a similar nature in other Ontario communities • Community history with the WWTP	The alternative has the potential to receive a high level of support and endorsement by the public – 10 The alternative has the potential to receive a moderate level of support and endorsement from the public – 5 The alternative has the potential to receive a low level of support and endorsement from the publication needed to control impacts – 0
Natural Environment	**Effluent Quality** – The potential of the alternative to meet WWTP effluent quality requirements	The alternative will contribute to the WWTP effluent by bettering the effluent criteria requirements on a consistent basis – 10 The alternative will contribute to the WWTP effluent meeting and sometimes bettering the effluent criteria requirements – 7 The alternative has no impact on WWTP effluent quality – 5 the alternative will not contribute to the WWTP meeting effluent quality requirements – 0
	Water Quality – The potential of the alternative to improve Grand River water quality and aquatic habitats	The alternative results in significant improvements to Grand River water quality and aquatic habitats – 10 The alternative results in moderate improvements to Grand River water quality and aquatic habitats – 7 The alternative has no impact on Grand River water quality and aquatic habitats – 5 The alternative results in little improvement to Grand River water quality beyond regulations; significant mitigation required to control impacts on aquatic habitats – 0

TABLE 6.4
EVALUATION OBJECTIVES, CRITERIA, AND MEASURE

Objective	Evaluation Criteria	Criteria Measure
	Terrestrial Systems – The potential of the alternative to improve terrestrial habitats/ systems (including mammals, reptiles, birds) and terrestrial features/functions	The alternative results in a net improvement in terrestrial systems and habitats –10 The alternative results in the maintenance of the existing terrestrial systems and habitats – 5 The alternative results in a net loss of terrestrial systems and habitats – compensation measures may be required – 0
	Soil Quality – The potential impact of an alternative on soil quality and productivity	The alternative has the potential to improve the quality and/or productivity of the soil through application -–10 The alternative does not have the potential to improve the quality or productivity of the soil (no positive or negative impact) -–5 The alternative has the potential to reduce the quality and/or productivity of the soil – 0
	Ground Water Quality and Flow – The potential of the alternative to protect groundwater resources	The alternative provides significant protection to groundwater resources – 10 The alternative provides moderate protection to groundwater resources – 7 The alternative has no impact on groundwater resources – 5 The alternative provides little if any protection to groundwater resources; significant mitigation needed to provide protection – 0
	Air Emissions – The potential for an alternative to meet provincial regulatory requirements for air emissions This criteria does not address odours	The alternative exceeds regulatory requirements and results in a significant reduction in overall air emissions from the WWTP – 10 The alternative meets the regulatory requirements and may result in a moderate reduction in overall air emissions from the WWTP – 7 The alternative has no impact on air emissions from the WWTP – 5 The alternative does not consistently meet regulatory requirements and results in no change or an increase in overall emissions from the WWTP; significant mitigation required to control air emissions to meet regulations – 0
Economic Environment	**Sales Demand** – The potential for the alternative to create a product that meets market demands	The product will have a high market demand; all of product sold – 10 The product will have a moderate market demand; 50% of product sold – 7 The product will have a low market demand; product given away free – 5 The product will have no market demand and may require incentives, i.e. pay to land apply the product – 0
	Contracts – What is the number and complexity of the service contracts required?	No contracts – 10 Multiple simple contracts – 7 Single complex contract – 5 Numerous complex contracts – 0

Development of Biosolids Management Strategies

Basis of Design

In order that a fair and equitable comparison and evaluation of the management strategies be made, a basis of design was developed for each alternative strategy. This is documented in TM4-IIIA.

The basis of design allowed for management of the biosolids over the full design period of the study, with equitable production, contingency and storage capacities. Redundancy requirements were assumed for each alternative.

For each management option the following assumptions were made:

- Product storage is based on four months of total storage to meet the minimum period requirement (December to March), when biosolids cannot be land applied
- Biosolids will be managed through disposal at a landfill when conditions are not suitable for land application
- As landfilling will be a contingency for each management strategy, it has further been assumed that the two new dewatering units will be centrifuges, to reduce or eliminate the need to blend cake with woodchips to obtain cake suitable for landfill disposal.

Using the assumptions stated above, the basis of design used for this study is as follows:

Capacity

The estimated mass of raw solids produced at capacity of the Stage 2 expansion of the liquid train at the Guelph WWTP (to a total plant capacity of 73.3 MLD) is about 26,700 kg/d, based on current per capita equivalent solids contributions to the City's wastewater.

Analysis of the data suggests that even if industries meet sewer by-law compliance limits (best case) in the future, with potential future industrial expansions and increasing population across the serviced area, the raw (undigested) solids production at the WWTP will still approach 26,700 kg/d (9,745 dt/yr) when the full capacity of Stage 2 expansion is completed.

Physical Characteristics

The physical characteristics of the biosolids produced at the Guelph WWTP, shown in Table 6.5, were developed from historical plant data and anticipated future biosolids quality for planned equipment.

TABLE 6.5
BASIS OF DESIGN: PHYSICAL CHARACTERISTICS OF BIOSOLIDS

	Average	Range
Concentration of Primary Biosolids (percent of total solids)	4%	3.5% – 4.5%
Concentration of WAS[1] (as % of total solids)	0.2%	0.1% – 0.3%
Concentration of Co-thickened Primary and WAS (percent of total solids)	3.3%	3% – 4%
Concentration of Mechanically Thickened WAS (TWAS) (percent of total solids)	6%	5.5% – 6.5%
Volatile Concentration (percent of dry solids)	70%	62% – 75%
Concentration of Digested Biosolids (percent of total solids)	2%	1.5% – 2.5%

TABLE 6.5
BASIS OF DESIGN: PHYSICAL CHARACTERISTICS OF BIOSOLIDS

	Average	Range
VS Destruction in Digestion	53%	50% – 58%
Concentration of Dewatered Biosolids (BFP) (percent of total solids)	18%	16% – 20%
Concentration of Dewatered Biosolids (Centrifuge) (percent of total solids)	28%	25% – 30%
Metals (mg/kg dry biosolids)		
Arsenic	0.03	0.002 – 0.1
Beryllium[2]	NM	NM
Cadmium	0.22	0.01 – 0.86
Chromium	3.6	0.1 – 8.3
Copper	13.3	0.1 – 26.5
Lead	0.9	0.1 – 2.3
Mercury	0.23	0.0001 – 3.5
Molybdenum	0.26	0.1 – 0.58
Nickel	0.27	0.1 – 0.78
Selenium	0.02	0.001 – 0.04
Zinc	30	1.15 – 43.7
Nutrients		
Total Kjehldahl Nitrogen (TKN)	1,230	620 – 2,040
Total Phosphorus	475	150 – 850

[1] Estimated; plant data not available
[2] NM = Not measured

Design Guidelines

The industry-standard design guidelines for each of the alternative technologies were reviewed, and are summarized in Table 6.6.

TABLE 6.6
SUMMARY OF DESIGN GUIDELINES FOR ALTERNATIVE TECHNOLOGIES SHORT-LISTED FOR EVALUATION

Alternative	Selected Technology	Design Guidelines
WAS Thickening[1]	Rotary Drum Thickener	Typical TWAS concentration: 5.5 – 6.6% Typical solids capture: 95 – 98% Typical hydraulic loading range: Not specified as success is highly dependant on biosolids characteristics Polymer Dose Rate: 7.5 g/kg [5]
Anaerobic Digestion[1]	High-rate, mesophilic	Working volume: 85 – 95% Volatile solids destruction: 40 – 65% Solids Residence Time: 10 – 20 days (MOE Guideline: 15 days) Peak Volatile solids loading: 1.9 – 2.5 kg VS/m^3·d Maximum VS loading: 3.2 kg VS/m^3.d Minimum VS loading: 1.3 kg VS/m^3·d
Acid-Phase Digestion[2]	Phase separated digestion	Design HRT: 2 days Design Maximum SLR: 32 kg VS/m^3/day

TABLE 6.6
SUMMARY OF DESIGN GUIDELINES FOR ALTERNATIVE TECHNOLOGIES SHORT-LISTED FOR EVALUATION

Alternative	Selected Technology	Design Guidelines
Mechanical Dewatering[1]	BFP	Typical: Cake Solids Loading Primary sludge 24 – 30% 1.9 –3.2 L/m.s WAS 12 – 20% 0.6 –2.5 L/m.s P + WAS 20 – 25% 1. –-3.2 L/m.s Typical solids capture: 80 – 95% Typical Polymer Dose Rate:1 to 6 g/kg dry solids[6]
	Centrifuge	Typically available capacity range: 0.6 – 44 L/s Cake solids concentration: 28 up to 40% (with high polymer dosage) Typical solids capture: 85 – 96% Typical Polymer Dose Rate:0 to 4 g/kg dry solids[6]
Biosolids Cake/ Woodchip Mixing[2]		Mixing is performed to meet the requirements of the landfill. Dose depends on the cake solids content to obtain a 30%+ solids blend.
Lystek		No industry standard – new technology
Composting[3]	In-vessel	Design input solids: 15,100 kg/day at 17 – 23% solids Design Retention time: 28 days
Heat Drying[1]	Rotary drum	Pellet (product) dryness: 92% (minimum) Specific Evaporation rate: 3,250 – 4,200 kJ/kg water evaporated Energy consumption is based on quantity of water evaporated, and therefore depends on the feed cake solids content
Alkaline Stabilization[4]	In-vessel	Lime Dose: 20 – 50% of the wet-weight 75 – 200% dry weight of biosolids Goal: 46% solids in mixed biosolids and alkaline amendment feed Retention time: Dryer – sufficient to obtain 62 – 65% solids in the product Heat Pulse – 12 hour Elevated pH Storage – 3 days

Notes:
[1] *Design of Municipal Wastewater Treatment Plants*; WEF Manual of Practice No. 8 (1992)
[2] CH2M HILL design guidelines
[3] Data typical of existing in-vessel system is provided
[4] Data typical of *N-Viro* system is provided
[5] Determined by bench-testing of Guelph's WAS (2004)
[6] *Sludge Conditioning*, Manual of Practice No. 14 (1988)

Description of Options

The short listed technologies, products and end uses served as a menu from which seven biosolids management strategies were developed. All seven strategies include treatment by digestion, dewatering and further processing, and result in diversified products with multiple potential end uses.

Option 1 – Expand Existing System

Option 1 involves expansion of the existing system to meet future flows and includes Lystek and WAS thickening. No new technologies are included. Storage is provided for composted biosolids, Lystek biosolids, and liquid biosolids. Final use options include land application for liquid, cake, and Lystek processed biosolids, and land application or alternative markets (such as sod farming) for composted biosolids. Landfilling of cake and composted biosolids are alternative contingency disposal options.

This option allows two- and four-month scheduled maintenance periods for the Lystek and composting facilities, respectively. The typical operating schedule would consist of the following:

- Composting at peak capacity (two operating reactor vessel, with additional curing in the third vessel and/or on the storage pad) for two months per year in the winter (January and February).
- Composting at firm capacity (one operating reactor vessels, with additional curing in a second vessel and/or on the storage pad, and one vessel out-of-service) for six months per year in the spring and fall (March, April, September, October, November, and December).
- Compost facility scheduled maintenance (all vessels out-of-service) for four months in the summer.
- Lystek treatment at peak capacity (6 m^3/day) for two months in the spring (May and June).
- Lystek treatment at firm capacity (3 m^3/day) for eight months of the year (March and April, and July through December).
- Lystek facility scheduled maintenance (all equipment out-of-service) for two months in the winter (January and February).
- Liquid biosolids storage and subsequent land application of approximately 20 percent of the total annual biosolids produced.
- Agricultural land application of liquid biosolids and Lystek-processed biosolids. Beneficial use of compost. Dewatering and land application of the remainder of the biosolids.

A process flow diagram for Option 1 is shown in Figure 6-2.

Option 2 – Expand Existing System with Phased Digestion

Option 2 involves expansion of the existing system to meet future flows utilizing acid phase digestion (a modification to conventional mesophilic anaerobic digestion), and includes WAS thickening and Lystek. Storage is provided for composted biosolids, Lystek biosolids and liquid biosolids, and the same operating schedule and maintenance periods were allowed for as in Option 1. Final use options are the same as for Option 1, and a process flow diagram is shown in Figure 6-3.

FIGURE 6-2
OPTION 1 EXPAND EXISTING SYSTEM

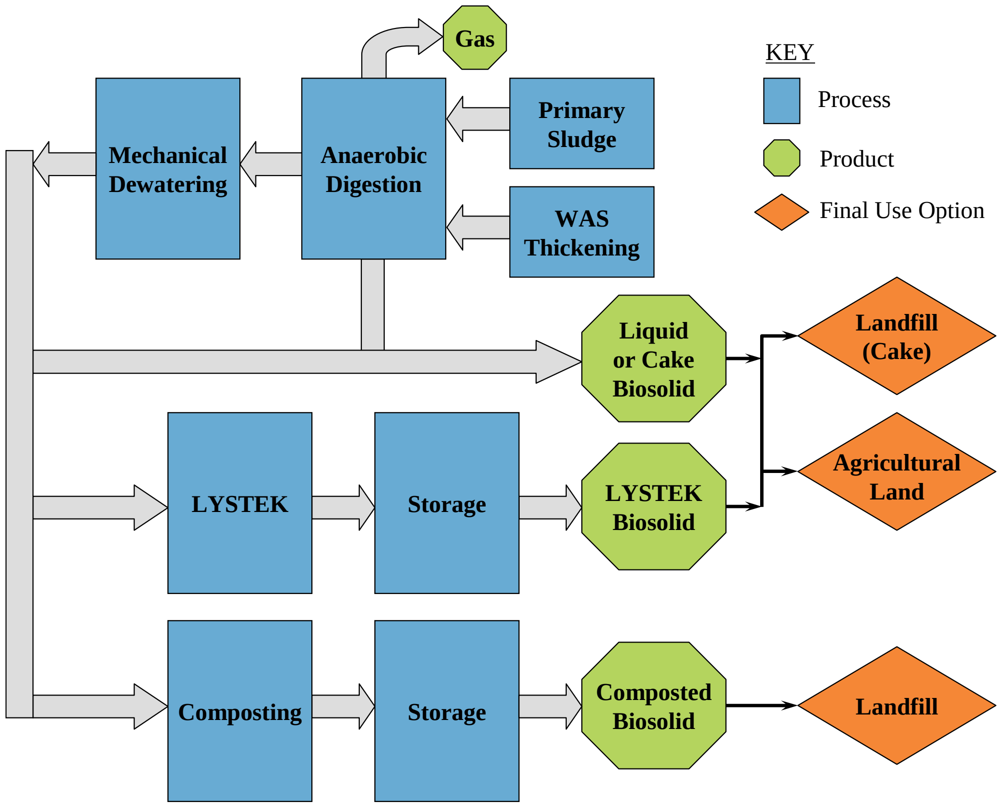
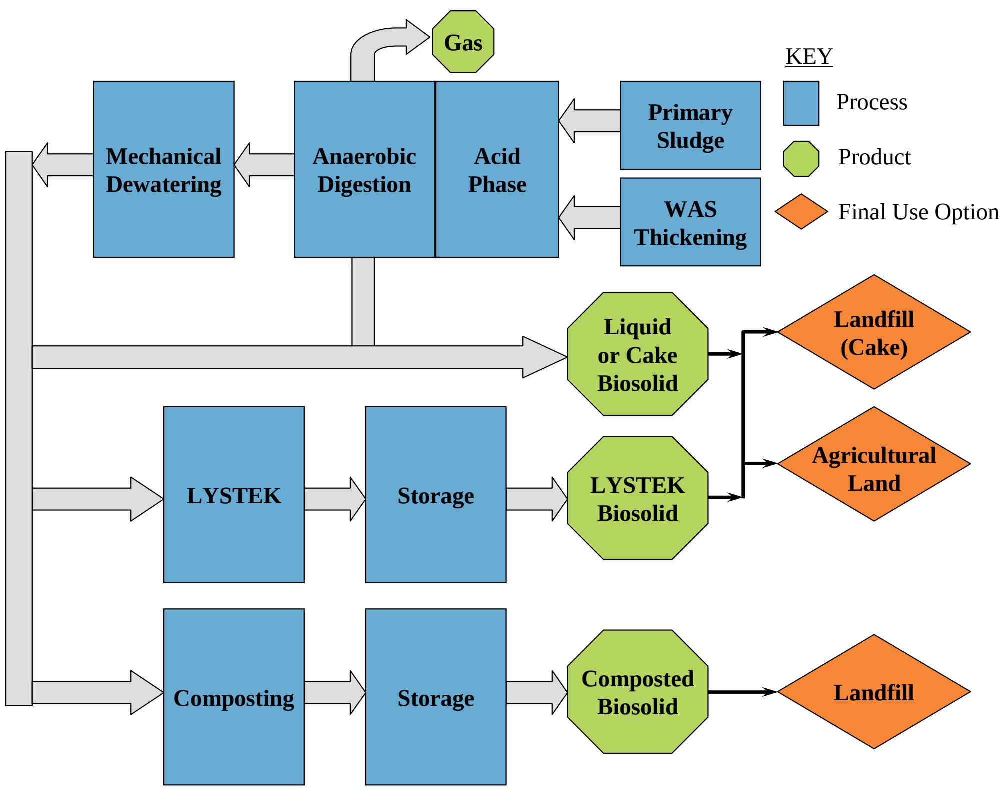


FIGURE 6-3
OPTION 2 EXPAND EXISTING SYSTEM WITH PHASED DIGESTION



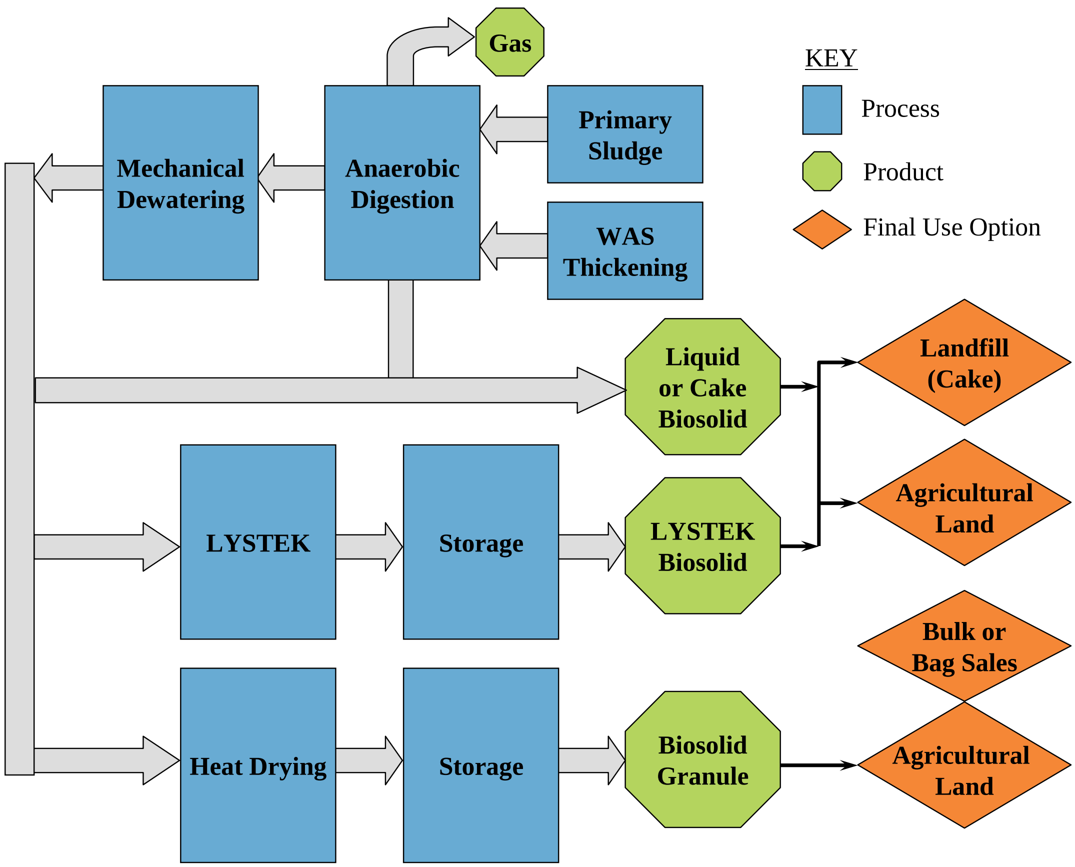
Option 3 – Expand Existing System with Heat Drying

The option expands the existing system to meet future flows and includes WAS thickening Lystek and heat drying. The composting system would be decommissioned and the new technology (heat drying) installed.

It was assumed that Lystek would operate at peak capacity for two months per year, firm capacity at eight months per year, and have a scheduled maintenance period of two months per year, as in all other Options. It was further assumed that the heat drying system would operate year-round, with a two-week scheduled maintenance period. The dryer would operate 24-hours per day, typically four to six days per week, depending on the requirements, as per the quantity of biosolids processed.

Storage is provided for heat dried biosolids pellets in silos and Lystek biosolids. Final use options include those identified in strategy Option 1 plus bulk or bag sales for the pelletized biosolids product that is generated with heat drying. The heat dried biosolids may also be disposed of at landfill if required. The process flow diagram for this option is shown in Figure 6-4.

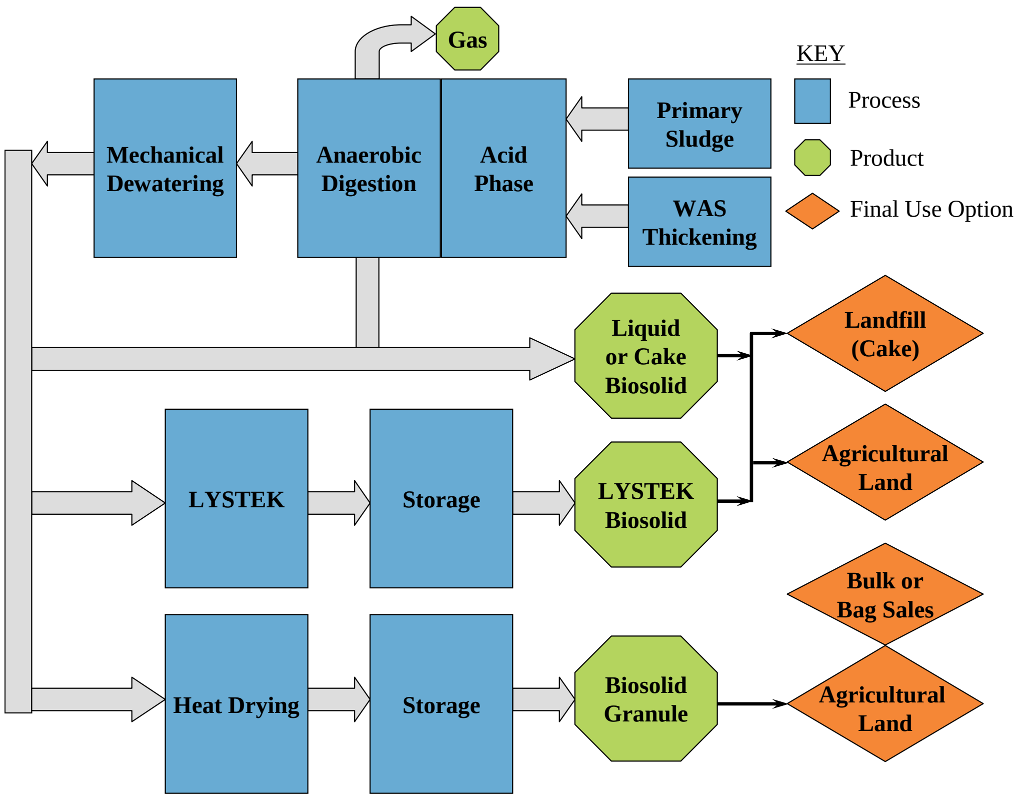
FIGURE 6-4
OPTION 3 EXPAND EXISTING SYSTEM WITH HEAT DRYING



Option 4 – Expand Existing System with Heat Drying and Phased Digestion

The option expands the existing system to meet future flows utilizing phased digestion, and includes WAS thickening, Lystek and heat drying. The compost system would be decommissioned. Storage is provided for heat dried biosolids pellets and Lystek biosolids, and process operating scenarios are the same as Option 3. Final use options are also the same as those identified in strategy Option 3 (Figure 6-5).

FIGURE 6-5
OPTION 4 EXPAND EXISTING SYSTEM WITH HEAT DRYING WITH PHASED DIGESTION



Option 5 – Expand Existing System with Primary Solids Only Digestion and Heat Drying

The option expands the existing system to meet future flows and includes WAS thickening, Lystek and heat drying. Only primary sludge would be digested; it would then be blended with the thickened WAS (TWAS) prior to heat drying. Additional digester capacity would not be required. Option 4 also includes demolition of the composting system and installation of a new heat drying facility. Storage is provided for heat dried biosolids pellets and Lystek biosolids, and process operating scenarios are the same as Options 3 and 4. Liquid WAS and biosolids cake could not be land applied, as the WAS would not be stabilized (digested) prior to dewatering. This Option is shown in Figure 6-6.

Option 6 – Expand Existing System with Alkaline Stabilization

The option, shown in Figure 6-7, expands the existing system to meet future flows and includes Lystek, alkaline stabilization and WAS thickening. Option 6 also includes demolition of the composting system and installation of a new alkaline stabilization facility. Storage is provided for alkaline biosolids material and Lystek biosolids. The operating scenario is similar to Option 3, with alkaline stabilization operating year-round, excluding a two-week scheduled maintenance period. An approximately eight-hour per day schedule would be required, unless process demand increased. Final use options are the same as those identified in strategy Option 3.

FIGURE 6-6
OPTION 5 EXPAND EXISTING SYSTEM WITH PRIMARY SOLIDS ONLY DIGESTION AND HEAT DRYING

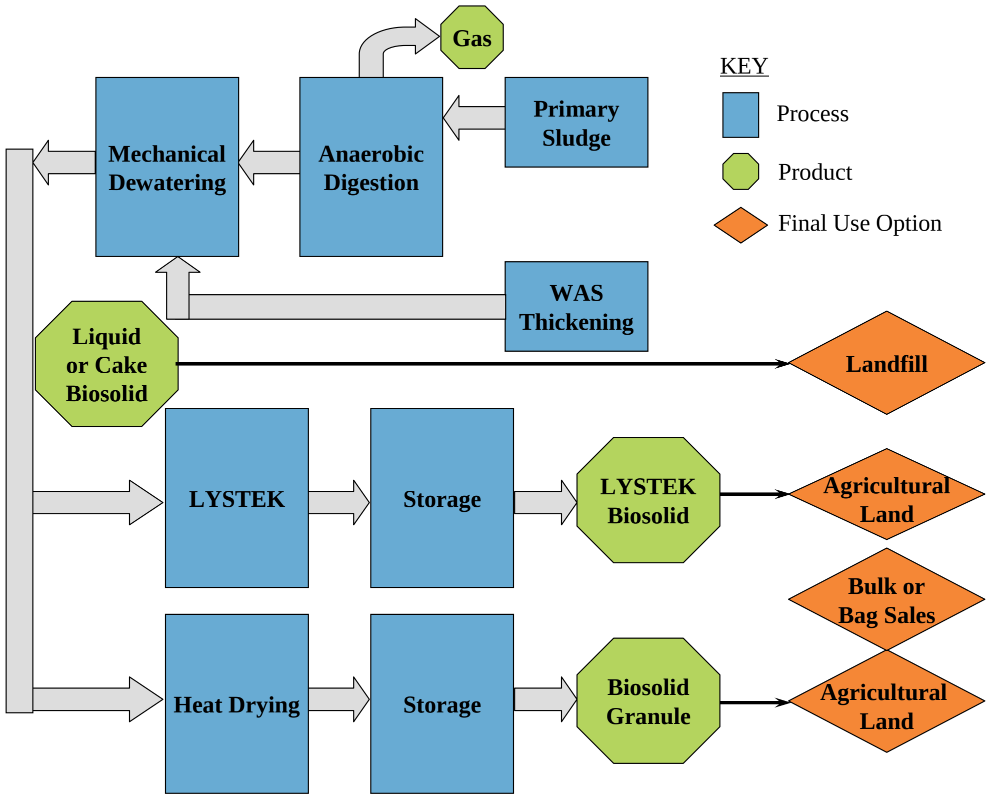
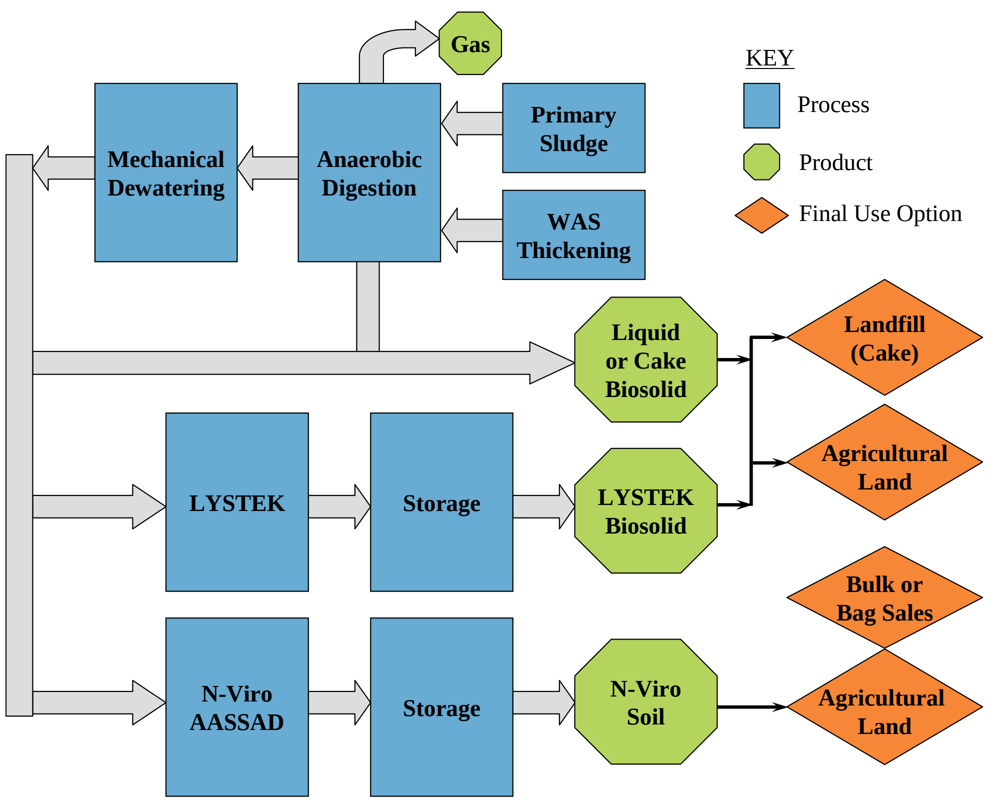


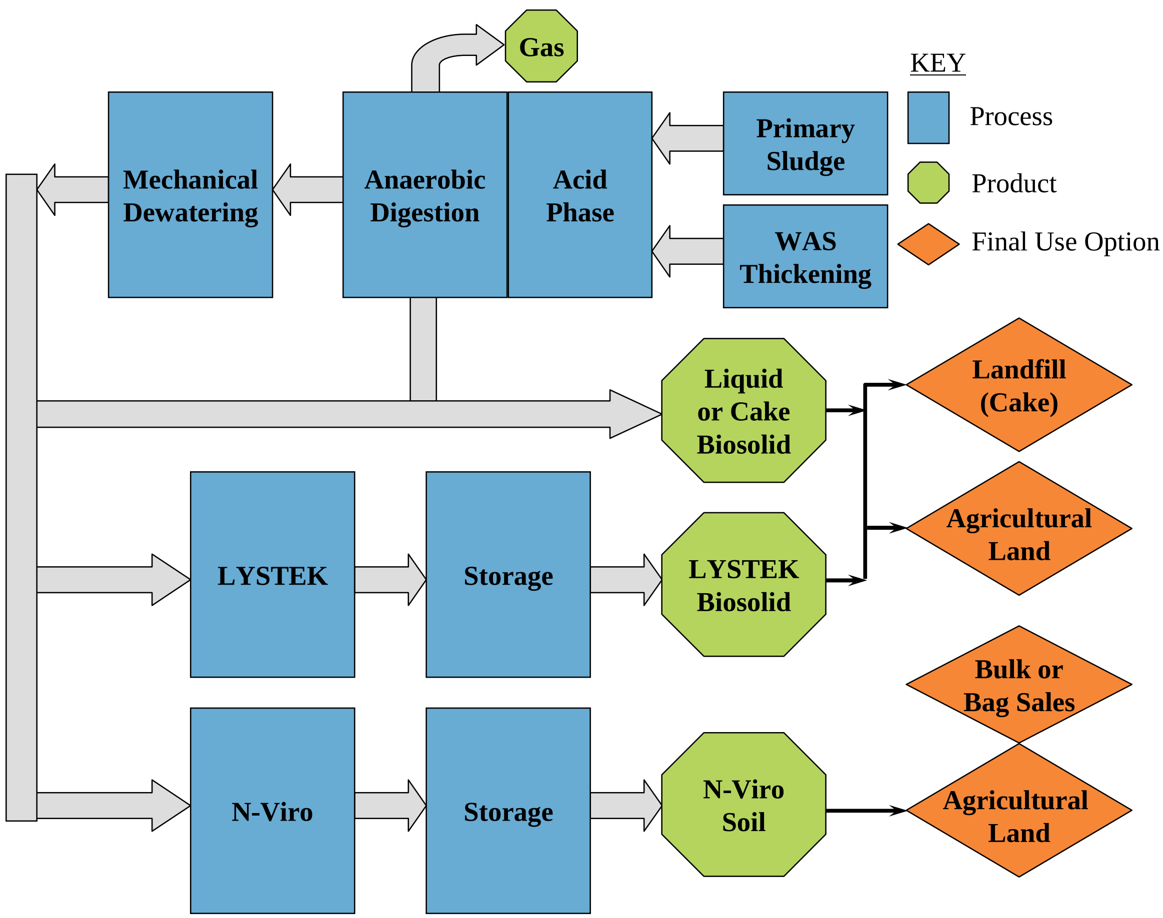
FIGURE 6-7
OPTION 6 EXPAND EXISTING SYSTEM WITH ALKALINE STABILIZATION



Option 7 – Expand Existing System with Alkaline Stabilization and Phased Digestion

The option expands the existing system to meet future flows utilizing phased digestion and includes WAS thickening, Lystek and alkaline stabilization. A new acid-phase digester would provide the required additional digester capacity. Option 7 also includes the demolition of the composting system and the installation of a new alkaline stabilization facility. Storage is provided for alkaline biosolids material and Lystek biosolids. Final use options are the same as those identified in strategy Option 6, as shown in Figure 6-8.

FIGURE 6-8
OPTION 7 EXPAND EXISTING SYSTEM WITH ALKALINE STABILIZATION AND PHASED DIGESTION



Summary of Biosolids Management Strategy Options

A summary of the biosolids management strategy options is presented in Table 6.7. The summary provides a comparison of the components for each strategy option.

TABLE 6.7
SUMMARY OF BIOSOLIDS MANAGEMENT STRATEGY OPTIONS

Description	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
	Expand Existing System	Expand Existing System with Phased Digestion	Expand Existing System with Heat Drying	Expand Existing System with Heat Drying and Phased Digestion	Expand Existing System with Primary Solids Only Digestion and Heat Drying	Expand Existing System with Alkaline Stabilization	Expand Existing System with Alkaline Stabilization and Phased Digestion
Primary Sludge	No change; Same for all options						
TWAS	No change; Same for all options Storage may be required if operating period is less than 24 hours/7 days						
Anaerobic Digestion	Additional digestion	Additional acid-phase digestion	Additional digestion	Additional acid-phase digestion	No change	Additional digestion	Additional acid-phase digestion
Liquid Biosolids	29,112 m^3 storage	27,207 m^3 storage	None; No change				
Mechanical Dewatering	Additional dewatering Same technology for all options (centrifuges assumed) Sizing for each option may vary if different operating schedules are required						
Cake Biosolids	No change; Same for all options						
Lystek	4,800 m^3 storage; Same for all options						
Composting	2,703 m^3 storage	2,726 m^3 storage	Decommission and reuse infrastructure				
Heat Drying	NA		4,572 dt/yr biosolids 1,652 wt storage	3,890 dt/yr biosolids 1,409 wt storage	6,487 dt/yr biosolids 2,708 wt storage	NA	
Alkaline Stabilization	NA					4,572 dt/yr biosolids 6,746 m^3 storage	3,890 dt/yr biosolids 5,589 m^3 storage

dt/yr – Dry tones per year
wt – Wet tonnes

Evaluation of Biosolids Management Strategy Options

Evaluation of Strategy Options

Each management strategy option was evaluated using the evaluation criteria and defined criteria measures presented in Table 6.4. The results of the evaluation are shown in detail in TM4-IIIB.

Table 6.8 summarizes the weighted scores and strategy ranking produced using the MUA tool for Total Benefit Analysis. The results are graphically displayed in Figure 6-9. Options 1 and 2 received the highest total weighted score, and therefore were evaluated to be highest ranked options, with regard to the criteria.

FIGURE 5-1
COMPOST SYSTEM PROCESS FLOW DIAGRAM SCHEMATIC

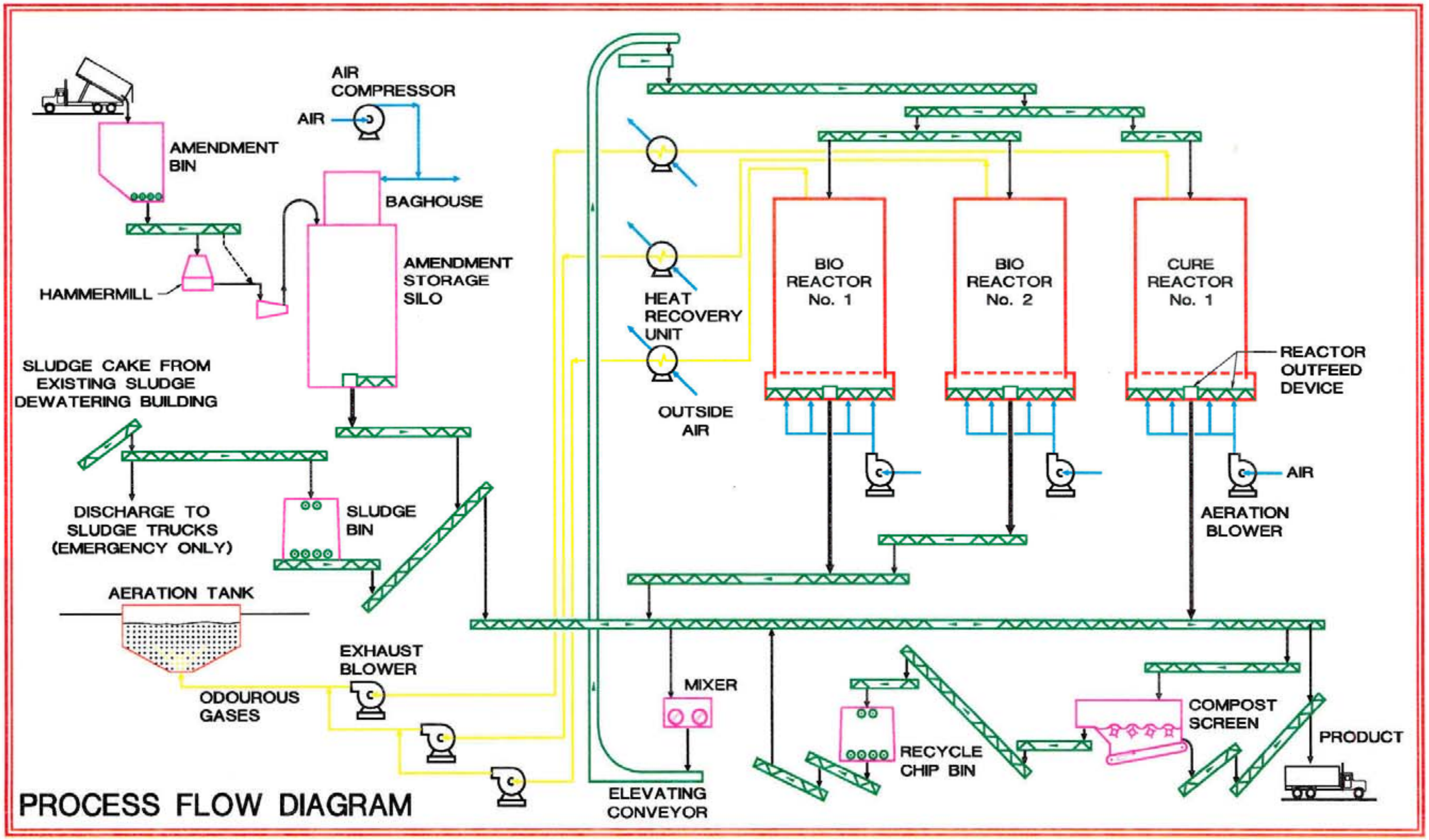


FIGURE 6-9
RANKING OF ALTERNATIVES BY TOTAL BENEFIT VALUE

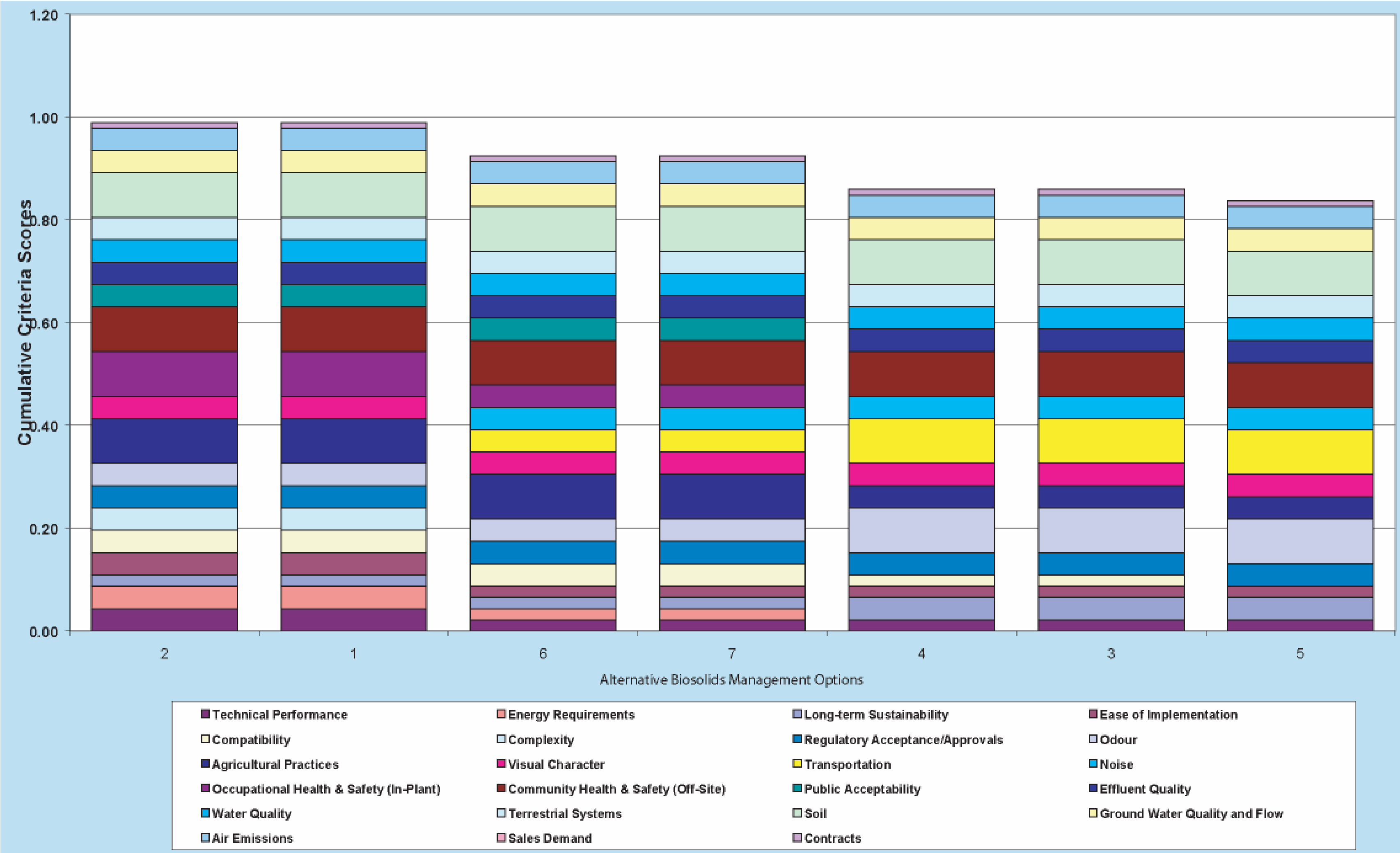


TABLE 6.8
EVALUATION OF BIOSOLIDS MANAGEMENT OPTIONS

Evaluation Criteria	Option 1 Expand Existing System	Option 2 Expand Existing System with Phased Digestion	Option 3 Heat Drying with Expanded Digestion	Option 4 Heat Drying with Phased Digestion	Option 5 Heat Drying with Primary Only Digestion	Option 6 Alkaline Stabilization with Expanded Digestion	Option 7 Alkaline Stabilization with Phased Digestion	Weight
	Score	Score	Score	Score	Score	Score	Score	
Technical Performance	10	10	5	5	5	5	5	50
Energy Requirements	10	10	0	0	0	5	5	50
Long-term Sustainability	5	5	10	10	10	5	5	50
Ease of Implementation	10	10	5	5	5	5	5	50
Compatibility	10	10	5	5	0	10	10	90
Complexity	10	10	0	0	0	0	0	90
Regulatory Acceptance/ Approvals	10	10	10	10	10	10	10	90
Odour	5	5	10	10	10	5	5	40
Agricultural Practices	10	10	5	5	5	10	10	40
Visual Character	5	5	5	5	5	5	5	40
Transportation	0	0	10	10	10	5	5	40
Noise	0	0	5	5	5	5	5	40
Occupational H&S (In-Plant)	10	10	0	0	0	5	5	60
Occupational H&S (Offsite)	10	10	10	10	10	10	10	60
Public Acceptability	5	5	0	0	0	5	5	40
Effluent Quality	5	5	5	5	5	5	5	60
Water Quality	5	5	5	5	5	5	5	40
Terrestrial Systems	5	5	5	5	5	5	5	25
Soil	10	10	10	10	10	10	10	25
Groundwater Quality and Flow	5	5	5	5	5	5	5	40
Air Emissions	5	5	5	5	5	5	5	25
Sales Demand	0	0	0	0	0	0	0	20
Contracts	5	5	5	5	5	5	5	20
Total Weighted Score	**80.10**	**80.10**	**50.40**	**50.40**	**46.89**	**61.44**	**61.44**	

Evaluation Criteria Sensitivity Analysis

Alternative weightings of the evaluation criteria were also examined to determine the sensitivity of the analysis.

- **Equally Weighted –** When each objective was weighted equally, Options 1 and 2 continued to receive the highest total weighted score. However, there was slightly less difference between the Options.
- **Technically Weighted –** When additional weight was given to the technical criteria, Options 1 and 2 continued to receive the highest total weighted score. Increased relative difference between the Options was evident.
- **Social/Natural Environment Weighted –** When additional weight was applied to the social/natural environment criteria Options 1 and 2 received the highest total weighted score, but there was less of a difference between the Options.

Table 6.9 summarizes the results of the sensitivity analysis. It shows that Options 1 and 2 ranked first in each of the objective weighting scenarios, followed by Options 6 and 7, then Options 3 and 4, and finally Option 5.

TABLE 6.9
SUMMARY OF SENSITIVITY ANALYSIS RESULTS FOR EVALUATION OF CRITERIA FOR BIOSOLIDS MANAGEMENT OPTIONS

Evaluation Criteria	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
	Expand Existing System	Expand Existing System with Phased Digestion	Heat Drying with Expanded Digestion	Heat Drying with Phased Digestion	Heat Drying with Primary Only Digestion	Alkaline Stabilization with Expanded Digestion	Alkaline Stabilization with Phased Digestion
	Rank	Rank	Rank	Rank	Rank	Rank	Rank
Base Case	1	1	5	5	7	3	3
Equally Weighted	1	1	5	5	7	3	3
Technically Weighted	1	1	5	5	7	3	3
Social/Environmental Weighted	1	1	5	5	7	3	3
Overall Rank	**1**	**1**	**5**	**5**	**7**	**3**	**3**

It was therefore determined that Options 1 and 2 are the most feasible and therefore preferred management options with respect to the evaluation criteria.

Economic Evaluation

Estimated capital and O&M costs were also considered in the evaluation. TM4-IIIB documents the detailed cost analyses, which are summarized in Table 6.10.

TABLE 6.10
SUMMARY OF ESTIMATED COSTS FOR BIOSOLIDS MANAGEMENT OPTIONS

Cost Criteria	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
	Expand Existing System	Expand Existing System with Phased Digestion	Heat Drying with Expanded Digestion	Heat Drying with Phased Digestion	Heat Drying with Primary Only Digestion	Alkaline Stabilization with Expanded Digestion	Alkaline Stabilization with Phased Digestion
Capital Cost	$25,090,000	$22,180,000	$35,820,000	$33,570,000	$33,640,000	$31,380,000	$27,850,000
O&M Annual Cost	$2,786,000	$2,694,000	$2,472,000	$2,254,000	$3,028,000	$4,098,000	$3,626,000
O&M Annual Credit	$767,000	$866,000	$767,000	$864,000	$428,000	$767,000	$864,000
Net O&M Annual Cost	$2,019,000	$1,828,000	$1,705,000	$1,390,000	$2,600,000	$3,331,000	$2,762,000
NPV	$62,915,000	$56,607,000	$67,837,000	$60,027,000	$81,432,000	$91,953,000	$78,364,000
Capital Cost /dt	$139	$123	$199	$186	$187	$174	$154
O&M Annual Cost /dt	$286	$276	$254	$231	$311	$421	$372
O&M Annual Credit /dt	$79	$89	$79	$89	$44	$79	$89
Net O&M Annual Cost/dt	$207	$188	$175	$143	$267	$342	$283
NPV/DT	$349	$314	$376	$333	$451	$510	$434

Notes: Costs are shown for ultimate year biosolids production rate (2025)
Dry Tonnes (dt) Raw Solids Processed (20-year project total) = 180,731
Dry Tonnes Raw Solids Processed (Ultimate Year) = 9,744
Costs per Dry Tonne are for Raw Solids processed
NPV – Net Present Value

Table 6.10 illustrates that the Options with phased digestion (or unexpanded digestion) had lower estimated capital costs than those with expanded digestion. Overall, expanding the existing system options had lower estimated capital costs, followed by the alkaline stabilization options. The highest estimated capital costs were associated with heat drying.

The heat drying options had the lowest O&M costs. Heat drying following primary-only digestion was more costly than heat drying following full digestion. Expanding the existing system options had the second lowest O&M costs. Alkaline stabilization options had the highest O&M costs.

O&M credits were greater for the options with phased digestion and least for the option with primary only digestion.

The net O&M costs were lowest for heat drying options and highest for the alkaline stabilization options.

The total net present value (NPV) was estimated to be least for the expanding the existing system options, followed by the heat drying options and highest for the alkaline stabilization options.

Benefit/Cost Evaluation Summary

The evaluation matrix was also utilized to determine the overall cost (economic) and benefit (objective) of each option. The best benefit to cost ratio was given a score of 1.41 and the other options were scored relative to the maximum score. Table 6.11 summarizes the scores.

TABLE 6.11
SUMMARY OF COST/BENEFIT EVALUATION

Cost/Benefit	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
	Expand Existing System	Expand Existing System with Phased Digestion	Heat Drying with Expanded Digestion	Heat Drying with Phased Digestion	Heat Drying with Primary Only Digestion	Alkaline Stabilization with Expanded Digestion	Alkaline Stabilization with Phased Digestion
Overall Score	1.27	1.41	0.77	0.89	0.57	0.67	0.78
Overall Rank	2	1	5	3	7	6	4

The cost/benefit analysis has shown that the highest ranked option is to expand the existing system. The economic evaluation suggests that phased digestion, compared to expanding the existing conventional anaerobic digestion facility, may be economically beneficial. It is recommended that this is considered and further evaluated in the planning and design stages of digester capacity expansion.

However, the existing compost facility at the WWTP was installed more than 10 years ago. It is therefore likely that it will reach the end of its service life before the 20-year planning period addressed in this study, even with the recommended capital investment to enable reliable service. Since biosolids compost has a limited commercial market, and the O&M costs are high, it is recommended that an alternative biosolids management treatment process should be considered when composting is no longer reliable. This analysis suggests that heat drying or alkaline stabilization would likely be the preferred technology if being considered at this time; however, technology advances, and regulatory and market changes should be re-addressed to determine the appropriate decision in the future.

Recommended Strategy

The recommended strategy is to maximize the City of Guelph's existing investment in the WWTP by utilizing the existing biosolids management system to the end of its useful operating life. This will require some unit process upgrades and expansions to provide reliable service for the projected biosolids quantities over the study period. It is also recommended to decommission the compost system and replace with an alternative processing technology. The City has determined that the composting equipment is at the end of its reliable service life and should be replaced as soon as possible.

Options 1 and 2 provide for liquid biosolids storage, Lystek-treated biosolids storage, and composted biosolids storage, to give four months' product storage, to provide an equal strategy for all the Options. Given the recommendation to decommission and replace composting with an alternative process as soon as possible, and it is anticipated that the process will be able to accommodate the storage, investment in liquid storage is not recommended at this time. Therefore, a modified Option 1 has been developed for implementation, which includes Lystek, no liquid storage, but storage for Lystek and other biosolids products. This is essentially the same as (a modified) Option 2, but as the decision to implement phased digestion would occur during the planning and design stages of digester capacity expansion, the more economically conservative Option 1 was utilized for analysis. Finally, for forecasting purposes, it was assumed that heat drying or alkaline stabilization, the preferred replacement technologies in this analysis, will be installed in the future.

7. Recommended Strategy

Seven feasible biosolids management strategies for Guelph were developed and evaluated and it was determined that the preferred strategy, which maximizes the City of Guelph's existing investments at the WWTP, includes the following:

- Maintain the existing biosolids management technologies, and expand process capacities as required, including:
  - WAS thickening;
  - Digestion;
  - Dewatering;
  - Lystek treatment and land application;
  - Dewatered cake land application;
  - Preferred technology replacing composting and beneficial use; and
  - Emergency liquid biosolids land application; dewatered cake and/or compost landfilling, if required.
- Construct storage facilities for Lystek-treated biosolids and preferred technology biosolids to maximize beneficial use.
- Consider alternative further treatment technologies as the equivalent compost facility capacity is exceeded, to maintain a diversified program.
- Develop a plan to implement this strategy. The implementation plan must include measures to reduce the City of Guelph's identified risk and liabilities associated with biosolids management.

This section provides an overview of the recommended strategy and implementation plan documented in TM4-4, shown in Appendix G, for the Guelph WWTP BMMP.

Strategy Overview

The City of Guelph currently processes the biosolids generated by the conventional activated sludge WWTP with anaerobic digestion and belt-press dewatering. The dewatered cake is primarily land applied or landfilled. The dewatered cake may also be composted in the in-vessel facility, but partly due to a lack of market for the composted biosolids and high maintenance, the composting facility is primarily used to increase the solids content of the cake so that it is accepted by, and easier to dispose of at, the landfill. The composting facility has operated at limited capacity because of mechanical and other operational problems. Composting is no longer considered a reliable component of the existing biosolids management program.

The review of the existing biosolids management program and the analysis of feasible alternative biosolids management options indicated that the existing method of management is the most economical for the City of Guelph and provides the greatest benefit per unit cost. It is anticipated that there will be sufficient agricultural land available to land apply biosolids over the planning period for this study (2025). There will be a need to provide storage for

Lystek-treated biosolids to maximize beneficial use and reduce dependency on landfilling. Long-term investment in biosolids management processes should be better directed to alternatives to maintain a diversified program. The evaluation of options found that alkaline stabilization and heat drying are feasible technologies for the City of Guelph to implement, but in the future, regulatory changes and new and emerging technologies should also be considered when determining the preferred strategy. In the future, the concept of partnering with private enterprises and/or other municipalities may also be appropriate to incorporate into the City's strategy. The concept of municipalities partnering lends itself to management solutions that could benefit all of the partners. These include adopting common best management practices and shared central facilities or contracting services effectively by utilizing contracts that fairly share risk between partners. This method of management could reduce each partner's costs. Municipalities will still have to proactively monitor programs that are contracted to the private sector to satisfy public concerns.

The following principles are key components included in the implementation plan:

- The City of Guelph will continue to produce a digested biosolids product at its WWTP.
- The City will maximize beneficial use of biosolids by maintaining the ability to produce diversified products and providing storage. Products will include Lystek-treated biosolids as an economical liquid-type product and dewatered cake in the land application season that can be easily utilized on agricultural land.
- The utilization of biosolids on agricultural land will be the mainstay of the City's BMMP.
- The City will strive to improve the quality of the end product to address public concerns regarding potential health issues.
- The City will continue to maintain a landfill contract for disposal of biosolids when beneficial use is not available.
- The City will contract with the private sector, as appropriate, to manage its land application of biosolids in an environmentally responsible and economical manner satisfactory to the City, its residents, and the farming community.
- The City will manage its risks and liabilities for biosolids use and disposal by entering into contracts and management arrangements that reduce the risks, while fairly apportioning the risks between the City and the private sector. The City will strive for effective management of the contract(s), including monitoring of the contractor's methods, operations, and record keeping. The City will also utilize stakeholder committees to review its programs.
- The City will consider partnering with other municipalities, and/or the private sector, to develop other biosolids products and markets that compliment this program, as a replacement for the composting facility. The mix of the future biosolids products will reflect the markets and will be adjusted periodically according to market trends. The evaluation will also weigh the costs of private sector solutions with the costs of building additional storage facilities.
- Should partnering not be the sole solution, the City will further investigate alternative technologies, including alkaline stabilization and heat drying, for long-term implementation to replace the compost facility when it is decommissioned. The market

and regulatory trends will be considered, as well as other (emerging) technologies if appropriate, to meet future demands and requirements.

- The City will implement a communication and education program with its stakeholders and the general public to provide them with a better understanding of biosolids management in Ontario and the City of Guelph. The goal of this program will be managing potential liabilities and risks associated with the management program. The program should be geared to increase public backing for the program supported by sound science.

Implementation Plan Development

Implementing the strategy presented above requires an approach that addresses the entire duration of the management planning period and that includes risk management. Because the implementation of this management plan is influenced by practices in other municipalities, such as availability of land for land application use, landfills and potential partnering opportunities, it is prudent to understand how municipalities in southern Ontario and other jurisdictions are managing their biosolids.

The proposed implementation plan provides for the City of Guelph to carry out some activities directly and others in conjunction with other parties, which include private sector proponents and, potentially, partner municipalities. The plan should allow the City to continue managing biosolids effectively while implementing plan components in an orderly, systematic fashion. During the initial five years of the plan, the City will be able to prepare for processes and facilities that will be required for capacity purposes, and begin developing long-term strategies for implementation to replace the compost facility. A review of the Guelph BMMP is scheduled at the end of five years and every five years thereafter, thus conforming to MEA Class EA procedures for master plans. The review allows the City to adjust the implementation plan to suit changes that may be required to update the plan for the next five-year period.

Since the BMMP study began in 2000 and as the study has proceeded, a number of programs identified have been initiated or implemented at the WWTP, including the following:

- WAS thickening trials
- Request for engineering proposals to expand the digestion process capacity
- Review of the dewatering needs and equipment tender
- Review of compost woodchips suppliers
- Investigation of the compost outfeed device and custom retrofitting
- Landfill contract negotiation
- Biosolids land application tender and contract negotiations
- Nutrient management strategy

The status of these programs and activities has been accounted for in the implementation plan.

Biosolids Management in Southern Ontario

Table 7.1 summarizes biosolids management programs in Southern Ontario, including program type and size of operation. The locations listed collectively manage about 566 dry tonnes per day (dt/d) of biosolids. The biosolids management programs include land application of liquid digested biosolids; land application of dewatered biosolids; land application of heat dried biosolids; land application of alkaline stabilized biosolids and incineration of biosolids and landfilling of ash. All digested (using the USEPA designation – Class B) biosolids are managed in Southern Ontario in accordance with the NMA, its Regulations, and *Guidelines for the Utilization of Biosolids and Other Wastes on Agricultural Land* (latest edition). In accordance with the MOE Design Guidelines, anaerobic or aerobic digestion is the preferred method of stabilization for liquid and dewatered biosolids. For anaerobic digestion, the MOE Design Guidelines require one or two-stage digestion, with processing in primary digesters at about 35°C for a nominal minimum HRT of 15 days. Management practices in the guidelines stipulate crop types, minimum times between application and harvesting or use and minimum separation distances from wells, residences and watercourses. These management practices, together with the minimum requirements for anaerobic or aerobic digestion, are intended to protect public health.

TABLE 7.1
SUMMARY OF BIOSOLIDS MANAGEMENT IN SOUTHERN ONTARIO

Location	Biosolids Production		Description of Current Biosolids Management Program
	dt/d	m^3/d	
City of Peterborough	3.5	74	Liquid application of digested biosolids
Region of Durham – except Pickering	10	550	Liquid application of digested biosolids, winter storage and incineration of excess at Duffin Creek WWTP
York Region and Region of Durham – Pickering	90	N/A	Incineration of raw and digested biosolids
City of Barrie	5	192	Liquid application of digested biosolids
City of Collingwood	2	52	Liquid application of digested biosolids
City of Toronto – Highland Creek	39	N/A	Incineration of raw sludge
City of Toronto – Ashbridges Bay	145	N/A	Land application and landfilling of dewatered digested biosolids, dryer being rehabilitated
Region of Peel – Lakeview	64	N/A	Incineration and ash disposal on plant site
Region of Halton	27	1,040	Liquid application of digested biosolids
City of Brantford	7	230	Liquid application of digested biosolids
City of Hamilton	60	N/A	Land application of dewatered digested biosolids
Region of Niagara	29	890	Liquid application of digested biosolids and alkaline stabilization of dewatered digested biosolids
City of Guelph	**10**	**N/A**	Land application and landfilling of dewatered digested biosolids
Region of Waterloo	29	822	Liquid application of digested biosolids
City of St. Thomas	0.3	11	Liquid application of digested biosolids
City of London – Greenway	11	N/A	Incineration of raw sludge from 3 London plants
City of Leamington	6	N/A	Land application of advanced alkaline stabilized biosolids
City of Sarnia	6	N/A	Advanced alkaline stabilized biosolids sold for soil blending
City of Windsor	22	N/A	Landfilling raw dewatered biosolids, dryer shutdown
Total Biosolids Production	**566**		

The City of Toronto, the Regions of Peel and Durham, and the City of London operate incinerators. The Region of Durham recently invested in a significant incineration facility upgrade, and landfilled dewatered cake during the construction period. The City of Toronto's Ashbridges Bay plant replaced incineration with heat drying and land application in 2001; however, the dryer system suffered from a fire and has not been repaired to date, although it is reported that the dryer will be rehabilitated within the next year. Incineration is now utilized for about 25 percent of Southern Ontario's biosolids; the remainder is managed through land application and landfilling when land application is not available.

Liquid land application and, to a lesser extent, dewatered land application, are well-established in Ontario. Liquid land application has been formally practiced since the original Land Application Guidelines were established in 1972. Land application of dewatered biosolids has only recently begun in a large scale, with the City of Toronto, City of Hamilton, and City of Ottawa moving to land application programs. These programs are addressing issues associated with odours from storage of dewatered biosolids, but they have not been completely solved.

Of the other biosolids management options noted in Table 5.1, the private sector is still developing reliable utilization methods or markets. The heat drying system in Windsor, which is owned and operated by Azurix Company (formerly Prism/Berlie), began operation in 1999. Azurix has applied for a license under the Federal Fertilizer Act to market the product. This heat drying system has spent the majority of the last three years out of service. Initially due to fire damage, Windsor landfilled dewatered biosolids while repairs to the facility were being made; however, Windsor has found that landfilling is currently more economically viable, and is continuing with this method at present. Another facility at Smith Falls in Eastern Ontario has been producing a heat-dried product since 1995, but does not have a well-established market for year-round utilization of the dried biosolids. Similar facilities in the U.S. market their products primarily to bulk fertilizer blenders for incorporation into chemical fertilizers. The advanced alkaline stabilization facility in Leamington has been in operation since 1998 and N-Viro, who is contracted to distribute the product, has a license to market the product under the Federal Fertilizer Act. The product is sold to farmers in Southwest Ontario. A similar N-Viro facility is also located in the City of Sarnia, and has been in operation since 2001. The alkaline stabilized biosolids are sold to a local agricultural cooperative for distribution as a fertilizer amendment. The Region of Niagara is also contracting with N-Viro, to alkaline stabilize and distribute approximately 50 percent of its biosolids. The facility is currently under construction and is scheduled to be in operation in the fall of 2006. This facility will have capacity to process biosolids from other municipalities.

The private sector may begin to play a major role in developing markets for biosolids utilization in Ontario. Through contracts with municipalities, the private sector contractors will continue to provide transportation and land application services, as well as providing facilities for further processing, such as in Windsor, Leamington, Sarnia, and the Region of Niagara, and develop markets to utilize this higher quality product. Some pioneering is required to overcome regulatory and social barriers, which will make development of new markets challenging; as such, the private sector may be better suited to achieve this.

Incineration has been practiced in Southern Ontario since the early 1950s, when the first incinerators began operating at Ashbridges Bay in Toronto. Incineration has been used by the bigger generators of biosolids and at one time included the City of Toronto (Ashbridges Bay and Highland Creek), the City of Hamilton (Woodward Avenue), the City of London (Greenway), the Regions of York, Durham (Duffin Creek) and the Region of Peel (Lakeview). The by-product of incineration, ash, was landfilled onsite and at municipal landfills or recycled as light weight aggregate.

The private operations contractor shut down the Woodward Avenue incinerators a few years ago to reduce costs and in response to local public concern. The dewatered biosolids are land applied. The Ashbridges Bay incinerators have also been phased out and were replaced by a combination of dewatered biosolids land application and heat drying. The program began in 1996, when a portion of the dewatered biosolids was diverted to land application. This change was initiated by public pressure on the City of Toronto when it was determining how to manage their biosolids after the existing incinerators reached the end of their useful operating life. Since the fire in the heat drying facility, the dewatered biosolids that cannot be land applied are landfilled, and the City of Toronto is re-addressing its biosolids management program needs.

The Regions of Peel and Durham recently carried out biosolids management studies to select a long-term biosolids management strategy, and both studies recommended that current practice of incineration continue.

Some of the larger biosolids producers will likely continue to incinerate during the future; however, if they decide to discontinue incineration, there will be another increase in the distribution and supply of land-destined products. Should this happen, there will be added demand on the agricultural land available for land application of biosolids in Southern Ontario.

Biosolids Management in Other Jurisdictions

WWTPs in Eastern Ontario anaerobically or aerobically digest their biosolids and utilize biosolids by land application. The smaller plants typically utilize aerobic digestion. The larger plants, including the Robert O. Pickard Centre, Ottawa, Cornwall, Brockville, and Kingston, anaerobically digest their biosolids. The Ottawa and Kingston biosolids are dewatered before land application. As previously noted, the Town of Smith's Falls heat dries its biosolids and produces a pelletized product.

In New Brunswick, the largest plant is located in Moncton. Raw primary biosolids are dewatered and alkaline stabilized prior to utilization. The Greater Moncton Sewerage Commission has a diversified utilization program, which includes land application, both agricultural and sod farming, application to forests, and composting.

In Quebec, the larger plants either heat dry or incinerate their biosolids. In Montreal, biosolids are managed by a combination of incineration and heat drying. Heat drying is utilized in Quebec City, Laval, and Gatineau, whereas Longueuil incinerates its biosolids. A number of other municipalities utilize land application.

Winnipeg is the largest city in Manitoba. Biosolids are anaerobically digested and dewatered prior to land application.

In Saskatchewan, Saskatoon, and Regina anaerobically digest their biosolids and land-apply them. The Regina biosolids are dewatered prior to land application.

In Alberta, most wastewater treatment plants anaerobically digest their biosolids, including Edmonton, Calgary, the Capital Region, and Lethbridge. The Edmonton biosolids are currently land applied, as well as being co-composted with municipal solid waste. The other cities land-apply their biosolids.

In British Columbia, most wastewater plants anaerobically digest their biosolids, including Lions Gate, Annacis Island and Lulu in Vancouver, Matsqui and Prince George. The

Vancouver plants are either using thermophylic digestion or are upgrading to thermophylic. There are a number of smaller plants that utilize autothermal aerobic digestion. Biosolids management practices include land application, land reclamation, and landfilling.

In the U.S. and Europe, the primary biosolids management practices are land application, incineration and landfilling. In the U.S., both Class B and Class A biosolids are land applied. (Class A and Class B are USEPA classifications designating levels of biosolids stabilization, pathogen reduction, and metals concentration quality, with Class A having the lower level of residual pathogens and bacteria, and having less stringent land application requirements due to the associated reduce risk.) Processing technologies that are used to produce Class A biosolids include heat drying, alkaline stabilization, and composting. Various forms of thermophylic digestion are being developed to produce Class A biosolids. Pre-pasteurization is also being used prior to anaerobic digestion to produce Class A biosolids.

In Europe, approximately 50 percent of the biosolids are landfilled, 30 percent are used in agriculture, and the remainder are incinerated, ocean dumped, or otherwise disposed of. Most of the larger countries have either banned or moved away from landfilling of biosolids. Additionally, regulations have been introduced, which require lower pollutant concentrations in biosolids that are land applied. This has resulted in either increased treatment or a move to incineration. Germany, the largest producer of biosolids in the European Union (EU), relies on land application and incineration for its biosolids. A report by the Department of the Environment, Transport, and the Regions of the United Kingdom Government indicated that by 2005, with the cessation of ocean dumping, the distribution of biosolids utilization will be 60 percent land application, 36 percent incinerated or gasified and 4 percent landfilled. The composting rate has risen in Europe over the past three years. In Switzerland, for example, land application has been banned and biosolids are managed through incineration. This is partly due to the nature of the country, for example, shallow overburden soils in the mountainous landscape.

Implementation of Plan Components

The recommended biosolids management strategy is sustainable for the duration of the planning period, meets regulatory requirements, and satisfies the City of Guelph's need to serve its customers economically and responsibly. The program is premised on the City of Guelph's core value of environmental responsibility, resulting in a plan to recycle the biosolids through utilization programs.

The current agricultural land application program, using dewatered biosolids, is vulnerable to several factors that could jeopardize the long-term viability of the current program. The biosolids only satisfy the nitrogen fertilizer requirements of a small percentage of the agricultural land in the area. As the NMA rolls into force, however, animal manure could consume the land currently available for biosolids land application. Should this happen, the biosolids would have to be transported to more distant locations, making the program more expensive to manage. Jurisdictional concerns may also increase the difficulty in managing the biosolids.

The NMA was enacted in June 2002. The legislation is intended to be a comprehensive province-wide approach to managing all nutrients on agricultural land. The impetus of the Act is protection of soil and water quality in Ontario's rural environment, while ensuring that farmers can invest in and operate their farms with confidence. The OMAFRA and the

MOE are responsible for governing the Act, as well as the 13-part Regulation that outlines standards and the four protocols which provide more detail to the Regulation. The Regulation and related protocols were enacted July 1, 2003, with implementation beginning September 30, 2003.

At this point, the Regulation primarily pertains to livestock farmers, but there are some land application standards that apply to biosolids (non-agricultural source material), as well as some requirements for municipal generators. As of September 30, 2003, no biosolids can be applied within 20 m of a watercourse (as defined by the NMA Regulation), the use of high trajectory irrigation guns for land application is banned, and no application of municipal biosolids can take place between December 1 and March 31 of the following year. In addition, the Regulation set a schedule for implementation of Nutrient Management Strategies (NMS) for municipal generators of nutrients, dependent upon size.

The City of Guelph completed its first NMS in late 2004, and is required to update it annually and resubmit it for approval at least once every five years. The NMS is a tool to document the volume of biosolids that are generated, how they are stored, and how they will be used. The NMS must also link to documents related to end use, such as land application Certificates of Approval (C of A) and farm nutrient management plans, as well as broker agreements for any “intermediate” handlers, such as a hauler or land application contractor. Another key component is a contingency plan that documents actions to be taken during times when the intended end use cannot be carried out. Once a municipal generator has an NMS in place, the Regulation requires 240 days of storage for municipal biosolids, unless an alternative disposal method is provided, such as landfilling.

Recent incidents, such as the Walkerton E. coli epidemic, have heightened public awareness of land application programs that include biosolids, septage, and animal manure. This could lead to public pressure requiring products that have been further processed to reduce pathogens to levels equivalent to a Class A biosolids, as defined by the USEPA. In the U.S., there have been recent cases of municipalities banning land application of Class B (equivalent to Guelph’s anaerobically digested biosolids) and requiring Class A products. While there are no regulatory requirements either in Ontario or the U.S., the possibility of public pressure driving the industry towards a Class A level of product would require further processing of all the biosolids to achieve this.

The private sector component of the program includes transportation and land application, as well as development of other product markets for the preferred biosolids technologies in the short term and future products in the long term.

Existing Process Capacity and Equipment Upgrades

Table 7.2 summarizes the existing processes that have been previously identified as requiring equipment upgrades and/or additional process capacity to meet the needs of this BMMP. Table 7.2 also identifies the process need, its driver and the anticipated schedule.

TABLE 7.2
EXISTING PROCESS CAPACITY AND EQUIPMENT UPGRADES

Unit Process	Need	Driver	Result	Schedule
WAS Thickening	• Stage 1: Complete the demonstration • Stage 2: Design, procure and construct full-scale WAS thickening	• Increased sludge production limiting effectiveness of co-thickening in the primaries • Digester capacity limitations	• Improved settling of primary solids • Increased raw solids content, decreased volume • Potentially reduce required scale of digester expansion	• Stage 1: 2005-2007 • Stage 2: 2008-2010
Digestion[1]	• Increase digestion capacity (primary or alternative such as two-phase)	• Current capacity is not sufficient for demand; digesters are overloaded • No excess capacity is available to allow a digester to be taken offline for maintenance; all digesters require cleaning	• Sufficient capacity for demand • Sufficient treatment of biosolids to meet regulatory requirements for land applied biosolids • Ability to take units offline for maintenance	• 2006-2009
Dewatering	• Increased dewatering capacity • Two-stage process anticipated: 1) Replace two oldest belt presses (equipment currently under procurement) 2) Replace remaining two belt presses; consider higher solids equipment, such as centrifuges. Program to include pilot testing	• Two oldest presses have come to the end of their useful life • Two other presses are rapidly approaching the end of their useful life • Lower solids content cake is required for Lystek and higher solids content cake is required for landfilling and will economize when land applying of further processing cake	• Reliable equipment • Reduced operating hours, increased efficiency and reduced costs • Cake properties (solids content) suitable for diversified end uses	• Stage 1: 2005-2006 • Stage 2: 2007-2010
Lystek facility	• Complete installation and commissioning for full-scale (6 m^3) facility – September 2006 • Install and implement storage for Lystek treated biosolids	• Economical and technically sound management process required storage to fully implement reliable program	• Viable Lystek land application program • Maximize investment in equipment • Maximize beneficial use of biosolids	• 2007-2010
Compost facility	• Replace processing capacity with another technology • Construct and utilize covered storage pad; existing unused facilities may be retrofitted	• Existing compost system no longer considered reliable • • Storage to reduce dependency on landfilling	• Viable alternative to composting year-round • Reliable product with feasible market • Maximize beneficial use of biosolids	• 2007-2010

Notes:

[1] The requirement for digestion capacity expansion has been identified as two additional primary digesters, each sized similar to the existing primary digesters (that is 2,440 m^3 volume each), or equivalent, based on raw sludge quantity produced predicted to the 73, 3000 m^3/d ultimate plant capacity. The actual technology selected and design details should be reviewed during design of these facilities.

Land Application Contract

Currently, private sector contractors operate most of the land application programs in Ontario. The involvement of the municipalities in the programs varies significantly and may include recordkeeping, assessment of sites, ownership and operation of storage facilities, development of public education programs and auditing. Contract conditions, scope, and length may also vary significantly. For example, in Niagara, the contractor operates the Region-owned storage facility. For comparison, the Cities of Barrie and Brantford own and operate their storage facilities and contract out the transportation and land application. The Town of Collingwood and City of Kingston lease storage capacity from contractor who owns and operates the storage facilities. The Regions of Halton and Waterloo are similar to Niagara, where the Region owns the storage facility, while the contractor manages the facility.

Some of the contract factors are discussed below and in Table 7.3. As previously mentioned, the City of Guelph tendered for a new land application contract in 2005. The procurement process, developed by the City, consisted of developing a tender document and requesting tenders from contractors. The tenders were reviewed to confirm the contractors met the minimum requirements of the tender and that each tender was complete. The qualified tenders were then evaluated against pre-determined criteria and a preferred contractor selected. The City is currently negotiating the terms with the preferred contractor. It is anticipated that the contract will be signed and effective for a five-year period commencing with the 2006 land application season.

TABLE 7.3
COMPARISON OF LAND APPLICATION PRACTICES AND CONTRACT CONDITIONS

Contract Factor	Advantages	Disadvantages	Recommendation
Contract Cost Breakdown	• Reduce risk of cost increases to contractor • Allow optimization of land application program costs, including mechanical thickening, higher solids products and storage facility sitting • Allow contract separation to two or more contracts if contract becomes too big for one contractor	• Increased administrative costs • Increased potential for contract changes	• Include cost requirement breakdown in tender and contract
Longer Contract Length	• Longer contract lengths reduces risk to contractor by allowing capital costs to be amortized over longer period • Increases number of contractors able to bid on contract • Promote contractor commitment to the community	• City tied into contract for longer period of time • Potential escalation of contract costs due to uncertainty in long-term labour and fuel costs	• Five-year contract with option to extend contract
Escalation Clauses	• Reduces uncertainty in contractors future costs • May reduce contract costs	• Potential increase in City's budgeted costs	• Fuel cost escalation clause recommended due to current uncertainty in future fuel costs. Escalation based on actual fuel expenditures or clause negotiated with City based on expected fuel costs
Performance Bonds	• Increased reliability of contractor obligations being fulfilled • A letter of Credit gives the City ready access to monies to effect changes in emergency situations.	• May reduce tender competition • Increased contract costs	• Bond valued at one year of the contact

TABLE 7.3
COMPARISON OF LAND APPLICATION PRACTICES AND CONTRACT CONDITIONS

Contract Factor	Advantages	Disadvantages	Recommendation
Contractor Storage Facility O&M	• Contractor best able to manage capacity	• Increased contract costs • Reduced control over method of operation and equipment maintenance	• Allow market to determine most viable solution: City owned or included in contractors scope with methods of operation and equipment maintenance specified in contract documents
Dual-Named Application Site Approvals	• City maintains quality assurance over land application program • City not liable for impacts on contractor • Reduce risk of contractor monopoly • Assurance of land availability	• Increased City staff time for reviewing and approving contractor proposed land application sites • Potential increase in liability • Joint responsibility for provision of enough sites	• Approvals be in both the contractors' and the City's name with responsibility for provision of potential sites by contractor for City approval
Record-Keeping by City	• City maintains quality assurance over program • Flexibility to adapt to future regulatory changes without contract amendments • Improve City's information for future planning and land management • Better risk management record	• Increased City staff time for administration • Potential increased liability	• City participate with contractor in development, entry into and review of the record-keeping system
Public Consultation – Contractor Participation	• Public acceptance and development of goodwill with farming community would improve the long term stability of the program	• Slight increase in contract costs	• The City should maintain a permanent Public Advisory Committee composed of stakeholders – farmers, contractor, and public citizens group
Minimum Equipment Requirements	• Improves program reliability. Sufficient equipment will ensure a reliable program in years where poor weather conditions limit the number of application days. • Reduces potential impacts on roads and farm application sites. Appropriate application equipment minimizes soil compaction, minimizes risk of odours and runoff/leaching, and ensures a consistent application rate.	• Increases contractor capital costs	• Specify minimum equipment requirements, including number and types of equip-ment.

Recommendations for inclusion in the contract and future tendering processes, considered as best practices for the City, are also included in Table 7.3.

The City's participation with the contractor in obtaining site approvals would provide additional assurance to the public that guidelines are being followed and may reduce future liabilities to the City. In most programs, the contractor obtains the site C of A. In some cases, the contractor is named as the proponent in the C of A. In other cases, both the municipality and the contractor are named as co-proponents. The Region of Halton obtains site approvals and both the Region and contractor are named proponents. In Durham Region and Barrie, the contractor obtains the C of As and both the municipality and contractor are co-proponents. The Durham Region and Barrie approach is most appropriate for Guelph. (The contractor obtains the C of As specifying the City as the only biosolids source.)

Most of the contracts in other municipalities are of five-year durations (i.e. Barrie, Brantford, Durham Region, Halton Region, Kingston), except for smaller municipalities, where contracts are typically renegotiated each year. Due to the size of the Guelph contract, a five-year contract, with options for extension is recommended. This will allow the contractor to amortize the equipment costs over a reasonable time frame and lower the contract costs. Five years also corresponds with the first review under the Class EA master planning process.

Record-keeping has become more important in the past year, to demonstrate compliance with the NMA. In most cases, the contractor is responsible for the keeping land application records, with municipalities compiling biosolids quality and quantity records. However, many of the larger municipalities are now taking a more active role in record-keeping, including Halton Region and Peterborough. It is recommended that Guelph develops a single record-keeping system, combining City and contractor records, with both parties having access to all the records.

Contract cost break downs, such as escalation clauses for fuel cost and other elements, could be included to minimize risks of future cost increases to the contractor and possibly reduce the contract costs.

Once the contract is executed, the City must administer it to ensure that both the City's and the community's interests are protected. The City's biosolids coordinator is the designated staff member responsible for overseeing the administration of the contract. These duties include the following:

- Establish and implement procedures to verify biosolids quantities picked up by the contractor
- Establish and implement procedures to verify submissions and approvals
- Establish and implement procedures to verify biosolids are being sampled and monitored and that records required by the MOE and the contract are being prepared and made available to the City
- Establish and implement procedures to verify that conditions of the C of As related to activities at the application sites are being complied with
- Establish and implement recordkeeping requirements of the NMA
- Set up monthly activity reports.

The City must set up auditing procedures to properly monitor that the contractor is performing the activities of the contract. Auditing may be performed by the City, or alternatively by an unbiased third party, which may give additional transparency to the program for the stakeholders and public. The following is a list of recommended auditing activities:

1. Review forms completed by truck drivers for completeness and accuracy.
2. Reconcile with monthly report by contractor.
3. Check biosolids processing, storage, and loading facilities including:
    - Storage levels
    - Equipment and road conditions
    - Housekeeping
    - Log book reports
    - Weekly inspection.

4. Spot check C of As for land application sites.
5. Spot check for transportation route road damages and report.
6. Maintain some "visual presence" at application sites and be available for questions from farmers and the public during application events.
7. Respond to correspondence from neighbours.
8. Respond to complaints from municipal politicians regarding roads, traffic, odours, and general concerns.
9. Audit records of field complaints to contractor by farmers, neighbours, and general public.
10. Review results of laboratory tests for biosolids quality.
11. Prepare reports for Public Works Committee on biosolids issues including:
    - Availability
    - Quality
    - Quantity
12. Respond to questions from the media.

Administering of the contract is anticipated to require full time attention approximately two days per week between December and April and approximately three days per week for the rest of the year.

Future Processing Needs

As discussed previously, the composting facility needs to be replaced as soon as possible. The analysis of alternatives determined that composting in the future is currently not a preferred alternative diversification strategy because of the regulatory climate respecting biosolids compost in Ontario. Because of this, it is difficult to justify the costs associated with a significant overhaul and future operation of the compost system when total renovation is required.

Two processing alternatives were found to be feasible for Guelph: heat drying and alkaline stabilization. These and other alternatives, including incineration, are also feasible if partnering with other municipalities is desired and successful.

It is anticipated that the preferred program to replace the compost system will be addressed within the initial stage of the plan implementation and before the first five-year review and update of this Biosolids Management Master Plan. Accordingly, it is recommended that the City initiate discussions with potential private and municipal partners during the period preceding the five-year review and initiate a pre-design study, to determine the preferred management method. The five-year review and update should also consider regulatory changes, market issues, technology advances and partnering opportunities that may emerged during initial five-year implementation of the plan. This would include the issues that may emerge due to the anticipation of an increased quantity of alkaline stabilized biosolids that will be on the market when the Niagara facility is commissioned and the potential for the State of Michigan to close it border to the import of Canadian wastes for landfill disposal.

Contingency Planning and Landfill Contract

The City currently has a landfill contract with the Green Lane landfill, near London, ON. This contract was negotiated in 2004 for all City non-hazardous wastes. Dewatered biosolids are currently landfilled under the contract conditions. However, the belt presses do not produce a cake with sufficiently high solids content for suitable handling at the landfill. The City therefore utilizes some equipment in the compost facility to blend the cake with woodchips, which produces a higher solids blended product. The recommended dewatering equipment replacements will eliminate this need in the future. Furthermore, this management plan will reduce dependency on landfilling.

The City's biosolids management auditing procedures should also include proper monitoring of the landfill contract to measure and track contractor performance compliance. Periodic auditing is recommended.

A landfill contract should be maintained at all times over the period of this BMMP to ensure that a feasible plan is available, as required under the NMA (where biosolids product storage of less than 240 days for land application programs is available).

Permits and Approval Requirements

Implementation of the plan will require the upgrade of some existing facilities and construction of new facilities. The various types and levels of approvals required for implementation are described below. Each of the regulatory acts, as well as local requirements, is addressed.

Class EA Approvals (Environmental Assessment Act)

Recommended component activities and programs identified in the Master Plan will require additional Class EA approval before their implementation. In all cases, the Master Plan document will provide the required project rationale and background data and must be clearly referenced in specific Class EA studies and reports.

Operational process improvements and upgrades to existing WWTPs, up to the existing rated capacity, will typically fall under Schedule A or Schedule B requirements. These types of projects include WAS thickening, digestion and dewatering upgrades, and Lystek and compost facility replacement. With the completion of this Master Plan, all Schedule A activities may proceed to implementation without the need for additional assessment. Schedule B activities may require additional assessment, depending on the specific undertaking and consultation with the stakeholders local to the project. A project file must be maintained for Schedule B activities and a 30-day review period must also be completed prior to project implementation.

Where proposed activities will require capacity increases beyond rated, or are located at a new site, the City will be required to complete the planning requirements for a Schedule C Class EA, including the preparation of an Environmental Study Report. The Guelph WWTP is approved for activities required to provide treatment up to a rated capacity of 73.3 MLD, the maximum flow upon which this BMMP was developed.

City used facilities that are owned and operated by the private sector typically are not subject to the Class EA process.

Certificates of Approval – Sewage (Ontario Water Resources Act)

Upgrades at the WWTP will require amendments to the existing C of A. If the City were to construct a facility at a new location, a new C of A would be required. City used facilities that are owned and operated by the private sector do not fall under the Act and do not need a C of A.

Certificates of Approval – Air (Environmental Protection Act)

Upgrades at the WWTP may require amendments to existing C of A and consolidation of all previous C of As. These permits cover emissions of contaminants, including odour and noise. For example, installation of additional boilers, if required, for increased digestion capacity, will require an amendment to a plant's C of A for its boilers. The MOE also currently requires that any facility applying for an amendment consolidates all previous C of As into one C of A. City-used facilities owned and operated by the private sector will require a C of A. C of As are designated Class I instruments under the Environmental Bill of Rights (EBR) and are advertised on the EBR Registry during a 30-day public comment period.

Certificates of Approval – System (Environmental Protection Act)

Biosolids land application contractors require an Organic Waste Management System C of A to transport waste material to the application site or between plant and offsite storage facility, if applicable. C of As are designated Class I instruments under the EBR and are advertised on the EBR Registry during a 30-day public comment period.

Certificates of Approval – Sites (Environmental Protection Act)

Each land application site requires an Organic Soil Conditioning Site C of A. C of As are designated Class I instruments under the EBR and are advertised on the EBR Registry during a 30-day public comment period.

Local Government Permits

Upgrades at the WWTP may require building permits. New facilities at other locations will require building permits and may require planning approval.

Risk Management Analysis and Recommendations

The management of risk is paramount as the City proceeds with the implementation of the biosolids management strategy. The first step in managing risk is to prepare a risk profile. This exercise included the identification of specific risk issues, evaluating the potential liability posed by each issue to the City, and then identifying the required actions, if any, to reduce or minimize the medium to high risk issues. This information constitutes the risk management plan and the issues and required actions are summarized in Table 7.4.

TABLE 7.4
RISK MANAGEMENT ANALYSIS AND RECOMMENDATIONS

Risk Issues	Potential Liabilities to City	Actions Required
City and Regulatory		
Biosolids Technologies – wrong selection	Low, because there are several options to utilize/dispose and a diversified program is recommended	
Biosolids Technologies – poor reliability	Low, because of diversified nature of program, scheduled maintenance periods for all components, and contingency planning	Develop, implement and audit contingency plan; perform routine and scheduled maintenance
Best Practices	Low	
Roads/Load Restrictions	Low/Manageable	
Monitoring of Land Application Contract – lack of	High	Develop Monitoring Plan and implement. Include application practices, as well as farming practices
Biosolids Volume vs. Other Agricultural Waste and nutrients from outside of area (land availability for nutrients and perceived risks)	Low to Medium	Require proactive communication program
Biosolids Characteristics – Off Spec Biosolids	Low/Manageable	Develop, implement and audit contingency plan for disposal
Contract failure	Medium, if contract fails other contractors are available	Ensure contract includes default and termination language
Site C of A – securing in a timely manner	Low to Medium	Ensure contract includes suitable language to have sufficient land base Communicate with MOE
Odours	Medium to High	Application by injection or incorporate within 8 hours of surface application
Total Watershed Management	Low	Continue participating with others to carry out total watershed management planning
Financial Considerations		
Program Costs – unanticipated escalation	Low to Medium	Typically self correcting due to industry competition Ensure contracts include escalation clauses
Farmer Compensation	Low	Requires proactive communication program
Indemnification	Low	
Public/Farmer Perceptions	Medium	City support and endorsement of land application Contractor's communication programs with farmers and public. Additional communication with public may be required for compost, depending on the market pursued.
Contingency Plan	Low to Medium	Maintain and audit landfill contract

In summary, the City can reduce and manage potential liability associated with the biosolids management strategy by improving overall communication with stakeholders, by maintaining an ongoing understanding of the current market in Ontario for biosolids management, and by continuing to implement the monitoring program developed for compliance with the environmental management strategy (EMS). This will increase public assurance that the programs and activities are being carried out as contracted and according to regulatory protocols.

Environmental Management Strategy (EMS) Program Management Option

The Guelph BMMP has many important and interconnected components. Given the growing public profile of biosolids, its management and associated risks, the City must consider and recognize the roles and responsibilities of its internal departments that are critical to the program's success. In the management and performance evaluation of the overall program, the City must also consider and recognize the roles and responsibilities of its contractors, suppliers, and the landowners that participate in the program.

It is recommended that the City consider adopting an EMS approach for its strategy implementation. An EMS is based on the foundations of quality management and continual improvements and is an iterative process of Plan-Do-Check-Act. This approach has been adopted by the National Biosolids Partnership, established in 1997, whose membership includes the National Association of Clean Water Agencies (NACWA), [formerly the Association of Metropolitan Sewerage Agencies (AMSA)], the USEPA and the Water Environment Federation (WEF). It was adopted in response to their collective need to improve public acceptance of their biosolids management programs, to reduce risks, and to improve productivity.

The elements of an EMS for biosolids include the following:

- **Development –** of a policy and making a commitment to an EMS framework
- **Planning** – to identify critical control points, determine legal, regulatory and other requirements and to establish desired outcomes/public expectations
- **Implementation** – including the assignment of roles and responsibilities, providing training to increase skills and knowledge, establish communication programs, standard operating procedures and institute corrective actions to resolve problems
- **Measurement/Corrective Action** – assess success in meeting requirements, goals, objectives and performance standards and in instituting corrective actions
- **Management review –** periodically to assure effectiveness of the EMS.

Developing an EMS is an effective management approach to:

- Establishing and protecting the integrity of a program
- Encouraging local involvement
- Building community and stakeholder support into the program
- Maintaining recognition that the program meets health and safety requirements
- Building credibility of public agencies and suppliers
- Guaranteeing regulatory compliance
- Avoiding costly mistakes
- Realizing financial efficiencies

An EMS framework provides a comprehensive approach to managing all aspects of a biosolids management program.

Summary and Implementation Schedule

Study Conclusions

The Guelph BMMP study included a review of the City's current biosolids management program and an analysis of alternative management (processing, disposal and utilization) options. The following represent the study conclusions generated:

1. **The existing method of management, that is, anaerobic digestion, dewatering, and land application of Lystek-treated, composted and dewatered biosolids, is the most economical for the City.** However, composting is infrequently used due to the age and unreliability of the system, as well as the regulators' difficulties with beneficial use. Due to the current lack of storage, landfilling of dewatered biosolids is utilized when required. Land application of liquid biosolids may be utilized for scheduled equipment shutdowns or during emergency situations.

   It was estimated that there will be sufficient agricultural land available to land apply biosolids over the long term. This conclusion assumes that there are no political or social barriers to this method of biosolids management. The City's procurement process and contract terms was also reviewed. It is recommended that the City will continue to contract with the private sector to manage its biosolids in an environmentally responsible and economical manner to the satisfaction of the City, its residents and the farming community.

2. **Process capacity and/or equipment upgrades are required for**:
   - **WAS thickening** – full scale facilities following demonstration
   - **Primary digestion** – two new primary digesters or equivalent
   - **Dewatering** – completion of replacement of presses 1 and 2 in 2006 followed by replacement of presses 3 and 4

   These facility improvements are required to provide the process ability to implement to management plan.

3. **The City needs to consider construction of storage facilities for Lystek-treated and other biosolids to be able to maximize beneficial use of biosolids, improve viability of the land application program and reduce dependency on landfilling.** Because the City currently has no storage facilities, land application occurs at the rate of the process capacity of Lystek treatment and dewatering. Sites applications would be more economical if sufficient material were available to complete the application in a concise time period. Storage also allows some homogenization of the product, resulting in a more consistent material.

   It is not recommended that the City invest in long-term storage facilities for dewatered cake, as the industry has not yet solved the problems with this technology for long-term storage. Rather, long-term storage facilities for the product that replaces composting should be provided. This storage could be used in the interim for dewatered cake. Storage for Lystek-treated biosolids is economical (compared to liquid biosolids storage) and the technologies are well-understood and proven reliable.

   Maintaining a landfill contract is also recommended as an important part of the strategy, for contingency and emergency biosolids disposal.

4. **The City needs to develop a plan for replacement of the composting facility as soon as possible.** The City should continue to maintain a diversified biosolids management strategy; however, the current regulatory framework does not support unrestricted use of biosolids compost. Also, the City has determined that this composting equipment is at the end of its reliable service life and should be replaced (decommissioned) as soon as possible. Alternative treatment technologies, including heat drying and alkaline stabilization, produce a product, at similar cost, that may be federally registered as a fertilizer and is therefore a higher value product.

   The City should use the available time, prior to the first five-year BMMP review and update, to investigate partnering with other municipalities and private companies to determine if a suitable opportunity exists e.g. the N-Viro Niagara facility could be used to manage some of the biosolids to gain some experience with the product. This could be achieved by initiating discussions with potential partners (other municipalities or private companies) to develop co-operative initiatives and to establish networks for investigating new strategy alternatives. This method of management could reduce each partner's costs. Municipalities will still have to proactively monitor programs that are contracted to the private sector to satisfy public concerns. The concept of municipalities partnering lends itself to management solutions that could provide benefits to all of the partners including adopting common best management practices and shared central facilities or contracting services effectively by utilizing contracts that fairly share risk between partners. The City should also initiate a pre-design study to determine the preferred replacement strategy.

   If the City determines that decommissioning of the compost facility and onsite replacement with another technology is preferred, this study concluded that heat drying or alkaline stabilization would currently be the preferred process. The City should commission a study to evaluate the market, regulatory trends and emerging technologies to confirm the analysis.

Implementation Plan

The study conclusions provided the basis for developing an Implementation Plan. The implementation plan identifies specific initiatives to maintain, improve and maximize the current land application program, to maintain the contingency disposal option, and to develop and plan for facility replacement. Accordingly, the Implementation Plan includes initiatives in three specific areas.

1. **Land Application Program – "Continuous Improvement"**

   The current land application program, with contingency landfill disposal, can be further supported and maintained into the future by implementing initiatives involving monitoring and quality control, communications, stakeholder involvement, improved procurement process, product market development, and appropriate storage capacity.

2. **Facility Replacement/Expansion Planning**

   To ensure a reliable, sustainable and diversified biosolids management program over the next 20+ years, the City must implement a number of initiatives. These include digestion and dewatering process improvements/expansion and compost processing replacement, as well as consideration of final markets, product quality enhancement and co-operative or Private, Public, Partnership (PPP) options. Contingency planning will be needed and can realistically be adjusted as options become available.

3. **Program Management**

The management of risk is paramount as the City proceeds with the implementation of the biosolids management strategy. The City can reduce and manage potential liability associated with the biosolids management strategy by implementing the following initiatives:

- Increase the awareness and understanding of City staff of the Ontario context for biosolids management through collaborative discussions with other municipalities and industry sector parties.
- Implement a monitoring program to increase public assurance that the City's programs and activities are being carried out as contracted and according to regulatory protocols.
- Consider adopting an EMS approach for its strategy implementation.
- Take co-responsibility and co-ownership of land application site approval with the contractor.

Schedule

Implementing the strategy presented above requires developing a schedule to address the entire time period of the Guelph BMMP and to include incorporating risk management. The proposed implementation schedule is illustrated in Figure 7-1 and the capital cash flow projection of implementation is shown in Figure 7-2.

It is recommended that the implementation schedule is reviewed and updated at least every five years to assist in capital budget forecasting.

The main components of the Guelph BMMP are:

- Three-stream biosolids management program with the City continuing to produce a Lystek 'liquid' product, dewatered cake, and a product from the replaced composting process:
  - Lystek processing to have a two-month scheduled maintenance period per year;
  - Storage for Lystek to maximize beneficial use and reduce landfill dependency.
- Process capacity and equipment upgrades to meet biosolids production requirements:
  - Implementation of full-scale WAS thickening;
  - Digestion expansion, consisting of two new primary digesters or equivalent compatible with the existing system;
  - Dewatering equipment replacement of all BFPs (two currently in tender), with ability to produce lower solids cake (for Lystek treatment) and higher solids cake (for further processing or landfilling);
  - Replace composting system with the preferred technologies.
- Implement the procurement process developed for the new land application contract. The land application contract to be arranged for five years, and renewable, will allow implementation and adjustment to the plan.
- Develop a plan for future partnering with the private sector or other municipalities, or ultimately replace the compost facility.
- Develop and implement a communications and education plan.

- Develop a risk management plan that incorporates elements to address the BMMP, including a contracting strategy to reduce risk, a contract monitoring plan, a public opinion tracking program, and an oversight committee.
- Implement a review and reassessment of the BMMP within five years.

FIGURE 7-1
IMPLEMENTATION SCHEDULE

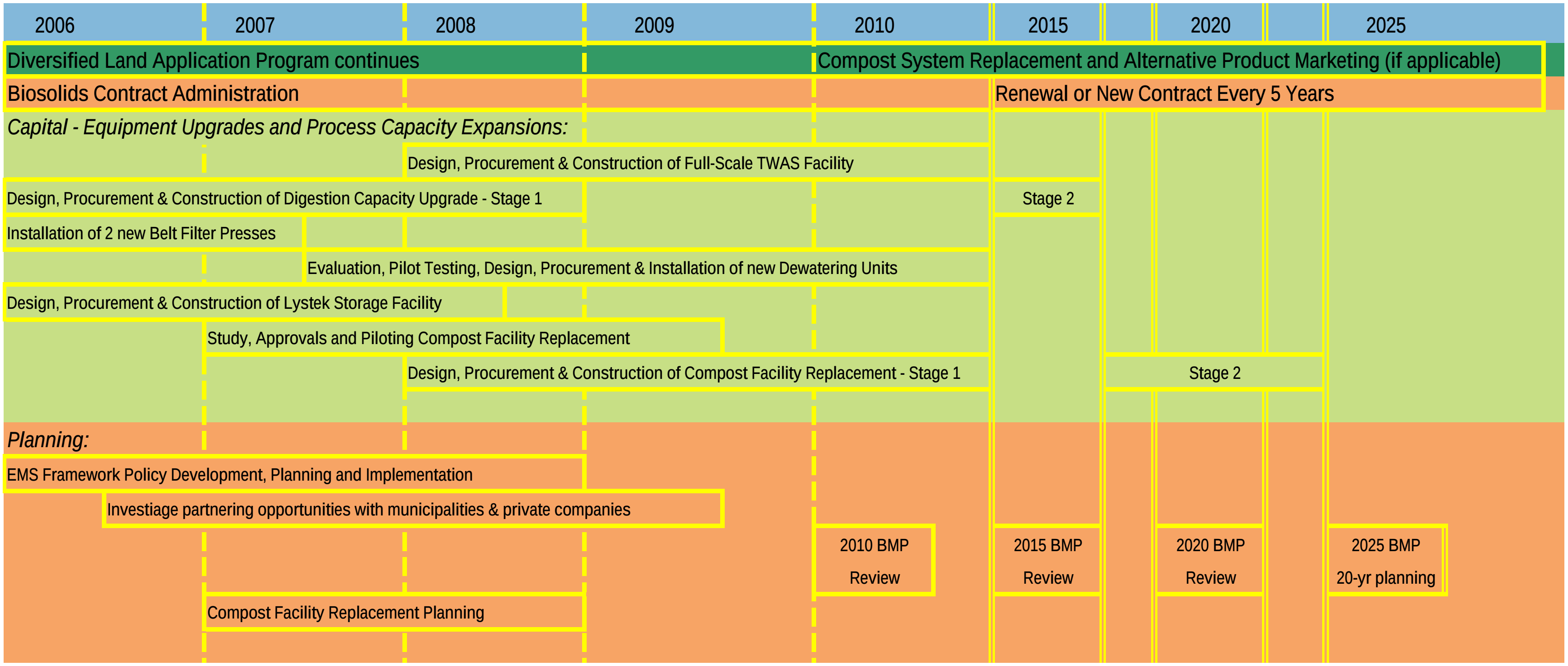


FIGURE 7-2
CAPITAL CASH FLOW PROJECTION FOR IMPLEMENTATION OF OPTION 1

($1,000,000; 2005 Dollars)

	Total Cost	2006	2007	2008	2009	2010	2011-2015	2016-2020	2021-2025
WAS Thickening	$2.2	$0.0	$0.0	$0.4	$1.1	$0.6	$0.0	$0.0	$0.0
Digestion	$13.0	$0.5	$5.8	$0.1	$0.0	$0.0	$0.4	$6.1	$0.0
Dewatering	$2.2	$0.0	$0.2	$1.5	$0.4	$0.0	$0.0	$0.0	$0.0
Miscellaneous	$2.7	$0.0	$0.4	$0.6	$0.5	$0.2	$0.0	$0.0	$0.0
Compost System Replacement	$13.0	$0.0	$0.7	$3.9	$2.6	$0.0	$0.0	$4.6	$1.3
Annual Total Cost	**$33.1**	**$0.5**	**$7.1**	**$6.6**	**$4.6**	**$0.9**	**$0.4**	**$10.7**	**$1.3**

Executive Summary

The City of Guelph initiated a project to prepare a Biosolids Management Master Plan (BMMP) to provide direction for biosolids management activities to the year 2025. The goal of the project is to recommend a management strategy that is economically viable, meets regulatory requirements, can be maintained in the long term and is supported and endorsed by stakeholders and, ultimately by City Council.

Currently, the City uses the services of a contractor to remove Lystek-treated and dewatered biosolids from the wastewater treatment plant (WWTP) and apply them to agricultural lands that have been pre-approved to accept these types of biosolids materials. Landowners and farmers receive this service at no cost. When land application is not available, the dewatered biosolids are blended with woodchips in the composting facility and disposed of at landfill.

Study Conclusions

The Master Plan study included a review of the City's current biosolids management program and an analysis of alternative management (processing, utilization and disposal) options. The study conclusions generated were:

1. **The existing method of management, that is, anaerobic digestion, dewatering, and land application of Lystek-treated, composted and dewatered biosolids, is the most economical for the City.** However, composting is infrequently used due to the age and unreliability of the system, as well as the regulatory difficulties with beneficial use. Due to the current lack of storage, landfilling of dewatered biosolids is utilized when required. Land application of liquid biosolids may be utilized for scheduled equipment shutdowns or during emergency situations.

   The City's procurement process and contract terms was also reviewed. It is recommended that the City will continue to contract with the private sector to manage its biosolids in an environmentally responsible and economical manner to the satisfaction of the City, its residents and the farming community.

2. **Process capacity and/or equipment upgrades are required for**:
   - **WAS thickening** – full scale facilities following demonstration
   - **Primary digestion** – two new primary digesters or equivalent
   - **Dewatering** – completion of replacement of presses 1 and 2 in 2006 followed by replacement of presses 3 and 4

   These facility improvements are required to provide the process ability to implement to management plan.

3. **The City needs to consider construction of storage facilities for Lystek-treated biosolids to be able to maximize beneficial use of biosolids, improve viability of the land application program and reduce dependency on landfilling.** Because the City currently has no storage facilities, land application can occur at the rate of the process capacity of Lystek treatment and dewatering. Site applications would be more

economical if sufficient material were available to complete applications in a concise time period. Storage also allows some homogenization of the product, resulting in a more consistent material.

It is recommended that the City not invest in long-term storage facilities for dewatered cake at this time, as the industry has not yet solved the problems with this technology for long-term storage. Rather, long-term storage facilities for the product that replaces composting should be provided. This storage could be used in the interim for dewatered cake. Storage for Lystek-treated biosolids is economical (compared to liquid biosolids storage) and the technologies are well-understood and proven reliable.

Maintaining a landfill contract is also recommended as an important part of the strategy, for contingency and emergency biosolids disposal.

4. **The City needs to develop a plan for replacement of the composting facility as soon as possible.** The City should continue to maintain a diversified biosolids management strategy; however, the current regulatory framework does not support unrestricted use of biosolids compost. Also, the City has determined that the composting equipment is at the end of its reliable secure life and should be replaced (decommissioned) as soon as possible. Alternative treatment technologies, including heat drying and alkaline stabilization, produce a product, at similar cost, that may be federally registered as a fertilizer and is therefore a higher value product.

   The City should use the available time, prior to the first five-year BMMP update, to investigate partnering with other municipalities and private companies to determine if a suitable opportunity exists e.g. the N-Viro Niagara facility could be used to manage some of the biosolids to gain experience with the product. This could be achieved by initiating discussions with potential partners (other municipalities or private companies) to develop co-operative initiatives and to establish networks for investigating new strategy alternatives. This method of management could reduce each partner’s costs.

   If the City determines that decommissioning of the compost facility and onsite replacement with another technology is preferred, this study concluded that heat drying or alkaline stabilization would currently be the preferred process. The City should commission a study to evaluate the market, regulatory trends, and emerging technologies to confirm the analysis.

Implementation Plan

The study conclusions provided the basis for developing an Implementation Plan. The implementation plan identifies specific initiatives to improve and maintain the current land application program, to strengthen the program and to continue to provide a contingency option. Accordingly, the Implementation Plan includes initiatives in three specific areas.

1. **Land Application Program – “Continuous Improvement”**

   The current land application program, with contingency landfill disposal, can be further supported and maintained into the future by implementing initiatives involving monitoring and quality control, communications, stakeholder involvement, improved procurement process, product market development and appropriate storage capacity.

2. **Facility Replacement/Expansion Planning**

   To ensure a reliable, sustainable and diversified biosolids management program over the next 20 years, the City must implement a number of initiatives. These include digestion and dewatering process improvements/expansion and compost processing replacement, as well as consideration of final markets, product quality enhancement and co-operative or Private, Public, Partnership (PPP) options. Contingency planning will be needed and can realistically be adjusted as options become available.

3. **Program Management**

   The management of risk is paramount as the City proceeds with the implementation of the biosolids management strategy. The City can reduce and manage potential liability associated with the biosolids management strategy by implementing the following initiatives:

   - Increase the City staff's awareness and understanding of the Ontario context for biosolids management through collaborative discussions with other municipalities and industry sector parties and opportunities for partnering.
   - Implement a monitoring program to increase public assurance that the City's programs and activities are being carried out as contracted and according to regulatory protocols.
   - Consider adopting an Environmental Management System (EMS) approach for its strategy implementation.
   - Take co-responsibility and co-ownership of land application site approval with the contractor.

The estimated capital cost to implement the recommended solutions is $33.1 million over 20 years. It is anticipated that approximately $19.6 million capital investment is needed over the next five years and approximately $13.0 million capital investment may be required for compost system replacement during the next five years and into the future.

Master Plan Development

The Guelph BMMP was developed following the Class Environmental Assessment (EA) requirements for a master plan. The two-phased process included the following key requirements:

- Understanding of the current program
- Examination of the alternative technologies, products, utilization, and disposal options
- Development of short-term actions and a long-term strategy to meet future requirements
- Documentation to provide clear and traceable decision-making
- Consultation with stakeholders throughout the decision-making process

Phase 1 activities included initial data gathering to determine the existing infrastructure conditions and future capacity requirements. This information was used to develop the "problem definition" or "needs statement" for the study.

Phase 2 activities included several component tasks focused on the screening of the long list of alternatives and a more detailed evaluation of a short list of seven alternative strategies including composting, heat drying and alkaline stabilization technologies as part of a diversified program.

The strategies were evaluated using an extensive set of criteria developed in consultation with public and agency stakeholders. The Master Plan strategy also included the development of an implementation plan, and recommendations for a risk management plan. Project information was available to the public at an Open House, Public Information Centre, via a project mailing list, and on the City's website.

The planning and decision-making process has been documented in the Master Plan report. All technical analyses and public correspondence are appended to the report. The Master Plan provides the basis for biosolids activities in the City to 2025 and must be reviewed and updated every five years.

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Glossary and Abbreviations

Glossary

Beneficial use**:** A disposal process that takes advantage of at least one of the nutrient, soil conditioning, or fuel properties of sludge. Beneficial use practices include land application of biosolids as a soil amendment or fertilizer supplement and various procedures that derive energy from biosolids or convert them to useful products.

Biochemical oxygen demand (BOD_5)**:** The amount of oxygen utilized during a 5-day incubation period for the biochemical degradation of organic material.

Biosolids**:** Primarily organic solid product produced by wastewater treatment processes that are of a quality that can be beneficially used.

Market: The end use for the biosolids product or the utilization site(s).

Pathogens**:** Disease-causing organisms found in wastewater and sludge.

Sludge**:** Solids removed from wastewater by mechanical or biological means. Sludge and biosolids, as used in the text, mean the same when the sludge is processed to a biosolid quality.

Wastewater**:** The spent or used water of a community or industry which contains dissolved or suspended matter. It is a general term for untreated discharged.

Abbreviations

°C	degrees Celsius
AMSA	Association of Metropolitan Sewerage Agencies
BFP	Belt filter press
BMMP	Biosolids Management Master Plan
C of A	Certificate of Approval issued by the MOE
CFIA	Canadian Food Inspection Agency
City	City of Guelph
D	day
dt	dry tonnes
EA	Environmental Assessment
EBR	Environmental Bill of Rights
EMS	Environmental Management Strategy
EU	European Union
GRCA	Grand River Conservation Authority
ha	hectare
HRT	Hydraulic retention time
kg	kilogram
L	litre
m	metre

m^3	cubic metre
mg	milligram
ML/d	megalitres per day
MLD	megalitres per day
MOE	Ontario Ministry of the Environment
MUA	Multi-attribute Utility Analysis
N	Nitrogen
NA	Not applicable
NACWA	Natural Association of Clean Water Agencies
NH_3	Ammonia
NM	Not measured
NMA	Nutrient Management Act
NMS	Nutrient management strategy
NO_3	Nitrate
NPV	Net Present Value
O&M	Operation and maintenance
OMAFRA	Ontario Ministry of Agriculture, Food and Rural Affairs
pH	non-dimensional measure of acidity or alkalinity of a fluid
PPP	Private, Public, Partnership
t	tonne (metric ton) or 1,000 kg
TKN	Total Kjeldahl Nitrogen
TM	Technical Memorandum
TWAS	Thickened waste activated sludge
USEPA	U.S. Environmental Protection Agency
WAS	Waste activated sludge
WEF	Water Environment Federation
wt	wet tonnes
WWTP	Wastewater treatment plant
y or yr	year

1. Introduction and Background

Project History

In response to growth pressures, the City of Guelph, in 1998, completed a Schedule C Class Environmental Assessment (EA) to identify a wastewater treatment strategy to serve the City's needs to the year 2016. The study considered the treatment requirements for the liquid portion of the wastewater stream and addressed issues associated with the management of the solids component of the wastewater stream. A two-stage liquid side expansion of the City's Wastewater Treatment Plant (WWTP) was recommended. The Stage 1 expansion, completed in 2002, increased the rated capacity of the WWTP from 54,000 to 64,000 m^3/d. The Stage 2 expansion will provide an additional increase in the rated capacity of the WWTP to 73,300 m^3/d.

The 1998 Class EA is currently being updated by the City of Guelph to review and select emerging treatment technologies for pilot testing and incorporation into the design of the Stage 2 expansion. This update is a result of a commitment included in the 1998 Class EA document to review technology options prior to the Stage 2 expansion.

The 1998 Class EA also recommended that biosolids management be further examined for the Stage 2 expansion to determine the most suitable approach for facility expansion and upgrade and for biosolids use or disposal. Since the Stage 1 expansion is complete and new legislation, including Ontario's Nutrient Management Act (NMA), was identified as potentially impacting the existing biosolids management approach, this Biosolids Management Master Plan (BMMP) was developed to address biosolids issues for the future.

The BMMP followed the Class Environmental Assessment planning and decision-making process identified for master plans.

The Class EA Update and the BMMP studies are related, as they both focus on activities and programs at the WWTP. The innovative technologies evaluated in the Class EA Update are focused on the liquid stream of the wastewater conveyed to the plant. The technology selection and implementation will generate biosolids with certain quality and quantity characteristics, depending on the technology selected for the Stage 2 expansion. This information is important to the BMMP decision-making process as it will determine the characteristics of the biosolids product and related feasible end uses and disposal options.

Report Organization

This report documents the BMMP. Section 1 provides a brief introduction and background to the study. The Master Planning process followed for this study is described in Section 2. The need and rationale for the BMMP is presented in Section 3. The assessment of compost utilization options and the examination of the existing compost facility are documented in Sections 4 and 5, respectively. Section 6 outlines the technology evaluation and strategy development. Section 7 provides an implementation plan for the recommended strategy. Reports on technical tasks are appended to this report, as are all correspondence and public consultation materials.

2. Master Planning Process

Class Environmental Assessment Process

This project followed the Municipal Engineer's Association Class Environmental Assessment (Class EA) (June 2000) process for master plans. Accordingly, Phases 1 and 2 of the Class EA decision-making process were completed including consultation with stakeholders and documentation of a Master Plan (Figure 2-1). For this project, the objective of the Master Plan was to develop a strategy for the management of biosolids generated at the Guelph WWTP in an environmentally sound, efficient, and cost-effective manner. The study included defining the need based on existing conditions and future wastewater treatment capacity, developing and assessing alternatives and identifying a preferred alternative, or set of alternatives, that will form a strategy for the long-term management of biosolids. This process included the participation of the community, whose input has influenced the development of the overall Master Plan components recommended in this plan. The Master Plan provides the basis and rationale for future Class EA studies prior to the design and construction of site-specific works recommended in the Master Plan.

Biosolids Master Plan Decision Tree

A decision process was developed for this study that incorporates the Class EA requirements. The preparation of the Master Plan involved the completion of six individual tasks that followed a logical, traceable and defensible sequence, serving as the foundation for a single decision-making process. The Decision Tree is presented in Figure 2-2. Tasks 1 and 2 (Master Plan definition and the determination of compost utilization opportunities) addressed Phase 1 of the Class EA requirements. Tasks 3 and 4 (the determination of compost optimization alternatives that provide cost savings and selection of a preferred biosolids management option to meet the City of Guelph's long-term needs) addressed Phase 2 of the Class EA requirements. Task 5 involved documenting the strategic activities of the BMMP, including recommended actions. The development and implementation of a stakeholder consultation plan to support and satisfy the Master Plan requirements under the Class EA process was completed as Task 6, and was undertaken concurrently with the other tasks.

Stakeholder Participation

Project Team

The project team for this study includes:

- City of Guelph
  - Management and operations staff of the WWTP

FIGURE 2-1
CITY OF GUELPH BIOSOLIDS MANAGEMENT ALTERNATIVES PLANNING

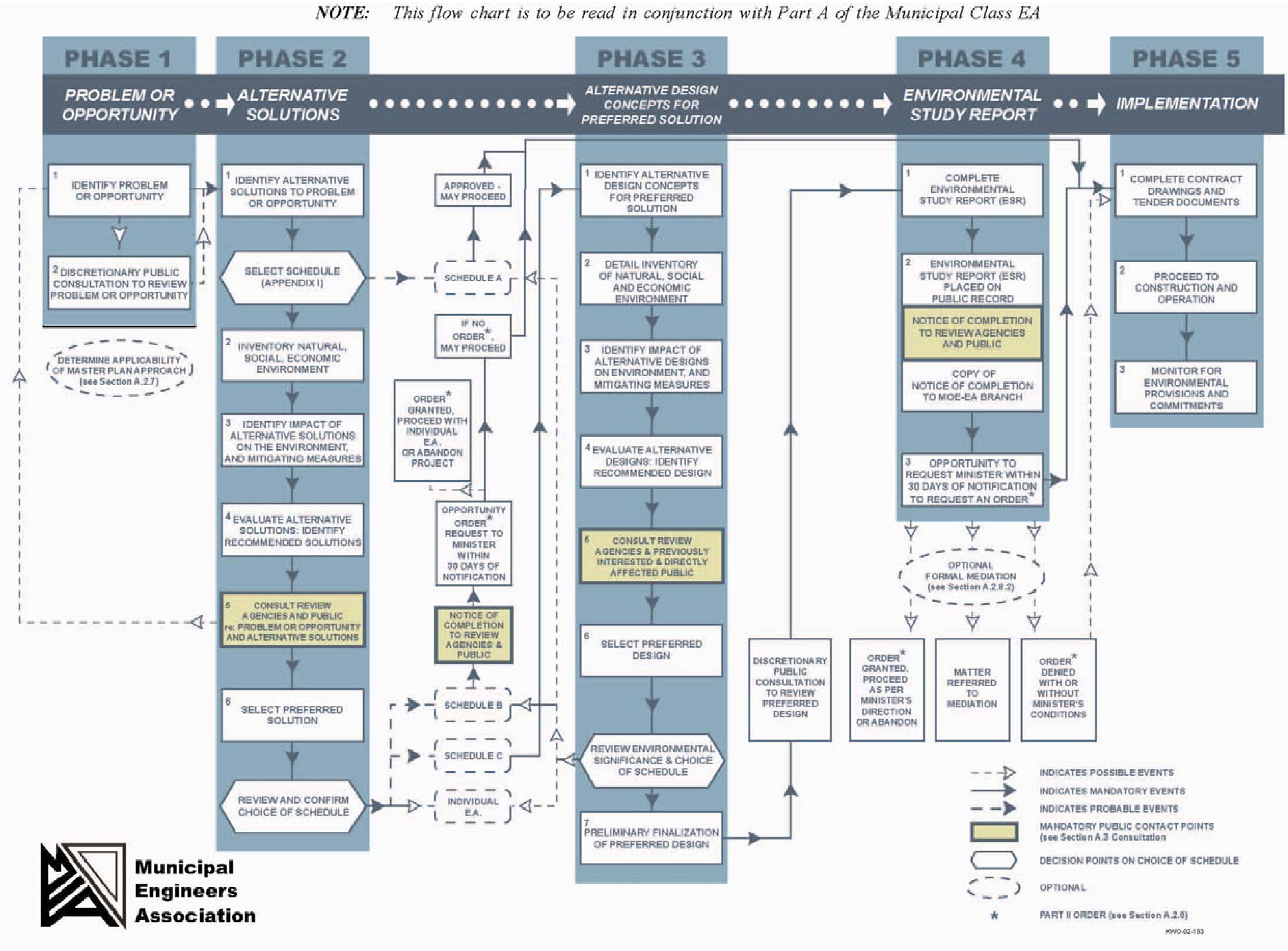
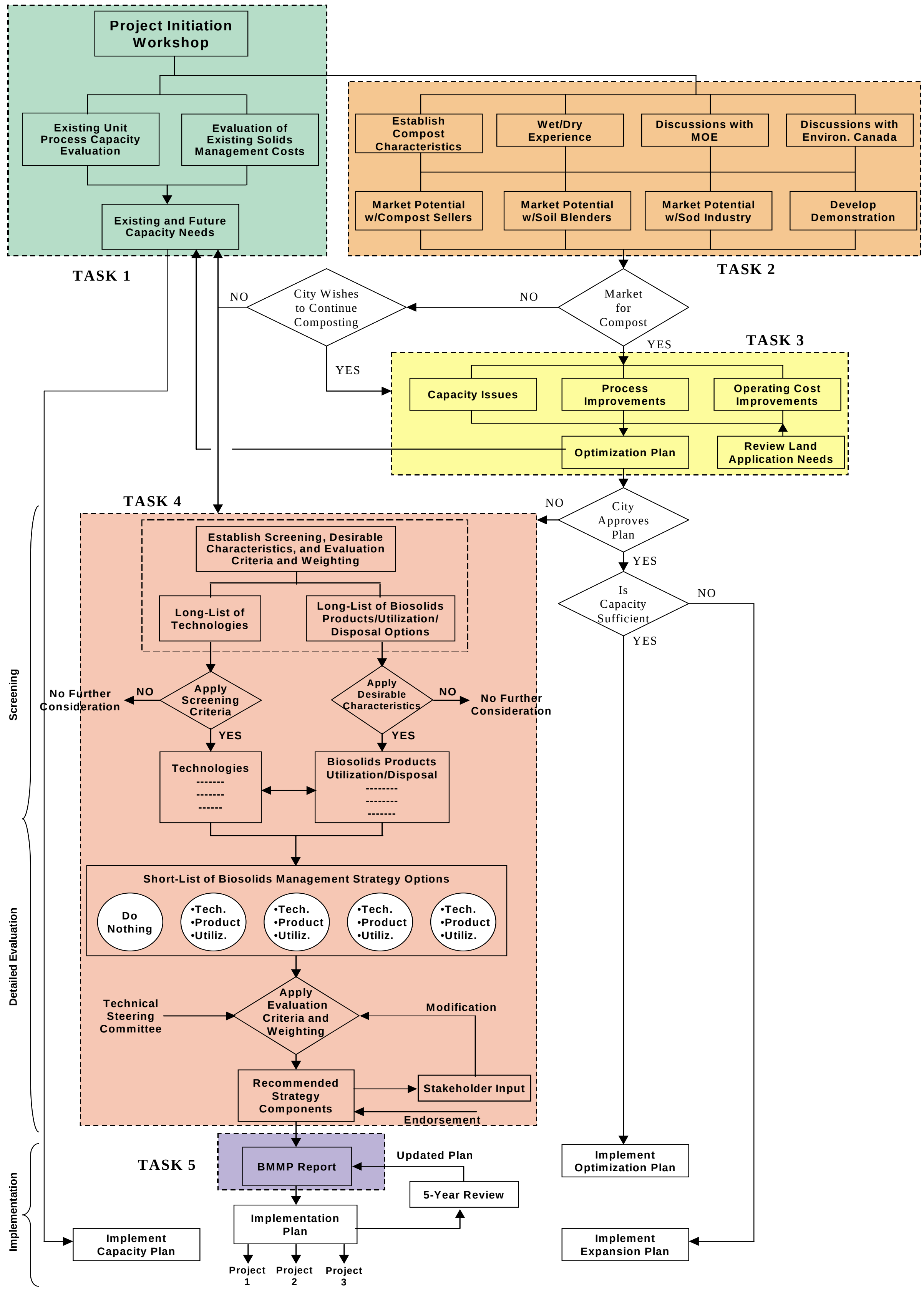


FIGURE 2-2
CITY OF GUELPH BIOSOLIDS MANAGEMENT DECISION TREE



- CH2M HILL Canada Limited
  - Peter Burrowes, Project Manager
  - Multi-disciplinary team of engineers and planners

Review Agencies

The following agencies were consulted during the preparation of this BMMP:

- The Ontario Ministry of the Environment (MOE)
- The Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA)
- The Grand River Conservation Authority (GRCA)

Agency correspondence is presented in Appendix A.

Public Involvement

Project Initiation

The public involvement activities for this project were initiated at the outset of the study with an "Invitation to Participate" that was published in the Guelph Tribune, posted on the City of Guelph's web site and mailed to those listed on the City's project mailing list. At the same time a Fact Sheet was also made available. It included an overview of the study components and decision-making process and provided contact information.

Public Open House

A Public Open House was held on February 27, 2002. The purpose of the Open House was to provide an introduction of the study, including the study purpose, decision-making process and background information on the biosolids produced and managed at the WWTP. The event included a display of project information. An Information Brief and Comment Sheet were provided to attendees. City of Guelph staff and members of the consultant team were on hand to discuss the information and to respond to questions. The Open House received 11 visitors. No significant issues were identified as a result of the Open House.

Public Information Centre

A Public Information Centre (PIC) was held on June 21, 2005. This event was conducted as a joint PIC with the WWTP Class EA Update. The purpose of the PIC was to present the evaluated options for biosolids management, disposal and end use, and the recommended biosolids management strategy. The PIC received nine visitors. There were no specific issues raised on the BMMP recommendations.

The public notices, Public Open House and PIC materials, and study correspondence are presented in Appendix B.

Rationale for this Project

The need for this Master Plan was identified in the 1998 Wastewater Treatment Strategy Class EA. The trigger for starting the Master Plan was determined by the need to proceed with the Stage 2 liquid side expansion of the WWTP. Accordingly, the goal of this study is to develop a Master Plan for the management and end use of biosolids generated at the WWTP.

For this project, the objective of the Master Plan was to develop a strategy for the management of biosolids generated at the Guelph WWTP in an environmentally sound, efficient, and cost-effective manner.

The service area for this Master Plan is the existing service area of the Guelph WWTP.

Project Expectations and Critical Success Factors

Project Expectations

The expectations for this project were:

- To find a beneficial use for the biosolids compost
- To address current and future needs for biosolids and the City of Guelph
- To formulate a plan which meets the City of Guelph's biosolids issues whilst also meeting government standards and public scrutiny
- To use the wet/dry facility's experience as a resource

Critical Success Factors

The success of this project will be determined based on the following critical success factors:

- Value provided (Capital and Operation and Maintenance [O&M])
- Solutions are forward-looking
- Solutions are integrated with the WWTP processes
- Project is consistent with the community's values and environmental focus
- Regulatory requirements are met or exceeded
- Preferred strategy is endorsed by the public and stakeholders

3. Task 1: Management Plan Definition

Task Objective and Description

Task 1 was initiated in November 2000, and was completed in May 2001. The objective of Task 1 was to develop a framework for preparing the Master Plan. It included: analyzing the condition and capacities of existing equipment, estimating existing operational costs and determining existing and future solids processing capacity and potential equipment needs. This task provided a baseline for the subsequent study tasks and enabled the biosolids management alternatives planning to proceed.

The activities and recommendations developed in Task 1 are documented in the Task 1 Technical Memorandum (TM). TM1 is presented in Appendix C and the findings are summarized in this section of the report.

What are Biosolids?

The City of Guelph operates the WWTP, which produces treated biosolids as a by-product of the process used to treat the liquid component of the wastewater received at the plant. Biosolids are primarily organic and are of a sufficient quality that they can be beneficially used for their nutrient, soil conditioning, or fuel properties. Beneficial practices include land application of biosolids as a soil amendment or as a fertilizer supplement and a variety of procedures that derive energy from biosolids or convert them to useful products. Currently, the majority of biosolids produced at the WWTP are applied on agricultural land when the weather and field conditions permit, and disposed of at landfill during all other times.

Biosolids Management History

The following provides a chronological history of biosolids management at the WWTP. Biosolids management facilities at the Guelph WWTP are identified in Figure 3-1.

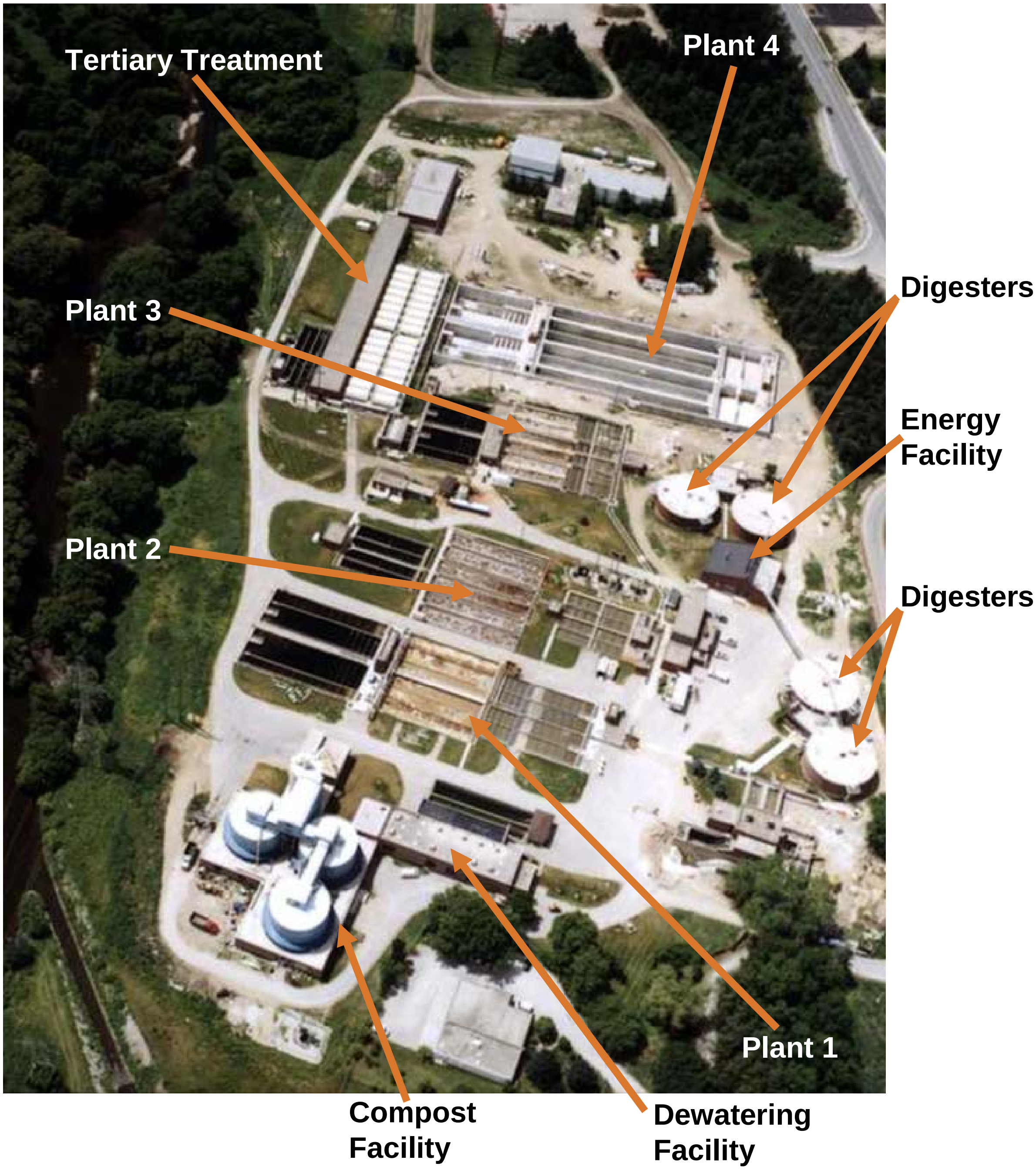
1950 -1980 – Digested (liquid) biosolids spread on land. Liquid biosolids were stored in lagoons located south of Plant 1. The lagoons were decommissioned and removed.

1980 – 1984 – The biosolids quality characteristics included a high heavy metal concentration, relative to the MOE guidelines for land application. The City of Guelph had difficulty locating sufficient agricultural lands to apply the biosolids product. This resulted in the decision to implement additional biosolids processing, including dewatering and air drying, followed by landfill disposal.

1984 – The additional processing resulted in problems with odours associated with air dried biosolids. There were also operational problems encountered at the landfill with the management of the dewatered product.

Late 1980s – The City of Guelph instituted composting and thermal drying pilot trials to find a solution to the operational and odour problems.

FIGURE 3-1
GUELPH WWTP BIOSOLIDS MANAGEMENT FACILITIES



1990 – 1995 – Biosolids Composting was selected as a preferred method to resolve the problems associated with the management of dewatered biosolids and a compost facility was constructed at the WWTP. The compost product was intended to be used as landfill cover at the City of Guelph's Eastview Landfill facility.

1995 – 1998 – All the biosolids material was digested, dewatered, composted and used as landfill cover.

1998 – In addition to composting, the City of Guelph applied digested (liquid) and dewatered biosolids on agricultural land. This allowed the City to reduce operating costs and carry out maintenance on the composting system.

2001 – City of Guelph commences work on the BMMP

2002 – Eastview Landfill is closed. Composting system used to blend dewatered biosolids with woodchips to satisfy requirements for disposal at Green Lane Landfill. Biosolids are land applied and landfilled.

2003 – City of Guelph completes Lystek demonstration trial. The Lystek process, which treats dewatered cake, produces a material that is approximately 14 to 15 percent solids, but has viscous properties similar to liquid biosolids, and can be manipulated to produce a "Class A" (under U.S. Environmental Protection Agency [USEPA] Part 503 definition) biosolids product. This process results in a reduction in the biosolids volume, compared to a traditional liquid product. Odour potential is also reduced. This results in reduced storage and transportation requirements. The product can be stored and land applied, similar to a liquid product.

2004-2005 – City of Guelph installs full-scale Lystek process and initiated waste activated sludge (WAS) thickening pilot testing. Lystek biosolids are applied to agricultural land, along with liquid (digested) and dewatered biosolids. Dewatered biosolids blended with woodchips are landfilled when land application is not available.

2005 – Due to age, the two oldest belt filter presses (BFPs) in the dewatering facility require replacement. A tender was issued and equipment selected for installation in 2006. A demonstration rotary drum thickener for waste activated sludge (WAS) was purchased. The unit will be operational in 2006 and will thicken WAS from Plants 1, 2 and 3.

Existing Biosolids Treatment System

With the compost system fully operational (1995–2000) the Guelph WWTP generated about 54 m^3/d (20,000 m^3/yr) of unscreened compost. The unit processes that comprise the solids treatment system at the WWTP include digestion, dewatering, Lystek treatment, and composting. Each process is summarized below.

Anaerobic Digestion

High rate mesophylic anaerobic digestion is the most commonly used biosolids stabilization process in Canada and the U.S. Biological organisms decompose organic matter in the absence of oxygen and at temperatures of 30°C to 38°C, which produces methane, carbon dioxide, water, and partly degraded organics. The MOE recommends a minimum 15-day hydraulic retention time (HRT) as a design guideline for this process to provide sufficient stabilization of organic material. The current facilities are operating at capacity. Additional digestion capacity is required to provide redundancy for maintenance and for future solids processing needs, to maintain a minimum 15-day HRT in the primary digesters. In 2000, digestion cost was approximately $31 per dry tonne produced.

Dewatering

BFPs are commonly used for dewatering biosolids. Liquid is removed by squeezing the biosolids between two porous belts. The existing facilities include four presses and can provide the dewatering capacity required for Stage 2 expansion to 73,300 m^3/d, assuming that the facility can be operated for a longer period of time each day. However, two BFPs require replacement in 2006 due to age and deteriorated condition. It is anticipated that the remaining two BFPs will require replacement due to age in approximately 2010. In 2000, the dewatering cost was $139 per dry tonne cake produced.

Lystek™

A proprietary process, Lystek treatment uses temperature and pH adjustment to promote cell lysis of dewatered biosolids. By breaking down cell walls in the batch process, a product with fluid-like properties is generated. This “high solids fluid”, with about 14 percent solids, is suitable for agricultural land application, with the benefit of reduced volume compared to traditional liquid biosolids, and easier storage and land application operation than dewatered biosolids. The demonstration trials in 2003 were successful and continued with land application of the Lystek-treated biosolids in 2004. Installation of the full-scale reactor was completed in 2006, with the ability to process a maximum of 6 dry tones (dt)/d.

Composting

Composting is a biological stabilization process for organic matter. An in-vessel (enclosed) system is used at the Guelph WWTP producing compost from a mixture of woodchips and dewatered biosolids. The compost facility was designed to process 15,100 dry kilograms of biosolids per operating day, dewatered to 20 percent total solids with an allowable range of 17 to 20 percent solids. The facility was designed as a three-vessel reactor system (two in operation with one for additional curing) with an estimated combined retention time of 26.5 days. Normally the system is forced to operate as a one- or two-vessel system due to scheduled and unscheduled reactor shutdowns. This results in a compost product that contains approximately five percent greater moisture content than design specifications due the decreased material resident time. In 2000, the cost of composting was $353 per tonne. The facility required a significant amount of unscheduled maintenance due in part to the increasing age of equipment and processing problems caused by metal, stones and oversized material mixed into the amendment material.

Task 1 Conclusions

The Task 1 conclusions are as follows:

- The Guelph WWTP solids management systems are sufficient to process the projected residuals, at current average influent concentration conditions, until the 73,300 m^3/d plant capacity has been reached, with required process unit replacements due to age. An increase in digestion capacity is required to meet the MOE 15-day HRT guideline.

- Industrial wastewater loadings may have a significant impact on solids production at the WWTP. Current maximum and City of Guelph by-law compliance loadings were estimated for predicted future industrial wastewater flows. This showed that if industries produce wastewater at current maximum loadings and predicted flow rates, the estimated WWTP solids production will be approximately 40 percent greater than industrial wastewater at by-law compliance loadings and predicted flow rates.
- The resulting solids contribution from industrial loading decreases the available capacity in the existing process units and would advance the requirement for additional unit process capacity in the solids management train. As the contribution loading of major industries is largely soluble in nature it may impact the secondary treatment system of the WWTP and increase the volume of WAS produced. Without WAS thickening, additional WAS would decrease the settleability of solids co-settled in the primary tanks, resulting in larger volumes of sludge, due to a decreased solids concentration and a greater mass of solids.
- The estimated operational costs provide a baseline to which future costs and costs of alternative management systems can be compared.
- Composting capacity is estimated to be sufficient to the capacity planning horizon, assuming that raw wastewater influent loadings remain stable or are reduced and a three-vessel system can be maintained. However, the degree of product stability required will depend on the ultimate end use or disposal of the compost product. Additional retention time in the reactor vessels can be obtained through a drier dewatered biosolids feedstock and additional stability can be obtained through additional curing of the material, by outdoor storage, if required. Retrofitting of the drive system of the outfeed device and other work is required to improve the reliability of the composting facility.

4. Task 2: Compost Utilization Assessment

Task Objective and Description

The objective of Task 2 was to determine if there are viable end uses for the composted biosolids product currently produced a the WWTP and to identify the required product quality. Subtasks included:

- *A Composting Market Survey* – Development and execution of a market survey to identify potential end users (companies and organizations) and uses for the composted biosolids product.
- *A Regulatory Review* – Identification of regulatory (quality) requirements for various composted biosolids end uses.
- *Utilization Demonstration Program Plan* – Development of demonstration program for selected composted biosolids end uses using the biosolids product currently produced at the WWTP.

The activities and recommendations developed in Task 2 are documented in the Task 2 TM. TM2 is presented in Appendix D and summarized in this section of the report.

Composting Market Survey

A telephone market survey was conducted in 2001–2002 to identify potential end uses and end users for the composted biosolids produced at the WWTP. The survey was designed to collect information on the following:

- Types of uses for the compost
- Potential demand for compost
- Potential revenues from the sale of compost
- Regulatory issues
- Compost quality issues

The end users surveyed included:

- Regulatory agencies including Ontario Ministry of Agriculture, Food and Rural Affairs (OMFRA), and the Ontario Ministry of the Environment (Guelph District and Approvals Branch)
- A landfill operation
- City of Guelph Public Works Department
- Landscape Companies
- Top Soil Blending Companies
- Sod Farm Operators
- Golf Course Operators

The results of the survey contributed, in part, to the determination of the future viability of the existing compost system at the WWTP and its potential contribution as a component of an overall biosolids management strategy.

Potential End Uses

The potential end uses identified through the market survey include:

- Agricultural land application, including:
  - Low nitrogen crops
  - Tree farms
  - Sod farms
- Recreational sites, including:
  - Golf courses
  - Ball parks
- Topsoil market
- Soil conditioner – where biosolids are blended with poor quality topsoil to improve fertility, including:
  - Bulk sales from the WWTP to the public and /or brokers and blenders
  - Bagging/Sales
- Landfill cover material
- Land reclamation operations, including:
  - Quarries
  - Mines
  - Aggregate extraction areas

Potential End Users and Demand

The market survey identified several viable end use markets for the composted biosolids produced at the WWTP. End users potentially include landscapers, topsoil blenders and distributors, landfill operators, mining and quarry operators, sod farm operations, and golf courses. The City of Guelph Municipal Works Department and provincial works operations were also identified as potential end users.

Based on the maximum potential capacity of the composting facility, the City of Guelph could produce about 27,000 m^3/yr of composted biosolids. The potential demand for compost within approximately 40 km of the City and the associated revenue is presented in Table 4.1.

TABLE 4.1
POTENTIAL DEMAND AND REVENUE FROM THE SALE OF COMPOST

Compost Market	Potential Demand and Revenues for Compost		
	Demand (m^3/yr)	Revenue	
		($/$m^3$)	($/yr)
Landscapers	26,000[1]		
Topsoil blenders and distributors	40,000[2]	$10	$400,000[3,9]
Landfill operators	0[4]	-[5]	-
Mining and Quarry Operators		-[5]	-
Agricultural (sod farms)	40,000[6]	-[5,7]	-[5,7]
Golf Courses	-[8]	-	-
Public Works	1,000	-	-
Total	**107,000**	**$0 – $10**	**$0 – $400,000**

Notes:
1 Landscapers assumed to utilize 65 percent of topsoil from distributors
2 Surveyed topsoil distributors assumed to represent 30 percent of local topsoil market
3 Concerned with composted biosolids quality
4 Sufficient construction soil wastes and topsoil available onsite
5 Users would take compost at no cost
6 Generator would pay for transportation costs to the site
7 At 20 tonnes (33 m^3) per hectare (ha) per year
8 No interest due to quality concerns
9 If all of Guelph's compost utilized, $270,000 potential revenue

The survey results show that maximum potential market demand is estimated to be 107,000 m^3/yr. The largest market demand is potentially from the sale of compost to topsoil blenders and distributors, and sod farm operations. The majority of this demand is of a seasonal nature, with peak demand identified in the spring period.

Potential Revenue and Market Issues

Through the survey it was determined that potential revenues from the sale of composted biosolids are estimated to be about $270,000 per year. Regulatory and biosolids quality characteristics must be demonstrated before potential users would consider purchasing the material.

Compost quality, public perception of product safety, and government approval requirements were identified as potential obstacles to the use of composted biosolids in the marketplace. Specific issues identified in the survey include:

- The impacts associated with metal, pathogens and toxic organics that are present in the compost product
- The uncertainty that sufficient monitoring and quality control practices are in place
- The lack of experience with using composted biosolids in the market place
- The public perception and the stigma associated with biosolids and potential impacts on business operations
- The concern with safety risks and public contact

Task 2 Recommendations

Based on the results of the market survey, the following recommendations were developed:

- **Recommendation #1** – Complete demonstrations with topsoil blenders, sod farms, and land reclamation activities in partnership with regulatory agencies. The purpose of the demonstrations is to:
  - Demonstrate operations and quality control practices to produce a safe consistent product for end use
  - Demonstrate the product with willing end users identified through the survey
  - Complete additional monitoring and identify further processing requirements if needed (i.e. screening, curing), depending on end use needs.
  - Develop new markets for the use of the composted biosolids

  Implementation of the demonstration projects must include the following components:
  - Defined demonstration objectives
  - Approval requirements
  - Demonstration project description, including application rates, methods, equipment requirements, area requirements, etc.
  - Implementation plan including costs
  - Schedule and logistics
  - Demonstration program participation
- **Recommendation #2** – Construct a storage facility for the storage and curing of composted biosolids
- **Recommendation #3** – Monitor the composted biosolids for bulk density and soluble salts parameters
- **Recommendation #4** – Combine marketing efforts with the City of Guelph's wet/dry composting operations as a means to address common issues
- **Recommendation #5** – Develop public education materials to improve public perception of the composted biosolids material and end uses
- **Recommendation #6** – In conjunction with demonstration projects, the City of Guelph should initiate discussions with the MOE and the Canadian Food Inspection Agency (CFIA) to develop support for the beneficial utilization of composted biosolids and to establish regulatory requirements and approaches to meet regulations. The City should continue to develop and compile analytical data on the composted biosolids to support these efforts.

Demonstration Project Recommendations

Based on the market survey, the following demonstration projects were identified:

- Sod Farm operations
- Land Reclamation activities
- Topsoil Production

The purpose of the demonstration projects is to develop new markets for the use of the compost product. Implementation of the demonstration project must include the following components:

- Defined demonstration objectives
- Approval requirements
- Demonstration project description, including application rates, methods, equipment requirements, area requirements, etc.
- Implementation plan including costs
- Schedule and logistics
- Demonstration program participation

At the time this report was prepared, the City of Guelph had been unable to carry out composting demonstration projects due to equipment and processing issues at the WWTP. Due to the processing issues, and a restricted regulatory environment, the City stated its wishes to proceed with the evaluation of other biosolids management alternatives. Accordingly, the study moved to the identification and evaluation of an expanded list of management alternatives. The composting alternative continued to be evaluated as a feasible option for the remainder of the operational life cycle of the existing compost processing facilities.

5. Task 3: Compost Process

The purpose of Task 3 was to investigate the alternatives for optimizing the existing composting operations. This task involved using the cost information generated in Task 1 and the composted biosolids quality requirements developed in Task 2 to identify recommendations for operational optimization that would result in both cost savings and process improvements. The activities and recommendations developed in Task 3 are documented in a Task 3 TM3. TM3 is presented in Appendix E and summarized in this section of the report.

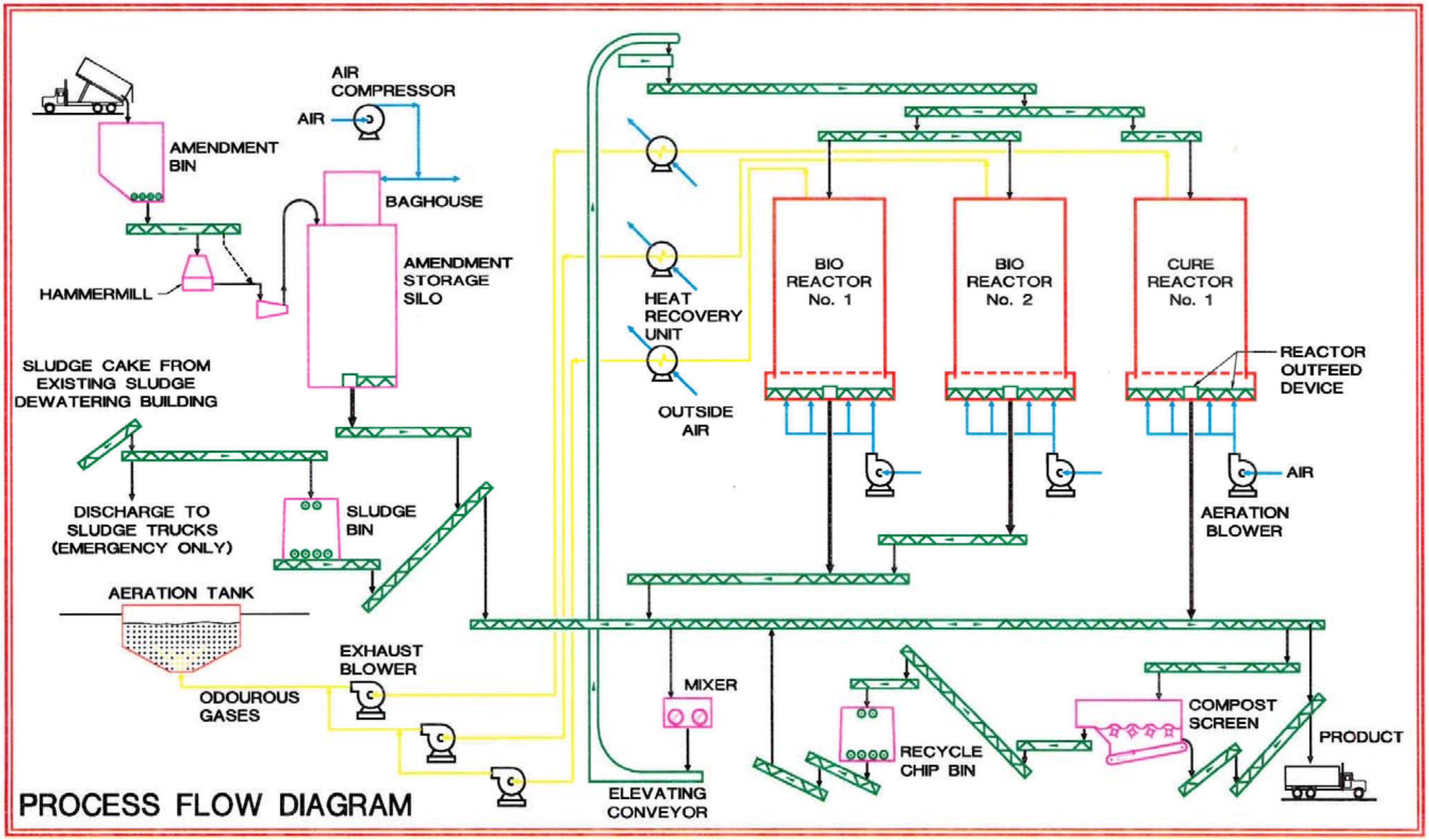
Major Equipment Components

The compost system includes the following major equipment components:

Major Equipment Component	*Function*
Amendment Receiving/Storage	Receives and stores amendment material (woodchips) in a large silo
Sludge Storage	Completely enclosed bin that receives dewatered biosolids cake.
Mixer	Blends the dewatered biosolids, wood chips, and recycled compost. Also homogenizes the compost product during the transfer from the bioreactor to the cure reactor.
Transport systems	A series of screw conveyors and sandwich-belt conveyors that move raw materials and intermediate and finished compost through the processing facility.
Bioreactors	Vessels where the composting occurs. Material is loaded at the top of the reactor. Composting occurs as the material moves down through various zone environments.
Loading	Conveys compost from the bioreactor to the cure reactor in batches
Aeration system	Provides a continuous flow of compressed air to each reactor through a system of perforated pipe together with a coarse gravel bed which provides for a comprehensive distribution of air. The reactors are kept under a very small negative pressure to prevent compost exhaust from escaping. Compost exhaust is collected, passed through air-to-air heat exchangers and discharged to the aeration tanks.
Instrumentation and Controls	A SCADA system provides automatic system controls based on a selection of operating conditions.

Figure 5-1 presents the Process Flow Diagram of the composting facility.

FIGURE 5-1
COMPOST SYSTEM PROCESS FLOW DIAGRAM SCHEMATIC



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The maintenance history of the facility was reviewed, as were the compost system processes and operating costs. A benchmark assessment was conducted to gauge the performance of the compost facility relative to other similar facilities in operation. Task 3 concluded with a summary of issues related to the operation of the facility and recommendations for optimizing operations and reducing costs. As the facility continues to age, the potential for major equipment repair increases as a result of failure.

Primary TM3 recommended actions for operating equipment (as of June 2002) are shown in Table 5.1.

TABLE 5.1
TASK 3 RECOMMENDED ACTIONS FOR OPERATING EQUIPMENT

Item	Comment	Potential Reliability/ Operations Improvement	Action
Amendment Receiving	Good condition; equipment may fail if amendment quality is poor	Amendment source control Ability to screen incoming amendment	Issue RFP for amendment Have contract with amendment supplier(s) with penalties for non-performance
Hammermill	Takes 3.5 to 4 hours to unload one truck of amendment through hammermill	If required for daily operation dry storage facility may be necessary	Cost/benefit analysis of dry storage area and hammermill use
Amendment storage silo	Under extreme cold weather conditions, amendment freezes in ring around the silo, can cause blockages if frozen lumps are knocked to bottom of silo	Insulate silo Heat silo	Insulate silo Heat silo
Sludge (day) bin	Capacity not compatible with current operations – dewatering operates 16 hours per day and composting 8 hours per day	Increase operations time of composting facility, requires more staff	Cost/benefit analysis of increased day bin capacity
Mixer and Controls	Top access hatch doors too big and heavy, hinges don’t work	Replace doors with removable light weight covers, replace hinges	Replace doors with removable light weight covers, replace hinges
	Mixer paddles ‘fling’ material onto far side of funnel feeding belt and stick to side, eventually plugging funnel; must be cleaned out two to three times per day (10 – 45 mins per clean)	Line interior of funnel with HDMWPE coating system Remove last few paddles and replace with short screw	Assess efficiency of HDMWPE coating – take equipment off line and coat, before retrofitting with short screw
Slide plates	Material builds up in grooves and eventually slide gate cannot close properly; difficult to clean; results in blowers overworking and tripping out	Redesign for self-cleaning (preferred) or manual cleaning	Redesign and maintain scheduled inspections and maintenance

TABLE 5.1
TASK 3 RECOMMENDED ACTIONS FOR OPERATING EQUIPMENT

Item	Comment	Potential Reliability/ Operations Improvement	Action
Bioreactors and Cure Infeed	A shadow is cast by the distributor supports and the feed mix is unevenly distributed Spinner plate difficult to adjust, at slow speeds does not work well	Need better adjustment for spinner plate Control for spinner plate direction through PLC from SCADA Redesign spinner plate as cone-shaped and improve attachment to vessel	Design and obtain budget quotation for new spinner plate and pilot test in one reactor
	Access to reactors difficult	Need cage for each reactor Need better way to put access cage into reactor – beam and power hoist preferred	Conceptually design and obtain budget quotation for cage and beam and pilot test in one reactor
Bioreactors and Cure Outfeed	Poor reliability due to excessive bearings wear and clutch breakdown (must be replaced every 2 months) and 6- to 10-week wait for replacement parts	Test different operating scenarios	Run outfeed devices at slower rate for longer periods; ensure Taulman operating instructions are reviewed (e.g. run outfeeds at same time as filling)
		Replace outfeed device	Contact other composting facilities in US to determine preferred outfeed device alternatives Visit US facilities Request proposals for preferred new outfeed devices
Aeration blower	Air flow rate may be limiting.	Adjustable output may be beneficial	Install VFDs
Heat recovery	Does not work effectively; difficult to clean, high maintenance – if filter plugs, ducting collapses Condensate presents problems (more prevalent in winter) in the heat exchanger units themselves	Install vacuum relief valve Install ability to bypass Determine efficiency of equipment Install condensate traps	Design and install vacuum relief valve, ability to bypass and condensate traps Request proposal by manufacturer to overhaul or retrofit to improve efficiency
Ventilation	Heat relief and ventilation poor; in summer 2001, 4 large fans were purchased to reduce temperature Some exhaust fan motors have failed to be accessed for maintenance	Place exhaust fan on building exterior Provide (fixed) safe access to motors Ensure louvre screens are clean	Assess building HVAC and air flow to determine best location of exterior fan and any necessary ducting retrofits Design and request budget quotations for access ladders to motors Maintain scheduled inspections and maintenance
Instrumentation	SCADA computer outdated	Update SCADA computer	Update to windows based system compatible with WWTP operating system Implement new logic and SCADA screens during computer upgrade

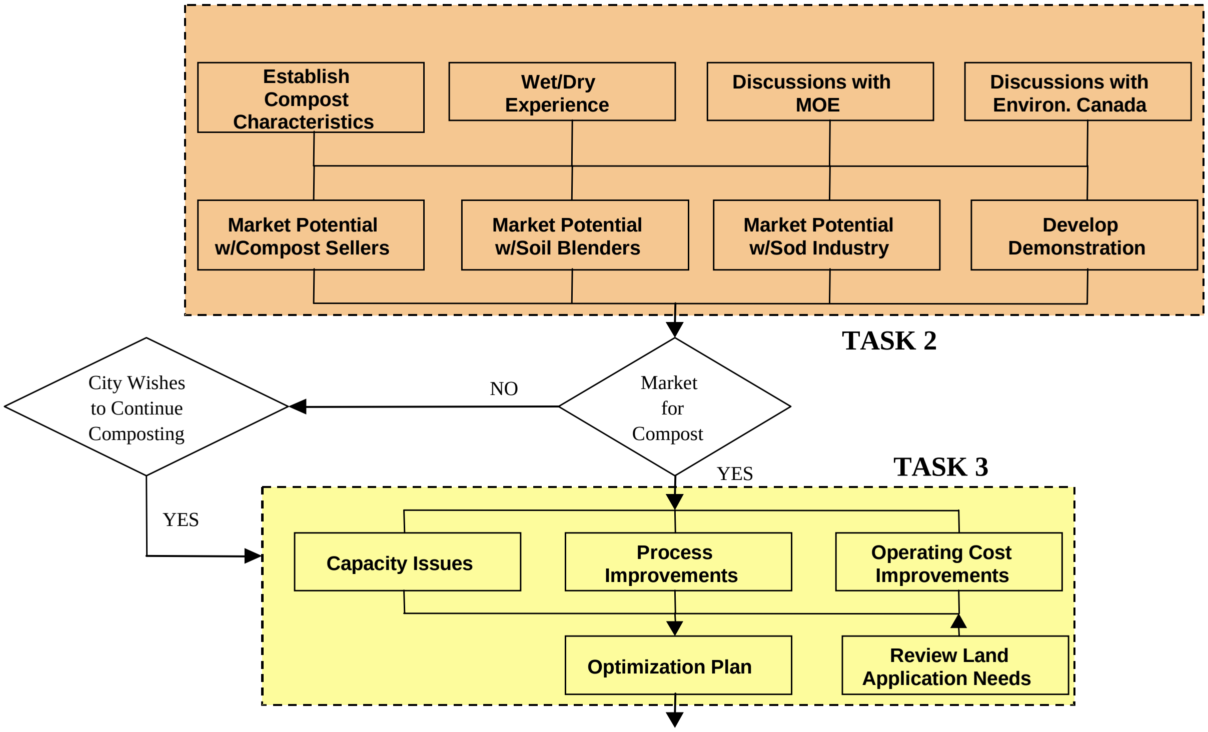
TABLE 5.1
TASK 3 RECOMMENDED ACTIONS FOR OPERATING EQUIPMENT

Item	Comment	Potential Reliability/ Operations Improvement	Action
Conveyors			
351	Requires replacement	Replacement is scheduled	Maintain scheduled inspections and maintenance
552 B	Requires replacement	Replacement to be scheduled	
550	Requires new endplate	Endplate replacement to be scheduled	
553 (final discharge)	Requires replacement	Replacement is scheduled	
554	Safety cages and rollers on doors require redesign and replacement	Redesign and replacement to be scheduled	
562	Requires new endplate	Endplate replacement is scheduled	
Feed mix	C:N ratio may not be optimum Moisture content difficult to control and maintain with one reactor system	Measure mix C:N of feed and moisture regularly Use Taulman 'recipe' as guideline	Discuss with other facilities any scientific approaches used
Level and temperature monitoring	1 level sensor per reactor system ineffective with current infeed distribution problems	Retrofit additional level sensors Mount IR camera, radar or ultrasonic sensor to show profile of top	Determine preferred alternative Obtain budget quotation Install in one reactor to pilot test
	Three temperature probes per reactor are insufficient to provide an accurate reactor profile	Retrofit additional 2 or 3 temperature probes at each level	
Maintenance Scheduling	Emergency maintenance predominant	Work towards preventative maintenance Correct continuous outfeed device problems	Employ dedicated maintenance worker(s)
Annual Costs	Amendment	Screen and recycle	Review effectiveness of screening, hammermill, etc.
		Issue amendment contract RFP to maintain competitiveness of suppliers	Produce amendment RFP for competitiveness of suppliers Review costs and benefits of amendment types and suppliers
	Operations overtime	Employ maintenance and cleaning staff	Employ dedicated maintenance worker(s) and cleaners/ labourers

Decision Process Triggers

The decision process for this Master Planning exercise was defined in Task 1. Tasks 2 and 3 were completed and, accordingly, the next steps in the planning process were determined through a decision triggered by the outcomes of Tasks 2 and 3. The triggers are explained below and illustrated in Figure 5-2.

FIGURE 5-2
TRIGGERS FOR DECISIONS



- **If Tasks 2 and 3** determined that the existing compost facility at the WWTP **has** reliable capacity for the solids produced at 73.3 megalitres per day (MLD) (the long-term planning period requirement) **and** reliable end use options (for the composted biosolids that are produced) **then no further evaluation would be required.** The Master Plan document would be prepared and the proposed activities would be implemented.
- **If Tasks 2 and 3** determined that the existing compost facility **has** reliable capacity **for less than** 73.3 MLD **and** reliable end use options **then** an evaluation of treatment and processing options would be required to identify a solution to provide the additional capacity requirement.
- **If Tasks 2 and 3** determined that the existing compost facility **does not have** reliable capacity for the future **or** there are no reliable end-use options **then** a comprehensive evaluation would required to determine a long-term solution to provide full biosolids production capacity and reliable end uses.

It was determined through Tasks 2 and 3 that the WWTP biosolids management treatment processes have or could have, with recommended upgrades, sufficient capacity to manage the anticipated biosolids volumes that are expected to be generated by the Stage 2 liquid side treatment capacity expansion to 73.3 ML/d. However, it was found that the compost system requires ongoing maintenance due to equipment and processing issues. Additionally, it was determined the composted biosolids product would likely not gain regulatory acceptance as a stand alone material for sale and that it would require demonstration, regulatory acceptance and effort to develop a suitable market for the composted biosolids. Accordingly, the City of Guelph decided to proceed with a comprehensive evaluation of biosolids management options to develop a long-term strategy for biosolids treatment capacity and end use. This decision initiated Task 4 of the Master Planning process.

Since initiating Task 4, the City has determined that the resources required to upgrade and keep the composting facility operational have and will impact its ability to keep the rest of the plant operating reliably. Therefore, the City has elected to operate the compost facility as little as possible and replace it as soon as is practically possible.

6. Task 4: Biosolids Management Strategy Development

The purpose of Task 4 was to develop a biosolids management strategy. The management strategy development included a two-staged evaluation process. Stage 1 included an initial screening of a long list of technologies, products and end uses (presented in TM4 Part I). The resulting short list of technologies, products and end uses were then combined to form management strategies (TM4 Part II). In stage 2, the strategies were then developed to determine the conceptual design requirements (TM4 Part IIIA) and evaluated using detailed evaluation criteria to rank strategies and to provide the basis for decisions on the long-term plan (TM4 Part IIIB). The activities and recommendations developed in Task 4 are documented in these TMs which are presented in Appendix F and summarized in this section of the report.

Developing the Long List

In order to determine which of the many technology alternatives available for biosolids management were feasible for the City of Guelph, the project team first reviewed all the possible end uses for biosolids based on defined priorities. Once feasible end uses had been identified, the products required for these end uses were then established. Finally, the technologies available to make these products, that met the defined priorities, were determined.

Stage 1 – Screening the Long List

In Stage 1, a set of screening or "must have" criteria were developed to screen the long list of alternative treatment technologies and end-use options (utilization and disposal). Those options that did not meet all criteria were eliminated from further evaluation. The screening resulted in a shortlist of desirable technology options and end use options. The options were then combined to produce biosolids management strategies that were further evaluated in more detail. The screening criteria are presented in Table 6.1.

Summary of Screening of Biosolids End Uses

For this study, six end uses were identified. From this set of end uses, three were found to meet the priorities defined for end use alternatives. The screening results are presented in Table 6.2.

TABLE 6.1
STAGE 1 – SCREENING CRITERIA

Screening Criteria	Considerations
Priorities for End-Uses	**Integration:** Opportunity to take advantage of existing infrastructure; the absence of major obstacles to implementation; end-uses must be within the City of Guelph's capability to implement (technically, financially, regulatory) **Sustainability:** End-uses should endure over time in an environmentally-safe manner; the long-term strategy must provide the capacity to manage all the biosolids produced at the WWTP **Reliability:** End-uses should meet or exceed Ontario's regulatory requirements and standards; the overall biosolids management strategy must be reliable, meet public scrutiny, and be enforceable within the City of Guelph's current framework **Flexibility**: Overall biosolids management strategy should include a variety of treatment and end-use options that should be adaptable under different circumstances
Priorities for Treatment Technologies	**Reliability**: Technologies should be proven to maintain uninterrupted options; treatment must be proven to demonstrate reliability; at least three years implementation at a similar size facility

TABLE 6.2
SUMMARY OF SCREENING EXERCISE FOR END USES

End Use Option	Must-Have Criteria				Remarks
	Community Health & Safety	Reliability	Sustainability	Flexibility	
Agricultural Land	Pass	Pass	Pass	Pass	
Forested Land	Pass	Pass	Fail	Pass	Sufficient area of forested land is not available
Land Reclamation	Pass	Pass	Pass	Pass	
Landfill Disposal*	Pass	Pass	Fail	Pass	No operating landfill in Guelph area
Public Contact	Pass	Pass	Pass	Pass	
Industrial Use	Pass	Pass	Fail	Pass	No market potential

Notes: * Landfilling could be maintained as a back-up end-use, utilizing facilities outside of the Guelph area.
The shaded End Use Options pass all must-have criteria

Three of the options failed the screening. Biosolids application to forested land does not meet the requirement for sustainability due to the limited area of forested land accessible to Guelph, at the present. As there is no active landfill in the Guelph area, this was not considered a sustainable option for the long term, but could be utilized as a back-up contingency. There is no identified market potential for industrial use of biosolids at this time in the Guelph area.

While land reclamation passes all the must-have criteria, as there is potential for quarry reclamation close to the WWTP, this market would have to be developed.

Should the markets for end use alternatives change in the future, the technology alternatives selected should allow for flexibility to adapt to these opportunities under the guidance of the subsequent updates of this BMMP.

Summary of Screening Long List of Process Technologies

Six categories of process technologies were screened using the defined priority (reliability) for technologies. For each process category a minimum of six technologies was evaluated against the Must-Have Criteria. The results of the screening are presented in Table 6.3.

TABLE 6.3
SUMMARY OF SCREENING LONG LIST OF PROCESS TECHNOLOGIES

Technology Category	Number of Technologies Evaluated	Number of Technologies that Met Defined Priorities	Technologies Passed
Conditioning/Optimization	19	1	• Polymer
Thickening	7	4	• Centrifuge • Gravity belt thickener • Rotary drum thickener • Dissolved air floatation
Stabilization – Liquid	22	3	• Conventional anaerobic digestion • Thermophilic anaerobic digestion • Lime stabilization (liquid)
Dewatering	14	2	• Centrifuge • Belt filter press
Stabilization – Post-Dewatering	24	3	• Thermal drying • Alkaline stabilization (AASSAD, Biodry, Envessel, Pasteurization, Biofix) • LystekTM
High Temperature Combustion/ Oxidation Processes	17	0	

Only one technology for conditioning/optimization, polymer, passed the screening exercise. The majority of WWTPs in North America utilize polymer for conditioning/optimization, and this practice is currently used at the Guelph WWTP.

Four thickening technologies (centrifuge, gravity belt thickener, rotary drum thickener and dissolved air floatation) met the must-have criteria.

The three liquid stabilization technologies that passed the screening exercise were conventional anaerobic digestion, thermophilic anaerobic digestion, and liquid lime stabilization. All these technologies are used in North America for liquid biosolids stabilization, and the Guelph WWTP currently uses conventional anaerobic digestion.

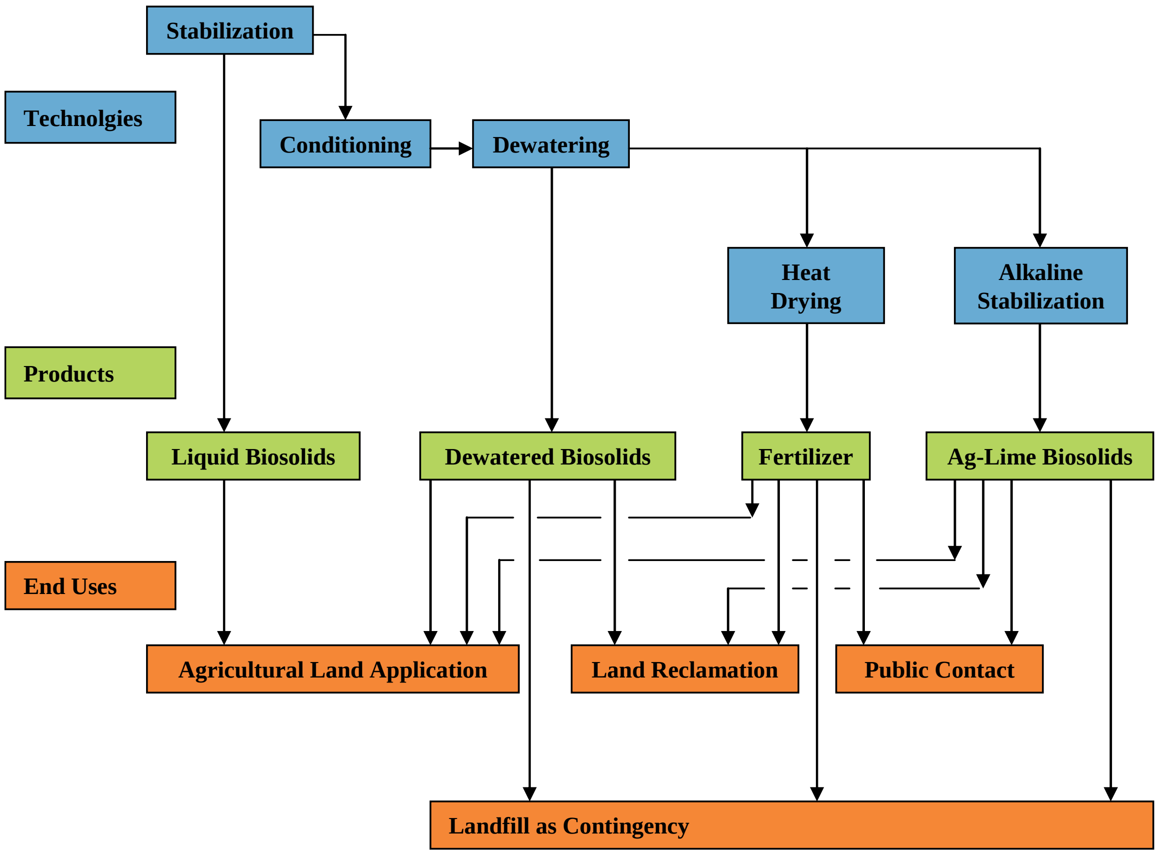
Of the 14 dewatering processes screened, two (centrifuge and belt press) technologies passed the exercise. BFPs are currently utilized at the Guelph WWTP, and the City of Guelph has recently tendered for replacement of the two oldest BFP with new BFPs.

Thermal drying, alkaline stabilization and Lystek treatment were the only post-dewatering technologies that passed the “must-have” criteria for technologies and subsequent product end uses. The other technologies listed in this group failed either due to the lack of sustainability related to final product use or as they are not proven technologies.

Summary of Stage 1 Screening

Figure 6-1 presents the results of the screening exercise and shows the process flow from the technologies which passed the screening exercise, through the products determined to be acceptable in the screening exercise, to the end uses which passed the must-have criteria, and the possible interactions between these component, thereby defining alternative biosolids management strategy options.

FIGURE 6-1
SUMMARY OF SCREENED ALTERNATIVES



Stage 2 – Detailed Evaluation of Biosolids Strategy Options

In the second stage, the biosolids management strategies were developed and evaluated using detailed evaluation criteria to provide an assessment of options relative to the potential impact on technical, natural environment, social, and economic criteria.

Stage 2 Evaluation Methodology

The biosolids management strategy options were evaluated using a Multi-Attribute Utility Analysis (MUA) methodology. This methodology involves a structured evaluation of the risks and benefits of a decision compared to the costs.

Steps in the MUA methodology include:

- Developing selection criteria for which project alternatives will be judged – for this project the selection criteria was developed with the consultant team and the City of

Guelph. The criteria includes technical, natural environment, social, and economic considerations, consistent with the intent of EA planning and decision-making

- Weighting the importance of the chosen criteria
- Development of performance measures associated with evaluation criteria
- Consultation with stakeholders
- Scoring of Alternatives
- Evaluation of costs and risks of potential project alternatives
- Ranking the potential project alternatives in relation to value to cost relationships

Evaluation Criteria

The set of evaluation criteria used to assess the short list of combined treatment, utilization, and disposal (strategy) options that resulted from the screening exercise are presented in Table 6.4.

TABLE 6.4
EVALUATION OBJECTIVES, CRITERIA, AND MEASURE

Objective	Evaluation Criteria	Criteria Measure
Technical Environment	**Technical Performance** – The ability of an alternative to satisfactorily perform its intended functions (treatment, utilization method, disposal options)	The alternative is very reliable, consistently meets or exceeds performance criteria and product quality – 10 The alternative is moderately reliable, meets performance criteria and product quality with regular O&M – 5 The alternative is not very reliable and requires high levels of O&M to meet performance and product quality – 0
	Energy Requirements – The energy, water, and other utilities requirements for the product produced by the alternative are comparable relative to the existing treatment system and other alternatives.	The alternative is very energy efficient; re-use and recycle options are possible – 10 The alternative is somewhat energy efficient – 5 The alternative is not very energy efficient; uses significant amounts of energy/utilities – 0
	Long-term Sustainability – The ability of an alternative (treatment, utilization/disposal) to adapt to changing conditions (technologies, regulations, market factors)	The alternative can easily be adapted to changing conditions to meet long term needs – 10 The alternative is somewhat flexible to meet long term needs (some constraints) – 5 The alternative is not very flexible; difficult to meet needs in the long term – 0
	Ease of Implementation – The alternative can be easily implemented on a technical, regulatory and practical basis (land availability, operational aspects, administrative requirements, etc.)	The alternative is very easy to implement with respect to approvals and construction – 10 The alternative is somewhat easy to implement (some constraints) – 5 The alternative has many difficulties with respect to implementation – 0

TABLE 6.4
EVALUATION OBJECTIVES, CRITERIA, AND MEASURE

Objective	Evaluation Criteria	Criteria Measure
	Compatibility – The alternative is compatible with current processing units and can be installed and integrated into the current plant operations with minimal impact to current operations	The alternative is very compatible and compliments current processing units and can be integrated into current plant operations with minimal impact – 10 The alternative is somewhat compatible and complimentary to current processing units and can be integrated with minimal impact – 5 The alternative is not compatible or complimentary to current processing units and integration may be difficult – 0
	Complexity – The alternative does not add complexity to current operations and can be operated and maintained by current level of licensed operators with appropriate training	The alternative is not complicated and can be operated and maintained by current staff competencies – 10 The alternative is somewhat complicated and can be operated and maintained with minimal staff training – 5 The alternative is complicated and significant staff training and development is necessary for O&M – 0
	Regulatory Acceptance/ Approvals – Regulatory approvals are not complicated, both processing and product utilization/disposal are approvable	The alternative is an accepted regulatory practice and approvals are not expected to be difficult – 10 The alternative is unique and expected to receive regulatory acceptance and approval with some effort – 5 The alternative is very unique and regulatory acceptance and approval may take significant effort – 0
Social/Cultural Consideration	**Odour** – The potential for alternative to minimize odour events	The alternative has little or no potential to produce odour – 10 The alternative has moderate potential to produce odour, odour control measures may be needed to prevent migration offsite – 5 The alternative has high potential to produce odour; significant mitigation needed to control migration offsite – 0
	Agricultural Practices – The potential for the alternative to be compatible with current (and developing) agricultural practices over the long term	The alternative is very compatible with current practices and developing practices – 10 The alternative is somewhat compatible with current and developing practices – 5 The alternative is not compatible with existing and developing practices; may require significant modifications to increase compatibility – 0
	Visual Character – The potential for the alternative to maintain the visual character of an area	The alternative is discreet and will have no impact on the visual character of an area ; existing visual character will be maintained – 10 Components of the alternative may have a minor impact on the visual character of an area: visual character may be modified somewhat – 5 The alternative will have a significant impact on the visual character of an area; existing character will be altered to a great degree – 0
	Transportation – The potential for the alternative to avoid increased demands on the transportation systems (patterns, volumes, and infrastructure requirements)	The alternative will not place additional demands on transportation system – 10 The alternative may place minor additional demands on the transportation system – 5 The alternative may place major demands on the transportation system – 0

TABLE 6.4
EVALUATION OBJECTIVES, CRITERIA, AND MEASURE

Objective	Evaluation Criteria	Criteria Measure
	Noise – The potential for the alternative to minimize the production of noise during normal operations	The alternative has little or no potential to produce noise – 10 The alternative has moderate potential to produce noise, noise control measures may be needed to prevent migration offsite – 5 The alternative has high potential to produce noise; significant mitigation needed to control migration offsite – 0
	Occupational Health & Safety (In-Plant) – Potential risk or liability to staff health and safety from exposure to: • Explosions • Processing chemicals • Gaseous emissions • Toxic organics	The alternative will result in very little potential risk to staff health and safety compared to other alternatives – 10 The alternative will result in a moderate potential risk to staff health and safety are compared with other alternatives – 5 The alternative will result in a high potential risk to staff health and safety compared to other alternatives (without substantial mitigation) – 0
	Occupational Health & Safety (Offsite) – Potential risk or liability to community health and safety from exposure to: • Explosions • Traffic accidents • Gaseous emissions • Toxic organics • Heavy metals • Flooding of watercourses (Speed/Grand River)	The alternative will result in very little potential risk to community health and safety compared to other alternatives – 10 The alternative will result in a moderate potential risk to community health and safety are compared with other alternatives – 5 The alternative will result in a high potential risk to community health and safety compared to other alternatives (without substantial mitigation) – 0
	Public Acceptability – The potential of the alternative to receive public support and acceptance based on: • Projects of a similar nature in other Ontario communities • Community history with the WWTP	The alternative has the potential to receive a high level of support and endorsement by the public – 10 The alternative has the potential to receive a moderate level of support and endorsement from the public – 5 The alternative has the potential to receive a low level of support and endorsement from the publication needed to control impacts – 0
Natural Environment	**Effluent Quality** – The potential of the alternative to meet WWTP effluent quality requirements	The alternative will contribute to the WWTP effluent by bettering the effluent criteria requirements on a consistent basis – 10 The alternative will contribute to the WWTP effluent meeting and sometimes bettering the effluent criteria requirements – 7 The alternative has no impact on WWTP effluent quality – 5 the alternative will not contribute to the WWTP meeting effluent quality requirements – 0
	Water Quality – The potential of the alternative to improve Grand River water quality and aquatic habitats	The alternative results in significant improvements to Grand River water quality and aquatic habitats – 10 The alternative results in moderate improvements to Grand River water quality and aquatic habitats – 7 The alternative has no impact on Grand River water quality and aquatic habitats – 5 The alternative results in little improvement to Grand River water quality beyond regulations; significant mitigation required to control impacts on aquatic habitats – 0

TABLE 6.4
EVALUATION OBJECTIVES, CRITERIA, AND MEASURE

Objective	Evaluation Criteria	Criteria Measure
	Terrestrial Systems – The potential of the alternative to improve terrestrial habitats/ systems (including mammals, reptiles, birds) and terrestrial features/functions	The alternative results in a net improvement in terrestrial systems and habitats –10 The alternative results in the maintenance of the existing terrestrial systems and habitats – 5 The alternative results in a net loss of terrestrial systems and habitats – compensation measures may be required – 0
	Soil Quality – The potential impact of an alternative on soil quality and productivity	The alternative has the potential to improve the quality and/or productivity of the soil through application -–10 The alternative does not have the potential to improve the quality or productivity of the soil (no positive or negative impact) -–5 The alternative has the potential to reduce the quality and/or productivity of the soil – 0
	Ground Water Quality and Flow – The potential of the alternative to protect groundwater resources	The alternative provides significant protection to groundwater resources – 10 The alternative provides moderate protection to groundwater resources – 7 The alternative has no impact on groundwater resources – 5 The alternative provides little if any protection to groundwater resources; significant mitigation needed to provide protection – 0
	Air Emissions – The potential for an alternative to meet provincial regulatory requirements for air emissions This criteria does not address odours	The alternative exceeds regulatory requirements and results in a significant reduction in overall air emissions from the WWTP – 10 The alternative meets the regulatory requirements and may result in a moderate reduction in overall air emissions from the WWTP – 7 The alternative has no impact on air emissions from the WWTP – 5 The alternative does not consistently meet regulatory requirements and results in no change or an increase in overall emissions from the WWTP; significant mitigation required to control air emissions to meet regulations – 0
Economic Environment	**Sales Demand** – The potential for the alternative to create a product that meets market demands	The product will have a high market demand; all of product sold – 10 The product will have a moderate market demand; 50% of product sold – 7 The product will have a low market demand; product given away free – 5 The product will have no market demand and may require incentives, i.e. pay to land apply the product – 0
	Contracts – What is the number and complexity of the service contracts required?	No contracts – 10 Multiple simple contracts – 7 Single complex contract – 5 Numerous complex contracts – 0

Development of Biosolids Management Strategies

Basis of Design

In order that a fair and equitable comparison and evaluation of the management strategies be made, a basis of design was developed for each alternative strategy. This is documented in TM4-IIIA.

The basis of design allowed for management of the biosolids over the full design period of the study, with equitable production, contingency and storage capacities. Redundancy requirements were assumed for each alternative.

For each management option the following assumptions were made:

- Product storage is based on four months of total storage to meet the minimum period requirement (December to March), when biosolids cannot be land applied
- Biosolids will be managed through disposal at a landfill when conditions are not suitable for land application
- As landfilling will be a contingency for each management strategy, it has further been assumed that the two new dewatering units will be centrifuges, to reduce or eliminate the need to blend cake with woodchips to obtain cake suitable for landfill disposal.

Using the assumptions stated above, the basis of design used for this study is as follows:

Capacity

The estimated mass of raw solids produced at capacity of the Stage 2 expansion of the liquid train at the Guelph WWTP (to a total plant capacity of 73.3 MLD) is about 26,700 kg/d, based on current per capita equivalent solids contributions to the City's wastewater.

Analysis of the data suggests that even if industries meet sewer by-law compliance limits (best case) in the future, with potential future industrial expansions and increasing population across the serviced area, the raw (undigested) solids production at the WWTP will still approach 26,700 kg/d (9,745 dt/yr) when the full capacity of Stage 2 expansion is completed.

Physical Characteristics

The physical characteristics of the biosolids produced at the Guelph WWTP, shown in Table 6.5, were developed from historical plant data and anticipated future biosolids quality for planned equipment.

TABLE 6.5
BASIS OF DESIGN: PHYSICAL CHARACTERISTICS OF BIOSOLIDS

	Average	Range
Concentration of Primary Biosolids (percent of total solids)	4%	3.5% – 4.5%
Concentration of WAS[1] (as % of total solids)	0.2%	0.1% – 0.3%
Concentration of Co-thickened Primary and WAS (percent of total solids)	3.3%	3% – 4%
Concentration of Mechanically Thickened WAS (TWAS) (percent of total solids)	6%	5.5% – 6.5%
Volatile Concentration (percent of dry solids)	70%	62% – 75%
Concentration of Digested Biosolids (percent of total solids)	2%	1.5% – 2.5%

TABLE 6.5
BASIS OF DESIGN: PHYSICAL CHARACTERISTICS OF BIOSOLIDS

	Average	Range
VS Destruction in Digestion	53%	50% – 58%
Concentration of Dewatered Biosolids (BFP) (percent of total solids)	18%	16% – 20%
Concentration of Dewatered Biosolids (Centrifuge) (percent of total solids)	28%	25% – 30%
Metals (mg/kg dry biosolids)		
Arsenic	0.03	0.002 – 0.1
Beryllium[2]	NM	NM
Cadmium	0.22	0.01 – 0.86
Chromium	3.6	0.1 – 8.3
Copper	13.3	0.1 – 26.5
Lead	0.9	0.1 – 2.3
Mercury	0.23	0.0001 – 3.5
Molybdenum	0.26	0.1 – 0.58
Nickel	0.27	0.1 – 0.78
Selenium	0.02	0.001 – 0.04
Zinc	30	1.15 – 43.7
Nutrients		
Total Kjehldahl Nitrogen (TKN)	1,230	620 – 2,040
Total Phosphorus	475	150 – 850

[1] Estimated; plant data not available
[2] NM = Not measured

Design Guidelines

The industry-standard design guidelines for each of the alternative technologies were reviewed, and are summarized in Table 6.6.

TABLE 6.6
SUMMARY OF DESIGN GUIDELINES FOR ALTERNATIVE TECHNOLOGIES SHORT-LISTED FOR EVALUATION

Alternative	Selected Technology	Design Guidelines
WAS Thickening[1]	Rotary Drum Thickener	Typical TWAS concentration: 5.5 – 6.6% Typical solids capture: 95 – 98% Typical hydraulic loading range: Not specified as success is highly dependant on biosolids characteristics Polymer Dose Rate: 7.5 g/kg [5]
Anaerobic Digestion[1]	High-rate, mesophilic	Working volume: 85 – 95% Volatile solids destruction: 40 – 65% Solids Residence Time: 10 – 20 days (MOE Guideline: 15 days) Peak Volatile solids loading: 1.9 – 2.5 kg VS/m^3·d Maximum VS loading: 3.2 kg VS/m^3.d Minimum VS loading: 1.3 kg VS/m^3·d
Acid-Phase Digestion[2]	Phase separated digestion	Design HRT: 2 days Design Maximum SLR: 32 kg VS/m^3/day

TABLE 6.6
SUMMARY OF DESIGN GUIDELINES FOR ALTERNATIVE TECHNOLOGIES SHORT-LISTED FOR EVALUATION

Alternative	Selected Technology	Design Guidelines
Mechanical Dewatering[1]	BFP	Typical: Cake Solids Loading Primary sludge 24 – 30% 1.9 –3.2 L/m.s WAS 12 – 20% 0.6 –2.5 L/m.s P + WAS 20 – 25% 1. –-3.2 L/m.s Typical solids capture: 80 – 95% Typical Polymer Dose Rate:1 to 6 g/kg dry solids[6]
	Centrifuge	Typically available capacity range: 0.6 – 44 L/s Cake solids concentration: 28 up to 40% (with high polymer dosage) Typical solids capture: 85 – 96% Typical Polymer Dose Rate:0 to 4 g/kg dry solids[6]
Biosolids Cake/ Woodchip Mixing[2]		Mixing is performed to meet the requirements of the landfill. Dose depends on the cake solids content to obtain a 30%+ solids blend.
Lystek		No industry standard – new technology
Composting[3]	In-vessel	Design input solids: 15,100 kg/day at 17 – 23% solids Design Retention time: 28 days
Heat Drying[1]	Rotary drum	Pellet (product) dryness: 92% (minimum) Specific Evaporation rate: 3,250 – 4,200 kJ/kg water evaporated Energy consumption is based on quantity of water evaporated, and therefore depends on the feed cake solids content
Alkaline Stabilization[4]	In-vessel	Lime Dose: 20 – 50% of the wet-weight 75 – 200% dry weight of biosolids Goal: 46% solids in mixed biosolids and alkaline amendment feed Retention time: Dryer – sufficient to obtain 62 – 65% solids in the product Heat Pulse – 12 hour Elevated pH Storage – 3 days

Notes:
[1] *Design of Municipal Wastewater Treatment Plants*; WEF Manual of Practice No. 8 (1992)
[2] CH2M HILL design guidelines
[3] Data typical of existing in-vessel system is provided
[4] Data typical of *N-Viro* system is provided
[5] Determined by bench-testing of Guelph's WAS (2004)
[6] *Sludge Conditioning*, Manual of Practice No. 14 (1988)

Description of Options

The short listed technologies, products and end uses served as a menu from which seven biosolids management strategies were developed. All seven strategies include treatment by digestion, dewatering and further processing, and result in diversified products with multiple potential end uses.

Option 1 – Expand Existing System

Option 1 involves expansion of the existing system to meet future flows and includes Lystek and WAS thickening. No new technologies are included. Storage is provided for composted biosolids, Lystek biosolids, and liquid biosolids. Final use options include land application for liquid, cake, and Lystek processed biosolids, and land application or alternative markets (such as sod farming) for composted biosolids. Landfilling of cake and composted biosolids are alternative contingency disposal options.

This option allows two- and four-month scheduled maintenance periods for the Lystek and composting facilities, respectively. The typical operating schedule would consist of the following:

- Composting at peak capacity (two operating reactor vessel, with additional curing in the third vessel and/or on the storage pad) for two months per year in the winter (January and February).
- Composting at firm capacity (one operating reactor vessels, with additional curing in a second vessel and/or on the storage pad, and one vessel out-of-service) for six months per year in the spring and fall (March, April, September, October, November, and December).
- Compost facility scheduled maintenance (all vessels out-of-service) for four months in the summer.
- Lystek treatment at peak capacity (6 m^3/day) for two months in the spring (May and June).
- Lystek treatment at firm capacity (3 m^3/day) for eight months of the year (March and April, and July through December).
- Lystek facility scheduled maintenance (all equipment out-of-service) for two months in the winter (January and February).
- Liquid biosolids storage and subsequent land application of approximately 20 percent of the total annual biosolids produced.
- Agricultural land application of liquid biosolids and Lystek-processed biosolids. Beneficial use of compost. Dewatering and land application of the remainder of the biosolids.

A process flow diagram for Option 1 is shown in Figure 6-2.

Option 2 – Expand Existing System with Phased Digestion

Option 2 involves expansion of the existing system to meet future flows utilizing acid phase digestion (a modification to conventional mesophilic anaerobic digestion), and includes WAS thickening and Lystek. Storage is provided for composted biosolids, Lystek biosolids and liquid biosolids, and the same operating schedule and maintenance periods were allowed for as in Option 1. Final use options are the same as for Option 1, and a process flow diagram is shown in Figure 6-3.

FIGURE 6-2
OPTION 1 EXPAND EXISTING SYSTEM

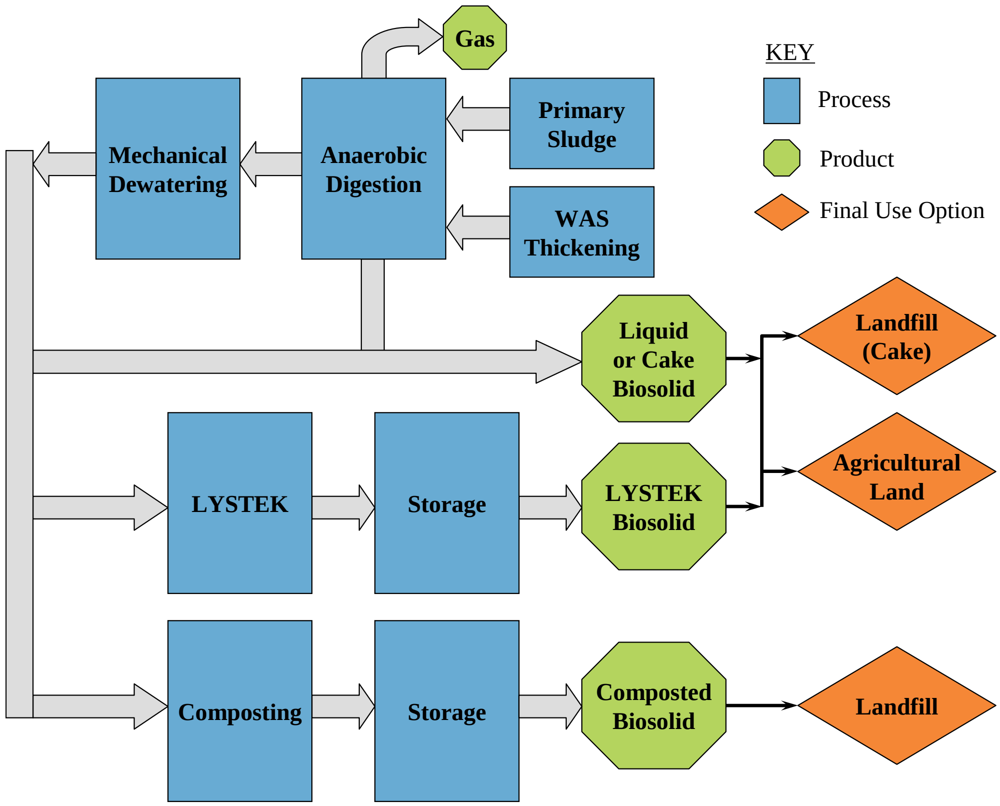
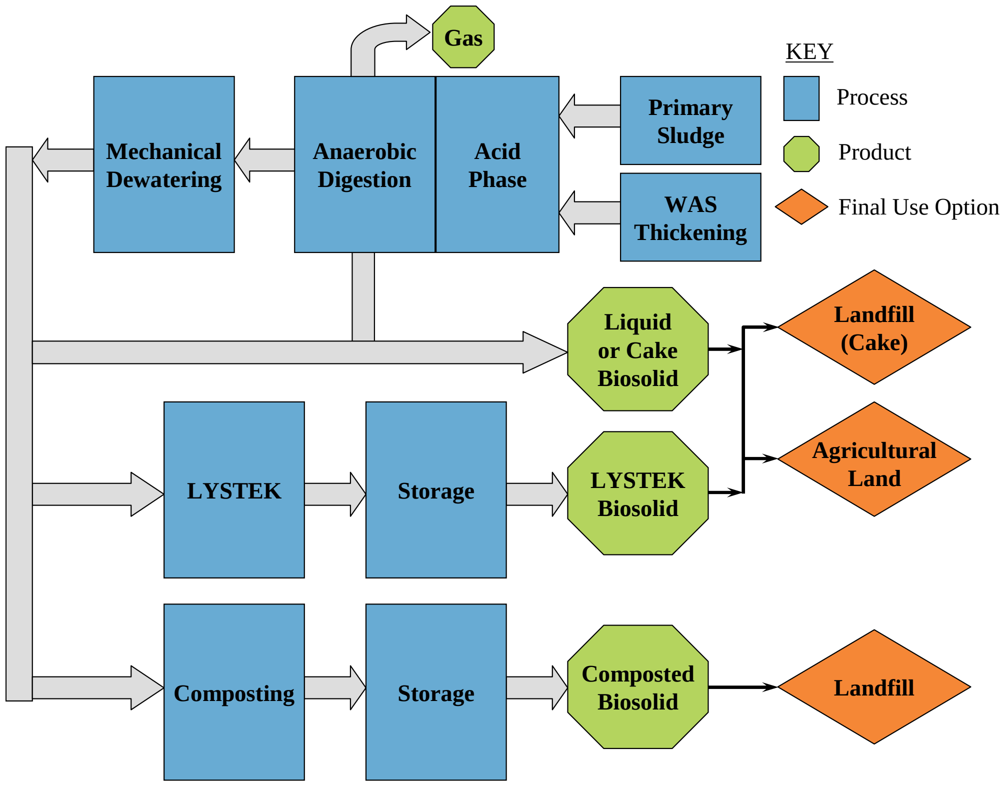


FIGURE 6-3
OPTION 2 EXPAND EXISTING SYSTEM WITH PHASED DIGESTION



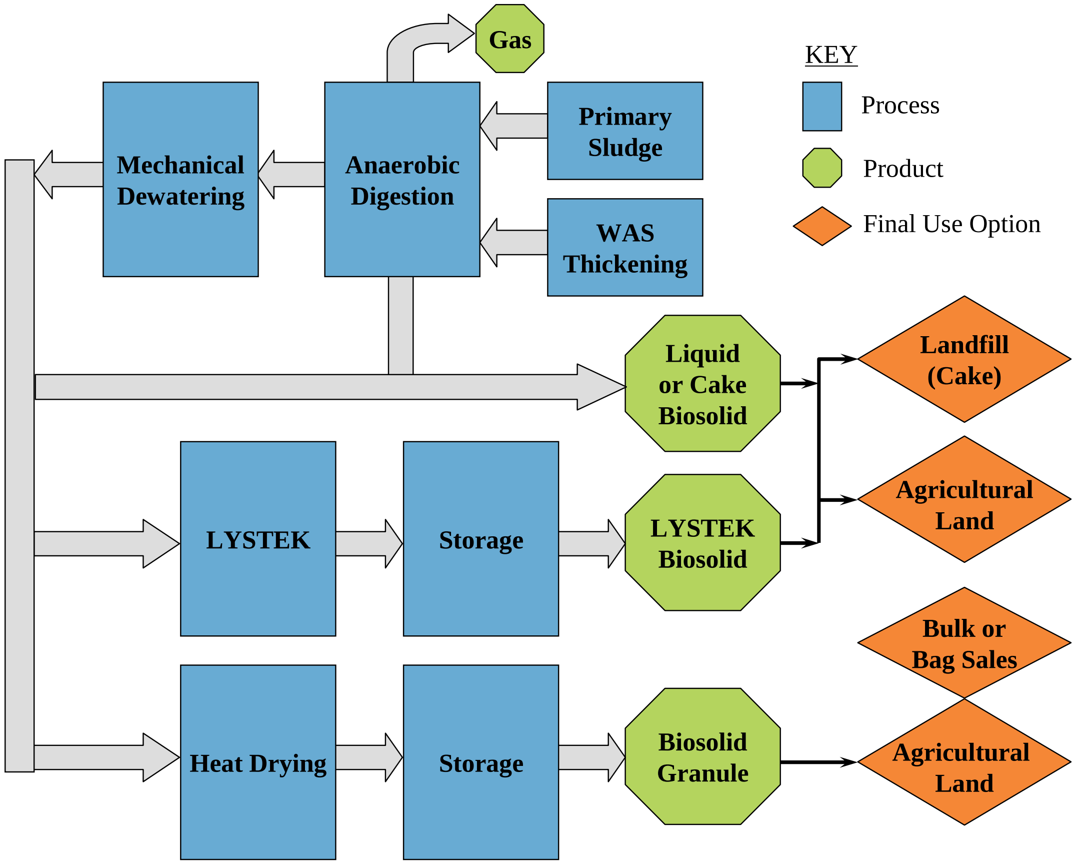
Option 3 – Expand Existing System with Heat Drying

The option expands the existing system to meet future flows and includes WAS thickening Lystek and heat drying. The composting system would be decommissioned and the new technology (heat drying) installed.

It was assumed that Lystek would operate at peak capacity for two months per year, firm capacity at eight months per year, and have a scheduled maintenance period of two months per year, as in all other Options. It was further assumed that the heat drying system would operate year-round, with a two-week scheduled maintenance period. The dryer would operate 24-hours per day, typically four to six days per week, depending on the requirements, as per the quantity of biosolids processed.

Storage is provided for heat dried biosolids pellets in silos and Lystek biosolids. Final use options include those identified in strategy Option 1 plus bulk or bag sales for the pelletized biosolids product that is generated with heat drying. The heat dried biosolids may also be disposed of at landfill if required. The process flow diagram for this option is shown in Figure 6-4.

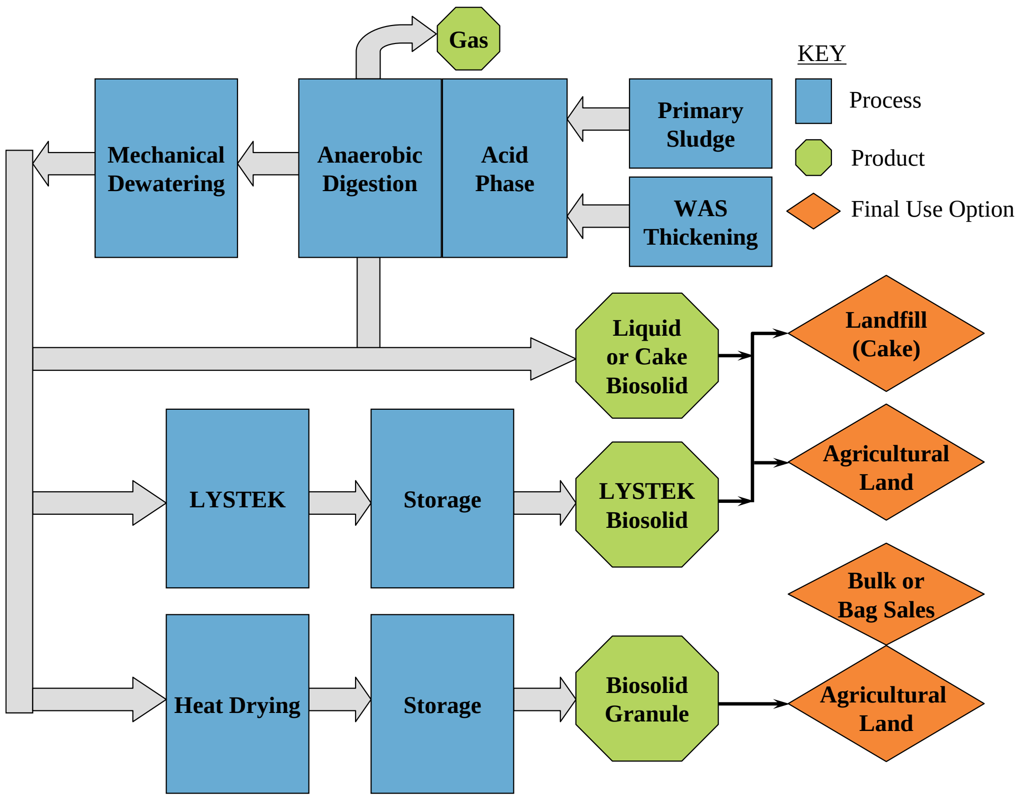
FIGURE 6-4
OPTION 3 EXPAND EXISTING SYSTEM WITH HEAT DRYING



Option 4 – Expand Existing System with Heat Drying and Phased Digestion

The option expands the existing system to meet future flows utilizing phased digestion, and includes WAS thickening, Lystek and heat drying. The compost system would be decommissioned. Storage is provided for heat dried biosolids pellets and Lystek biosolids, and process operating scenarios are the same as Option 3. Final use options are also the same as those identified in strategy Option 3 (Figure 6-5).

FIGURE 6-5
OPTION 4 EXPAND EXISTING SYSTEM WITH HEAT DRYING WITH PHASED DIGESTION



Option 5 – Expand Existing System with Primary Solids Only Digestion and Heat Drying

The option expands the existing system to meet future flows and includes WAS thickening, Lystek and heat drying. Only primary sludge would be digested; it would then be blended with the thickened WAS (TWAS) prior to heat drying. Additional digester capacity would not be required. Option 4 also includes demolition of the composting system and installation of a new heat drying facility. Storage is provided for heat dried biosolids pellets and Lystek biosolids, and process operating scenarios are the same as Options 3 and 4. Liquid WAS and biosolids cake could not be land applied, as the WAS would not be stabilized (digested) prior to dewatering. This Option is shown in Figure 6-6.

Option 6 – Expand Existing System with Alkaline Stabilization

The option, shown in Figure 6-7, expands the existing system to meet future flows and includes Lystek, alkaline stabilization and WAS thickening. Option 6 also includes demolition of the composting system and installation of a new alkaline stabilization facility. Storage is provided for alkaline biosolids material and Lystek biosolids. The operating scenario is similar to Option 3, with alkaline stabilization operating year-round, excluding a two-week scheduled maintenance period. An approximately eight-hour per day schedule would be required, unless process demand increased. Final use options are the same as those identified in strategy Option 3.

FIGURE 6-6
OPTION 5 EXPAND EXISTING SYSTEM WITH PRIMARY SOLIDS ONLY DIGESTION AND HEAT DRYING

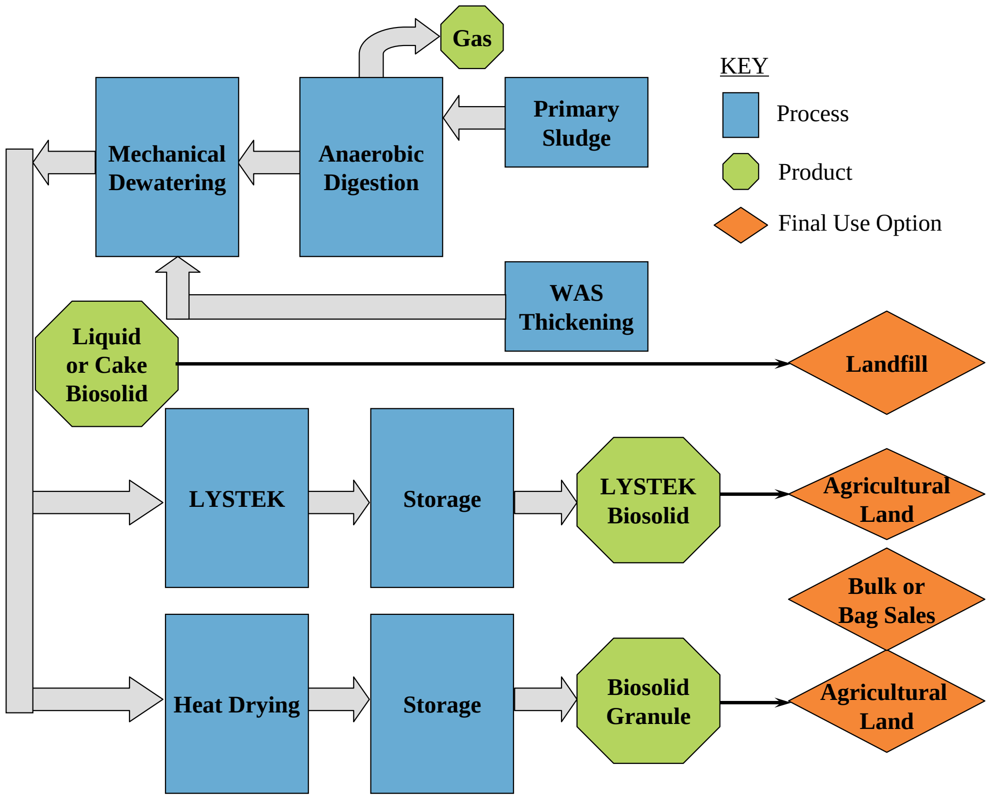
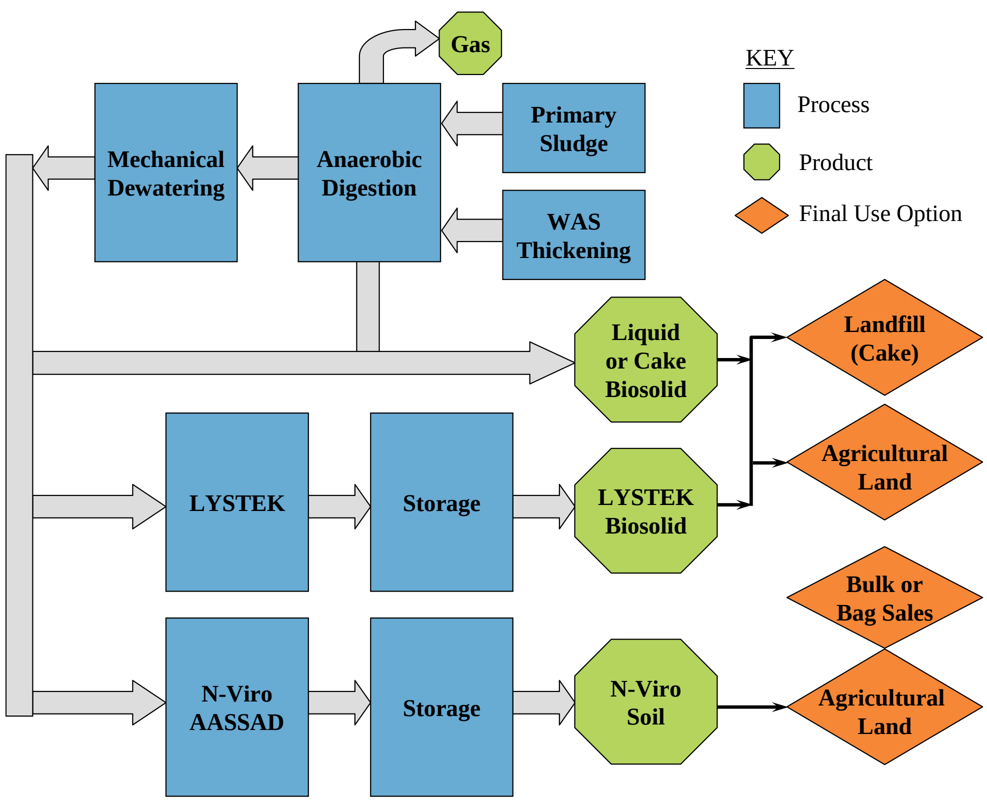


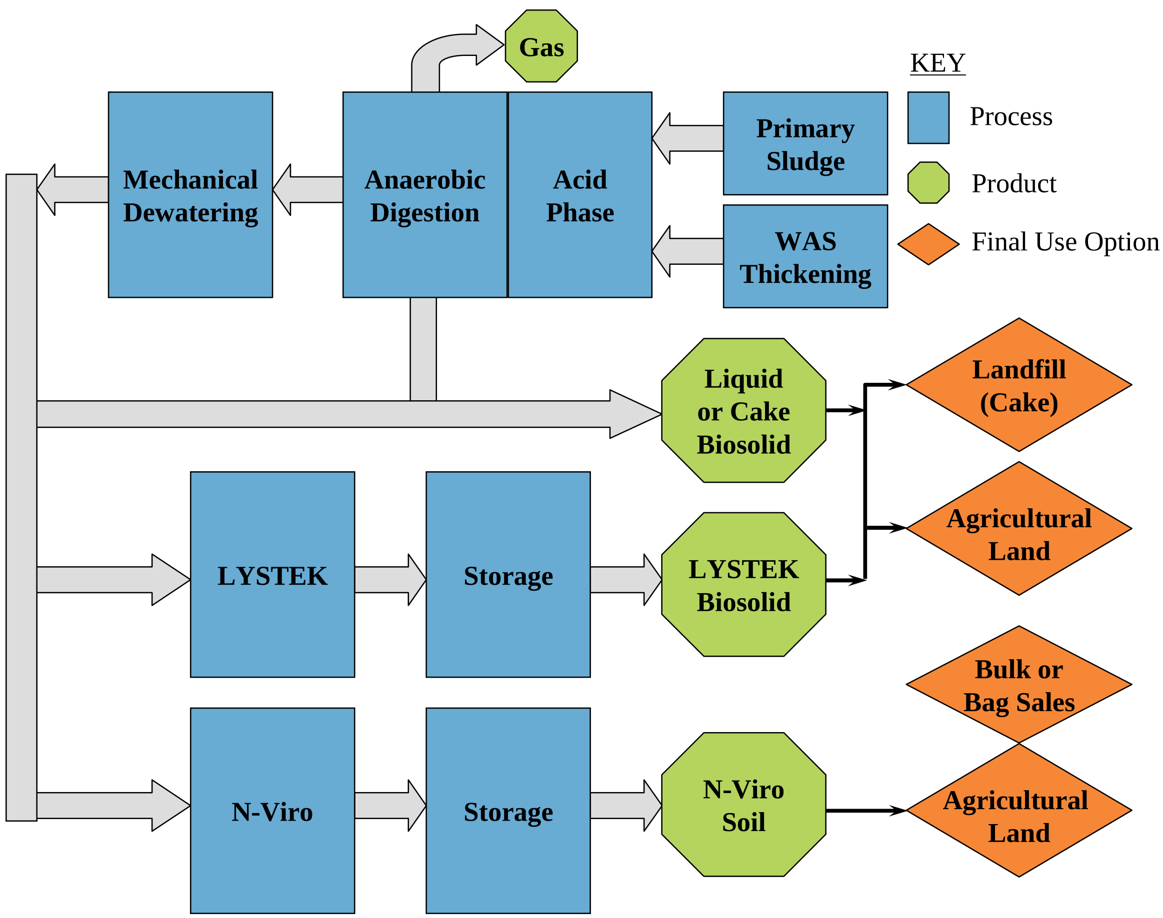
FIGURE 6-7
OPTION 6 EXPAND EXISTING SYSTEM WITH ALKALINE STABILIZATION



Option 7 – Expand Existing System with Alkaline Stabilization and Phased Digestion

The option expands the existing system to meet future flows utilizing phased digestion and includes WAS thickening, Lystek and alkaline stabilization. A new acid-phase digester would provide the required additional digester capacity. Option 7 also includes the demolition of the composting system and the installation of a new alkaline stabilization facility. Storage is provided for alkaline biosolids material and Lystek biosolids. Final use options are the same as those identified in strategy Option 6, as shown in Figure 6-8.

FIGURE 6-8
OPTION 7 EXPAND EXISTING SYSTEM WITH ALKALINE STABILIZATION AND PHASED DIGESTION



Summary of Biosolids Management Strategy Options

A summary of the biosolids management strategy options is presented in Table 6.7. The summary provides a comparison of the components for each strategy option.

TABLE 6.7
SUMMARY OF BIOSOLIDS MANAGEMENT STRATEGY OPTIONS

	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Description	Expand Existing System	Expand Existing System with Phased Digestion	Expand Existing System with Heat Drying	Expand Existing System with Heat Drying and Phased Digestion	Expand Existing System with Primary Solids Only Digestion and Heat Drying	Expand Existing System with Alkaline Stabilization	Expand Existing System with Alkaline Stabilization and Phased Digestion
Primary Sludge	No change; Same for all options						
TWAS	No change; Same for all options Storage may be required if operating period is less than 24 hours/7 days						
Anaerobic Digestion	Additional digestion	Additional acid-phase digestion	Additional digestion	Additional acid-phase digestion	No change	Additional digestion	Additional acid-phase digestion
Liquid Biosolids	29,112 m^3 storage	27,207 m^3 storage	None; No change				
Mechanical Dewatering	Additional dewatering Same technology for all options (centrifuges assumed) Sizing for each option may vary if different operating schedules are required						
Cake Biosolids	No change; Same for all options						
Lystek	4,800 m^3 storage; Same for all options						
Composting	2,703 m^3 storage	2,726 m^3 storage	Decommission and reuse infrastructure				
Heat Drying	NA		4,572 dt/yr biosolids 1,652 wt storage	3,890 dt/yr biosolids 1,409 wt storage	6,487 dt/yr biosolids 2,708 wt storage	NA	
Alkaline Stabilization	NA					4,572 dt/yr biosolids 6,746 m^3 storage	3,890 dt/yr biosolids 5,589 m^3 storage

dt/yr – Dry tones per year
wt – Wet tonnes

Evaluation of Biosolids Management Strategy Options

Evaluation of Strategy Options

Each management strategy option was evaluated using the evaluation criteria and defined criteria measures presented in Table 6.4. The results of the evaluation are shown in detail in TM4-IIIB.

Table 6.8 summarizes the weighted scores and strategy ranking produced using the MUA tool for Total Benefit Analysis. The results are graphically displayed in Figure 6-9. Options 1 and 2 received the highest total weighted score, and therefore were evaluated to be highest ranked options, with regard to the criteria.

FIGURE 6-9
RANKING OF ALTERNATIVES BY TOTAL BENEFIT VALUE

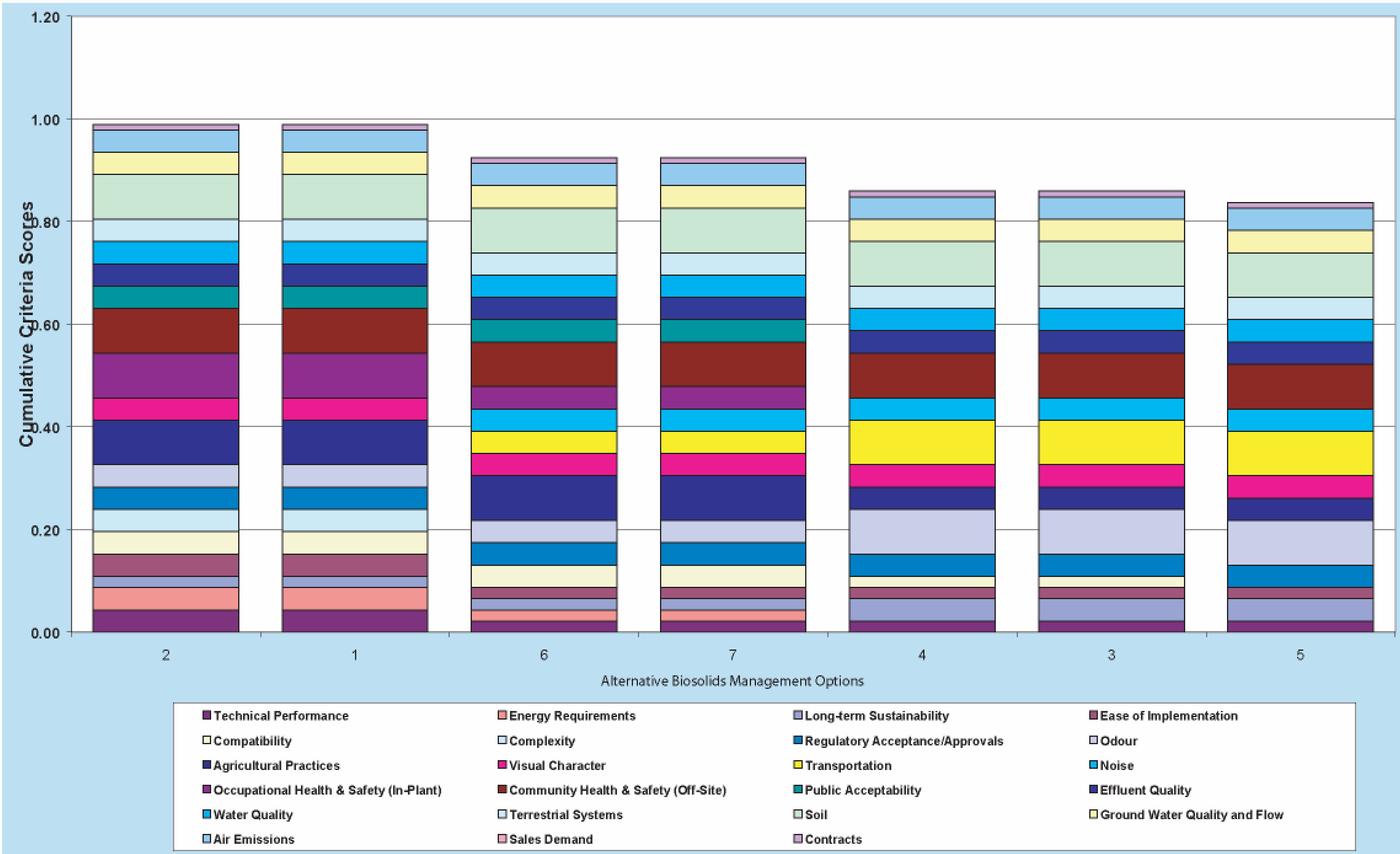


TABLE 6.8
EVALUATION OF BIOSOLIDS MANAGEMENT OPTIONS

Evaluation Criteria	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Weight
	Expand Existing System	Expand Existing System with Phased Digestion	Heat Drying with Expanded Digestion	Heat Drying with Phased Digestion	Heat Drying with Primary Only Digestion	Alkaline Stabilization with Expanded Digestion	Alkaline Stabilization with Phased Digestion	
	Score	Score	Score	Score	Score	Score	Score	
Technical Performance	10	10	5	5	5	5	5	50
Energy Requirements	10	10	0	0	0	5	5	50
Long-term Sustainability	5	5	10	10	10	5	5	50
Ease of Implementation	10	10	5	5	5	5	5	50
Compatibility	10	10	5	5	0	10	10	90
Complexity	10	10	0	0	0	0	0	90
Regulatory Acceptance/ Approvals	10	10	10	10	10	10	10	90
Odour	5	5	10	10	10	5	5	40
Agricultural Practices	10	10	5	5	5	10	10	40
Visual Character	5	5	5	5	5	5	5	40
Transportation	0	0	10	10	10	5	5	40
Noise	0	0	5	5	5	5	5	40
Occupational H&S (In-Plant)	10	10	0	0	0	5	5	60
Occupational H&S (Offsite)	10	10	10	10	10	10	10	60
Public Acceptability	5	5	0	0	0	5	5	40
Effluent Quality	5	5	5	5	5	5	5	60
Water Quality	5	5	5	5	5	5	5	40
Terrestrial Systems	5	5	5	5	5	5	5	25
Soil	10	10	10	10	10	10	10	25
Groundwater Quality and Flow	5	5	5	5	5	5	5	40
Air Emissions	5	5	5	5	5	5	5	25
Sales Demand	0	0	0	0	0	0	0	20
Contracts	5	5	5	5	5	5	5	20
Total Weighted Score	**80.10**	**80.10**	**50.40**	**50.40**	**46.89**	**61.44**	**61.44**	

Evaluation Criteria Sensitivity Analysis

Alternative weightings of the evaluation criteria were also examined to determine the sensitivity of the analysis.

- **Equally Weighted –** When each objective was weighted equally, Options 1 and 2 continued to receive the highest total weighted score. However, there was slightly less difference between the Options.
- **Technically Weighted –** When additional weight was given to the technical criteria, Options 1 and 2 continued to receive the highest total weighted score. Increased relative difference between the Options was evident.
- **Social/Natural Environment Weighted –** When additional weight was applied to the social/natural environment criteria Options 1 and 2 received the highest total weighted score, but there was less of a difference between the Options.

Table 6.9 summarizes the results of the sensitivity analysis. It shows that Options 1 and 2 ranked first in each of the objective weighting scenarios, followed by Options 6 and 7, then Options 3 and 4, and finally Option 5.

TABLE 6.9
SUMMARY OF SENSITIVITY ANALYSIS RESULTS FOR EVALUATION OF CRITERIA FOR BIOSOLIDS MANAGEMENT OPTIONS

Evaluation Criteria	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
	Expand Existing System	Expand Existing System with Phased Digestion	Heat Drying with Expanded Digestion	Heat Drying with Phased Digestion	Heat Drying with Primary Only Digestion	Alkaline Stabilization with Expanded Digestion	Alkaline Stabilization with Phased Digestion
	Rank	Rank	Rank	Rank	Rank	Rank	Rank
Base Case	1	1	5	5	7	3	3
Equally Weighted	1	1	5	5	7	3	3
Technically Weighted	1	1	5	5	7	3	3
Social/Environmental Weighted	1	1	5	5	7	3	3
Overall Rank	**1**	**1**	**5**	**5**	**7**	**3**	**3**

It was therefore determined that Options 1 and 2 are the most feasible and therefore preferred management options with respect to the evaluation criteria.

Economic Evaluation

Estimated capital and O&M costs were also considered in the evaluation. TM4-IIIB documents the detailed cost analyses, which are summarized in Table 6.10.

TABLE 6.10
SUMMARY OF ESTIMATED COSTS FOR BIOSOLIDS MANAGEMENT OPTIONS

Cost Criteria	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
	Expand Existing System	Expand Existing System with Phased Digestion	Heat Drying with Expanded Digestion	Heat Drying with Phased Digestion	Heat Drying with Primary Only Digestion	Alkaline Stabilization with Expanded Digestion	Alkaline Stabilization with Phased Digestion
Capital Cost	$25,090,000	$22,180,000	$35,820,000	$33,570,000	$33,640,000	$31,380,000	$27,850,000
O&M Annual Cost	$2,786,000	$2,694,000	$2,472,000	$2,254,000	$3,028,000	$4,098,000	$3,626,000
O&M Annual Credit	$767,000	$866,000	$767,000	$864,000	$428,000	$767,000	$864,000
Net O&M Annual Cost	$2,019,000	$1,828,000	$1,705,000	$1,390,000	$2,600,000	$3,331,000	$2,762,000
NPV	$62,915,000	$56,607,000	$67,837,000	$60,027,000	$81,432,000	$91,953,000	$78,364,000
Capital Cost /dt	$139	$123	$199	$186	$187	$174	$154
O&M Annual Cost /dt	$286	$276	$254	$231	$311	$421	$372
O&M Annual Credit /dt	$79	$89	$79	$89	$44	$79	$89
Net O&M Annual Cost/dt	$207	$188	$175	$143	$267	$342	$283
NPV/DT	$349	$314	$376	$333	$451	$510	$434

Notes: Costs are shown for ultimate year biosolids production rate (2025)
Dry Tonnes (dt) Raw Solids Processed (20-year project total) = 180,731
Dry Tonnes Raw Solids Processed (Ultimate Year) = 9,744
Costs per Dry Tonne are for Raw Solids processed
NPV – Net Present Value

Table 6.10 illustrates that the Options with phased digestion (or unexpanded digestion) had lower estimated capital costs than those with expanded digestion. Overall, expanding the existing system options had lower estimated capital costs, followed by the alkaline stabilization options. The highest estimated capital costs were associated with heat drying.

The heat drying options had the lowest O&M costs. Heat drying following primary-only digestion was more costly than heat drying following full digestion. Expanding the existing system options had the second lowest O&M costs. Alkaline stabilization options had the highest O&M costs.

O&M credits were greater for the options with phased digestion and least for the option with primary only digestion.

The net O&M costs were lowest for heat drying options and highest for the alkaline stabilization options.

The total net present value (NPV) was estimated to be least for the expanding the existing system options, followed by the heat drying options and highest for the alkaline stabilization options.

Benefit/Cost Evaluation Summary

The evaluation matrix was also utilized to determine the overall cost (economic) and benefit (objective) of each option. The best benefit to cost ratio was given a score of 1.41 and the other options were scored relative to the maximum score. Table 6.11 summarizes the scores.

TABLE 6.11
SUMMARY OF COST/BENEFIT EVALUATION

Cost/Benefit	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
	Expand Existing System	Expand Existing System with Phased Digestion	Heat Drying with Expanded Digestion	Heat Drying with Phased Digestion	Heat Drying with Primary Only Digestion	Alkaline Stabilization with Expanded Digestion	Alkaline Stabilization with Phased Digestion
Overall Score	1.27	1.41	0.77	0.89	0.57	0.67	0.78
Overall Rank	2	1	5	3	7	6	4

The cost/benefit analysis has shown that the highest ranked option is to expand the existing system. The economic evaluation suggests that phased digestion, compared to expanding the existing conventional anaerobic digestion facility, may be economically beneficial. It is recommended that this is considered and further evaluated in the planning and design stages of digester capacity expansion.

However, the existing compost facility at the WWTP was installed more than 10 years ago. It is therefore likely that it will reach the end of its service life before the 20-year planning period addressed in this study, even with the recommended capital investment to enable reliable service. Since biosolids compost has a limited commercial market, and the O&M costs are high, it is recommended that an alternative biosolids management treatment process should be considered when composting is no longer reliable. This analysis suggests that heat drying or alkaline stabilization would likely be the preferred technology if being considered at this time; however, technology advances, and regulatory and market changes should be re-addressed to determine the appropriate decision in the future.

Recommended Strategy

The recommended strategy is to maximize the City of Guelph's existing investment in the WWTP by utilizing the existing biosolids management system to the end of its useful operating life. This will require some unit process upgrades and expansions to provide reliable service for the projected biosolids quantities over the study period. It is also recommended to decommission the compost system and replace with an alternative processing technology. The City has determined that the composting equipment is at the end of its reliable service life and should be replaced as soon as possible.

Options 1 and 2 provide for liquid biosolids storage, Lystek-treated biosolids storage, and composted biosolids storage, to give four months' product storage, to provide an equal strategy for all the Options. Given the recommendation to decommission and replace composting with an alternative process as soon as possible, and it is anticipated that the process will be able to accommodate the storage, investment in liquid storage is not recommended at this time. Therefore, a modified Option 1 has been developed for implementation, which includes Lystek, no liquid storage, but storage for Lystek and other biosolids products. This is essentially the same as (a modified) Option 2, but as the decision to implement phased digestion would occur during the planning and design stages of digester capacity expansion, the more economically conservative Option 1 was utilized for analysis. Finally, for forecasting purposes, it was assumed that heat drying or alkaline stabilization, the preferred replacement technologies in this analysis, will be installed in the future.

7. Recommended Strategy

Seven feasible biosolids management strategies for Guelph were developed and evaluated and it was determined that the preferred strategy, which maximizes the City of Guelph's existing investments at the WWTP, includes the following:

- Maintain the existing biosolids management technologies, and expand process capacities as required, including:
  - WAS thickening;
  - Digestion;
  - Dewatering;
  - Lystek treatment and land application;
  - Dewatered cake land application;
  - Preferred technology replacing composting and beneficial use; and
  - Emergency liquid biosolids land application; dewatered cake and/or compost landfilling, if required.
- Construct storage facilities for Lystek-treated biosolids and preferred technology biosolids to maximize beneficial use.
- Consider alternative further treatment technologies as the equivalent compost facility capacity is exceeded, to maintain a diversified program.
- Develop a plan to implement this strategy. The implementation plan must include measures to reduce the City of Guelph's identified risk and liabilities associated with biosolids management.

This section provides an overview of the recommended strategy and implementation plan documented in TM4-4, shown in Appendix G, for the Guelph WWTP BMMP.

Strategy Overview

The City of Guelph currently processes the biosolids generated by the conventional activated sludge WWTP with anaerobic digestion and belt-press dewatering. The dewatered cake is primarily land applied or landfilled. The dewatered cake may also be composted in the in-vessel facility, but partly due to a lack of market for the composted biosolids and high maintenance, the composting facility is primarily used to increase the solids content of the cake so that it is accepted by, and easier to dispose of at, the landfill. The composting facility has operated at limited capacity because of mechanical and other operational problems. Composting is no longer considered a reliable component of the existing biosolids management program.

The review of the existing biosolids management program and the analysis of feasible alternative biosolids management options indicated that the existing method of management is the most economical for the City of Guelph and provides the greatest benefit per unit cost. It is anticipated that there will be sufficient agricultural land available to land apply biosolids over the planning period for this study (2025). There will be a need to provide storage for

Lystek-treated biosolids to maximize beneficial use and reduce dependency on landfilling. Long-term investment in biosolids management processes should be better directed to alternatives to maintain a diversified program. The evaluation of options found that alkaline stabilization and heat drying are feasible technologies for the City of Guelph to implement, but in the future, regulatory changes and new and emerging technologies should also be considered when determining the preferred strategy. In the future, the concept of partnering with private enterprises and/or other municipalities may also be appropriate to incorporate into the City's strategy. The concept of municipalities partnering lends itself to management solutions that could benefit all of the partners. These include adopting common best management practices and shared central facilities or contracting services effectively by utilizing contracts that fairly share risk between partners. This method of management could reduce each partner's costs. Municipalities will still have to proactively monitor programs that are contracted to the private sector to satisfy public concerns.

The following principles are key components included in the implementation plan:

- The City of Guelph will continue to produce a digested biosolids product at its WWTP.
- The City will maximize beneficial use of biosolids by maintaining the ability to produce diversified products and providing storage. Products will include Lystek-treated biosolids as an economical liquid-type product and dewatered cake in the land application season that can be easily utilized on agricultural land.
- The utilization of biosolids on agricultural land will be the mainstay of the City's BMMP.
- The City will strive to improve the quality of the end product to address public concerns regarding potential health issues.
- The City will continue to maintain a landfill contract for disposal of biosolids when beneficial use is not available.
- The City will contract with the private sector, as appropriate, to manage its land application of biosolids in an environmentally responsible and economical manner satisfactory to the City, its residents, and the farming community.
- The City will manage its risks and liabilities for biosolids use and disposal by entering into contracts and management arrangements that reduce the risks, while fairly apportioning the risks between the City and the private sector. The City will strive for effective management of the contract(s), including monitoring of the contractor's methods, operations, and record keeping. The City will also utilize stakeholder committees to review its programs.
- The City will consider partnering with other municipalities, and/or the private sector, to develop other biosolids products and markets that compliment this program, as a replacement for the composting facility. The mix of the future biosolids products will reflect the markets and will be adjusted periodically according to market trends. The evaluation will also weigh the costs of private sector solutions with the costs of building additional storage facilities.
- Should partnering not be the sole solution, the City will further investigate alternative technologies, including alkaline stabilization and heat drying, for long-term implementation to replace the compost facility when it is decommissioned. The market

and regulatory trends will be considered, as well as other (emerging) technologies if appropriate, to meet future demands and requirements.

- The City will implement a communication and education program with its stakeholders and the general public to provide them with a better understanding of biosolids management in Ontario and the City of Guelph. The goal of this program will be managing potential liabilities and risks associated with the management program. The program should be geared to increase public backing for the program supported by sound science.

Implementation Plan Development

Implementing the strategy presented above requires an approach that addresses the entire duration of the management planning period and that includes risk management. Because the implementation of this management plan is influenced by practices in other municipalities, such as availability of land for land application use, landfills and potential partnering opportunities, it is prudent to understand how municipalities in southern Ontario and other jurisdictions are managing their biosolids.

The proposed implementation plan provides for the City of Guelph to carry out some activities directly and others in conjunction with other parties, which include private sector proponents and, potentially, partner municipalities. The plan should allow the City to continue managing biosolids effectively while implementing plan components in an orderly, systematic fashion. During the initial five years of the plan, the City will be able to prepare for processes and facilities that will be required for capacity purposes, and begin developing long-term strategies for implementation to replace the compost facility. A review of the Guelph BMMP is scheduled at the end of five years and every five years thereafter, thus conforming to MEA Class EA procedures for master plans. The review allows the City to adjust the implementation plan to suit changes that may be required to update the plan for the next five-year period.

Since the BMMP study began in 2000 and as the study has proceeded, a number of programs identified have been initiated or implemented at the WWTP, including the following:

- WAS thickening trials
- Request for engineering proposals to expand the digestion process capacity
- Review of the dewatering needs and equipment tender
- Review of compost woodchips suppliers
- Investigation of the compost outfeed device and custom retrofitting
- Landfill contract negotiation
- Biosolids land application tender and contract negotiations
- Nutrient management strategy

The status of these programs and activities has been accounted for in the implementation plan.

Biosolids Management in Southern Ontario

Table 7.1 summarizes biosolids management programs in Southern Ontario, including program type and size of operation. The locations listed collectively manage about 566 dry tonnes per day (dt/d) of biosolids. The biosolids management programs include land application of liquid digested biosolids; land application of dewatered biosolids; land application of heat dried biosolids; land application of alkaline stabilized biosolids and incineration of biosolids and landfilling of ash. All digested (using the USEPA designation – Class B) biosolids are managed in Southern Ontario in accordance with the NMA, its Regulations, and *Guidelines for the Utilization of Biosolids and Other Wastes on Agricultural Land* (latest edition). In accordance with the MOE Design Guidelines, anaerobic or aerobic digestion is the preferred method of stabilization for liquid and dewatered biosolids. For anaerobic digestion, the MOE Design Guidelines require one or two-stage digestion, with processing in primary digesters at about 35°C for a nominal minimum HRT of 15 days. Management practices in the guidelines stipulate crop types, minimum times between application and harvesting or use and minimum separation distances from wells, residences and watercourses. These management practices, together with the minimum requirements for anaerobic or aerobic digestion, are intended to protect public health.

TABLE 7.1
SUMMARY OF BIOSOLIDS MANAGEMENT IN SOUTHERN ONTARIO

Location	Biosolids Production		Description of Current Biosolids Management Program
	dt/d	m^3/d	
City of Peterborough	3.5	74	Liquid application of digested biosolids
Region of Durham – except Pickering	10	550	Liquid application of digested biosolids, winter storage and incineration of excess at Duffin Creek WWTP
York Region and Region of Durham – Pickering	90	N/A	Incineration of raw and digested biosolids
City of Barrie	5	192	Liquid application of digested biosolids
City of Collingwood	2	52	Liquid application of digested biosolids
City of Toronto – Highland Creek	39	N/A	Incineration of raw sludge
City of Toronto – Ashbridges Bay	145	N/A	Land application and landfilling of dewatered digested biosolids, dryer being rehabilitated
Region of Peel – Lakeview	64	N/A	Incineration and ash disposal on plant site
Region of Halton	27	1,040	Liquid application of digested biosolids
City of Brantford	7	230	Liquid application of digested biosolids
City of Hamilton	60	N/A	Land application of dewatered digested biosolids
Region of Niagara	29	890	Liquid application of digested biosolids and alkaline stabilization of dewatered digested biosolids
City of Guelph	**10**	**N/A**	Land application and landfilling of dewatered digested biosolids
Region of Waterloo	29	822	Liquid application of digested biosolids
City of St. Thomas	0.3	11	Liquid application of digested biosolids
City of London – Greenway	11	N/A	Incineration of raw sludge from 3 London plants
City of Leamington	6	N/A	Land application of advanced alkaline stabilized biosolids
City of Sarnia	6	N/A	Advanced alkaline stabilized biosolids sold for soil blending
City of Windsor	22	N/A	Landfilling raw dewatered biosolids, dryer shutdown
Total Biosolids Production	**566**		

The City of Toronto, the Regions of Peel and Durham, and the City of London operate incinerators. The Region of Durham recently invested in a significant incineration facility upgrade, and landfilled dewatered cake during the construction period. The City of Toronto's Ashbridges Bay plant replaced incineration with heat drying and land application in 2001; however, the dryer system suffered from a fire and has not been repaired to date, although it is reported that the dryer will be rehabilitated within the next year. Incineration is now utilized for about 25 percent of Southern Ontario's biosolids; the remainder is managed through land application and landfilling when land application is not available.

Liquid land application and, to a lesser extent, dewatered land application, are well-established in Ontario. Liquid land application has been formally practiced since the original Land Application Guidelines were established in 1972. Land application of dewatered biosolids has only recently begun in a large scale, with the City of Toronto, City of Hamilton, and City of Ottawa moving to land application programs. These programs are addressing issues associated with odours from storage of dewatered biosolids, but they have not been completely solved.

Of the other biosolids management options noted in Table 5.1, the private sector is still developing reliable utilization methods or markets. The heat drying system in Windsor, which is owned and operated by Azurix Company (formerly Prism/Berlie), began operation in 1999. Azurix has applied for a license under the Federal Fertilizer Act to market the product. This heat drying system has spent the majority of the last three years out of service. Initially due to fire damage, Windsor landfilled dewatered biosolids while repairs to the facility were being made; however, Windsor has found that landfilling is currently more economically viable, and is continuing with this method at present. Another facility at Smith Falls in Eastern Ontario has been producing a heat-dried product since 1995, but does not have a well-established market for year-round utilization of the dried biosolids. Similar facilities in the U.S. market their products primarily to bulk fertilizer blenders for incorporation into chemical fertilizers. The advanced alkaline stabilization facility in Leamington has been in operation since 1998 and N-Viro, who is contracted to distribute the product, has a license to market the product under the Federal Fertilizer Act. The product is sold to farmers in Southwest Ontario. A similar N-Viro facility is also located in the City of Sarnia, and has been in operation since 2001. The alkaline stabilized biosolids are sold to a local agricultural cooperative for distribution as a fertilizer amendment. The Region of Niagara is also contracting with N-Viro, to alkaline stabilize and distribute approximately 50 percent of its biosolids. The facility is currently under construction and is scheduled to be in operation in the fall of 2006. This facility will have capacity to process biosolids from other municipalities.

The private sector may begin to play a major role in developing markets for biosolids utilization in Ontario. Through contracts with municipalities, the private sector contractors will continue to provide transportation and land application services, as well as providing facilities for further processing, such as in Windsor, Leamington, Sarnia, and the Region of Niagara, and develop markets to utilize this higher quality product. Some pioneering is required to overcome regulatory and social barriers, which will make development of new markets challenging; as such, the private sector may be better suited to achieve this.

Incineration has been practiced in Southern Ontario since the early 1950s, when the first incinerators began operating at Ashbridges Bay in Toronto. Incineration has been used by the bigger generators of biosolids and at one time included the City of Toronto (Ashbridges Bay and Highland Creek), the City of Hamilton (Woodward Avenue), the City of London (Greenway), the Regions of York, Durham (Duffin Creek) and the Region of Peel (Lakeview). The by-product of incineration, ash, was landfilled onsite and at municipal landfills or recycled as light weight aggregate.

The private operations contractor shut down the Woodward Avenue incinerators a few years ago to reduce costs and in response to local public concern. The dewatered biosolids are land applied. The Ashbridges Bay incinerators have also been phased out and were replaced by a combination of dewatered biosolids land application and heat drying. The program began in 1996, when a portion of the dewatered biosolids was diverted to land application. This change was initiated by public pressure on the City of Toronto when it was determining how to manage their biosolids after the existing incinerators reached the end of their useful operating life. Since the fire in the heat drying facility, the dewatered biosolids that cannot be land applied are landfilled, and the City of Toronto is re-addressing its biosolids management program needs.

The Regions of Peel and Durham recently carried out biosolids management studies to select a long-term biosolids management strategy, and both studies recommended that current practice of incineration continue.

Some of the larger biosolids producers will likely continue to incinerate during the future; however, if they decide to discontinue incineration, there will be another increase in the distribution and supply of land-destined products. Should this happen, there will be added demand on the agricultural land available for land application of biosolids in Southern Ontario.

Biosolids Management in Other Jurisdictions

WWTPs in Eastern Ontario anaerobically or aerobically digest their biosolids and utilize biosolids by land application. The smaller plants typically utilize aerobic digestion. The larger plants, including the Robert O. Pickard Centre, Ottawa, Cornwall, Brockville, and Kingston, anaerobically digest their biosolids. The Ottawa and Kingston biosolids are dewatered before land application. As previously noted, the Town of Smith's Falls heat dries its biosolids and produces a pelletized product.

In New Brunswick, the largest plant is located in Moncton. Raw primary biosolids are dewatered and alkaline stabilized prior to utilization. The Greater Moncton Sewerage Commission has a diversified utilization program, which includes land application, both agricultural and sod farming, application to forests, and composting.

In Quebec, the larger plants either heat dry or incinerate their biosolids. In Montreal, biosolids are managed by a combination of incineration and heat drying. Heat drying is utilized in Quebec City, Laval, and Gatineau, whereas Longueuil incinerates its biosolids. A number of other municipalities utilize land application.

Winnipeg is the largest city in Manitoba. Biosolids are anaerobically digested and dewatered prior to land application.

In Saskatchewan, Saskatoon, and Regina anaerobically digest their biosolids and land-apply them. The Regina biosolids are dewatered prior to land application.

In Alberta, most wastewater treatment plants anaerobically digest their biosolids, including Edmonton, Calgary, the Capital Region, and Lethbridge. The Edmonton biosolids are currently land applied, as well as being co-composted with municipal solid waste. The other cities land-apply their biosolids.

In British Columbia, most wastewater plants anaerobically digest their biosolids, including Lions Gate, Annacis Island and Lulu in Vancouver, Matsqui and Prince George. The

Vancouver plants are either using thermophylic digestion or are upgrading to thermophylic. There are a number of smaller plants that utilize autothermal aerobic digestion. Biosolids management practices include land application, land reclamation, and landfilling.

In the U.S. and Europe, the primary biosolids management practices are land application, incineration and landfilling. In the U.S., both Class B and Class A biosolids are land applied. (Class A and Class B are USEPA classifications designating levels of biosolids stabilization, pathogen reduction, and metals concentration quality, with Class A having the lower level of residual pathogens and bacteria, and having less stringent land application requirements due to the associated reduce risk.) Processing technologies that are used to produce Class A biosolids include heat drying, alkaline stabilization, and composting. Various forms of thermophylic digestion are being developed to produce Class A biosolids. Pre-pasteurization is also being used prior to anaerobic digestion to produce Class A biosolids.

In Europe, approximately 50 percent of the biosolids are landfilled, 30 percent are used in agriculture, and the remainder are incinerated, ocean dumped, or otherwise disposed of. Most of the larger countries have either banned or moved away from landfilling of biosolids. Additionally, regulations have been introduced, which require lower pollutant concentrations in biosolids that are land applied. This has resulted in either increased treatment or a move to incineration. Germany, the largest producer of biosolids in the European Union (EU), relies on land application and incineration for its biosolids. A report by the Department of the Environment, Transport, and the Regions of the United Kingdom Government indicated that by 2005, with the cessation of ocean dumping, the distribution of biosolids utilization will be 60 percent land application, 36 percent incinerated or gasified and 4 percent landfilled. The composting rate has risen in Europe over the past three years. In Switzerland, for example, land application has been banned and biosolids are managed through incineration. This is partly due to the nature of the country, for example, shallow overburden soils in the mountainous landscape.

Implementation of Plan Components

The recommended biosolids management strategy is sustainable for the duration of the planning period, meets regulatory requirements, and satisfies the City of Guelph's need to serve its customers economically and responsibly. The program is premised on the City of Guelph's core value of environmental responsibility, resulting in a plan to recycle the biosolids through utilization programs.

The current agricultural land application program, using dewatered biosolids, is vulnerable to several factors that could jeopardize the long-term viability of the current program. The biosolids only satisfy the nitrogen fertilizer requirements of a small percentage of the agricultural land in the area. As the NMA rolls into force, however, animal manure could consume the land currently available for biosolids land application. Should this happen, the biosolids would have to be transported to more distant locations, making the program more expensive to manage. Jurisdictional concerns may also increase the difficulty in managing the biosolids.

The NMA was enacted in June 2002. The legislation is intended to be a comprehensive province-wide approach to managing all nutrients on agricultural land. The impetus of the Act is protection of soil and water quality in Ontario's rural environment, while ensuring that farmers can invest in and operate their farms with confidence. The OMAFRA and the

MOE are responsible for governing the Act, as well as the 13-part Regulation that outlines standards and the four protocols which provide more detail to the Regulation. The Regulation and related protocols were enacted July 1, 2003, with implementation beginning September 30, 2003.

At this point, the Regulation primarily pertains to livestock farmers, but there are some land application standards that apply to biosolids (non-agricultural source material), as well as some requirements for municipal generators. As of September 30, 2003, no biosolids can be applied within 20 m of a watercourse (as defined by the NMA Regulation), the use of high trajectory irrigation guns for land application is banned, and no application of municipal biosolids can take place between December 1 and March 31 of the following year. In addition, the Regulation set a schedule for implementation of Nutrient Management Strategies (NMS) for municipal generators of nutrients, dependent upon size.

The City of Guelph completed its first NMS in late 2004, and is required to update it annually and resubmit it for approval at least once every five years. The NMS is a tool to document the volume of biosolids that are generated, how they are stored, and how they will be used. The NMS must also link to documents related to end use, such as land application Certificates of Approval (C of A) and farm nutrient management plans, as well as broker agreements for any “intermediate” handlers, such as a hauler or land application contractor. Another key component is a contingency plan that documents actions to be taken during times when the intended end use cannot be carried out. Once a municipal generator has an NMS in place, the Regulation requires 240 days of storage for municipal biosolids, unless an alternative disposal method is provided, such as landfilling.

Recent incidents, such as the Walkerton E. coli epidemic, have heightened public awareness of land application programs that include biosolids, septage, and animal manure. This could lead to public pressure requiring products that have been further processed to reduce pathogens to levels equivalent to a Class A biosolids, as defined by the USEPA. In the U.S., there have been recent cases of municipalities banning land application of Class B (equivalent to Guelph’s anaerobically digested biosolids) and requiring Class A products. While there are no regulatory requirements either in Ontario or the U.S., the possibility of public pressure driving the industry towards a Class A level of product would require further processing of all the biosolids to achieve this.

The private sector component of the program includes transportation and land application, as well as development of other product markets for the preferred biosolids technologies in the short term and future products in the long term.

Existing Process Capacity and Equipment Upgrades

Table 7.2 summarizes the existing processes that have been previously identified as requiring equipment upgrades and/or additional process capacity to meet the needs of this BMMP. Table 7.2 also identifies the process need, its driver and the anticipated schedule.

TABLE 7.2
EXISTING PROCESS CAPACITY AND EQUIPMENT UPGRADES

Unit Process	Need	Driver	Result	Schedule
WAS Thickening	• Stage 1: Complete the demonstration • Stage 2: Design, procure and construct full-scale WAS thickening	• Increased sludge production limiting effectiveness of co-thickening in the primaries • Digester capacity limitations	• Improved settling of primary solids • Increased raw solids content, decreased volume • Potentially reduce required scale of digester expansion	• Stage 1: 2005-2007 • Stage 2: 2008-2010
Digestion[1]	• Increase digestion capacity (primary or alternative such as two-phase)	• Current capacity is not sufficient for demand; digesters are overloaded • No excess capacity is available to allow a digester to be taken offline for maintenance; all digesters require cleaning	• Sufficient capacity for demand • Sufficient treatment of biosolids to meet regulatory requirements for land applied biosolids • Ability to take units offline for maintenance	• 2006-2009
Dewatering	• Increased dewatering capacity • Two-stage process anticipated: 1) Replace two oldest belt presses (equipment currently under procurement) 2) Replace remaining two belt presses; consider higher solids equipment, such as centrifuges. Program to include pilot testing	• Two oldest presses have come to the end of their useful life • Two other presses are rapidly approaching the end of their useful life • Lower solids content cake is required for Lystek and higher solids content cake is required for landfilling and will economize when land applying of further processing cake	• Reliable equipment • Reduced operating hours, increased efficiency and reduced costs • Cake properties (solids content) suitable for diversified end uses	• Stage 1: 2005-2006 • Stage 2: 2007-2010
Lystek facility	• Complete installation and commissioning for full-scale (6 m^3) facility – September 2006 • Install and implement storage for Lystek treated biosolids	• Economical and technically sound management process required storage to fully implement reliable program	• Viable Lystek land application program • Maximize investment in equipment • Maximize beneficial use of biosolids	• 2007-2010
Compost facility	• Replace processing capacity with another technology • Construct and utilize covered storage pad; existing unused facilities may be retrofitted	• Existing compost system no longer considered reliable • • Storage to reduce dependency on landfilling	• Viable alternative to composting year-round • Reliable product with feasible market • Maximize beneficial use of biosolids	• 2007-2010

Notes:

[1] The requirement for digestion capacity expansion has been identified as two additional primary digesters, each sized similar to the existing primary digesters (that is 2,440 m^3 volume each), or equivalent, based on raw sludge quantity produced predicted to the 73, 3000 m^3/d ultimate plant capacity. The actual technology selected and design details should be reviewed during design of these facilities.

Land Application Contract

Currently, private sector contractors operate most of the land application programs in Ontario. The involvement of the municipalities in the programs varies significantly and may include recordkeeping, assessment of sites, ownership and operation of storage facilities, development of public education programs and auditing. Contract conditions, scope, and length may also vary significantly. For example, in Niagara, the contractor operates the Region-owned storage facility. For comparison, the Cities of Barrie and Brantford own and operate their storage facilities and contract out the transportation and land application. The Town of Collingwood and City of Kingston lease storage capacity from contractor who owns and operates the storage facilities. The Regions of Halton and Waterloo are similar to Niagara, where the Region owns the storage facility, while the contractor manages the facility.

Some of the contract factors are discussed below and in Table 7.3. As previously mentioned, the City of Guelph tendered for a new land application contract in 2005. The procurement process, developed by the City, consisted of developing a tender document and requesting tenders from contractors. The tenders were reviewed to confirm the contractors met the minimum requirements of the tender and that each tender was complete. The qualified tenders were then evaluated against pre-determined criteria and a preferred contractor selected. The City is currently negotiating the terms with the preferred contractor. It is anticipated that the contract will be signed and effective for a five-year period commencing with the 2006 land application season.

TABLE 7.3
COMPARISON OF LAND APPLICATION PRACTICES AND CONTRACT CONDITIONS

Contract Factor	Advantages	Disadvantages	Recommendation
Contract Cost Breakdown	• Reduce risk of cost increases to contractor • Allow optimization of land application program costs, including mechanical thickening, higher solids products and storage facility sitting • Allow contract separation to two or more contracts if contract becomes too big for one contractor	• Increased administrative costs • Increased potential for contract changes	• Include cost requirement breakdown in tender and contract
Longer Contract Length	• Longer contract lengths reduces risk to contractor by allowing capital costs to be amortized over longer period • Increases number of contractors able to bid on contract • Promote contractor commitment to the community	• City tied into contract for longer period of time • Potential escalation of contract costs due to uncertainty in long-term labour and fuel costs	• Five-year contract with option to extend contract
Escalation Clauses	• Reduces uncertainty in contractors future costs • May reduce contract costs	• Potential increase in City's budgeted costs	• Fuel cost escalation clause recommended due to current uncertainty in future fuel costs. Escalation based on actual fuel expenditures or clause negotiated with City based on expected fuel costs
Performance Bonds	• Increased reliability of contractor obligations being fulfilled • A letter of Credit gives the City ready access to monies to effect changes in emergency situations.	• May reduce tender competition • Increased contract costs	• Bond valued at one year of the contact

TABLE 7.3
COMPARISON OF LAND APPLICATION PRACTICES AND CONTRACT CONDITIONS

Contract Factor	Advantages	Disadvantages	Recommendation
Contractor Storage Facility O&M	• Contractor best able to manage capacity	• Increased contract costs • Reduced control over method of operation and equipment maintenance	• Allow market to determine most viable solution: City owned or included in contractors scope with methods of operation and equipment maintenance specified in contract documents
Dual-Named Application Site Approvals	• City maintains quality assurance over land application program • City not liable for impacts on contractor • Reduce risk of contractor monopoly • Assurance of land availability	• Increased City staff time for reviewing and approving contractor proposed land application sites • Potential increase in liability • Joint responsibility for provision of enough sites	• Approvals be in both the contractors' and the City's name with responsibility for provision of potential sites by contractor for City approval
Record-Keeping by City	• City maintains quality assurance over program • Flexibility to adapt to future regulatory changes without contract amendments • Improve City's information for future planning and land management • Better risk management record	• Increased City staff time for administration • Potential increased liability	• City participate with contractor in development, entry into and review of the record-keeping system
Public Consultation – Contractor Participation	• Public acceptance and development of goodwill with farming community would improve the long term stability of the program	• Slight increase in contract costs	• The City should maintain a permanent Public Advisory Committee composed of stakeholders – farmers, contractor, and public citizens group
Minimum Equipment Requirements	• Improves program reliability. Sufficient equipment will ensure a reliable program in years where poor weather conditions limit the number of application days. • Reduces potential impacts on roads and farm application sites. Appropriate application equipment minimizes soil compaction, minimizes risk of odours and runoff/leaching, and ensures a consistent application rate.	• Increases contractor capital costs	• Specify minimum equipment requirements, including number and types of equip-ment.

Recommendations for inclusion in the contract and future tendering processes, considered as best practices for the City, are also included in Table 7.3.

The City's participation with the contractor in obtaining site approvals would provide additional assurance to the public that guidelines are being followed and may reduce future liabilities to the City. In most programs, the contractor obtains the site C of A. In some cases, the contractor is named as the proponent in the C of A. In other cases, both the municipality and the contractor are named as co-proponents. The Region of Halton obtains site approvals and both the Region and contractor are named proponents. In Durham Region and Barrie, the contractor obtains the C of As and both the municipality and contractor are co-proponents. The Durham Region and Barrie approach is most appropriate for Guelph. (The contractor obtains the C of As specifying the City as the only biosolids source.)

Most of the contracts in other municipalities are of five-year durations (i.e. Barrie, Brantford, Durham Region, Halton Region, Kingston), except for smaller municipalities, where contracts are typically renegotiated each year. Due to the size of the Guelph contract, a five-year contract, with options for extension is recommended. This will allow the contractor to amortize the equipment costs over a reasonable time frame and lower the contract costs. Five years also corresponds with the first review under the Class EA master planning process.

Record-keeping has become more important in the past year, to demonstrate compliance with the NMA. In most cases, the contractor is responsible for the keeping land application records, with municipalities compiling biosolids quality and quantity records. However, many of the larger municipalities are now taking a more active role in record-keeping, including Halton Region and Peterborough. It is recommended that Guelph develops a single record-keeping system, combining City and contractor records, with both parties having access to all the records.

Contract cost break downs, such as escalation clauses for fuel cost and other elements, could be included to minimize risks of future cost increases to the contractor and possibly reduce the contract costs.

Once the contract is executed, the City must administer it to ensure that both the City's and the community's interests are protected. The City's biosolids coordinator is the designated staff member responsible for overseeing the administration of the contract. These duties include the following:

- Establish and implement procedures to verify biosolids quantities picked up by the contractor
- Establish and implement procedures to verify submissions and approvals
- Establish and implement procedures to verify biosolids are being sampled and monitored and that records required by the MOE and the contract are being prepared and made available to the City
- Establish and implement procedures to verify that conditions of the C of As related to activities at the application sites are being complied with
- Establish and implement recordkeeping requirements of the NMA
- Set up monthly activity reports.

The City must set up auditing procedures to properly monitor that the contractor is performing the activities of the contract. Auditing may be performed by the City, or alternatively by an unbiased third party, which may give additional transparency to the program for the stakeholders and public. The following is a list of recommended auditing activities:

1. Review forms completed by truck drivers for completeness and accuracy.
2. Reconcile with monthly report by contractor.
3. Check biosolids processing, storage, and loading facilities including:
    - Storage levels
    - Equipment and road conditions
    - Housekeeping
    - Log book reports
    - Weekly inspection.

4. Spot check C of As for land application sites.
5. Spot check for transportation route road damages and report.
6. Maintain some “visual presence” at application sites and be available for questions from farmers and the public during application events.
7. Respond to correspondence from neighbours.
8. Respond to complaints from municipal politicians regarding roads, traffic, odours, and general concerns.
9. Audit records of field complaints to contractor by farmers, neighbours, and general public.
10. Review results of laboratory tests for biosolids quality.
11. Prepare reports for Public Works Committee on biosolids issues including:
    - Availability
    - Quality
    - Quantity
12. Respond to questions from the media.

Administering of the contract is anticipated to require full time attention approximately two days per week between December and April and approximately three days per week for the rest of the year.

Future Processing Needs

As discussed previously, the composting facility needs to be replaced as soon as possible. The analysis of alternatives determined that composting in the future is currently not a preferred alternative diversification strategy because of the regulatory climate respecting biosolids compost in Ontario. Because of this, it is difficult to justify the costs associated with a significant overhaul and future operation of the compost system when total renovation is required.

Two processing alternatives were found to be feasible for Guelph: heat drying and alkaline stabilization. These and other alternatives, including incineration, are also feasible if partnering with other municipalities is desired and successful.

It is anticipated that the preferred program to replace the compost system will be addressed within the initial stage of the plan implementation and before the first five-year review and update of this Biosolids Management Master Plan. Accordingly, it is recommended that the City initiate discussions with potential private and municipal partners during the period preceding the five-year review and initiate a pre-design study, to determine the preferred management method. The five-year review and update should also consider regulatory changes, market issues, technology advances and partnering opportunities that may emerged during initial five-year implementation of the plan. This would include the issues that may emerge due to the anticipation of an increased quantity of alkaline stabilized biosolids that will be on the market when the Niagara facility is commissioned and the potential for the State of Michigan to close it border to the import of Canadian wastes for landfill disposal.

Contingency Planning and Landfill Contract

The City currently has a landfill contract with the Green Lane landfill, near London, ON. This contract was negotiated in 2004 for all City non-hazardous wastes. Dewatered biosolids are currently landfilled under the contract conditions. However, the belt presses do not produce a cake with sufficiently high solids content for suitable handling at the landfill. The City therefore utilizes some equipment in the compost facility to blend the cake with woodchips, which produces a higher solids blended product. The recommended dewatering equipment replacements will eliminate this need in the future. Furthermore, this management plan will reduce dependency on landfilling.

The City's biosolids management auditing procedures should also include proper monitoring of the landfill contract to measure and track contractor performance compliance. Periodic auditing is recommended.

A landfill contract should be maintained at all times over the period of this BMMP to ensure that a feasible plan is available, as required under the NMA (where biosolids product storage of less than 240 days for land application programs is available).

Permits and Approval Requirements

Implementation of the plan will require the upgrade of some existing facilities and construction of new facilities. The various types and levels of approvals required for implementation are described below. Each of the regulatory acts, as well as local requirements, is addressed.

Class EA Approvals (Environmental Assessment Act)

Recommended component activities and programs identified in the Master Plan will require additional Class EA approval before their implementation. In all cases, the Master Plan document will provide the required project rationale and background data and must be clearly referenced in specific Class EA studies and reports.

Operational process improvements and upgrades to existing WWTPs, up to the existing rated capacity, will typically fall under Schedule A or Schedule B requirements. These types of projects include WAS thickening, digestion and dewatering upgrades, and Lystek and compost facility replacement. With the completion of this Master Plan, all Schedule A activities may proceed to implementation without the need for additional assessment. Schedule B activities may require additional assessment, depending on the specific undertaking and consultation with the stakeholders local to the project. A project file must be maintained for Schedule B activities and a 30-day review period must also be completed prior to project implementation.

Where proposed activities will require capacity increases beyond rated, or are located at a new site, the City will be required to complete the planning requirements for a Schedule C Class EA, including the preparation of an Environmental Study Report. The Guelph WWTP is approved for activities required to provide treatment up to a rated capacity of 73.3 MLD, the maximum flow upon which this BMMP was developed.

City used facilities that are owned and operated by the private sector typically are not subject to the Class EA process.

Certificates of Approval – Sewage (Ontario Water Resources Act)

Upgrades at the WWTP will require amendments to the existing C of A. If the City were to construct a facility at a new location, a new C of A would be required. City used facilities that are owned and operated by the private sector do not fall under the Act and do not need a C of A.

Certificates of Approval – Air (Environmental Protection Act)

Upgrades at the WWTP may require amendments to existing C of A and consolidation of all previous C of As. These permits cover emissions of contaminants, including odour and noise. For example, installation of additional boilers, if required, for increased digestion capacity, will require an amendment to a plant's C of A for its boilers. The MOE also currently requires that any facility applying for an amendment consolidates all previous C of As into one C of A. City-used facilities owned and operated by the private sector will require a C of A. C of As are designated Class I instruments under the Environmental Bill of Rights (EBR) and are advertised on the EBR Registry during a 30-day public comment period.

Certificates of Approval – System (Environmental Protection Act)

Biosolids land application contractors require an Organic Waste Management System C of A to transport waste material to the application site or between plant and offsite storage facility, if applicable. C of As are designated Class I instruments under the EBR and are advertised on the EBR Registry during a 30-day public comment period.

Certificates of Approval – Sites (Environmental Protection Act)

Each land application site requires an Organic Soil Conditioning Site C of A. C of As are designated Class I instruments under the EBR and are advertised on the EBR Registry during a 30-day public comment period.

Local Government Permits

Upgrades at the WWTP may require building permits. New facilities at other locations will require building permits and may require planning approval.

Risk Management Analysis and Recommendations

The management of risk is paramount as the City proceeds with the implementation of the biosolids management strategy. The first step in managing risk is to prepare a risk profile. This exercise included the identification of specific risk issues, evaluating the potential liability posed by each issue to the City, and then identifying the required actions, if any, to reduce or minimize the medium to high risk issues. This information constitutes the risk management plan and the issues and required actions are summarized in Table 7.4.

TABLE 7.4
RISK MANAGEMENT ANALYSIS AND RECOMMENDATIONS

Risk Issues	Potential Liabilities to City	Actions Required
City and Regulatory		
Biosolids Technologies – wrong selection	Low, because there are several options to utilize/dispose and a diversified program is recommended	
Biosolids Technologies – poor reliability	Low, because of diversified nature of program, scheduled maintenance periods for all components, and contingency planning	Develop, implement and audit contingency plan; perform routine and scheduled maintenance
Best Practices	Low	
Roads/Load Restrictions	Low/Manageable	
Monitoring of Land Application Contract – lack of	High	Develop Monitoring Plan and implement. Include application practices, as well as farming practices
Biosolids Volume vs. Other Agricultural Waste and nutrients from outside of area (land availability for nutrients and perceived risks)	Low to Medium	Require proactive communication program
Biosolids Characteristics – Off Spec Biosolids	Low/Manageable	Develop, implement and audit contingency plan for disposal
Contract failure	Medium, if contract fails other contractors are available	Ensure contract includes default and termination language
Site C of A – securing in a timely manner	Low to Medium	Ensure contract includes suitable language to have sufficient land base Communicate with MOE
Odours	Medium to High	Application by injection or incorporate within 8 hours of surface application
Total Watershed Management	Low	Continue participating with others to carry out total watershed management planning
Financial Considerations		
Program Costs – unanticipated escalation	Low to Medium	Typically self correcting due to industry competition Ensure contracts include escalation clauses
Farmer Compensation	Low	Requires proactive communication program
Indemnification	Low	
Public/Farmer Perceptions	Medium	City support and endorsement of land application Contractor's communication programs with farmers and public. Additional communication with public may be required for compost, depending on the market pursued.
Contingency Plan	Low to Medium	Maintain and audit landfill contract

In summary, the City can reduce and manage potential liability associated with the biosolids management strategy by improving overall communication with stakeholders, by maintaining an ongoing understanding of the current market in Ontario for biosolids management, and by continuing to implement the monitoring program developed for compliance with the environmental management strategy (EMS). This will increase public assurance that the programs and activities are being carried out as contracted and according to regulatory protocols.

Environmental Management Strategy (EMS) Program Management Option

The Guelph BMMP has many important and interconnected components. Given the growing public profile of biosolids, its management and associated risks, the City must consider and recognize the roles and responsibilities of its internal departments that are critical to the program's success. In the management and performance evaluation of the overall program, the City must also consider and recognize the roles and responsibilities of its contractors, suppliers, and the landowners that participate in the program.

It is recommended that the City consider adopting an EMS approach for its strategy implementation. An EMS is based on the foundations of quality management and continual improvements and is an iterative process of Plan-Do-Check-Act. This approach has been adopted by the National Biosolids Partnership, established in 1997, whose membership includes the National Association of Clean Water Agencies (NACWA), [formerly the Association of Metropolitan Sewerage Agencies (AMSA)], the USEPA and the Water Environment Federation (WEF). It was adopted in response to their collective need to improve public acceptance of their biosolids management programs, to reduce risks, and to improve productivity.

The elements of an EMS for biosolids include the following:

- **Development –** of a policy and making a commitment to an EMS framework
- **Planning** – to identify critical control points, determine legal, regulatory and other requirements and to establish desired outcomes/public expectations
- **Implementation** – including the assignment of roles and responsibilities, providing training to increase skills and knowledge, establish communication programs, standard operating procedures and institute corrective actions to resolve problems
- **Measurement/Corrective Action** – assess success in meeting requirements, goals, objectives and performance standards and in instituting corrective actions
- **Management review –** periodically to assure effectiveness of the EMS.

Developing an EMS is an effective management approach to:

- Establishing and protecting the integrity of a program
- Encouraging local involvement
- Building community and stakeholder support into the program
- Maintaining recognition that the program meets health and safety requirements
- Building credibility of public agencies and suppliers
- Guaranteeing regulatory compliance
- Avoiding costly mistakes
- Realizing financial efficiencies

An EMS framework provides a comprehensive approach to managing all aspects of a biosolids management program.

Summary and Implementation Schedule

Study Conclusions

The Guelph BMMP study included a review of the City's current biosolids management program and an analysis of alternative management (processing, disposal and utilization) options. The following represent the study conclusions generated:

1. **The existing method of management, that is, anaerobic digestion, dewatering, and land application of Lystek-treated, composted and dewatered biosolids, is the most economical for the City.** However, composting is infrequently used due to the age and unreliability of the system, as well as the regulators' difficulties with beneficial use. Due to the current lack of storage, landfilling of dewatered biosolids is utilized when required. Land application of liquid biosolids may be utilized for scheduled equipment shutdowns or during emergency situations.

   It was estimated that there will be sufficient agricultural land available to land apply biosolids over the long term. This conclusion assumes that there are no political or social barriers to this method of biosolids management. The City's procurement process and contract terms was also reviewed. It is recommended that the City will continue to contract with the private sector to manage its biosolids in an environmentally responsible and economical manner to the satisfaction of the City, its residents and the farming community.

2. **Process capacity and/or equipment upgrades are required for**:
   - **WAS thickening** – full scale facilities following demonstration
   - **Primary digestion** – two new primary digesters or equivalent
   - **Dewatering** – completion of replacement of presses 1 and 2 in 2006 followed by replacement of presses 3 and 4

   These facility improvements are required to provide the process ability to implement to management plan.

3. **The City needs to consider construction of storage facilities for Lystek-treated and other biosolids to be able to maximize beneficial use of biosolids, improve viability of the land application program and reduce dependency on landfilling.** Because the City currently has no storage facilities, land application occurs at the rate of the process capacity of Lystek treatment and dewatering. Sites applications would be more economical if sufficient material were available to complete the application in a concise time period. Storage also allows some homogenization of the product, resulting in a more consistent material.

   It is not recommended that the City invest in long-term storage facilities for dewatered cake, as the industry has not yet solved the problems with this technology for long-term storage. Rather, long-term storage facilities for the product that replaces composting should be provided. This storage could be used in the interim for dewatered cake. Storage for Lystek-treated biosolids is economical (compared to liquid biosolids storage) and the technologies are well-understood and proven reliable.

   Maintaining a landfill contract is also recommended as an important part of the strategy, for contingency and emergency biosolids disposal.

4. **The City needs to <u>develop a plan for replacement of the composting facility</u> as soon as possible.** The City should continue to maintain a diversified biosolids management strategy; however, the current regulatory framework does not support unrestricted use of biosolids compost. Also, the City has determined that this composting equipment is at the end of its reliable service life and should be replaced (decommissioned) as soon as possible. Alternative treatment technologies, including heat drying and alkaline stabilization, produce a product, at similar cost, that may be federally registered as a fertilizer and is therefore a higher value product.

   The City should use the available time, prior to the first five-year BMMP review and update, to investigate partnering with other municipalities and private companies to determine if a suitable opportunity exists e.g. the N-Viro Niagara facility could be used to manage some of the biosolids to gain some experience with the product. This could be achieved by initiating discussions with potential partners (other municipalities or private companies) to develop co-operative initiatives and to establish networks for investigating new strategy alternatives. This method of management could reduce each partner's costs. Municipalities will still have to proactively monitor programs that are contracted to the private sector to satisfy public concerns. The concept of municipalities partnering lends itself to management solutions that could provide benefits to all of the partners including adopting common best management practices and shared central facilities or contracting services effectively by utilizing contracts that fairly share risk between partners. The City should also initiate a pre-design study to determine the preferred replacement strategy.

   If the City determines that decommissioning of the compost facility and onsite replacement with another technology is preferred, this study concluded that heat drying or alkaline stabilization would currently be the preferred process. The City should commission a study to evaluate the market, regulatory trends and emerging technologies to confirm the analysis.

Implementation Plan

The study conclusions provided the basis for developing an Implementation Plan. The implementation plan identifies specific initiatives to maintain, improve and maximize the current land application program, to maintain the contingency disposal option, and to develop and plan for facility replacement. Accordingly, the Implementation Plan includes initiatives in three specific areas.

1. **Land Application Program – "Continuous Improvement"**

   The current land application program, with contingency landfill disposal, can be further supported and maintained into the future by implementing initiatives involving monitoring and quality control, communications, stakeholder involvement, improved procurement process, product market development, and appropriate storage capacity.

2. **Facility Replacement/Expansion Planning**

   To ensure a reliable, sustainable and diversified biosolids management program over the next 20+ years, the City must implement a number of initiatives. These include digestion and dewatering process improvements/expansion and compost processing replacement, as well as consideration of final markets, product quality enhancement and co-operative or Private, Public, Partnership (PPP) options. Contingency planning will be needed and can realistically be adjusted as options become available.

3. Program Management

The management of risk is paramount as the City proceeds with the implementation of the biosolids management strategy. The City can reduce and manage potential liability associated with the biosolids management strategy by implementing the following initiatives:

- Increase the awareness and understanding of City staff of the Ontario context for biosolids management through collaborative discussions with other municipalities and industry sector parties.
- Implement a monitoring program to increase public assurance that the City's programs and activities are being carried out as contracted and according to regulatory protocols.
- Consider adopting an EMS approach for its strategy implementation.
- Take co-responsibility and co-ownership of land application site approval with the contractor.

Schedule

Implementing the strategy presented above requires developing a schedule to address the entire time period of the Guelph BMMP and to include incorporating risk management. The proposed implementation schedule is illustrated in Figure 7-1 and the capital cash flow projection of implementation is shown in Figure 7-2.

It is recommended that the implementation schedule is reviewed and updated at least every five years to assist in capital budget forecasting.

The main components of the Guelph BMMP are:

- Three-stream biosolids management program with the City continuing to produce a Lystek 'liquid' product, dewatered cake, and a product from the replaced composting process:
  - Lystek processing to have a two-month scheduled maintenance period per year;
  - Storage for Lystek to maximize beneficial use and reduce landfill dependency.
- Process capacity and equipment upgrades to meet biosolids production requirements:
  - Implementation of full-scale WAS thickening;
  - Digestion expansion, consisting of two new primary digesters or equivalent compatible with the existing system;
  - Dewatering equipment replacement of all BFPs (two currently in tender), with ability to produce lower solids cake (for Lystek treatment) and higher solids cake (for further processing or landfilling);
  - Replace composting system with the preferred technologies.
- Implement the procurement process developed for the new land application contract. The land application contract to be arranged for five years, and renewable, will allow implementation and adjustment to the plan.
- Develop a plan for future partnering with the private sector or other municipalities, or ultimately replace the compost facility.
- Develop and implement a communications and education plan.

- Develop a risk management plan that incorporates elements to address the BMMP, including a contracting strategy to reduce risk, a contract monitoring plan, a public opinion tracking program, and an oversight committee.
- Implement a review and reassessment of the BMMP within five years.

FIGURE 7-1
IMPLEMENTATION SCHEDULE

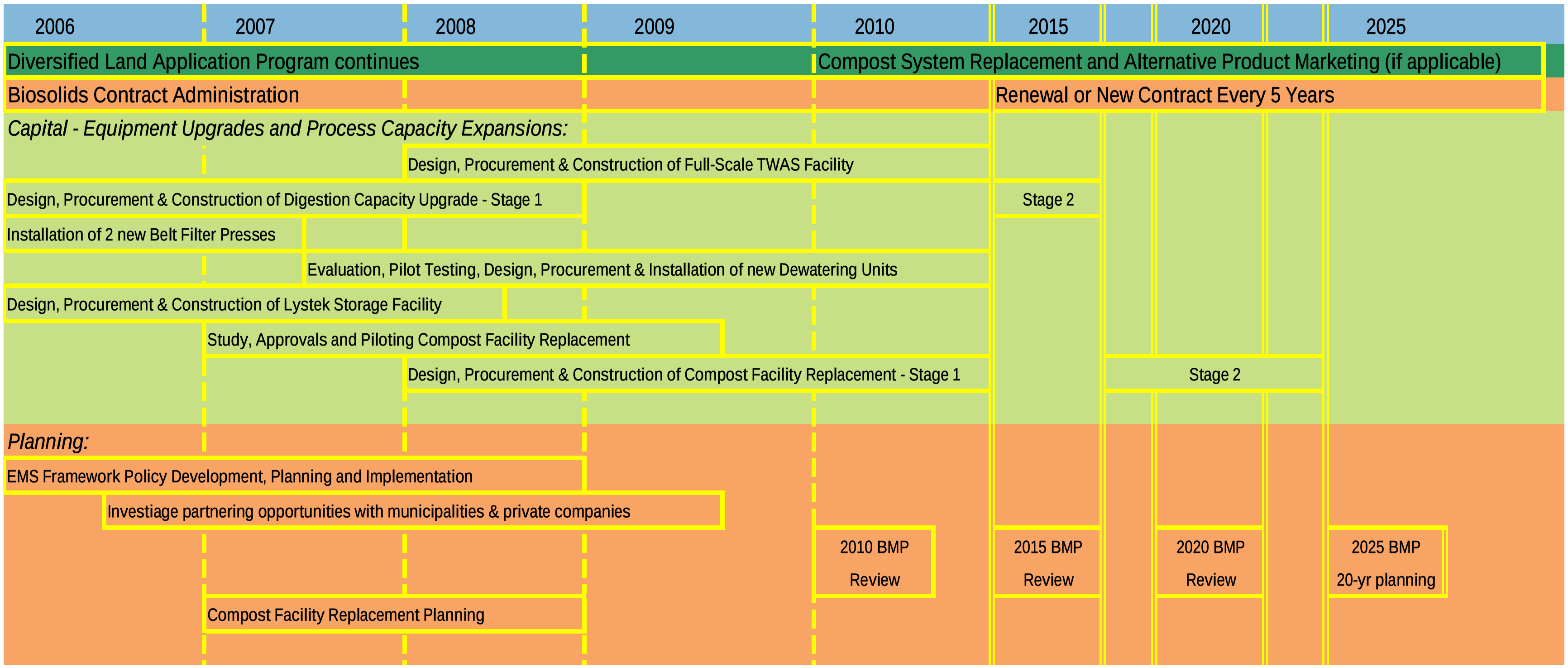


FIGURE 7-2
CAPITAL CASH FLOW PROJECTION FOR IMPLEMENTATION OF OPTION 1

($1,000,000; 2005 Dollars)

	Total Cost	2006	2007	2008	2009	2010	2011-2015	2016-2020	2021-2025
WAS Thickening	$2.2	$0.0	$0.0	$0.4	$1.1	$0.6	$0.0	$0.0	$0.0
Digestion	$13.0	$0.5	$5.8	$0.1	$0.0	$0.0	$0.4	$6.1	$0.0
Dewatering	$2.2	$0.0	$0.2	$1.5	$0.4	$0.0	$0.0	$0.0	$0.0
Miscellaneous	$2.7	$0.0	$0.4	$0.6	$0.5	$0.2	$0.0	$0.0	$0.0
Compost System Replacement	$13.0	$0.0	$0.7	$3.9	$2.6	$0.0	$0.0	$4.6	$1.3
Annual Total Cost	**$33.1**	**$0.5**	**$7.1**	**$6.6**	**$4.6**	**$0.9**	**$0.4**	**$10.7**	**$1.3**

Appendix A

Agency Correspondence

The following includes the list of EA Reviews that should receive the PIC Notice:

M. Hartley, P. Eng
Water Quality Engineer
Grand River Conservation Authority
400 Clyde Road, P.O Box 729
Cambridge ON N1R 5W6

Mr. Rob Dobos, Head
EA Section, Ontario Region
Environment Canada
P.O. Box 5050, 867 Lakeshore Road
Burlington, ON L7R 4A6

Mr. Tony Ierullo
Manager
Hydro One Inc.
483 Bay Street, North Tower, 14th Floor
Toronto, ON M5G 2P5

Mr. Neal Ferris
Heritage Planner/Archaeologist
Ministry of Culture
900 Highbury Ave.
London, ON N6A 1L3

Wellington-Dufferin-Guelph Health Unit
8460 Wellington Road, #19
R.R. 1
Belwood ON N0B 1J0
Tel: (519) 843-2460
Fax: (519) 843-2321
Web: http://www.wdghu.org/
Medical Officer of Health: Dr. Troy Herrick
Board of Health Chair: Lynda Davenport

Mr. Bruce Curtis, Manager
Community Planning and Development
Southwestern Municipal Services Office
Ministry of Municipal Affairs and Housing
659 Exeter Road, 2nd Floor
London, ON N6E 1L3

Ministry of Natural Resources
Guelph District
1 Stone Road West
Guelph, ON N1G 4Y2
Attention: Environmental Assessment Coordinator

Mr. Kevin Bently, Manager
Engineering Office, Ministry of Transportation
Southwestern Region
659 Exeter Road, 2nd Floor
London, ON N6E 1L3

Ministry of the Environment
Hamilton Regional Office
12th floor
119 King St. W.
Hamilton, ON L8P 4Y7
Attention: EA&P Coordinator
Toll free: 1-800-668-4557
Tel: (905) 521-7640
Fax: (905) 521-7820

Ministry of the Environment
Guelph District Office
1 Stone Road W.
Guelph, ON N1G 4Y2
Attention: EA&P Coordinator
Toll free: 1-800-265-8658
Tel: (519) 826-4255
Fax: (519) 826-4286

APPENDIX B

PUBLIC INFORMATION CENTRE MATERIAL

CITY OF GUELPH

BIOSOLIDS MANAGEMENT MASTER PLAN

FACT SHEET # 1 SEPTEMBER 2001

Background

In response to growth, the City of Guelph in 1998 undertook a Schedule C Class Environmental Assessment (EA) to identify a wastewater treatment strategy to serve the City's needs into the future. A two-stage liquid side expansion was recommended. The Class EA also recommended that biosolids management be further examined to determine the most suitable approach for facility expansion and upgrade and for biosolids reuse. Now that the Stage 1 expansion is nearing completion, there is a need to develop a Biosolids Master plan to address these biosolids issues. In addition, a proposed Nutrient Management Act, which may be part of the Province of Ontario's Operation Clean Water Strategy, could have impacts on the existing Biosolids management approach.

This Fact Sheet includes an introduction to the proposed Biosolids Management Master Plan (BMMP), and provides highlights of proposed key project activities.

What are Biosolids?

The City operates the WWTP, which produces treated biosolids as a by-product of the process used to treat wastewater at the plant. Biosolids are primarily organic and are of a sufficient quality that they can be beneficially used for their nutrient, soil conditioning, or fuel properties. Beneficial practices include land application of biosolids as a soil amendment or as a fertilizer supplement and a variety of procedures that derive energy from biosolids. Currently, the majority of biosolids from the plant are composted and used as landfill cover.

Why a Master Plan?

Master Plans focus on long range infrastructure planning with a broad scope and typically include an analysis of a system in order to determine a framework for future individual projects and activities. This project will follow the Municipal Engineer's Association Class Environmental Assessment process for master planning. For this project, the objective of the Master Plan is to develop a strategy for the management of biosolids generated in the Guelph service area in an environmentally sound, efficient, and cost-effective manner.

Public and Stakeholder Participation

The master planning process is designed to include participation from a wide audience, and the consultation program includes open house events and the preparation of information bulletins and questionnaires. As well, consultations will be undertaken with review agencies that have an interest in being engaged in the master planning process and in commenting on aspects of the Master Plan as it is developed.

Implementation Plan

The City, with the assistance of the consulting firm of CH2M HILL Canada Limited, has developed a work scope to provide a framework for the preparation of the Master Plan, which will address a variety of biosolids management issues.

The preparation of the Master Plan will involve the completion of 6 individual tasks that follow a logical sequence, serving as the foundation for a single decision-making process. Tasks 1 and 2 (Master Plan definition and the determination of compost utilization opportunities) address Phase 1 Class EA requirement of defining the need. Tasks 3 and 4 (the determination of compost optimization alternatives that provide cost savings and selection of a preferred biosolids management option to meet the City's long-term needs) address Phase II Class EA requirements of assessing alternatives and recommending a preferred alternative. Task 5 entails documenting the activities of the BMMP, including recommended actions. The development of a stakeholder consultation plan to support and satisfy the master plan requirements under the Class EA process will be completed as Task 6, which will occur concurrently with the other tasks.

Task 1 was initiated in November 2000, and was completed in May 2001. The purpose of Task 1 was to establish the capacity and condition of the existing solids management infrastructure and to determine future solids management requirements, essentially defining the Master Plan. With the necessary background study completed and a baseline established, the City is at a logical point at which to launch a comprehensive master planning exercise for the long term. The work that has been done to date will provide a foundation for this. During the master planning process, the City will clearly establish a study process that is traceable, repeatable, and incorporates stakeholder input beginning at the early stages in the decision process.

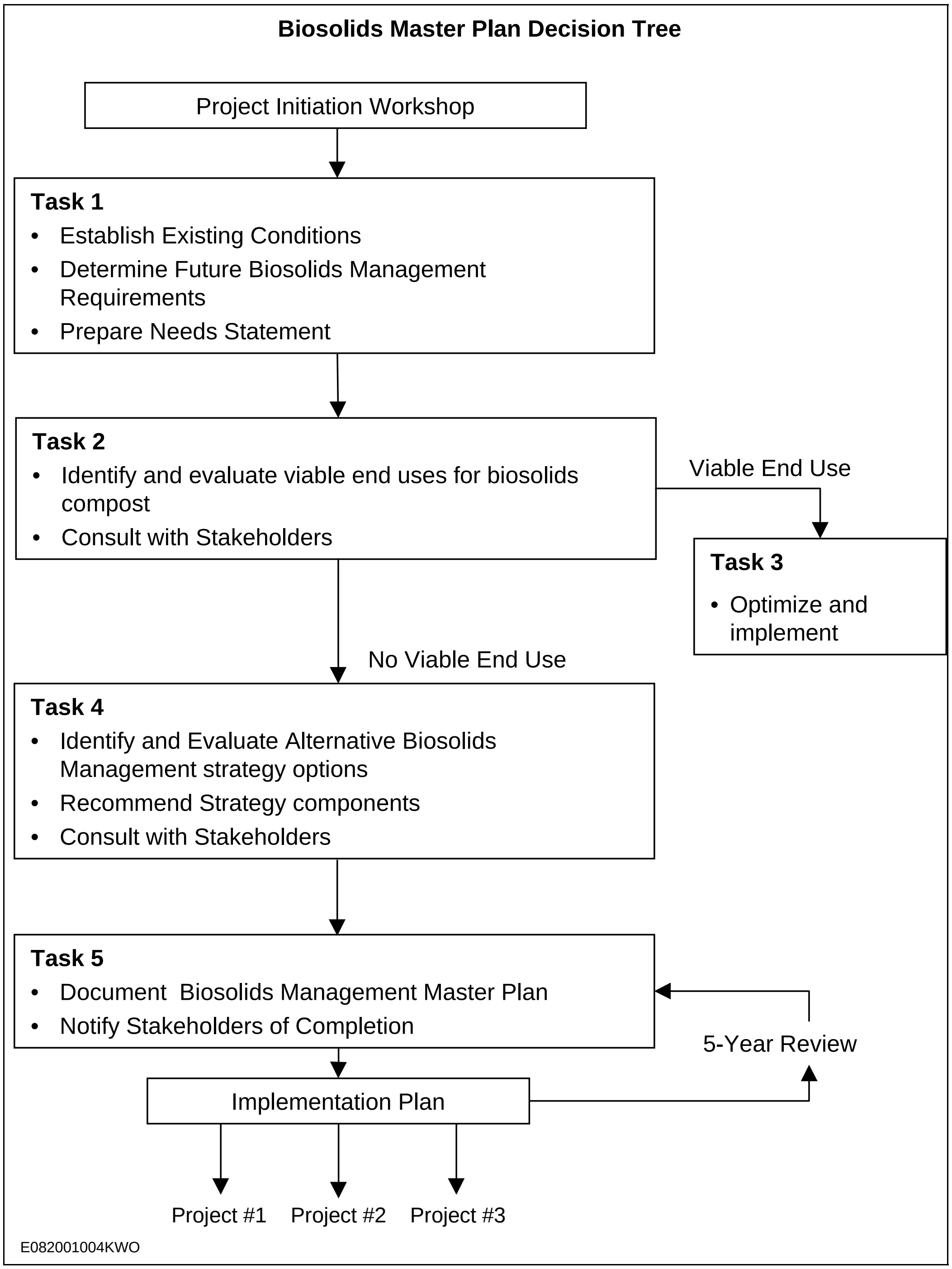
The Next Step

The next step is to continue the master plan beginning with Task 2 the identification and evaluation of viable end uses for biosolids compost and consultation with stakeholders.

A decision tree, which outlines the tasks and chronology of the project, is provided below:

For additional information, please contact:

James Etienne, P. Eng.
Infastructure Planning Engineer
City of Guelph Works Department
59 Carden Street
Guelph, ON N1H 3A7
Phone: (519) 837-5604
Fax: (519) 822-6194
e-mail: jetienne@city.guelph.on.ca



Biosolids Master Plan Decision Tree

CH2MHILL

Biosolids Management Master Plan

NOTICE OF PUBLIC OPEN HOUSE

The City of Guelph's Works Department has initiated a Biosolids Management Master Plan to provide direction for biosolids management activities to the year 2016. The purpose of the Master Plan is to develop a long term strategy for managing all aspects of biosolids produced at the City's Wastewater Treatment Plant, including processing, quality, storage, utilization and disposal.

This project is following the Municipal Class Environmental Assessment process for master plans. Major tasks include the preparation of a statement of need, development of a management strategy through an evaluation of alternatives and documentation of a Master Plan.

A Public Open House has been scheduled for Wednesday February 27, 2002 from 6:00 p.m. to 8:00 p.m. at the Evergreen Senior Centre, 683 Woolwich Street (parking available). A display of project information will be available for visitor to view. The City's consultants and the project team will be on hand to answer questions and to discuss the project.

If you are unable to attend the Open House and wish to comment on the project or receive information, please contact:

James B. Etienne, P. Eng.
Infrastructure Planning Engineer
Works Department
City Hall, 59 Carden Street
Guelph, Ontario N1H 3A1

Phone: (519) 837-5604 x2223
FAX: (519) 822-6194
email: *jetienne@city.guelph.on.ca*

Janet Laird, Ph. D.
Director of Works

Biosolids Management Master Plan

Introduction

The City of Guelph's Works Department has initiated a Biosolids Management Master Plan to provide direction for biosolids management activities to the year 2016. The purpose of the Master Plan is to develop a long-term strategy for managing all aspects of biosolids produced at the City's Wastewater Treatment Plant, including processing, quality, storage, utilization, and disposal. This Information Brief provides a summary of the progress of the first stage of the master plan study.

Project Expectations and Critical Success Factors

The expectations for this project are:

- To find a beneficial use for the biosolids compost
- To address current and future needs for biosolids and the City
- To formulate a plan that meets the City's biosolids and residuals issues while also meeting government standards and public scrutiny
- To use the wet/dry facility's experience as a resource

Critical Success Factors

The success of this project will be determined based on the following critical success factors:

- Value provided (Capital and O&M)
- Solutions are forward-looking
- Solutions are integrated with the WWTP processes
- Project is consistent with the community's values and environmental focus
- Regulatory requirements are met or exceeded
- Preferred strategy is endorsed by public and stakeholders

The Decision-Making Process

This project will follow the Municipal Engineer's Association Class Environmental Assessment process for master plans. The objective of the Master Plan is to develop a strategy for the management of biosolids generated in the Guelph service area in an environmentally sound, efficient, and cost-effective manner. The study includes defining the need based on existing conditions, developing and assessing alternatives and identifying a preferred alternative, or set of alternatives, that will form a strategy for the long-term management of biosolids. This process includes the participation of the community, whose input will influence the development of the overall master plan components.

Biosolids Production

The treatment processes that produce biosolids at the Guelph WWTP include:

Anaerobic Digestion – High rate mesophyllic process is the most commonly used stabilization process in Canada and the U.S. Biological organisms decompose organic matter in the absence of oxygen and at temperatures at 30°C to 38°C, which produces methane, carbon dioxide, water, and partly degraded organics. The MOE recommends a 15-day Hydraulic Retention Time (HRT) as a design guideline for this process.

Dewatering – Belt Filter presses (BFPs) are commonly used for dewatering biosolids. Liquid is removed by squeezing the biosolids between two porous belts.

Composting – A biological stabilization process. In-vessel (enclosed) system is used at the Guelph WWTP.

The Decision Triggers

Task 1 of the Master Plan project includes the project definition. **Task 2** includes the identification utilization options for the composted materials currently produced at the WWTP. **Task 3** includes an assessment of compost optimization options.

- **If Tasks 2 and 3** determine that the existing compost facility at the WWTP **has** reliable capacity for 73MLD (the long-term planning period) **and** reliable end use options – **then no further evaluation is required** and the Master Plan document will be prepared.
- **If Tasks 2 and 3** determine that the existing compost facility **has** reliable capacity **for less than** 73 MLD **and** reliable end use options **then** an evaluation of options is required to identify a solution to provide the additional capacity.
- **If Tasks 2 and 3** determine that the existing compost facility **does not have** reliable capacity for the future **or** there are no reliable end-use options **then** a comprehensive evaluation is required to determine a solution to provide full biosolids production capacity and reliable end uses.

End Use Options

As the Master Plan study continues, options for the end-use or utilization of composted biosolids will be evaluated and may include:

Landscape Operations – Compost material must be odour free, neutral pH, low soluable salt content, consistent quality, black colour, screened to remove woodchips, and have regulatory approval.

Top Soil Blenders and Distributors – Large potential market for a product. Concerns and desired characteristics include, regulatory approval, low soluable salt content, less than 10 percent organic matter and no issues of metals, organics or pathogens after blending. **Recommended for demonstration project.**

Landfill Operations – Composted material could be blended with cover material to increase organic matter and nutrient content.

Land Reclamation – Topsoil is used in the reclamation of mines and quarries and industrial site. The potential use of composted biosolids depends on the contractor, site characteristics, location and costs. **Recommended for demonstration project.**

Sod Farm Operations – Compost material could be used as topsoil replacement and for nutrient enhancement. Desired characteristics include regulatory approval, consistent quality and no safety concerns. **Recommended for demonstration project.**

Golf Course Operations – There is stringent criteria for top soil and soil amendments. Composted material would need to meet the criteria.

Municipal/Provincial Works – Composted material could be used in highway medians and for facility landscaping. Material is usually purchased from topsoil distributors.

Regulatory Requirements – All end uses for composted biosolids will require regulatory approval.

Ministry of the Environment – Regulates compost usage on land. Issues Certificate of Approval based on hydrogeological, agronomic and environmental assessments and soil analysis to determine application rates and methods.

Ministry of Agriculture, Food and Rural Affairs – Provides guidelines for nutrient applications for turf and agricultural crops.

Canadian Food Inspection Agency – Sets out regulations in the Fertilizer Regulations Act. Recommends generators intending to sell biosolids products submit detailed processing and product quality information.

Agriculture and Agri-Food Canada – Regulates the sale of fertilizers and soil amendments.

Canadian Council of the Ministers of the Environment *and the* ***Bureau de Normalization du Quebec*** – Developed voluntary standards for the distribution of compost in Canada including metal and pathogen criteria.

Evaluation Process

If the study moves to a more detailed assessment of biosolids management alternatives, a two-stage evaluation process will be followed.

Stage One – Screening

In the first stage a set of *screening* or "must have" criteria will be developed to *screen* the long list of alternatives (treatment technologies, and end use options (utilization and disposal). Those options that do not meet all criteria will be eliminated from further evaluation. The screening will result in a shortlist of desirable technology options and end use options. The options will be combined to produce management strategies that will then be further evaluated in more detail.

Stage 2 – Detailed Evaluation

Evaluation criteria have been developed and are presented on the back page of this Information Brief. The criteria will be used to assess the short list of combined treatment, utilization and disposal options that resulted from the screening exercise.

It is proposed that each category of criteria will be weighted equally in the evaluation.

Within each category, it is proposed that criteria limits will be nominal. For example, impacts of alternatives will be assessed as Very Good, Good, Poor or Non-applicable.

Next Steps

The next steps in this study include:

- Demonstration projects to determine compost specifications, best practices, and cost implications.
- The identification of treatment plant optimization options based on the results of the demonstration projects
- Development of the Biosolids management strategy.

For additional information, please contact:

James B. Etienne, P. Eng., Infrastructure Planning Engineer
Works Department, City Hall, 59 Carden Street
Guelph, Ontario N1H 3A1
Phone: (519) 837-5604 x2223 Fax:(519) 822-6194
email: jetienne@city.guelph.on.ca

Evaluation Criteria	Measure	Weighting
Technical Environment		
Technology Performance	The ability of an alternative to satisfactorily perform its intended functions (treatment, utilization method, disposal options)	20%
Energy Requirements	The direct and indirect energy requirements of an alternative	
Reliability	The ability of the alternative to maintain uninterrupted operations The ability to have predictable control of process considerations and product quality to reduce the discharge of pollutants to the environment	
Long-Term Sustainability	The ability of an alternative (treatment, utilization/disposal) to adapt to changing conditions (technologies, regulations, market factors)	
Operational Compatibility	The ability of an alternative (treatment, utilization/disposal) to be easily integrated with the existing operations	
Ease of Implementation		
Regulatory Requirements (existing and future)	The ability of the alternative to be compatible with existing approval requirements The ability of the alternative to be flexible to adapt to anticipated future regulatory requirements	20%
Liability and Risk: Community Health and Safety Occupational Health and Safety	The ability of an alternative to limit liability and potential risk to the City of Guelph The ability of an alternative to limit risk to health and safety of the local community The ability of an alternative to limit risk to health and safety of City and contractor staff	
Public Acceptability	The public (stakeholder) support for (acceptability of) an alternative	
Technology	Ability of an alternative to be easily implemented on a technical basis (land availability, operational aspects, etc.)	
Social/Cultural Considerations		
Odour: Process Utilization/Disposal	 The potential for alternative treatment method to produce odour The potential for alternative utilization/disposal method to produce odour	20%
Agricultural Practice	The potential for the ultilization method to be compatible with current (and future) agricultural practices over the long term	
Visual Character (Viewscape): Process Utilization/Disposal	 The impact of an alternative on the visual character of an area The impact of an alternative on the visual character of an area	
Transportation	The impact of an alternative on transportation patterns and volumes	
Noise	The potential for noise to be created during normal operations	
Recreational Uses	The impact on an alternative treatment, utilization/disposal method on recreational resources	
Natural Environment Considerations		
Effluent Quality	The impact of an alternative on effluent quality	20%
Water Quality	The impact of an alternative on water quality	
Groundwater Quality and Flow	The impact of an alternative on groundwater quality and flow	
Air Emissions	The potential for an alternative to meet provincial regulatory requirements for air emissions	
Soil Quality	The impact of an alternative on soil productivity	
Economic Considerations		
Capital Costs	Estimated costs for capital works	20%
O/M Costs	Estimated costs for staff resources, energy needs, ongoing routine operation, and maintenance activities	

Phase 1
Master Plan Definition

Background

In 1998, the City completed an Environmental Assessment (Schedule C) of the Wastewater Treatment Plant. This study resulted in the development of a wastewater treatment strategy to service the City's future needs. The strategy included a two-stage expansion of the WWTP, to treat the liquid component of the wastewater flows up to 73,300 m^3/d. The study recommended that the management of the solids component of the wastewater flow, known as biosolids, be considered during the Stage 2 expansion.

The Stage 1 expansion will be completed by the spring of 2002 and will bring the plant to a rated capacity of 64,000 m^3/d . There is now a need to develop a Biosolids Master Plan to determine the most suitable approach for the Stage 2 expansion and biosolids utilization.

What are Biosolids?

Biosolids are a by-product of the process used to treat wastewater at the Guelph Wastewater Treatment Plant. Biosolids are primarily organic and are of a sufficient quality that they can be beneficially used for their nutrient, soil conditioning, or fuel properties. Beneficial practices include land application of biosolids as a soil amendment or as a fertilizer supplement and a variety of procedures that derive energy from biosolids. Currently, the majority of biosolids from the plant are composted and used as landfill cover.

Management History

1950 - 80: Digested (liquid) biosolids spread on land. Storage provided in lagoons south of Plant 1.

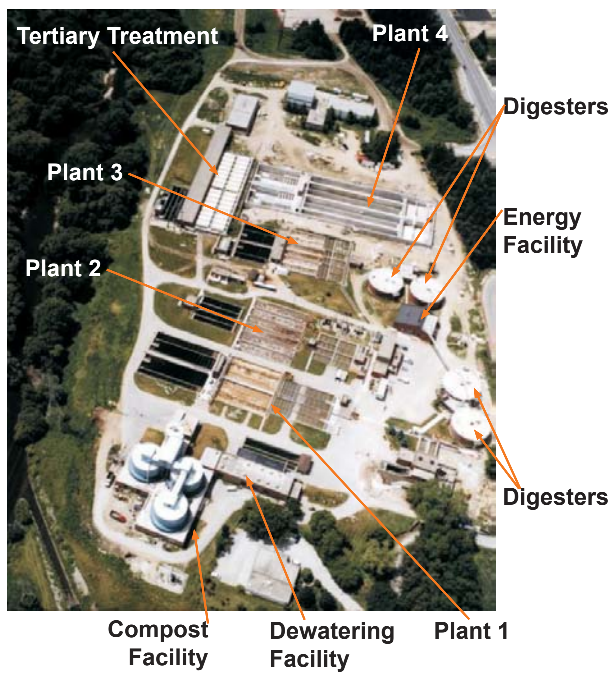
1980-1984: High heavy metals relative to the guidelines, City had difficulty finding sufficient farm land; led to decision to go to dewatering, air drying and land fill disposal

1984: Odours from air dried sludge and problems with handling dewatered biosolids at the landfill

Late 1980s: Composting and thermal drying pilot trials

1990-1995: Composting selected and facility constructed to resolve dewatered sludge disposal problems. Compost planned to be used as landfill cover at the Eastview Landfill

1998: Digested (liquid) and dewatered biosolids spread on agricultural land



Evaluation Process

If the study moves to a more detailed assessment of biosolids management alternatives, a two-stage evaluation process will be followed.

Stage One - Screening

In the first stage, a set of screening or "must have" criteria will be developed to screen the long list of alternative treatment technologies and end-use options (utilization and disposal). Those options that do not meet all criteria will be eliminated from further evaluation.

Screening Criteria	Considerations
Priorities for End-Uses	**Integration:** Opportunity to take advantage of existing infrastructure; the absence of major obstacles to implementation; end-uses must be within the City's capability to implement (technically, financially, regulatory)
	Sustainability: End-uses should endure over time in an environmentally safe manner; the long-term strategy must provide the capacity to manage all the biosolids produced at the WWTP
	Reliability: End-uses should meet or exceed Ontario's regulatory requirements and standards; the overall biosolids management strategy must be reliable, meet public scrutiny, and be enforceable within the City's current framework
	Flexibility: Overall biosolids management strategy should include a variety of treatment and end-use options that should be adaptable under different circumstances
Priorities for Treatment Technologies	**Reliability:** Technologies should be proven to maintain uninterrupted options; treatment must be proven to demonstrate reliability; at least three years implementation at a similar size facility
	Environmental Safety: Technologies must produce biosolids that will be safe for the health of the environment (quality of air, water and land resources, and human health)
	Integration: Technologies must integrate with the existing WWTP processes, add value, and be forward looking

The screening will result in a short list of desirable technology options and end-use options. The options will be combined to produce management strategies that will then abe further evaluated in more detail.

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Evaluation Criteria

The following set of evaluation criteria will be used to assess the short list of combined treatment, utilization, and disposal options that resulted from the screening exercise.

It is proposed that each category of criteria will be weighted equally in the evaluation.

Within each category, it is proposed that criteria limits will be nominal. For example, impacts of alternatives will be assessed as Very Good, Good, Poor, or Non-applicable.

Evaluation Criteria	Measure	Weighting
	Technical Evironment	
Technology Performance	The ability of an alternative to satisfactorily perform its intended functions (treatment, utilization method, disposal options)	20%
Energy Requirements	The direct and indirect energy requirements of an alternative	
Reliability	The ability of the alternative to maintain uninterrupted operations The ability to have predictable control of process considerations and product quality to reduce the discharge of pollutants to the environment	
Long-Term Sustainability	The ability of an alternative (treatment, utilization/disposal) to adapt to changing conditions (technologies, regulations, market factors)	
Operational Compatibility	The ability of an alternative (treatment, utilization/disposal to be easily integrated with the existing operations	
	Ease of Implementation	
Regulatory Requirements (existing and future)	The ability of the alternative to be compatible with existing approval requirements The ability of the alternative to be flexibe to adapt to anticipated future regulatory requirements	20%
Liability and Risk:	The ability of an alternative to limit liability and potential risk to the City of Guelph	
Community Health & Safety	The ability of an alternative to limit risk to health and safety of the local community	
Occupational Health &Safety	The ability of an alternative to limit risk to health and safety of City and contractor staff	
Public Acceptability	The public (stakeholder) support for (acceptability of) an alternative	
Technology	Ability of an alternative to be easily implemented on a technical basis (land availability, operational aspects, etc.)	
	Social/Cultural Considerations	
Odour:		20%
Process	The potential for alternative treatment method to produce odour	
Utilization/Disposal	The potential for alternative utilization/ disposal method to produce odour	
Agricultural Practice	The potential for the ultilization method to be compatible with current (and future) agricultural practices over the long term	
Visual Character (Viewscape):		
Process	The impact of an alternative on the visual character of an area	
Utilization/Disposal	The impact of an alternative on the visual character of an area	
Transportation	The impact of an alternative on transportation patterns and volumes	
Noise	The potential for noise to be created during normal operations	
Recreational Uses	The impact on an alternative treatment, utilization/disposal method on recreational resources	
	Natural Environment Considerations	
Effluent Quality	The impact of an alternative on effluent quality	20%
Water Quality	The impact of an alternative on water quality	
Groundwater Quality and Flow	The impact of an alternative on groundwater quality and flow	
Air Emissions	The potential for an alternative to meet provincial regulatory requirements for air emissions	
Soil Quality	The impact of an alternative on soil productivity	
	Economic	
Capital Costs	Estimated costs for capital works	20%
O/ M Costs	Estimated costs for staff resources, energy needs, ongoing routine operation, and maintenance activities	
Costs Savings Opportunities	The ability of an alternative to generate cost savings	

Are there additional screening and evaluation criteria that should be considered? Should the weighting of the evaluation criteria be adjusted? If so, please complete a Comment Sheet and provide us with your suggestions.

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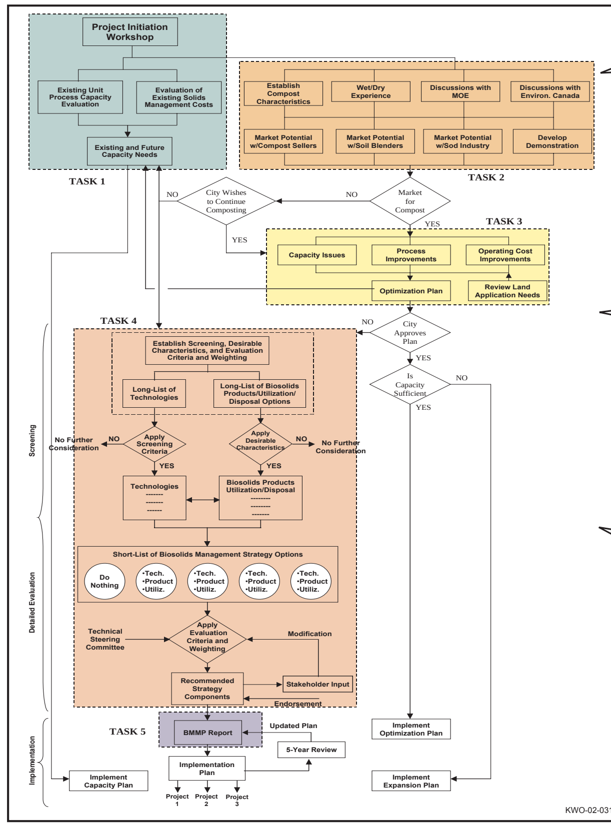
Master Plan Decision Tree

The preparation of the Master Plan follows Phases 1 and 2 of the Class EA process and includes a problem definition phase and an alternatives evaluation phase. The decision tree developed for this project outlines the completion of 6 individual tasks that follow a logical sequence, serving as the foundation for a single decision-making process.

- **Task 1** and **Task 2** (Master Plan definition and the determination of compost utilization opportunities) address Phase 1 Class EA requirements of defining the need.
- **Task 3** and **Task 4** (the determination of compost optimization alternatives that provide cost savings and selection of a preferred biosolids management option to meet the City's long-term needs) address Phase II Class EA requirements of assessing alternatives and recommending a preferred alternative solution.
- **Task 5** entails documenting the activities of the Biosolids Management Master Plan (BMMP), including recommended actions, an implementation strategy and future approval requirements.
- The development of a stakeholder consultation plan to support and satisfy the master plan requirements under the Class EA process will be completed as Task 6 and will occur concurrently with the other tasks.

Decision Tree



Triggers for Decisions:

If Tasks 2 and 3 determine that the existing compost facility at the WWTP **has** reliable capacity for 73MLD (the long-term planning period) **and** reliable end use options **- then no further evaluation is required** and the Master Plan document will be prepared.

If Tasks 2 and 3 determine that the existing compost facility **has** reliable capacity **for less than** 73 MLD and reliable end use options, **then** an evaluation of options is required to identify a solution to provide the additional capacity.

If **Tasks 2 and 3** determine that the existing compost facility **does not have** reliable capacity for the future **or** there are no reliable end use options, **then** a comprehensive evaluation is required to determine a solution to provide full biosolids production capacity and reliable end uses.

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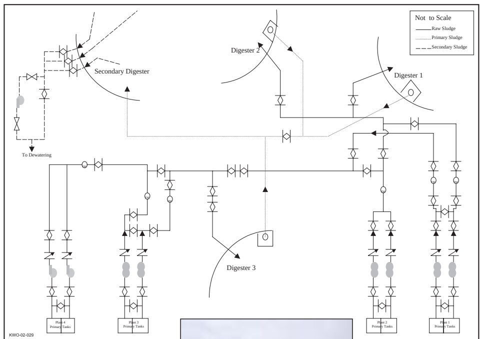
Biosolids Production

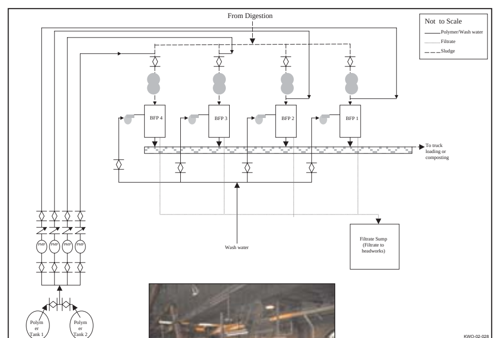
Digestion Process Flow Diagram



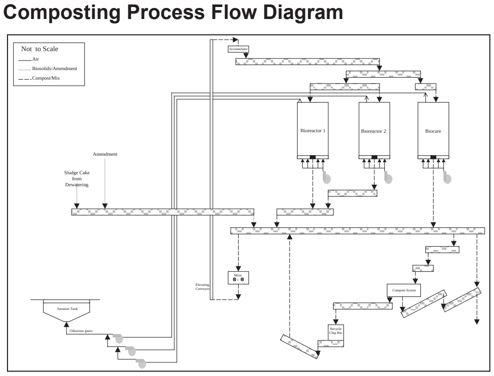
Anaerobic Digestion High rate mesophyllic process is the most commonly used stabilization process in Canada and the U.S. Biological organisms decompose organic matter in the absence of oxygen and at temperatures of 30°C to 38°C, which produces methane, carbon dioxide, water, and partly degraded organics. The MOE recommends a 15-day hydraulic retention time (HRT) as a design guideline for this process. The current facilities are operating at a capacity that meets the MOE HRT guideline. Additional digestion capacity is required for Stage 2 expansion. In 2000, digestion cost was $31 per dry tonne produced.

Dewatering Belt filter presses (BFPs) are commonly used for dewatering biosolids. Liquid is removed by squeezing the biosolids between two porous belts. The existing facilities will provide the dewatering capacity required for Stage 2 expansion to 73 m^3/d. However, two filter belt presses will require replacement in the next 2 years due to age and deteriorating condition. In 2000, the dewatering cost was $139 per dry tonne cake produced.

Dewatering Process Flow Diagram



Composting Process Flow Diagram



Composting A biological stabilization process. In-vessel (enclosed) system is used at the Guelph WWTP producing a compost from woodchips and dewatered biosolids. The facility has three reactors (two in operation with one standby) with an estimated combined HRT of 26.5 days. Under average conditions, the compost facility will provide the required HRT for the planning period. Additional HRT would be required under a scenario of maximum industrial loading. In 2000, the cost of composting was $353 per tonne.

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Existing and Future Needs

The existing solids handling capacity was determined based on an evaluation of the unit processes and equipment associated with solids handling at the WWTP and historical solids production data and mass balance calculations.

Existing Total Solids Production

Year	Dewatered Total Solids - Cake Production (dry tonnes per day)
1998	9.04
1999	8.13
2000	8.12
1998-2000	8.43 (plant average)

Future Total Solids Production

Expansion Capacity	Cake Production (dry tonnes per day)
64,000 m^3/d (Stage 1)	8.28 (based on compliance* requirements)
	11.57 (based on average current** loading)
	13.64 (based on maximum*** current loading from industry)
73,000 m^3/d (Stage 2)	9.30 (based on compliance requirements)
	13.25 (based on average current loading)
	14.66 (based on maximum current loading from industry)

* Compliance loadings parameters for the Guelph WWTP are 300 mg/L biochemical oxygen demand (BOD) and 350 mg/L total suspended solids (TSS)

** Average current loading are the average influent loading conditions as recorded at the WWTP from 1998 to 2000.

*** Maximum current loading is defined as the potential impact from two major industries in Guelph that can significantly increase the loadings to the WWTP

The solids handling system capacity is sufficient to process the future solids production at current average loadings. Under a future scenario of maximum industrial loadings, additional solids handling capacity will be required.

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Wet–Dry Recycling Centre

The City's Wet–Dry program began in November 1995

The Vision

To provide a leading-edge and sustainable waste management system for our customers.

The Mission

- We will serve our customers needs and expectations
- We commit to our employees to share in profits and opportunities
- We will develop as a profit-oriented centre of excellence in partnership with government, institutions and the private sector
- We will be globally recognized as a leader in waste management

The Mandate

- To minimize waste
- To collect and process waste in order to recover and market waste resources
- To ensure disposal of residues
- To monitor and improve our performance
- To encourage a sense of ownership among employees
- To be a profit centre through public, private and global partnerships; and
- To develop as a centre of excellence for research development and training

The Program begins in homes and businesses where waste is sorted into two streams:

Wet Waste	Dry Waste
Food waste Sanitary products Floor sweepings Dryer lint Hair Cigarette butts Ashes	Recyclable items: Newspaper Glass Steel Aluminum Glass Bottles
11,198 tonnes received in 2001, less 2,448 tonnes residues, equal to 78% diversion	32,758 tonnes received in 2001, less 14,881 tonnes residues, equal to 55% diversion

In 2001, 61% of the total materials received was diverted. The composted biosolids produced at the WWTP may provide a suitable topsoil blending/amendment material for landscape applications. These options will be assessed as part of this Master Plan Study.

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End Use Options

Options for the end use or "utilization" of composted biosolids

Landscape Operations Compost material must be odour free, neutral pH, low soluable salt content, consistent quality, black colour, screened to remove woodchips, and have regulatory approval.

Top Soil Blenders and Distributors Large potential market for a product. Concerns and desired characteristics include, regulatory approval, low soluble salt content, less than 10% organic matter and no issues of metals, organics, or pathogens after blending.

Landfill Operations Composted material could be blended with cover material to increase organic matter and nutrient content.

Land Reclamation Topsoil is used in the reclamation of mines and quarries and industrial site. The potential use of composted biosolids depends on the contractor, site characteristics, location, and costs.

Sod Farm Operations Compost material could be used as topsoil replacement and for nutrient enhancement. Desired characteristics include regulatory approval, consistent quality and no safety concerns.

Golf Course Operations There is stringent criteria for top soil and soil amendments. Composted material would need to meet the criteria.

Municipal/Provincial Works Composted material could be used in highway medians and for facility landscaping. Material is usually purchased from topsoil distributors.

REGULATORY REQUIREMENTS

All end uses for composted biosolids will require regulatory approval, depending on the specific end use.

Ministry of Environment – Regulates compost usage on land. Issues Certificate of Approval based on hydrogeological, agronomic, and environmental assessments and soil analysis to determine application rates and methods.

Ministry of Agriculture, Food and Rural Affairs – Provides guidelines for nutrient applications for turf and agricultural crops.

Canadian Food Inspection Agency – Sets out regulation in the Fertilizer Regulations Act. Recommends generators intending to sell biosolids products submit detailed processing and product quality information.

Agriculture and Agri-Food Canada – Regulates the sale of fertilizers and soil amendments.

Canadian Council of the Ministers of the Environment and the Bureau de Normalization du Quebec – Developed voluntary standards for the distribution of compost in Canada including metal and pathogen criteria.

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Next Steps - Phase 2

Demonstration Projects

The largest potential market for composted biosolids is likely to be from sales to topsoil blenders, distributors and sod farmers. Demonstration projects in partnership with regulatory agencies are recommended to determine:

- Compost specifications
- Best practices for minimizing potential environmental impacts
- Optimum application rates for soil improvement and fertilizer benefit
- Timing of application and storage requirements
- Increasing public/user awareness of the benefits and methods of utilizing compost
- Equipment, labour and logistical requirements
- Capital and operating costs

Three demonstration projects are recommended in the following market areas:

- Sod Farm
- Land Reclamation
- Top Soil Production

The results of the demonstration projects will determine the feasibility of each end use as a potential component of a long-term biosolids management strategy.

Treatment Plant Optimization Options

Demonstration projects will determine the specifications for compost quality, which will, in turn, determine if modifications are required at the wastewater treatment plant (specifically the solids handling facilities) to produce a composted product with the desired end use quality specifications.

Biosolids Management Strategy Development

If the demonstration projects result in a viable long term utilization option and the compost specification can be produced at the WWTP, then the consideration of a broader range of utilization options may not be warranted. If, however, the demonstration projects do not identify a viable option, then the study will advance to the next phase, which will include the identification of alternative management options for a long-term strategy.

The development of a long-term management strategy will include an initial screening of a long list of technologies, products and end uses. Following screening, the resulting short list of technologies, products and end uses will be combined to form management strategies. The strategies will then be evaluated against detailed evaluation criteria to rank strategies and provide the basis for decisions on the long-term plan.

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City of Guelph

WASTEWATER TREATMENT PLANT

CLASS EA UPDATE AND
BIOSOLIDS MANAGEMENT MASTER PLAN

Notice of Public Information Centre

The City of Guelph is undertaking an update to the Wastewater Treatment Strategy that was developed through the Class Environmental Assessment Process in 1998. The strategy addresses wastewater treatment needs to the year 2016 and recommended expansion of the treatment plant in two stages. The Stage 1 expansion is complete. The purpose of the update is to review and incorporate emerging treatment technologies into the design of the Stage 2 expansion.

The City is also undertaking a related study to develop a Biosolids Management Master Plan. This was also recommended in the wastewater treatment strategy. The purpose of the master plan is to identify a plan for the management and end use of biosolids generated at the Wastewater Treatment Plant. This study is following the Class EA requirements for master plans and the first Public Information Centre to present the need for the study was held in February 2002. Since that time, the City has evaluated options for biosolids management, disposal and end use.

A Public Information Centre is planned for Tuesday June 21, 2005 from 4:00 p.m. to 9:00 p.m. at the Wastewater Treatment Plant, 530 Wellington Street West (parking available). The purpose of the Open House is to provide the community with information on the progress of both studies. A display of information on both projects will be available for visitors. The City and the consultant team will be on hand to answer questions and to discuss the projects.

If you are unable to attend the Information Centre and wish to comment on these projects or receive information, please contact:

James B. Etienne, P.Eng.
Director of Environmental Services
Environment & Transportation Group
City Hall, 59 Carden Street
Guelph, ON N1H 3A1
james.etienne@guelph.ca

City of Guelph

Wastewater Treatment Strategy
Class EA Update *and Biosolids Master Plan*

JUNE 2005

Sign-up Sheet

Note: This information will be used to notify you of activities and recommendations developed for this project.

Please print clearly.

Name	Address		Telephone
1. LAURA MURR (GRT)	123 DOWNEY RD	N1C 1A3	8245606
2. LEO KEATING	31 Crane Ave.	N1G 2R3	763-3397
3. LYNDA WALTERS	759 Flamosa Rd		822-0712
4. Hank VanVeen	973 Alberton Rd S.	Jerseyville	519-752-0837
5. Councillor Birtwistle	50 Rochelle Dr	Guelph N1K 1L2	822 5478
6. James Etienne	Environmental Services		837-5604
7. Bill Mungall	34 Hickory St.	N1G 2X3	836-5567
8. Sandra Cooke	GRCA, 400 Clyde Rd	Cambridge	621-2763 x224
9. Mark Anderson	GRCA, 400 Clyde Rd	Cambridge	621-2763 x226
10. Cathy Hamlen	B-36 Green St	Guelph	821-3362
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City of Guelph

Wastewater Treatment Strategy Class EA Update and Biosolids Management Master Plan

COMMENT SHEET

JUNE 2005

The City of Guelph is interested in hearing the community's comments, questions, and concerns on the Class Environmental Assessment (EA) Update to the Wastewater Treatment Strategy and the related Biosolids Management Master Plan project. Please take a few minutes to complete this brief comment sheet. Comments at this stage of both projects will contribute to the development of the study recommendations. The City will carefully consider all comments before the next phase of activity is initiated.

1. These studies are following the requirements of the EA process. Do you have any questions, comments, or concerns about the decision-making processes that are being followed to prepare the Class EA Update and to develop the Biosolids Master plan?

☐ No ☒ Yes Please provide details: THE GUELPH HIKING TRAIL CLUB SEEKS TO OBTAIN PERMISSION FOR AN UNIMPROVED FOOTPATH ROUTE (TO BE BUILT BY THE GHTC) ALONG THE RIVER'S EDGE, FROM THE DOLIME ACCESS ROAD, TO THE SOUTHERN END OF THE CITY'S PROPERTY. THIS FEATURE SHOULD BE PROVIDED FOR IN ANY DESIGN OPTION. PRESUMABLY, THE CITY WOULD NEED THE WWTP PORTION OF THE PROPERTY SECURED WITH A FENCE; THIS SHOULD BE INCLUDED IN A FINAL DESIGN (ATOP BANK, PARALLEL TO RIVER.) AT CITY'S COST.

2. Do you have any questions or concerns about the need for these studies?

☒ No ☐ Yes. Please provide details: ______

3. The Class EA Update included the evaluation of a long list of technology options for possible inclusion in the design of the Stage 2 expansion of the Wastewater Treatment Plant. The evaluation has resulted in the recommendation to proceed with pilot testing of the Bioaugmentation technology.

Do you have any questions, comments, or concerns with this technology recommendation?

~~☒ No~~ ☒ Yes Please provide details: I UNDERSTAND THIS WILL REQUIRE THE SMALLEST "FOOTPRINT" OF THE OPTIONS. THIS IS GOOD... LESS CHANCE OF A CONFLICT WITH A TRAIL. THE E.A. SHOULD NOTE SIGNIFICANT PUBLIC BENEFITS FROM A RIVER-EDGE TRAIL THRU THE SITE AS A LINK BETWEEN CAMBRIDGE + GUELPH WOULD AT LAST BE SECURED WITHOUT RESORT TO A "ROUTE" ALONG WELLINGTON ST.

4. The Biosolids Master Plan has considered technologies to treat biosolids and end uses. The long lists were screened to identify realistic options for the City of Guelph.

Do you have any questions, comments, or concerns about the evaluation of biosolids technologies and end uses?

☒ No ☐ Yes Please comment: ______

– AM INTERESTED IN SEEING ADDL. NOTICES RE FUTURE MTGS.
– WHAT IS TIMELINE OR SCHEDULE FOR COMPLETION OF THIS PROCESS?

5. Seven biosolids strategies were developed from the short list of technologies and end uses. The evaluation determined that Option 1 (Expand Existing System) and Option 2 (Expand Existing System with Phased Digestion) rated higher than other strategies.

Do you have any questions, comments, or concerns with the results of the evaluation of biosolids strategies?

☐ No ☒ Yes Please comment: TOTAL BENEFIT STILL NEEDS BREAKING OUT WITH COSTS FOR EACH OPTION.

Do you have a preference for either Strategy Option #1 or Option #2?

I prefer Option #1 ☐ I prefer Option #2 ☐ I have no preference ☐

Public Consultation

1. Was the time and location of the Public Information Centre convenient for you?
   ☒ Yes ☐ No
2. Did the Public Information Centre help you to better understand the need for these projects?
   ☒ Yes ☐ No ☐ Uncertain
3. Did you have enough opportunity to ask questions, make comments or express concerns?
   ☒ Yes ☐ No
4. Were those questions answered to your satisfaction?
   ☒ Yes ☐ No ☐ Not applicable
5. How useful did you find the Public Information Centre? (please circle one)

   Very Useful — (1) 2 3 4 5 — Not Very Useful

6. How would you describe the nature of your interest in this study?

   ☐ Member of the General Public
   ☒ Member of an Interest Group. Please specify: GUELPH HIKING TRAIL CLUB (BILL MUNGALL, CO-ORDINATOR, SPEED RIVER TRAIL)
   ☐ Consultant
   ☐ Agency Representative. Please specify: ____________
   ☐ Other. Please specify: ____________

Your completed Comment Sheet will be included in the Class EA Update report and the Biosolids Management Master Plan report, which will be made public at the completion of these studies. Please place a (✓) in the box below if you wish to have your comments included anonymously.

☐ Please withhold my name, address, and telephone number from publication in reports.

Please return this completed Comment Sheet to staff at the Registration Table or you may fax or mail it, by June 30, to:

James Etienne, P.Eng.,
Director of Environmental Services, Environment and Transportation Group
City Hall, 59 Carden Street, Guelph, ON N1H 3A7
Phone: (519) 837-5604, Fax: (519) 822-6194
e-mail: jetienne@city.guelph.on.ca

Thank You for Your Participation in these projects!

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JBC RMT DSF RHF

Guelph Hiking Trail Club Newsletter

P.O. Box 1, Guelph, Ontario, Canada N1H 6J6
Telephone: 822-3672 Web: www.guelphhiking.com
Volume 33 Number 2, July 2005

Ramblings From the President

Insurance Crisis Hits Ontario Hiking Trails

Our annual Hike Ontario Liability Insurance renewal arrived in mid March creating a crisis that threatened to close trails. The Guelph Hiking Trail Club was facing a stiff $1000 increase in our insurance costs, plus legal restrictions that would make operating our trails difficult. The Ganaraska Trail Association and the Voyageur Trail Association received renewals in the 10's of thousands of dollars which amounted to virtual death sentences.

About 8 days before our insurance lapsed, a new insurer was found, but the crisis remains.

I organized a province wide letter writing campaign to local politicians, and the Ministry of Tourism and Recreation. David Wallace, Henry Graupner and myself met with Guelph MPP Liz Sandals. City Councils throughout the province are being petitioned for support. A quiet vigil was held in Sault Ste. Marie by the Voyageur Trail Association to celebrate their survival. As I write this the survival of two hiking clubs, The Avon Trail and Sudbury Hiking Club is still in doubt, since they cannot afford liability insurance.

A series of high profile mountain bike law suits will no doubt affect the insurance climate.

At the end of July we expect the Ontario Trails Strategy to be released by the Ontario Government. We are demanding legislative changes to protect our Club and volunteers from law suits. We need affordable insurance and a climate where people take responsibility for themselves.

I ask all Guelph Hiking Trail Club members to send me their e-mail address (the_canns@porchlight.ca) When the Trails Strategy is shortly released we will e-mail you what we need you to do and who we need you to write to and phone. We will fight for our trails.

Happy Hiking, Andy Cann

(Ed. Notes:

1. *See also the Hike Ontario material on pages 3-4. Letters to the Ontario Government are still needed in support of the Trails Strategy.*
2. *Our President has been tireless in the past few months lobbying politicians, writing to all and sundry and urging others to get involved. Many thanks Andy.*
3. *The* Guelph Mercury *carried a story on the present plight of Ontario trails on April 30 (p. A3), quoting Andy, our Vice-President John Hueniken, our MPP Liz Sandals, Mike Landmark of the Voyageur Trail Association and John Karapita, a spokesperson for the Insurance Bureau of Canada.)*

Mark This Date!!

SLIDE NIGHT: Thursday, October 20th, 7:30 p.m.
Program TBA
Zehrs Community Room, Imperial & Paisley Roads

■ Patrick Holland and Graham Huggan. *Tourists With Typewriters: A Critical Reflection on Contemporary Travel Writing*. University of Michigan Press, 1998. 261 p. I would hazard a guess that most hikers like travel literature - top of my list of genres. This is a book written by two academics (Holland is a recently retired professor from the Department of Literature and Performance Studies in English at the University of Guelph), and for those of us who don't have a degree in English literature, might be a bit of a slog. However, if you are interested in travel writing, ploughing through this tome is well worth the effort. Books on travel that Holland has enjoyed include Bruce Chatwin's *In Patagonia*, Pico Iyer's *Video Night in Kathmandu*, Mary Morris' *Wall to Wall: From Beijing to Berlin by Rail*, and Karen Connelly's *Touch the Dragon*. I might add the following that I have particularly enjoyed: Laurie Lee's *As I Walked Out One Midsummer Morning*, Robyn Davidson's *Tracks*, Patrick Leigh Fermor's *A Time of Gifts*, and Eric Newby's *A Short Walk in the Hindu Kush*. **If you have favourites please send them in to the Editor and we will publish them.**

Dave Hull

Speed River Trail Report

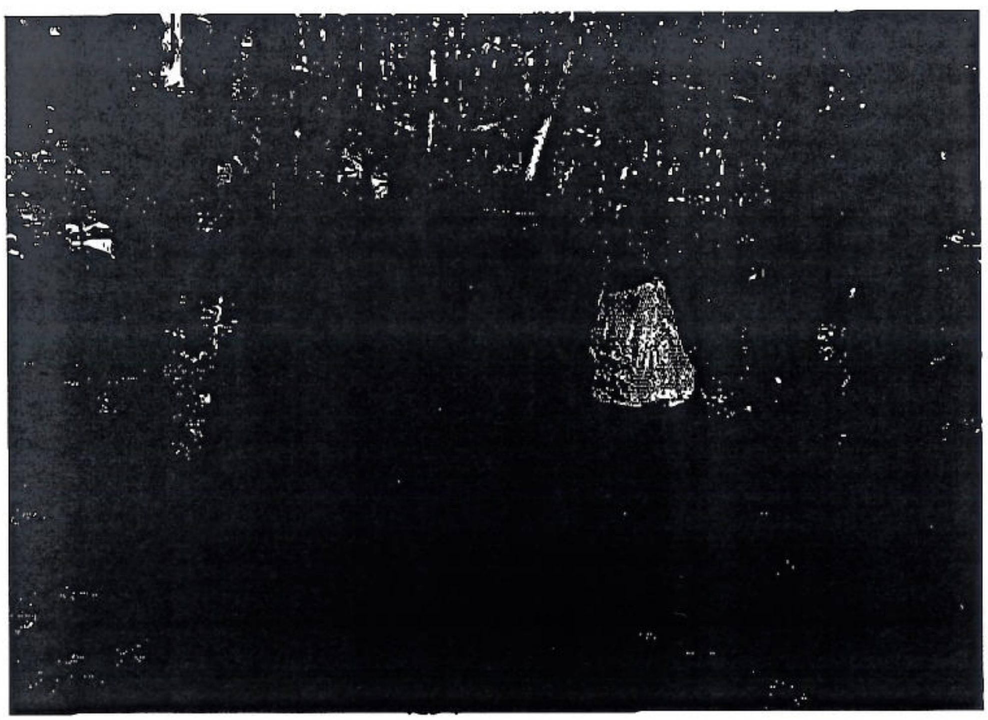
I attended the Wastewater Treatment Plant Expansion environmental assessment open house on behalf of the Club. Left verbal and written comments with City's Director of Environmental Services and their consultants indicating that the Club will require a trail through the 1.3 km of river frontage occupied by the plant and the snow dump as early as next spring due to imminent development of the property to the West of the City's land where the Speed River eastern trailhead is presently located. This will enable the City to be connected to the trail without the long dreary walk along busy Wellington Street that has existed since 1972.

All club signs are up wherever the trail meets a road.

John Brehaut has been mowing portions of the trail with the weed whacker, but I encourage club members to also get out onto two sections of trail in particular to help tramp down the grass and fern growth in the more open areas to get a trail better established: Section 2 heading south from Road 124 (beside the gas compressor station, for about 2km) and Section 3 heading west from Road 32 (for about 3 km until the trail heads inland away from the river.

We will need volunteers in September and October to join Stan Stanek and myself in building bridges over the creeks in Section 1, north of Niska Road.

Bill Mungall



Ross and Brigette Clark on the Trout Hollow Trail. Remains of hydro electric station on Bighead River. Photo by Ross Clark.

Evolve.

OUR COMMITMENT TO PROVIDING INNOVATIVE, PRACTICAL, AND SUSTAINABLE SOLUTIONS KEEPS GROWING. EVOLUTION IS GOOD.

Lynda Walters - want:
- Need to have Annual Rpt online - for public

Sludge evaluation - Class B

- Want T of R. for next Master Plan process - put online (when ready)

Benthic Study just sent to MOE

- Put on City's Web Site
- Golder Rpt => is required also -

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TORONTO BARRIE CALGARY NIAGARA OTTAWA VANCOUVER WATERLOO bearjakey@rogers.com

LAURA MURR

- Electronic format of 1998 Report and ~~2005~~ earth 3 years Benthic studies
- sludge composition
- copies of display boards on City's webpage
- water monitoring - at Edenvale Rd station & downstream of sewage tr plant

Wastewater Treatment Strategy Class EA Update and Biosolids Management Master Plan

INFORMATION BRIEF **JUNE 2005**

Introduction. . .

The City of Guelph is undertaking an update to the Wastewater Treatment Strategy that was developed through the Class Environmental Assessment (EA) process in 1998. The City is also undertaking a related study to develop a Biosolids Management Master Plan. This Information Brief provides a summary of the progress made on these two studies.

Study Purposes. . .

Class EA Update

The 1998 Wastewater Treatment Strategy addressed treatment needs to the year 2016 and recommended expansion of the Wastewater Treatment Plant (WWTP) in two stages. The Stage 1 expansion is complete and the WWTP is currently operating at a rated capacity of 64 million litres per day (MLD). The Stage 2 expansion will increase capacity of the WWTP to 73.3 MLD. **The purpose of the Class EA Update is to review and select emerging treatment technologies for pilot testing and incorporation in to the design of the Stage 2 expansion.**

Biosolids Management Master Plan

The 1998 Class EA included a recommendation to develop a master plan for the management of the increased volume of biosolids that would be generated by the WWTP Stage 2 expansion. **The purpose of master plan is to identify a plan for the management and end use of biosolids generated at the WWTP.** This study is following the Class EA process for master plans and the first public information Centre to present the need for the study was held in February 2002. Since that time, the City has evaluated options for biosolids management, disposal, and end use.

These Studies are Related…

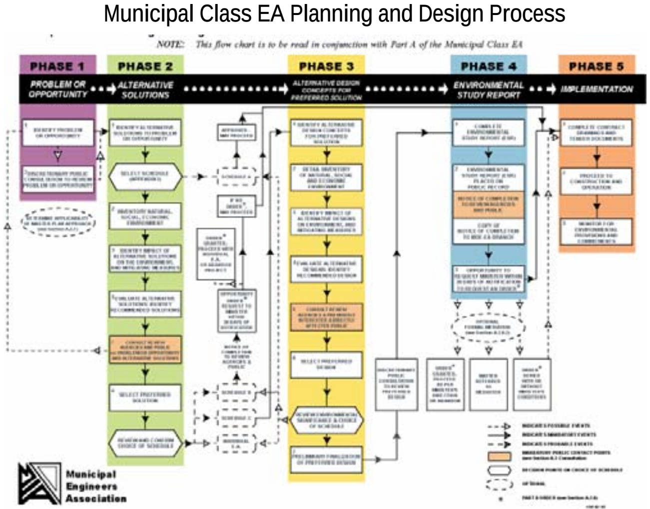
Both of these studies involve activities and programs at the WWTP. The Class EA Update is focused on technologies to treat the liquid stream of the wastewater conveyed to the WWTP. The technologies will generate biosolids which will require further treatment, management and disposal. This information is important to the Biosolids Master Plan. The de-watering processes evaluated for the management of biosolids will produce sidestream wastewater that will be recirculated back to the liquid treatment processes. This side stream will have quantity and quality characteristics that will need to be considered in the evaluation of innovative treatment technologies.

Class EA Update

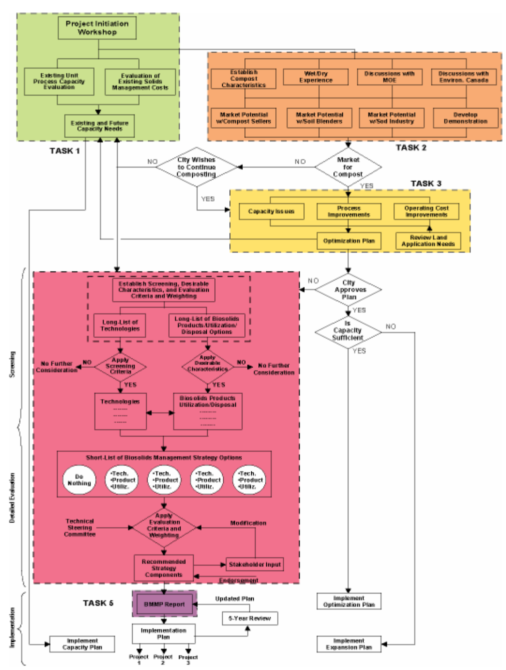
Decision-Making Process. . .

The studies are following the Municipal Engineer's Association Class Environmental Assessment process. The decision making processes are being carried out to be transparent and repeatable. Consultation with the community and regulatory agencies is integral to both studies.

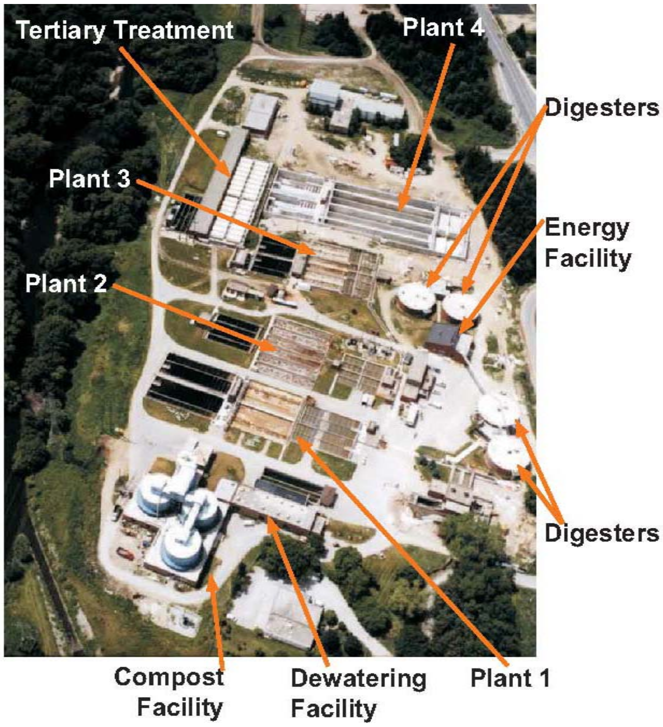
Municipal Class EA Planning and Design Process



Biosolids Master Plan Decision Tree



The Existing WWTP



With the Stage 1 expansion complete, the existing WWTP consists of four treatment plants. Wastewater received primary treatment (including screening and grit removal). Partial secondary treatment in achieved in Plants 1 to 3 followed by tertiary treatment in rotating biological reactors to remove additional ammonia. Wastewater flow treated in Plant 4 receives full nitrification. The combined wastewater flows are then passed through tertiary filters, received disinfection and final treated effluent is then discharged through an outfall pipe to the Speed River.

Class EA Update

Evaluation of Innovative Technologies. . .

The evaluation of potential innovative technologies included a long list of 10 treatment technologies. The 10 technologies were then screened and four technologies were short listed and evaluated in more detail, along with the base case existing treatment processes at the WWTP.

The evaluation process identified Bioaugmentation as the treatment technology recommended for pilot testing at the WWTP.

Screening Criteria for Treatment Technologies

Emerging and Innovative Technologies	Technology "Must Have" Criteria					Carry Forward?	Comments Related to Carry Forward Recommendation
	Effluent Requirements are Reliably Met	Additional Tankage is Minimized	Demonstrated Reliability at Full-Scale (2 years in similar sized facility)	Compatibility with Existing Plant	Not Have Prohibitive Cost		
1. Step Feed Activated Sludge	No	Yes	Yes	Yes	Yes	No	Cannot reach low ammonia limits <1 mg/L without very long sludge retention time May be used in combination with another option, but not on its own
2. Biological Nutrient Removal (BNR)	Yes	No	Yes	Yes	Yes	No	Will require larger bioreactor volumes than current plants designed for nitrification Would require existing plants to be de-rated significantly
3. Tertiary Nitrification with Biological Aerated Filters (BAF)	Yes	Yes	Yes	Yes	Yes	Yes	Adds tertiary treatment capacity for nitrification option. Well proven for tertiary nitrification. Would either augment or replace Guelph's RBCs
4. Integrated Fixed-Film Activated Sludge (IFAS)	Yes	Yes	Yes	Yes	Yes	Yes	May allow year round nitrification in existing Plants 1 to 3, thereby allowing increased capacity
5. Membrane Bioreactor (MBR)	Yes	Yes	Yes	No	No	No	High capital, operating, and maintenance costs Increased complexity in operation Requires ultra-fine screening and flow equalization
6. Nitrifier Bioaugmentation	Yes	Yes	Yes	Yes	Yes	Yes	Can be used to re-rate Guelph's treatment capacity with minimal additional tankage Allows management of troublesome recycle flows
7. Sharon* Anammox Processes	Yes	Yes	Yes	Yes	Yes	Yes	Allows for efficient management of troublesome recycle stream and may allow for increased mainstream treatment capacity.
8. Chemically Enhanced Primary Treatment (CEPT)	Yes	Yes	Yes	Yes	No	No	Significant annual chemical costs Substantially increased raw solids production (majority chemical sludge); can lead to significantly reduced solids digestion and handling capacity
9. Aquifer Storage and Recovery (ASR)	No	Yes	No	No	No	No	May need to purchase land and construct long pipelines Potential negative impacts on river due to reduced flow from effluent discharge
10a. Phosphorus Recovery Technologies	No	No	No	Yes	No	No	Little to no benefit in terms of increased capacity Significantly increased operational complexity
10b. Nitrogen Recovery Technologies	No	Yes	No	Yes	Yes	No	Have not been demonstrated at full-scale

Each of the highlighted components met all "Must Have" criteria and were recommended for further review.

Biosolids Master Plan

Compost Utilization Opportunities. . .

An important step in the biosolids master plan decision process was to determine the potential opportunities to utilize the biosolids compost produced at the WWTP. A market assessment was conducted to identify markets with viable end uses including, landscaping, soil blending, sod farms, mining reclamation, golf courses, etc. The assessment concluded that potential revenues from the sale of compost could be approximately $400,000 per year. Demonstration trails and regulatory approvals would first be required.

The City has been unable to carry out composting demonstration projects due to equipment and processing issues at the WWTP. As these issues are addressed the City wishes to proceed with the evaluation of other biosolids management alternatives. The composting alternative will continue to be evaluated as a feasible option for the remainder of the operational lifecycle of the existing facilities.

Biosolids Master Plan

Screening the Long List. . .

The long list of 102 treatment technologies and the long list of six biosolids end uses were screened using "must have criteria". The screening results in a menu to feasible technologies, biosolids products, and end uses were then combined to develop seven Biosolids Management Strategies.

Screening Criteria

Priorities for End-Uses	• **Community health and safety (pathogen management, quality of air, water and land)**: risks associated with end-use options should be managed to protect community health and safety • **Reliability**: end-uses should meet or exceed Ontario's regulatory requirements and standards; the overall biosolids management strategy must be reliable and enforceable within the City of Ottawa's current framework • **Sustainability**: end-uses should endure over time in an environmentally safe manner, and the solution implemented must have the capacity to handle all of the biosolids produced at R.O. Pickard Environmental Centre (ROPEC) • **Flexibility**: end-use options should include a variety of treatment and end-use options to be adaptable under different circumstances
Priorities for Treatment Technologies	• **Environmentally safe (quality of air, water, and land)**: technologies must produce biosolids which will endure over time in an environmentally safe manner • **Odour**: technologies should minimize odours • **Reliability**: technologies should be proven to maintain interrupted operations, treatment must be proven to demonstrate reliability, at least three years implementation at a similar size facility

Biosolids Management Strategies. . .

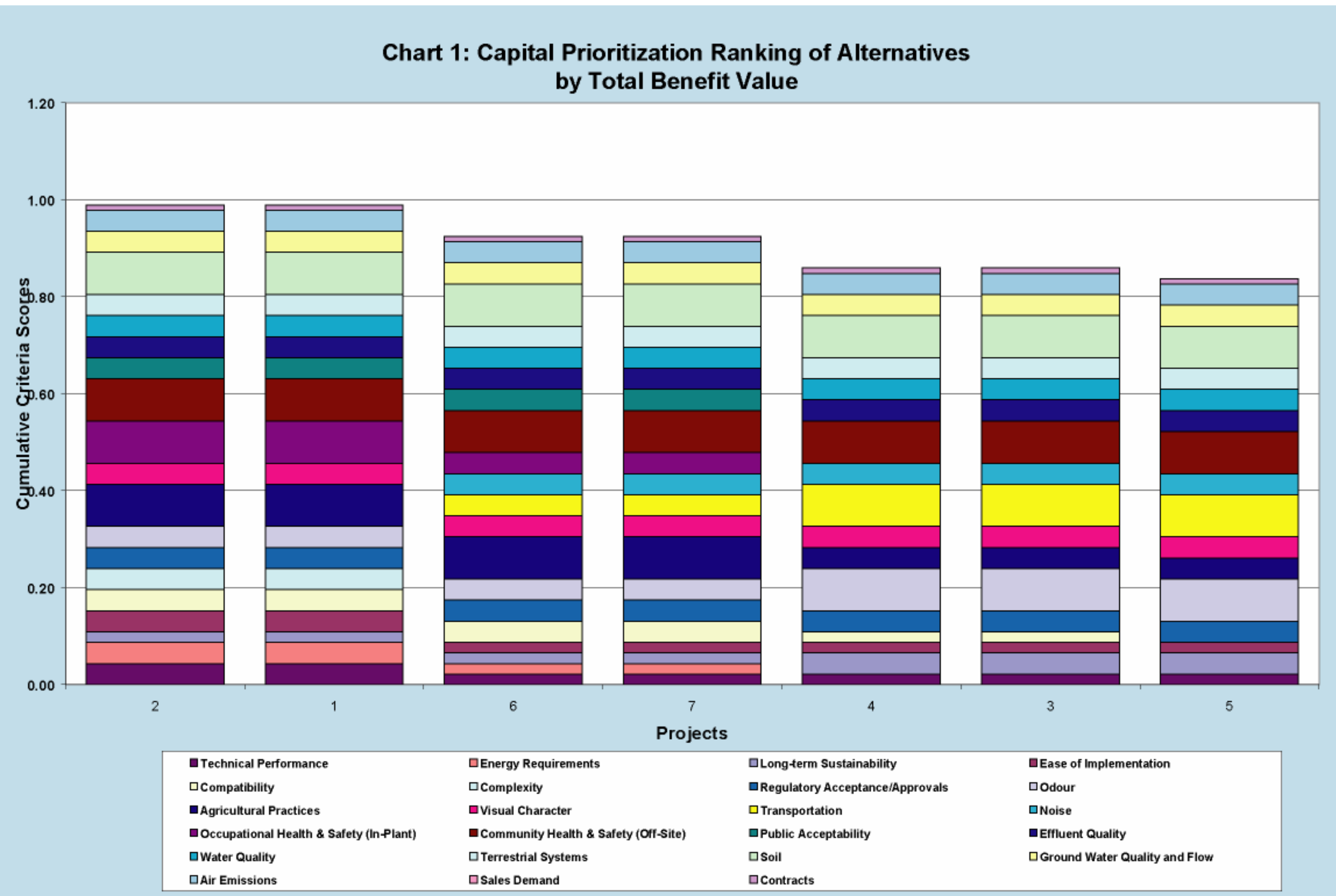
All seven strategies include digestion treatment, biosolids dewatering and further processing and result in a product that has multiple potential end uses.

- Option 1: Expand Existing System
- Option 2: Expand Existing System with Phased Digestion
- Option 3: Expand Existing System with Heat Drying
- Option 4: Expand Existing System with Heat Drying and Phased Digestion
- Option 5: Expand Existing System with Primary Solids only, Digestion, and Heat Drying
- Option 6: Expand Existing System with Alkaline Stabilization
- Option 7: Expand Existing System with Alkaline Stabilization and Phased Digestion

Evaluation of Biosolids Management Strategies. . .

The biosolids management strategy options were evaluated using a Multi-Attribute Analysis. The Multi-Attribute Utility Analysis (MUA) approach conducts a structured evaluation of the risks and benefits of a decision compared to costs.

The evaluation identifies Option 1 (Expand Existing System) and Option 2 (Expand Existing with Phased Digestion) as rated the highest among the alternative strategies.



Next Steps . . .

Class EA Update	Biosolids Master Plan
• Modify recommended pilot testing options based on public comment • Finalize recommended technology pilot test	• Modify recommendation based on public comments • Confirm recommended strategy (Preferred Solution)
• Document EA Update	• Document Biosolids Master Plan
• Inform Council • Publish Notice of Update • Implement Pilot Test	• Inform Council • Publish Notice of Master Plan Study Completion

For additional information, please contact:

James Etienne, P.Eng.
Director of Environmental Services
Environment and Transportation Group
City Hall, 59 Carden Street
Guelph, ON N1H 3A7
Phone: (519) 837-5604
Fax: (519) 822-6194
e-mail: jetienne@citgy.guelph.on.ca

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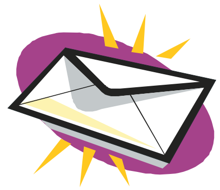
City of Guelph

Wastewater Treatment Strategy Class EA Update and Biosolids Master Plan

Welcome!

Please sign in



Take an information bulletin and review the display materials

The staff of the City and the study team are available to discuss your questions and concerns

Public opinion will influence this study; please fill out a comment sheet

Thanks to all!!

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Class EA Update

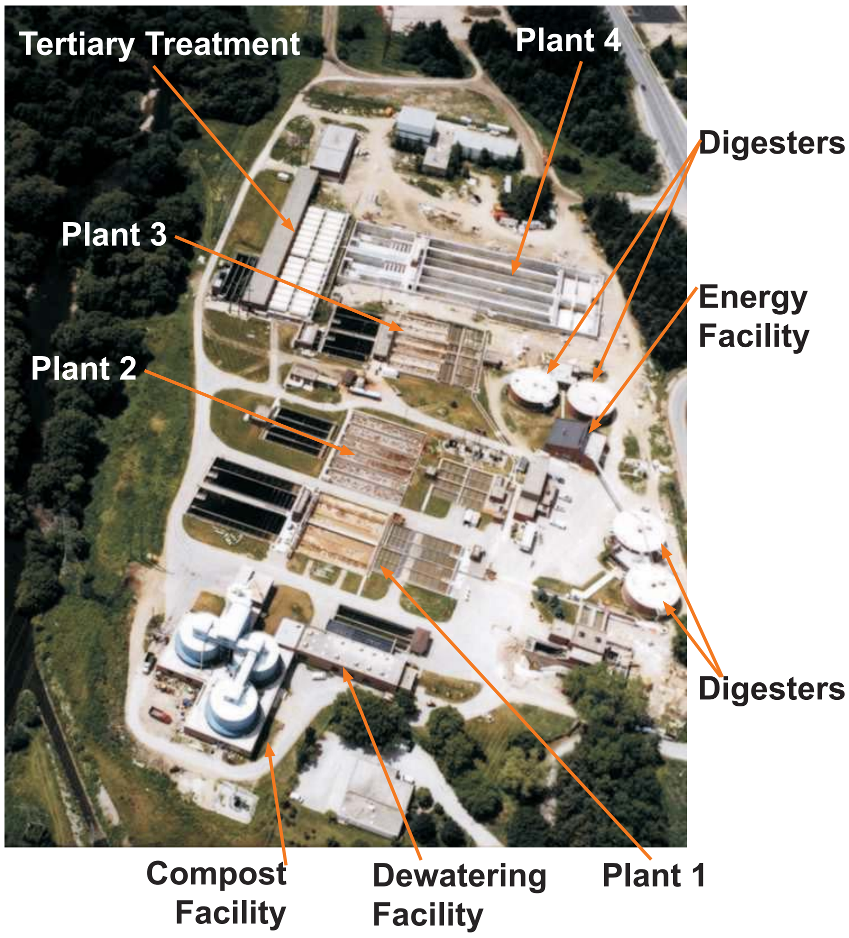
The City of Guelph is undertaking an update to the Wastewater Treatment Strategy that was developed through the Class Environmental Assessment (EA) Process in 1998. The strategy addressed wastewater treatment needs to the year 2016 and recommended expansion of the wastewater treatment plant (WWTP) in two stages. The Stage 1 expansion is complete and the treatment plant is currently operating with a capacity of 64 million litres per day (MLD). The Stage 2 expansion will increase the capacity of the treatment plant to 73.3 MLD.

The purpose of the Class EA Update is to review and select emerging treatment technologies for pilot testing and incorporation in to the design of the Stage 2 expansion.

Biosolids Management Master Plan

The City is also undertaking a related study to develop a Biosolids Management Master Plan. This study was also recommended in the 1998 Wastewater Treatment Strategy. **The purpose of the master plan is to identify a plan for the management and end use of biosolids generated at the WWTP.**

This study is following the Class EA requirements for master plans and the first Public Information Centre to present the need for the study was held in February 2002. Since that time, the City has evaluated options for biosolids management, disposal, and end use.

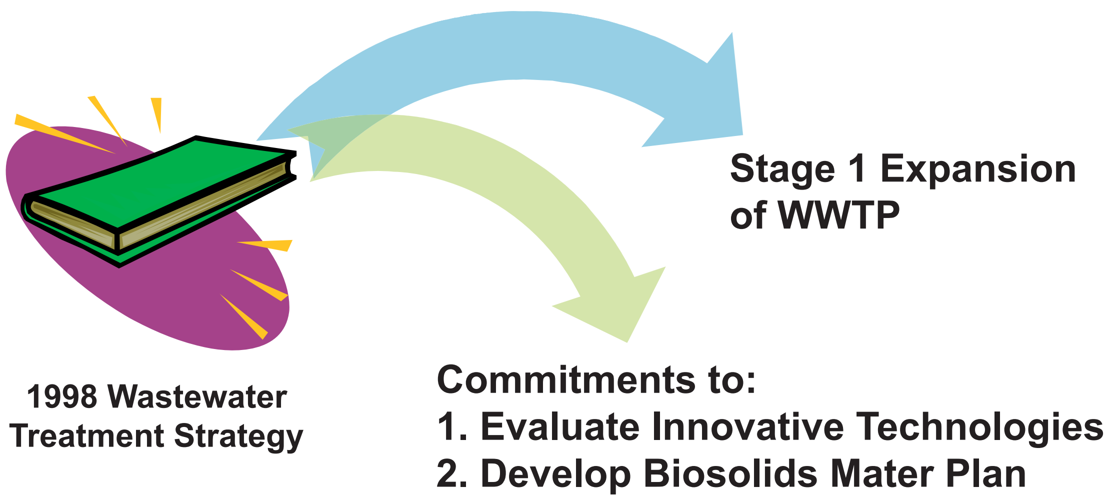


Existing Wastewater Treatment Plant

Currently the City of Guelph WWTP is rated at 64 MLD and consists of four treatment plants (Plant 1 – 16 MLD, Plant 2 – 13 MLD, Plant 3 – 13 MLD, and Plant 4 – 22 MLD). Combined flow from the preliminary treatment system, including screening and grit removal, is directed to Plants 1 to 4 for Primary and Secondary treatment. Co-settling of influent solids and waste activated sludge (WAS) is currently practiced in the primary tanks. Partial nitrification is achieved in Plants 1 to 3 secondary treatment trains, while full nitrification is achieved in Plant 4. Secondary effluent from Plants 1 to 3 is directed to tertiary rotating biological contactors (RBCs) for additional removal of ammonia. The combined secondary effluent flow is directed to tertiary filters prior to disinfection.

These Studies are Related…

Both of these studies involve activities and programs at the WWTP. The innovative technologies evaluated in the Class EA update are focused on treating the liquid stream of wastewater conveyed to the plant. The technologies will generate biosolids with a certain quality and quantity, depending on the technology selected. This information is important to the Biosolids Management Master Plan, as it will determine the characteristics of the biosolids product and related end uses and disposal options. These studies are the result of commitments the City of Guelph made and documented in the 1998 Wastewater Treatment Strategy.

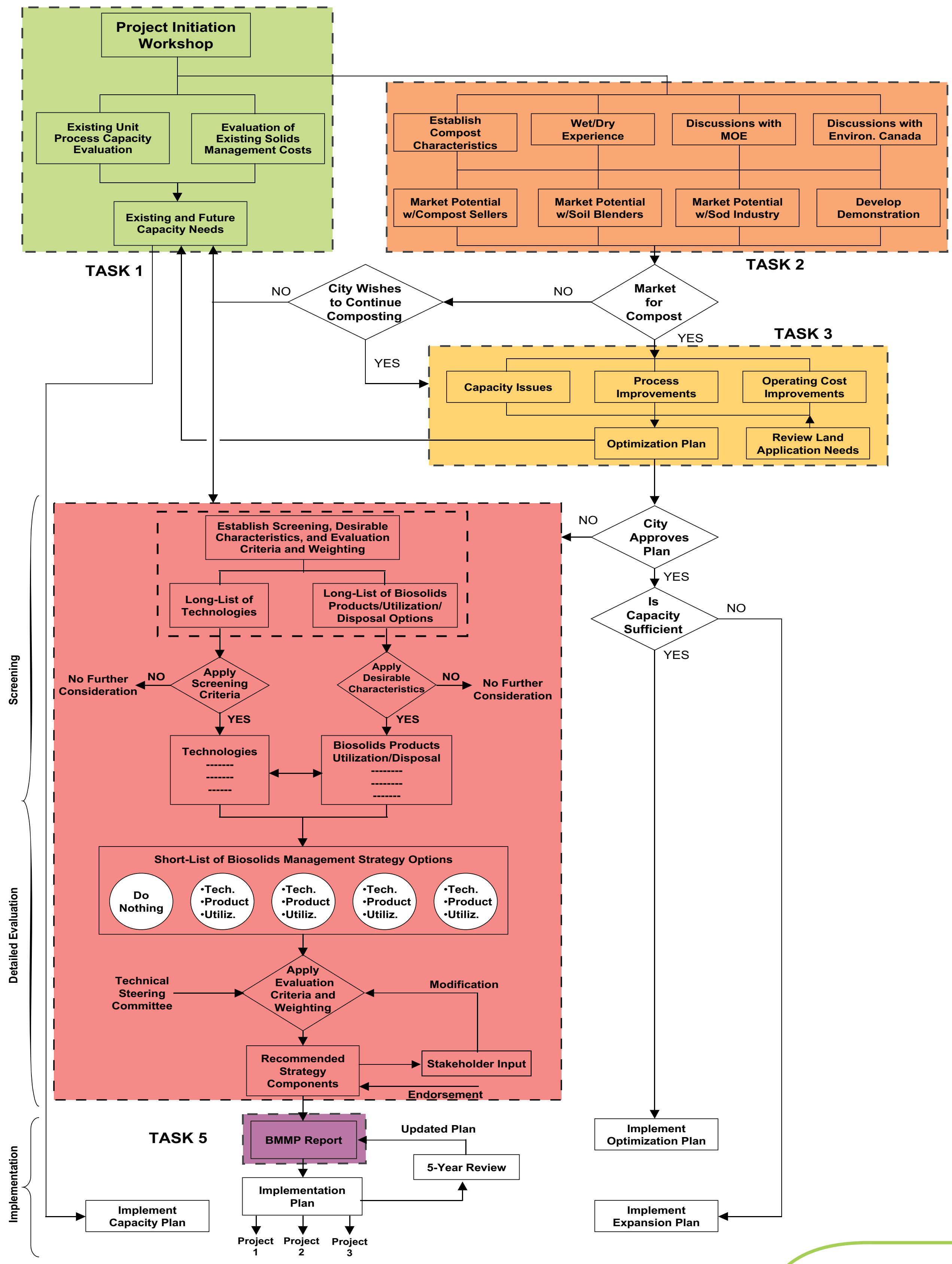


Biosolids Master Plan

The preparation of the Master Plan follows Phases 1 and 2 of the Class Environmental Assessment (EA) process and includes a problem definition phase and an alternatives evaluation phase. The decision tree developed for this project outlined the compilation of six individual tasks, serving as the foundation for a single decision-making process

- Task 1 and Task 2 (Master Plan Definition and the Determination of Compost Utilization Opportunities) address Phase 1 Class EA requirements of defining the need.
- Task 3 and Task 4 (the Determination of Compost Optimization Alternatives that Provide Cost Savings and Selection of a Preferred Biosolids Management Option to meet the City's long-term needs) address Phase 2 Class EA requirements of assessing alternatives and recommending a preferred alternative solution.
- Task 5 entails documenting the Biosolids Management Master Plan (BMMP).

Biosolids Master Plan Decision Tree



Potential Revenues

Potential revenues from the sale of the compost could be up to $400,000 per year. Regulatory and biosolids quality issues must be addressed before potential users are willing to pay for the composted biosolids. Also, demonstration trials and sample lots are needed to let the potential users become familiar with the use of the composted biosolids and encourage future usage.

Compost Market	Potential Demand and Revenues for Compost		
	Demand (m^3/yr)	Revenue	
		($/$m^3$)	($/yr)
Landscapers	26,000[1]		
Topsoil blenders and distributors	40,000[2]	$10	$400,000[3]
Landfill operators	0[4]	–[5]	–
Mining and Quarry Operators		–[5]	–
Agricultural (sod farms)	40,000[6]	–[5,7]	–[5,7]
Golf Courses	–[8]	–	–
Public Works	1,000	–	–
Total	**107,000**	**$0 – $10**	**$0 – $400,000**

[1] Landscapers assumed to utilize 65% of topsoil from distributors
[2] Surveyed topsoil distributors assumed to represent 30% of local topsoil market
[3] Concerned with composted biosolids quality
[4] Sufficient construction soil wastes and topsoil available onsite
[5] Users would take compost at no cost
[6] Generator would pay for transportation costs to the site
[7] At 20 tonnes (33 m^3) per hectare per year
[8] No interest due to quality concerns

Recommendations

Complete demonstrations with topsoil blenders in partnership with regulatory authorities

- Demonstrate blending operations and quality controls to produce a safe, consistent topsoil product
- Demonstrate the product with willing end users
- Complete additional monitoring and identify further processing requirements (i.e. screening, curing) for the different end uses
- Develop public education materials to improve the public perception of the material
- Construct a storage facility for the storage and curing of the compost

Monitor the composted biosolids for the following additional parameters:

- Bulk density
- Soluble Salts
- Combined marketing efforts with the wet-dry composting operation is recommended.

Update on Compost Utilization Options

The City has been unable to carry out composting demonstration trials due to equipment and processing issues at the WWTP. As these issues are addressed, the City wishes to proceed with the evaluation of other biosolids management alternatives. The composting alternative will continue to be evaluated as a feasible option for the remainder of the operational life cycle of the existing facilities.

City of Guelph

Biosolids Master Plan

Screening Long List of Options. . .

WASTEWATER TREATMENT STRATEGY CLASS EA UPDATE AND BIOSOLIDS MASTER PLAN

Stage One – Screening

In the first stage, a set of screening or "Must Have" criteria were be developed to screen the long list of alternative treatment technologies and end-use options (utilization and disposal). Those options that did not meet all criteria were eliminated from further evaluation. The screening resulted in a short list of desirable technology options and end-use options.
The options were then combined to produce management strategies that are then evaluated in more detail.

Screening Criteria

Priorities for End-Uses	• **Community health and safety (pathogen management, quality of air, water and land)**: risks associated with end-use options should be managed to protect community health and safety • **Reliability**: end-uses should meet or exceed Ontario's regulatory requirements and standards; the overall biosolids management strategy must be reliable and enforceable within the City of Ottawa's current framework • **Sustainability**: end-uses should endure over time in an environmentally safe manner, and the solution implemented must have the capacity to handle all of the biosolids produced at R.O. Pickard Environmental Centre (ROPEC) • **Flexibility**: end-use options should include a variety of treatment and end-use options to be adaptable under different circumstances
Priorities for Treatment Technologies	• **Environmentally safe (quality of air, water, and land)**: technologies must produce biosolids which will endure over time in an environmentally safe manner • **Odour**: technologies should minimize odours • **Reliability**: technologies should be proven to maintain interrupted operations, treatment must be proven to demonstrate reliability, at least three years implementation at a similar size facility

Summary of Screening of Technologies

A number of categories of process technologies were evaluated. For each process category a minimum of six technologies was evaluated against Must Have Criteria.

Technology Category	Number of Technologies Evaluated	Number of Technologies Passed	Technologies Passed
Conditioning/ Optimization	19	1	• Polymer
Thickening	7	4	• Centrifuge • Gravity belt thickener • Rotary drum thickener • Dissolved air flotation
Stabilization – Liquid	22	4	• Conventional anaerobic digestion • Thermophilic anaerobic digestion • Lime stabilization (liquid) • RDP
Dewatering	14	2	• Centrifuge • Belt filter press
Stabilization – Post Dewatering	24	3	• Thermal drying • Alkaline stabilizaiton (AASSAD, Biodry, Envessel, Pasteurization, Biofix) • Lystek™
High Temperature Combustion/ Oxidation Processes	17	0	

Summary of Screening of Biosolids End Uses

Summary of Screening Exercise for End Uses

End Use Option	Must Have Criteria: Community Health and Safety	Reliability	Sustainability	Flexibility	Remarks
Agricultural Land	Pass	Pass	Pass	Pass	
Forested Land	Pass	Pass	Fail	Pass	Sufficient area of forested land is not available
Land Reclamation	Pass	Pass	Pass	Pass	
Landfill Disposal*	Pass	Pass	Fail	Pass	No operating landfill in Guelph area
Public Contact	Pass	Pass	Pass	Pass	
Industrial Reuse	Pass	Pass	Fail	Pass	No market potential

Notes: * Landfilling could be maintained as a back-up end-use, utilizing facilities outside of the Guelph area.
The shaded End Use Options pass all Must Have criteria.

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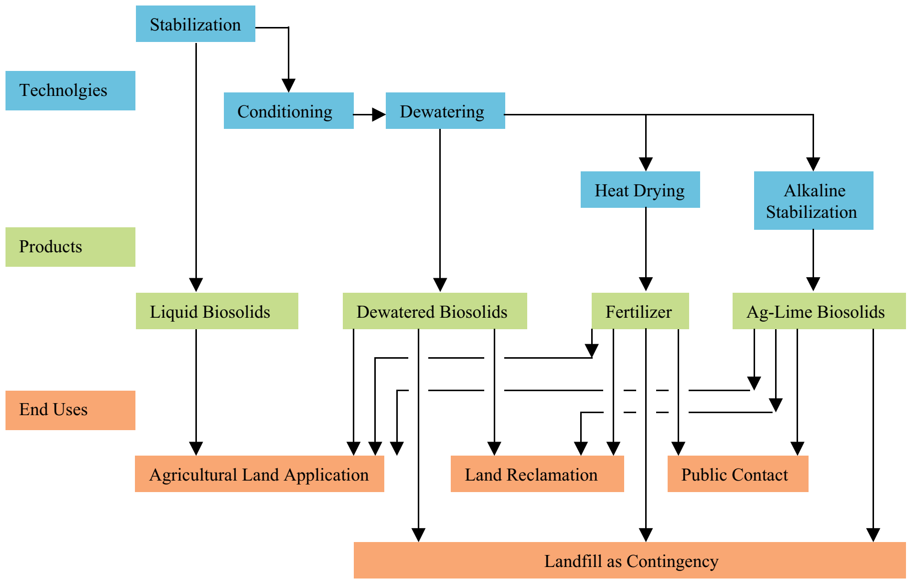
City of Guelph

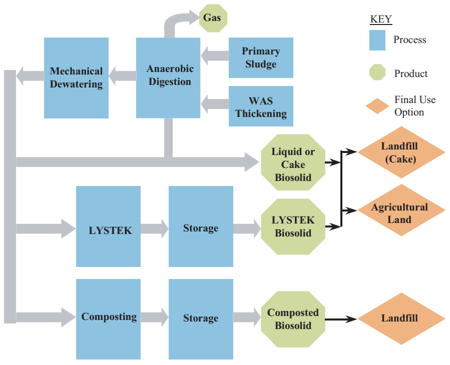
Building Biosolids Management Strategies. . .

WASTEWATER TREATMENT STRATEGY CLASS EA UPDATE AND BIOSOLIDS MASTER PLAN

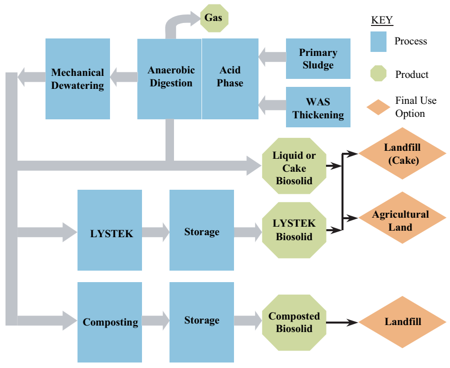
The short listed technologies, products and end uses serve as a menu from which a biosolids management strategy can be developed. Using the short listed menu items, seven alternative biosolids management strategies were developed for the City of Guelph. All seven strategies include digestion, dewatering and further processing and result in a product with multiple potential end uses.



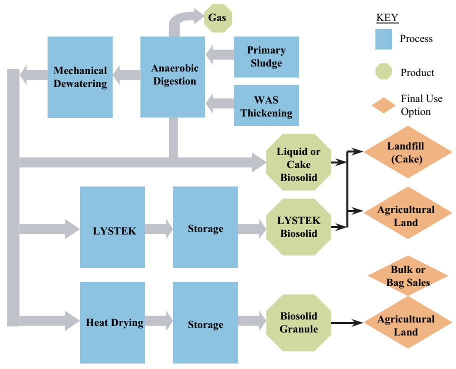
Option 1
Expand Existing System



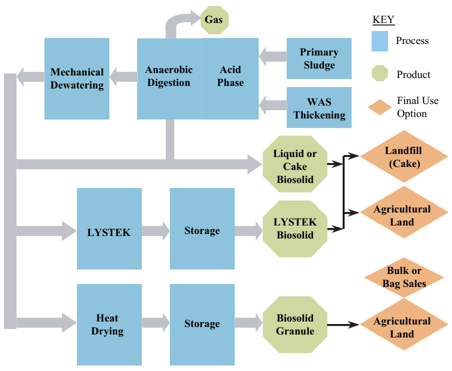
Option 2
Expand Existing System with Phased Digestion



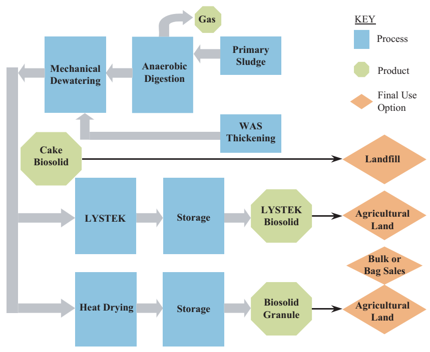
Option 3
Expand Existing System with Heat Drying



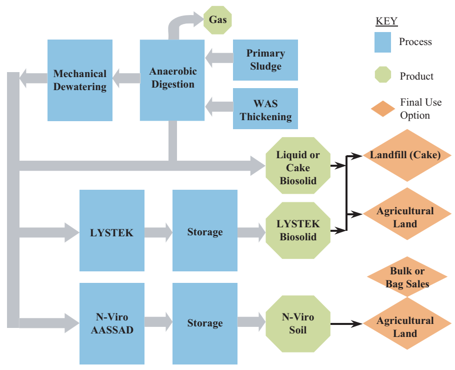
Option 4
Expand Existing System with Heat Drying and Phased Digestion



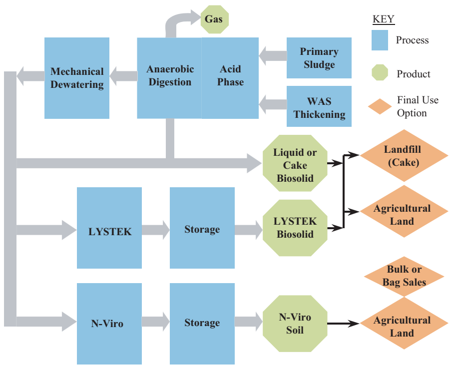
Option 5
Expand Existing System with Primary Solids only, Digestion, and Heat Drying



Option 6
Expand Existing System with Alkaline Stabilization



Option 7
Expand Existing System with Alkaline Stabilization and Phased Digestion



Evaluation of Biosolids Management Strategies. . .

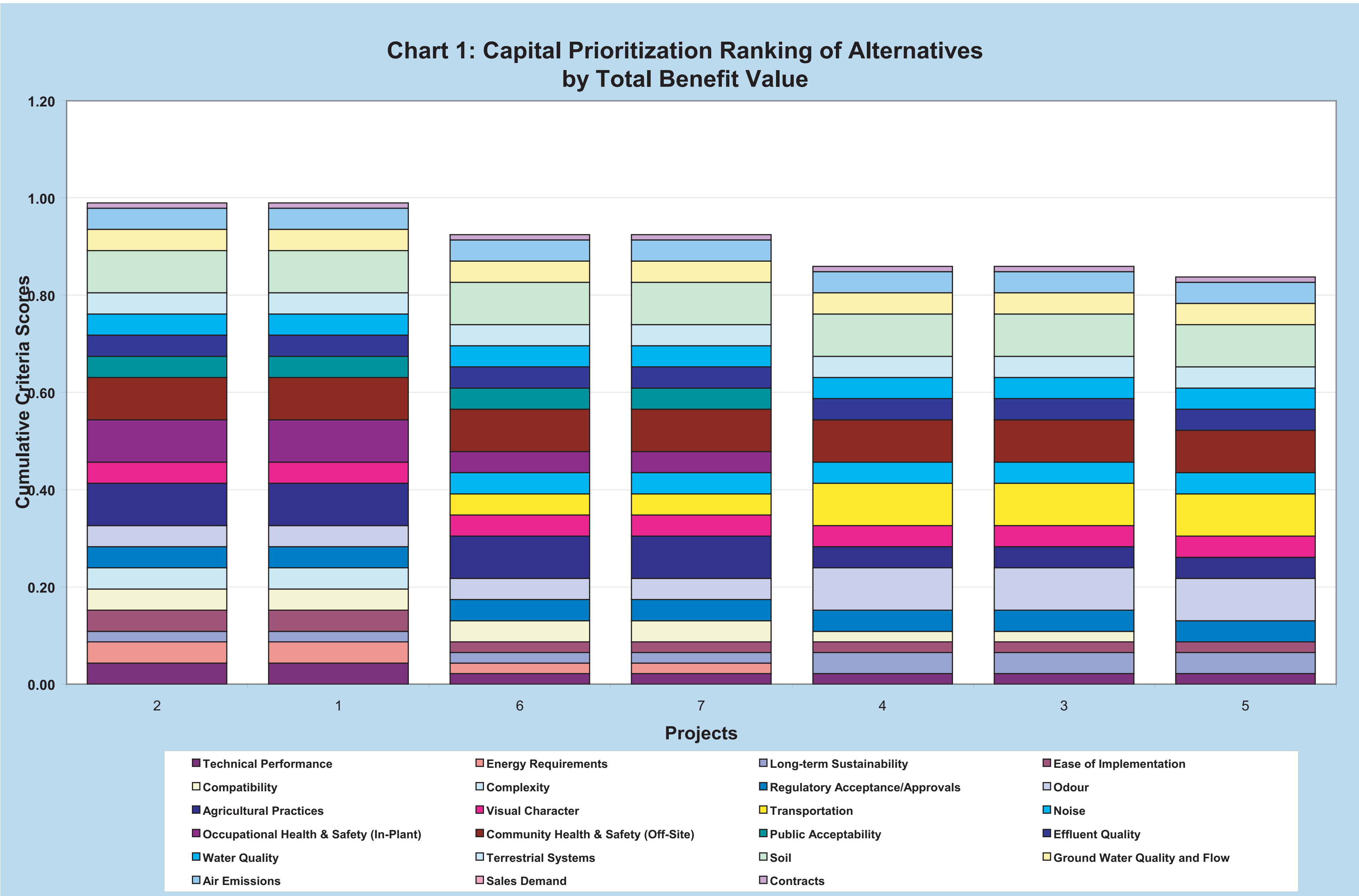
WASTEWATER TREATMENT STRATEGY CLASS EA UPDATE AND BIOSOLIDS MASTER PLAN

The biosolids management strategy options were evaluated using a Multi-Attribute Analysis. The Multi-Attribute Utility Analysis (MUA) approach conducts a structured evaluation of the risks and benefits of a decision compared to costs.

Steps in the MUA process include:

- Developing selection criteria for which competing projects (alternatives) will be judged – for this project the selection criteria was developed with the consultant team and the City of Guelph
- Weighting the importance of the chosen criteria
- Development of performance measures associated with evaluation criteria
- Consultation with stakeholders
- Scoring of alternatives
- Evaluation of costs and risks of potential project alternatives
- Ranking the potential project alternatives in relation to value to cost relationships

The Total Benefit Value was considered by assigning all the criteria an equal weighting, thus considering all criteria to be of equal importance. After rating equal option based on those criteria, the results of this ranking are shown below.



The evaluation identifies Option 1 (Expand Existing System) and Option 2 (Expand Existing with Phased Digestion) as rated the highest among the alternative strategies.

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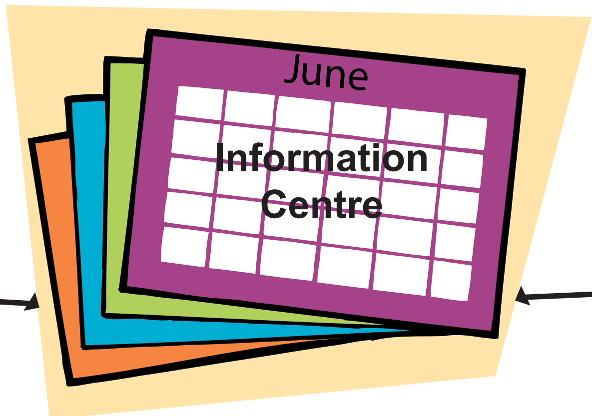
City of Guelph

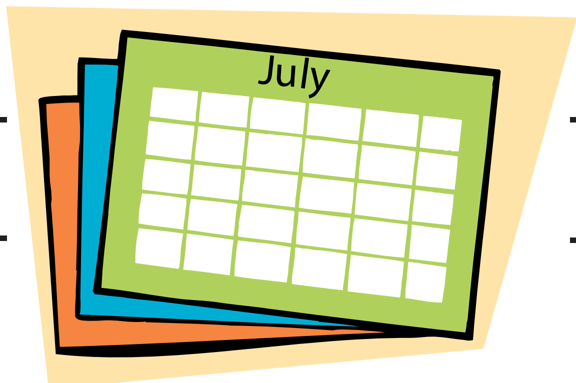
Next Steps. . .

WASTEWATER TREATMENT STRATEGY CLASS EA UPDATE AND BIOSOLIDS MASTER PLAN

Class EA Update

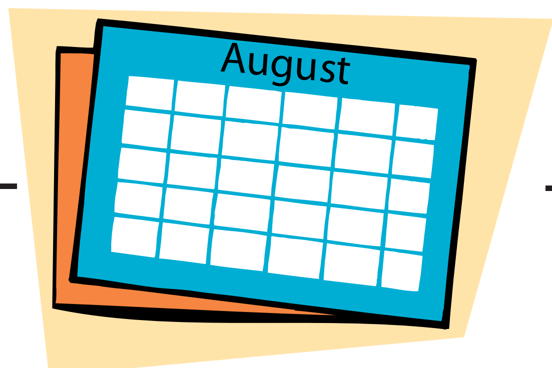


Biosolids Master Plan



Class EA Update:
- Modify recommended pilot testing options based on public comment
- Finalize recommended technology pilot test

Biosolids Master Plan:
- Modify recommendation based on public comments
- Confirm recommended strategy (Preferred Solution)



Class EA Update:
- Document EA Update

Biosolids Master Plan:
- Document Biosolids Master Plan

Class EA Update:
- Inform Council
- Publish Notice of Update
- Implement Pilot Test

Biosolids Master Plan:
- Inform Council
- Publish Notice of Master Plan Study Completion

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APPENDIX C

TECHNICAL MEMORANDUM 1

The City of Guelph

Biosolids Management Alternatives Planning

Task 1 Technical Memorandum Final Draft

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PREPARED BY:	Peter Burrowes Warren Saint Sally Baldwin
DATE:	May 14, 2001

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1 Summary

The City of Guelph are currently addressing their wastewater treatment requirements by expanding the capacity of the Guelph Wastewater Treatment Plant (WWTP), to ultimately enable the City to treat wastewater flows up to 73,300 m^3/d. This biosolids management study project has been initiated to ensure that the solids handling systems at the wastewater treatment plant are sufficient to deal with the increased residuals that will inevitably result from the increased wastewater flow, and that the solids handling systems are cost-effective with respect to capital, operations and maintenance (O&M).

This technical memorandum covers Task 1 of the project, which includes, analyzing the condition and capacities of existing equipment, estimating existing operational costs and determining existing and future processing capacity and potential equipment needs. This task provides a baseline for the future study tasks and will enable the biosolids management alternatives planning to proceed.

Figure 1-1 shows the projected solids mass balance through the plant at various raw wastewater influent flow rates and loading characteristics of the WWTP, averaged over the years 1998 to 2000, and those characteristics which were identified in the industrial influence study. It is expected that Plant 4 will be operational in the spring of 2002, at which time the rated capacity will become 64,000 m^3/d. The plant will attain a capacity rating of 73,300 m^3/d at the completion of the scheduled Stage 2 expansion.

By comparing the current unit processes, the equipment conditions and the process capacity, facility needs and future capacity requirements were determined, and these are summarised in Table 1-1.

Table 1-1: Facility Needs and Future Capacity Requirements

Process	Facility Need / Capacity Requirement
Digestion	The MOE recommends 15 days HRT as a design guideline for primary anaerobic digestion to provide sufficient stabilization of organic material. At current loading conditions, it is projected that the existing primary digesters will have a 10.6-day HRT at the 64,000 m^3/d hydraulic limit of the Stage 1 expansion. Increased primary digestion capacity may be needed, depending on the ultimate biosolids management approach. Composting currently provides additional stabilization of organic material. Alternatively, waste activated sludge thickening could decrease the volume of the material pumped to the digesters, thereby increasing the effective residence time.
Dewatering	The two oldest belt filter presses require replacement due to age and wear. The equipment manufacturer has determined that they have an approximate remaining life to 2 years, with replacement of the oldest presses. At current loading conditions, it is estimated that the dewatering facility has sufficient capacity to treat the solids from wastewater flows up to 73,300 m^3/d, assuming that the facility can be operated for a longer period of time each day.
Composting	At current loading conditions, it is projected that there is sufficient capacity in the composting facility to treat the solids from wastewater flows up to 73,300 m^3/d. Additional storage/curing may be necessary. The reliability issues related to the outfeed devices require assessment.

Costs of running the solids handling facility were also examined, and are summarised in Table 1-2.

Table 1-2: Solids Handling Costs, 1998 to 2000.

$/dry tonne Solids Produced	**1998**	**1999**	**2000**	**Average**
Digestion	26	30	31	29
Dewatering	80	118	139	112
Composting	167	423	353	315
Land Application	94	98	95	96
Landfilling	22	37	41	33
Total Costs	**1998**	**1999**	**2000**	**Average**
Total Cost ($)	$907,604	$1,142,922	$1,261,744	$1,104,090
Total Solids Produced (dry tonnes/day)[1]	9.0	8.1	8.1	8.4
Average Cost per dry tonne ($/dry tonne)				**359**

Note: [1] Total Solids Produced was calculated from plant data, and is further described in Section 6.1.1 of this memorandum.

The purpose of Task 1 was to establish capacity conditions and the estimated operating costs of the current systems. The findings are summarised below:

- Excluding the potential needs and requirements listed in Table 1-1, the Guelph WWTP solids handling systems are sufficient to process the projected residuals, at current average influent concentration conditions, until the 73,300 m^3/d plant capacity has been reached.

- Industrial loadings may have a significant impact on solids production at the WWTP. Current maximum and City by-law compliance loadings were estimated for predicted future industrial flows (see Attachment F and Section 6 of this memorandum). This showed that if industries produce wastewater at current maximum loadings and predicted flow rates, the estimated WWTP solids production will be approximately 40% greater than industrial wastewater at by-law compliance loadings and predicted flow rates.

  The resulting solids contribution from industrial loading decrease the available capacity in the existing process units and would advance the requirement for additional unit process capacity in the solids handling train. As the contribution loading of major industries is largely soluble in nature it may impact the secondary treatment system of the WWTP and increase the volume of waste activated sludge (WAS) produced. Additional WAS will decrease the settleability of solids in the primary tanks, resulting in larger volumes of primary sludge, due to a decreased solids concentration and a greater mass of solids. A more detailed assessment of the impacts of industrial waste on the liquid and solids handling train is recommended.

- The estimated operational costs provide a baseline to which future costs and costs of alternative management systems can be compared.

- Composting capacity is estimated to be sufficient to the capacity planning horizon, assuming that raw wastewater influent loadings remain stable or are reduced. However, the degree of product stability required will depend on the ultimate end use or disposal of the compost product. Additional hydraulic retention time in the reactor vessels can be obtained through a drier dewatered biosolids feedstock and additional stability can be obtained through additional curing of the material, by outdoor storage, if required. Retrofitting of the drive system of the outfeed device is required to improve the reliability of the composting facility.

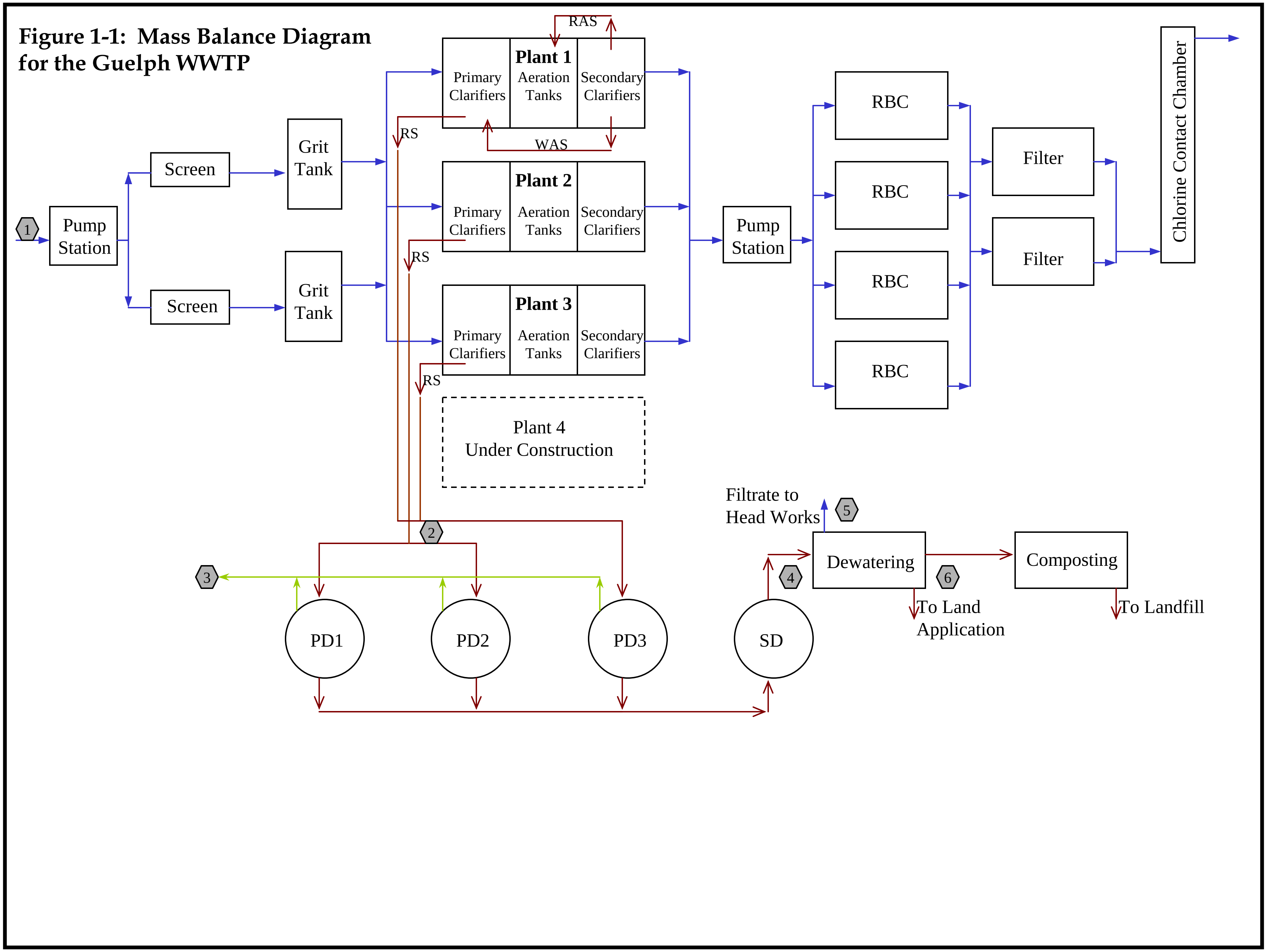


Figure 1-1: Mass Balance Diagram
for the Guelph WWTP
1
Pump Station
Screen
Screen
Grit Tank
Grit Tank
RAS
Plant 1
Primary Clarifiers
Aeration Tanks
Secondary Clarifiers
RS
WAS
Plant 2
Primary Clarifiers
Aeration Tanks
Secondary Clarifiers
RS
Plant 3
Primary Clarifiers
Aeration Tanks
Secondary Clarifiers
RS
Plant 4
Under Construction
Pump Station
RBC
RBC
RBC
RBC
Filter
Filter
Chlorine Contact Chamber
2
3
PD1
PD2
PD3
SD
4
Filtrate to
Head Works
5
Dewatering
6
Composting
To Land
Application
To Landfill

Mass Balance Projection for the Guelph WWTP

		Maximum Loading			Current Loading			Compliance Loading			Stage 1 Design		
ID #	**Description**	**Volume (m^3/d)**	**Mass (kg/d)**	**%TS**	**Volume (m^3/d)**	**Mass (kg/d)**	**%TS**	**Volume (m^3/d)**	**Mass (kg/d)**	**%TS**	**Volume (m^3/d)**	**Mass (kg/d)**	**%TS**
1	Raw Water Influent	64,000			64,000			64,000			64,000		
2	Raw Sludge	768	26,884	3.5%	652	22,806	3.5%	466	16,322	3.5%	612	21,421	3.5%
3	Biogas												
4	Digested Biosolids	815	15,501	1.9%	691	13,150	1.9%	495	9,411	1.9%	649	12,351	1.9%
5	Dewatering Supernate[1]												
6	Dewatered Biosolids	86	13,641	18%	73	11,572	18%	52	8,282	18%	69	10,869	18%

		Maximum Loading			Current Loading			Compliance Loading			Stage 2 Design		
ID #	**Description**	**Volume (m^3/d)**	**Mass (kg/d)**	**%TS**	**Volume (m^3/d)**	**Mass (kg/d)**	**%TS**	**Volume (m^3/d)**	**Mass (kg/d)**	**%TS**	**Volume (m^3/d)**	**Mass (kg/d)**	**%TS**
1	Raw Water Influent	73,300			73,300			73,300			73,300		
2	Raw Sludge	826	28,893	3.5%	746	26,120	3.5%	524	18,331	3.5%	701	24,534	3.5%
3	Biogas												
4	Digested Biosolids	876	16,660	1.9%	792	15,061	1.9%	555	10,570	1.9%	743	14,146	1.9%
5	Dewatering Supernate[1]												
6	Dewatered Biosolids	93	14,661	18%	84	13,254	18%	59	9,301	18%	79	12,448	18%

[1] Supernate Volume and %TS depends on amount of wash water used

2 Introduction to the Project

2.1 Purpose

The project purpose statement, developed and endorsed at the project initiation workshop, is as follows:

"*The project will result in:*

A long-term biosolids management plan that provides value, is endorsed by the public and other stakeholders, and meets or exceeds regulatory requirements."

This project provides the City with an opportunity to take a comprehensive look at its biosolids operations and to plan for the future needs in the City.

2.2 Previous Studies

2.2.1 Polymer Optimization Study

In 1996 an "Audit of the Guelph WWTP" was conducted to quantify the plant's actual total hydraulic and organic capacity and determine the amount still available to handle additional future loadings, with respect to the unit process directly associated with wastewater treatment but not solids processing. The study concluded that virtually all of the existing wet-side treatment units were operating at close to their maximum actual capacity and that very little treatment capacity remained available. The report recommended that bench-scale and full-scale trial testing of enhanced primary treatment be conducted. The aim of enhanced primary treatment is to decrease the organic loading to the secondary treatment units and therefore allow for an increase in the secondary treatment SRT and potentially extend nitrification into the periods of colder water temperatures.

Bench-scale and a full-scale test of enhanced primary treatment were performed in 1996 and 1997 respectively, and the results presented in the report "*Report on Guelph WWTP Audit Phase II, Plant-scale Test of Enhanced Primary Treatment*", by CH2M Gore and Storrie Limited (now CH2M HILL Canada Limited) dated February 1998. The bench-scale jar tests showed that the raw influent could be successfully treated, and the polymers recommended by Allied Colloid had a potential for 85% to 90% reduction in suspended solids and 80%+ reduction in BOD removal in primary clarification.

Plant-scale testing was performed to determine whether or not the enhancement chemical indicated during jar testing could in fact be used effectively for full-scale treatment. The results showed that the primary clarifier performance did not substantially improve with the addition of the treatment chemicals. This was due, in part, to insufficient gentle and prolonged flocculation immediately upstream, or as part of, the primary clarifiers, which could not be achieved due to physical restraints.

The study concluded that enhanced primary treatment would not provide an effective add-on treatment for the existing primary clarifiers at the Guelph WWTP. Therefore, alternative methods to treat an increasing wastewater flow had to be assessed.

2.2.2 Environmental Assessment

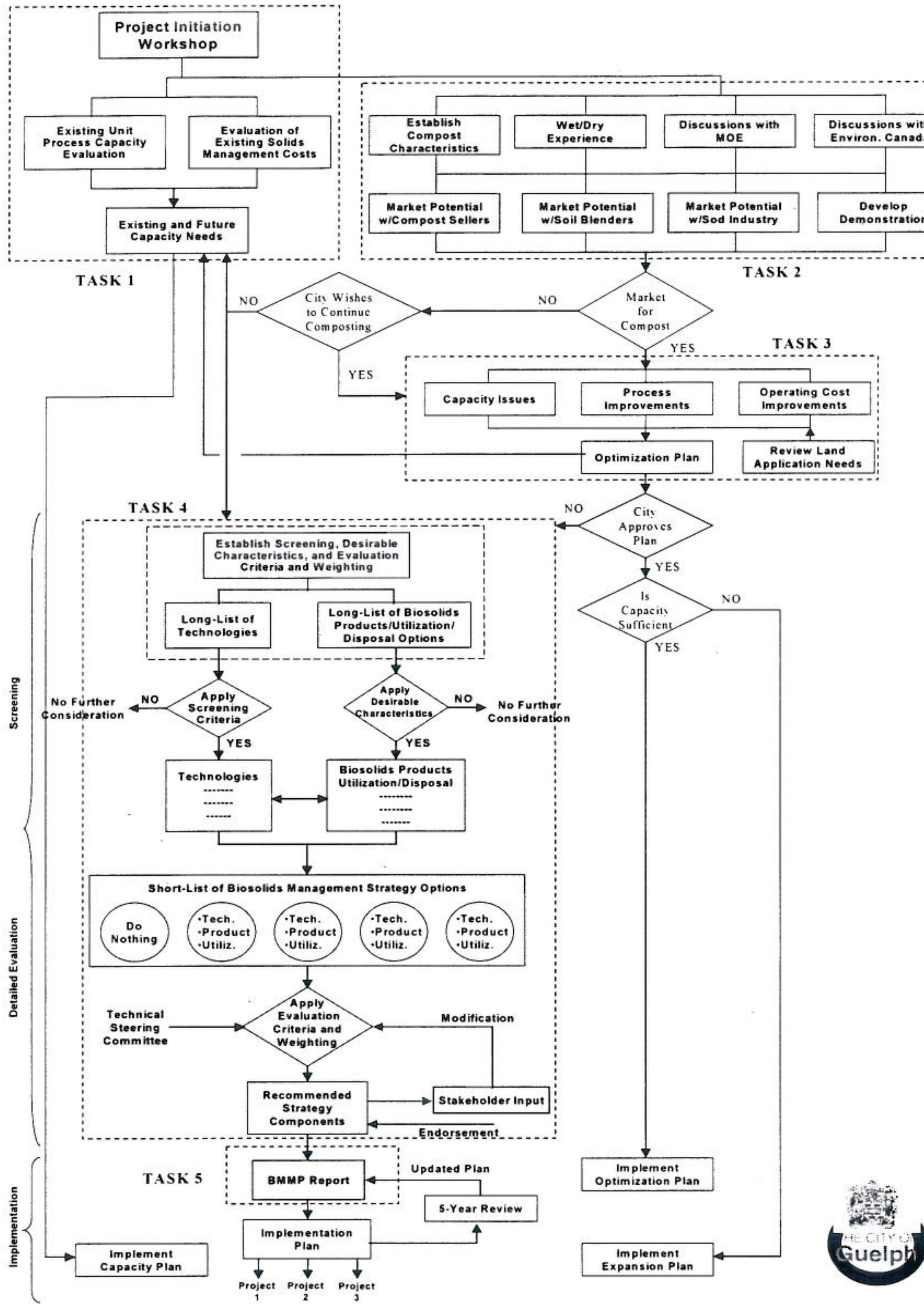
In 1998 CH2M Gore and Storrie Limited (now CH2M HILL Canada Limited) completed the "City of Guelph Wastewater Treatment Strategy Schedule C Class Environmental Assessment". This study concluded in a report, which examined wastewater treatment needs to the year 2016 and identified solutions for meeting those needs. With respect to biosolids management, the report stated "*Treatment of an increased volume of wastewater to increased treatment standards will generate a proportionally greater volume of sludge, which will require stabilization and dewatering*". Assuming a digested sludge solids content of approximately 3.3% from the digesters, and similar influent loading characteristics as the historical data suggests, the report went on to state "*The Stage 1 expansion of the WWTP [to 64 ML/d] will not require any significant upgrades or expansion to the existing solids handling train……The Stage 2 expansion of the WWTP from 64 to 73.3 ML/d would require an expansion of the anaerobic digestion process by increasing the number of primary digesters from three to four. The biosolids composting facility would not require an expansion*".

2.2.3 Work Plan

The purpose of this project is to examine the biosolids handling train at the Guelph WWTP and to develop a biosolids management plan to provide direction for biosolids management activities in the City of Guelph, upto and including, the planned expansion of the WWTP to a rated capacity of 73.3 ML/d.

Figure 2-1 shows an overview of the project tasks. This technical memorandum summarises the findings of the work identified in Task 1.

Figure 2-1: The City of Guelph Biosolids Management Alternatives Planning



3 Introduction to Task 1

Task 1 of the Biosolids Management Alternatives Planning Project included the following assignments:

- Project Initiation Workshop.
- Review the existing solids handling unit process capacities.
- Determine existing and future capacity needs.
- Estimate the existing solids management costs.

These items are reviewed in the sections below.

4 Project Initiation Workshop

The project initiation and chartering meeting was held at the City's Engineering Department on October 11, 2000 at 2pm.

The meeting enabled the City and consultant team to discuss Task 1 and to meet with Trevor Barton of the City's Wet-Dry facility. A meeting summary is included in this Technical Memorandum (TM) as Attachment A.

5 Existing Unit Capacity Evaluation

This evaluation was performed in order to determine the existing solids handling facility capacity. The first step was to identify all the unit processes and associated equipment related to the WWTP's solids handling process train. Process flow diagrams for digestion, dewatering and composting are shown in Attachment B, and a list of solids handling equipment with equipment details, including installed, operating and firm capacity, is shown in Attachment C.

- Installed capacity is defined as the equipment capacity in a new or nearly new condition.
- Operating capacity is defined as the actual capacity that can be reasonably used on a continuous basis, assuming all units of any one process are in operation.
- Firm capacity is defined as operating capacity of the process assuming the largest unit is out of service.

For example:

The Guelph WWTP has four belt filter presses, two with an installed capacity of 7.5 L/s each and two with an installed capacity of 9.5 L/s each. Therefore the installed capacity is 34 L/s. The operating capacity of the smaller presses has been determined as 3.3 L/s each, and the operating capacity of the larger presses has been determined as 6.3 L/s each, resulting in a total operating capacity of 19.2 L/s. The firm capacity is, therefore, 12.9 L/s (19.2-6.3).

6 Existing and Future Capacity Needs

In order to determine the existing and future capacity needs, the historical and predicted future solids production rates were compared to the existing unit process capacities.

6.1 Historical Solids Production

The data displayed in Table 6-1 shows total historical solids production, 1998 to 2000, as calculated from WWTP in-house data.

Table 6-1: Plant Recorded Total Solids Production Data

Year	Average Day Raw Water Flow (m^3/d)	Raw Total Solids (dry tonnes/day)	Digested Total Solids (dry tonnes/year)	Dewatered Total Solids (dry tonnes/day)
1998	49,414	17.81	10.27	9.04
1999	50,430	16.03	9.24	8.13
2000	56,202	16.00	9.23	8.12

The raw solids were calculated from daily raw solids flow and percent total solids. The digested solids were calculated by subtracting the digested volatile solids (based on the average percent volatile solids destruction over the 3-year period) from the raw volatile solids. The dewatered solids were calculated based on an 88% capture rate of digested sludge applied to the belt filter presses, as determined by mass balance calculations, described below.

In order to determine dewatered cake production, the belt filter press solids capture was estimated by calculating the total monthly volume of sludge fed to dewatering multiplied by the average monthly sludge feed solids content, to determine total solids mass fed to dewatering. The mass of anaerobic sludge fed to dewatering was compared to the total solids produced from dewatering, as determined by dewatered cake mass and solids content. The final dewatered cake production was approximately 88% of the total solids production over the period of study. Therefore, the belt filter presses were characterised as operating at approximately 88% solids capture, which is a reasonable solids capture for this type of equipment.

6.2 Predicted Future Solids Production

In order to estimate the future solids production rates, the historical data was reviewed and used to calibrate and validate CH2M wastewater treatment plant modelling software called Pro2D. It was recognised that industrial loadings could have a significant impact on solids production in the future; therefore, the model was run for various scenarios for industrial loadings to the WWTP. The TM shown in Attachment F, prepared by CH2M HILL Canada Limited for the City of Guelph, describes the industrial loading scenarios studied.

6.2.1 Impact of Industrial Loadings

The two major industries in Guelph that can significantly impact the raw wastewater characteristics and solids production at the Guelph WWTP are Sleeman’s and Better Beef. In order to determine the magnitude of their impacts, three scenarios were examined in this TM:

- Scenario 1: Maximum loadings
  - Sleeman’s wastewater at maximum loadings of 2,100 mg/L BOD and 2,900 mg/L TSS, equivalent to 1,818 kg/d BOD and 2,504 kg/d TSS at 360,800 hL/yr production rate and 3,780 kg/d BOD and 9,063 kg/d TSS at 750,000 hL/yr production rate
  - Better Beef’s wastewater at maximum loadings of 3,634 mg/L BOD and 1,000 mg/L TSS, equivalent to 3,155 kg/d BOD and 1,157 kg/d TSS
  - All other industries at current average loadings of BOD and TSS

- Scenario 2: Average loadings
  - Current 1998 to 2000 average influent loading conditions

- Scenario 3: Compliance loadings
  - All industries which have wastewater at current average BOD and TSS loadings greater than compliance loadings at compliance loading
  - All industries which have wastewater at current average BOD and TSS loadings equal to or less than compliance loadings, at current average loadings

The predicted solids production rates, and their impact on the potential capacity requirements at the Guelph WWTP, associated with each of these scenarios are discussed later in this TM.

6.2.2 Pro2D Model Calibration

The Pro2D model predicted the following solids production for the years 1998, 1999 and 2000, using the average influent characteristics shown in Table 6-2:

Table 6-2: Pro2D and Plant Recorded Solids Production

	1998	1999	2000	Average
Raw Influent BOD (mg/L)	249	237	182	
Raw Influent TSS (mg/L)	346	280	226	
Pro2D Digested Solids Production (dt/d)	11.36	10.11	9.00	
Pro2D Dewatered Solids Production at (88% Capture) (dt/d)	10.00	8.90	7.92	8.94
Dewatered Cake Production (Plant Data) (dt/d)	9.04	8.13	8.12	8.43
Difference between Plant Data & Model				6.0%

This data provides a satisfactory calibration of the model, but to ensure validation, dry solids production per cubic metre of inflow was also compared to MOE guidelines and 'rule-of-thumb' assumptions for solids production.

- Plant recorded: 1998: 183 mgSS/L of WWTP inflow
  1999: 161 mgSS/L of WWTP inflow
  2000: 144 mgSS/L of WWTP inflow
- Modelled: 1998: 202 mgSS/L of WWTP inflow
  1999: 176 mgSS/L of WWTP inflow
  2000: 141 mgSS/L of WWTP inflow
- MOE guideline: 155 mgSS/L of WWTP inflow
- 'Rule-of-thumb': 168 mgSS/L of WWTP inflow

As can be seen above, the plant-recorded solids production in 1998, 1999 and 2000 was within 10% of that estimated by the model. It is also similar to that given by the MOE guidelines and that estimated by the 'rule-of-thumb' approach. While it is noted that 1998 showed higher than typical dry solids production, the average WWTP solids production and that predicted by the model over the 3-year period showed close agreement.

Based on the preceding, we believe that the model is sufficiently calibrated to be used over the long-term planning period.

6.2.3 Solids Production

Two capacities were studied: Stage 1 expansion capacity, 64,000 m^3/d, and Stage 2 expansion capacity, 73,300 m^3/d. Included in Table 6-3, for comparative purposes, are the projected solids production rates based on the average influent raw sewage strength of 200 mg/L BOD and 275 mg/L TSS used in the design of the Stage I expansion (currently under construction) and the projected Stage II expansion. Three scenarios with regard to industrial loadings were also studied, as described previously.

Projected solids production data, as predicted by Pro2D, are shown in Table 6-3.

Table 6-2: Pro2D Projected Solids Production

	Raw Influent Flow	Maximum Loadings	Average Loadings	Compliance Loadings	Stage I Design
Solids Production (dry kg/d)	**64,000 m^3/d**	15,501	13,150	9,411	12,315
Cake Production (dry kg/d)		13,641	11,572	8,282	
Cake Production (dry tonnes/d)		13.64	11.57	8.28	
					Stage II Design
Solids Production (dry kg/d)	**73,300 m^3/d**	16,660	15,061	10,570	14,146
Cake Production (dry kg/d)		14,661	13,254	9,301	
Cake Production (dry tonnes/d)		14.66	13.25	9.30	

The Pro2D summary spreadsheet is displayed in Attachment D. The projected flows and solids production rates were compared to the existing unit process capacities (Attachment C) in order to determine existing and future needs. This information is summarised in Tables 6-4 and 6-5.

Table 6-4: Existing Solids Handling Facility Capacity Needs

			Capacity Required				Expansion required?
		Inflow	49,414 m^3/day	50,430 m^3/day	56,202 m^3/day		
		Year	**1998**	**1999**	**2000**	**Average**	
Equipment Capacity	**Description**	**Unit**					**(Excludes scheduled expansion)**
Raw Sludge							
Installed, Operating & Firm	Raw Sludge Pumps	m^3/d	11,113	9,174	8,256	9,514	No
Primary Digestion							
Installed & Operating	Primary digestion HRT at 7,320 m^3 capacity	days	12.4	14.0	15.5	14.0	Possibly: MOE guidelines require min. 15 day HRT in primary digesters
Firm	Primary digestion HRT at 4,880 m^3 capacity[1]	days	8.3	9.3	10.3	9.3	
Secondary Digestion							
Installed	Secondary digestion HRT at 2,350 m^3 capacity	days	4.0	4.5	5.0	4.5	No: Secondary digester operation is not a requirement, but a site specific objective
Operating	Secondary digestion HRT at 1,774 m^3 capacity	days	3.0	3.4	3.7	3.4	
Firm	Secondary digestion HRT at 0 m^3 capacity	days	0	0	0	0	
Dewatering (based on 5-day week)							
Operating	BFP run time at 19.2 L/s	hrs	11.9	10.6	9.6	10.7	No, provided BFP operation time can be increased to provide sufficient capacity
Firm	BFP run time at 12.9 L/s	hrs	17.8	15.8	14.3	16.0	
	Auxiliary BFP Equipment						Capacity is sufficient for current installed equipment
	Polymer system						Capacity is sufficient for current installed equipment
Composting – Total							
Installed	Total HRT at 4,500 m^3	days	42.5	47.7	53.1	47.8	No, amount of stabilization required is dependent on utilization method selected. Additional stabilization and curing could be achieved by outdoor storage if necessary.
Operating	Total HRT at 3,750 m^3	days	35.4	39.8	44.3	39.8	
Firm	Total HRT at 2,500 m^3	days	23.6	26.5	29.5	26.5	
	Compost Material Handling Systems						Upgrades to compost outfeed devices required to improve reliability
	Amendment Material Handling Systems						Capacity is sufficient for current installed equipment
	Screen System						Unknown

Table 6-5: Future Solids Handling Facility Capacity Needs

			Capacity Required at 64,000 m3/d			Capacity Required at 73,300 m3/d			Expansion required?
Equipment Capacity	**Description**	**Unit**	**max loading**	**average loading**	**compliance loading**	**max loading**	**average loading**	**compliance loading**	**(Excludes scheduled expansion)**
Raw Sludge									
Installed, Operating & Firm	Raw Sludge Pumps	m^3/d	768	652	466	826	746	524	No
Primary Digestion									
Installed & Operating	Primary digestion HRT at 7,320 m^3 capacity	days	9.0	10.6	14.8	8.4	9.2	13.2	Possibly: MOE guidelines require min. 15 day HRT in primary digesters
Firm	Primary digestion HRT at 4,880 m^3 capacity[1]	days	6.0	7.1	9.9	5.6	6.2	8.8	
Secondary Digestion									
Installed	Secondary digestion HRT at 2,350 m^3 capacity	days	2.9	3.4	4.8	2.7	3.0	4.2	No: Secondary digester operation is not a requirement, but a site specific objective
Operating	Secondary digestion HRT at 1,774 m^3 capacity	days	2.2	2.5	3.5	2.0	2.2	3.1	
Firm	Secondary digestion HRT at 0 m^3 capacity	days	0	0	0	0	0	0	
Dewatering (based on 5-day week)									
Operating	BFP run time at 19.2 L/s	hrs	16.5	14.0	10.0	17.7	16.0	11.3	Possibly: depends on preferred staffing, near continuous 5-day operation is required based on current firm capacity
Firm	BFP run time at 12.9 L/s	hrs	24.6	20.8	14.9	26.4	23.9	16.7	
	Auxiliary BFP Equipment								Capacity is sufficient for current installed equipment
	Polymer system								Capacity is sufficient for current installed equipment
Composting – Total									
Installed	Total HRT at 4,500 m^3	days	31.1	36.7	51.3	29.0	32.0	45.6	No, amount of stabilization required is dependent on utilization method selected. Additional stabilization and curing could be achieved by outdoor storage if necessary.
Operating	Total HRT at 3,750 m^3	days	25.9	30.6	42.7	24.1	26.7	38.0	
Firm	Total HRT at 2,500 m^3	days	17.3	20.4	28.5	16.1	17.8	25.4	
	Compost Material Handling Systems								Upgrades to compost outfeed devices required to improve reliability
	Amendment Material Handling Systems								Capacity is sufficient for current installed equipment
	Screen System								Unknown

Table 6-4 identifies solids unit processes which are approaching or exceeding their firm capacity and require review, if the current solids handling methods are to be maintained. The review would include upstream unit process changes or downstream unit processes that could increase the firm capacity of the units, and assess the impact on downstream unit processes from re-rating of the firm capacity of the process.

- Primary Digestion: The HRT of the primary digestion facility, at current organic loading rates, is equal to the MOE guideline HRT of 15 days with three primary digesters in service. As solids production increases with increasing raw wastewater flows, the capacity of the primary digesters would require expansion to maintain the MOE guideline of an HRT of 15-daysto provide adequate stabilization of volatile organic matter.

  However, the requirement for additional digestion depends on the ultimate biosolids management strategy selected as some options may not necessarily require a 15-day HRT or any digestion. For example, composting provides stabilization and could handle undigested solids. Additionally, improvements to upstream unit processes may increase the solids content of digester feed, thereby increasing the HRT in the digesters.

- Dewatering: While no capacity expansion is necessary for the dewatering equipment, assuming that the equipment can be operated for longer period during the day or over an extended work-day week, two of the belt filter presses are old and in poor condition. A recent inspection by the manufacturer’s service technician stated that the units would require replacement within 2 years due to age and condition.

  The type of dewatering equipment best suited for the WWTP will be related to their overall biosolids management plan adopted by the City. If the decision is made to continue with dewatering by belt presses, it may be beneficial to replace the belt presses with larger units than those which are currently in place to reduce the amount of time the dewatering facility will be in operation over the planning period.

- The composting facility provides high rate aerobic stabilization of volatile solids, producing compost from woodchips and dewatered biosolids. Based on the average data over the 1998 to 2000 period, the composting facility had an estimated HRT of 39.8 days with all three reactors in operation in steady state conditions. The firm capacity of the facility has been established as two reactor units in service. Under this scenario, based on the average data over the 1998 to 2000 period, the composting facility had an estimated HRT of 26.5 days.

  As influent flows to the WWTP increase, the corresponding solids loading to the compost facility will increase, thereby decreasing the in-vessel HRT and increasing the operational time to process the materials. Literature suggests that an in-vessel HRT of 28 days is sufficient to produce a stable compost, however, the actual HRT required will depend on the quantity of volatile solids processed in the facility, with a sludge partially stabilized through anaerobic digestion requiring less in-vessel HRT. Furthermore, the degree of stability required depends on the final use of the compost product; compost used as a cover at a landfill does not require the degree of stability as compost packaged in bag form. The City landfill is anticipated to close operations in 2003 and no sites have yet been identified for a new City landfill.

  Based on current and projected uses of the compost it is not anticipated that expansion of the compost facility would be required to provide additional HRT in the planning horizon under average and compliance conditions. Under the maximum industrial loading scenario, the composting facility will have a 17.3 day and 16.1 day firm HRT at the 64 MLD and 73.3 MLD planning horizon respectively. Generally a minimum HRT of 14 days is recommended for the type of in-vessel composting system in use at the plant to achieve proper conditioning and to establish high rate composting conditions and temperatures reflective of a high rate stabilization process. A further 14 to 20 days is required in the cure reactor or approximately 60 days for static curing.

Additional HRT, if required, may be achieved through a higher solids content in the dewatering process as this process input dramatically affects the quantity of recycle and woodchips required. Furthermore, if additional product stability is required, it is possible to accomplish this outside of the reactor vessels by storage of the compost in windrows.

The reliability of the compost facility is compromised by the frequent repairs necessary to the drive assembly of the reactor outfeed devices. Staff at the WWTP have made some improvements through modifications and have developed additional modification concepts to further improve reliability. It is suggested that the design and operation of these devices be reviewed in detail with a manufacturer or firm specializing in the design of this type of equipment.

7 Evaluation of Existing Solids Management Costs

In order to determine the costs of solids handling at Guelph WWTP, the City provided all available data from the past three (3) years. The method of accounting used to record the costs was changed in 1999 so that the actual costs of each process could be more accurately tracked. Therefore, the cost estimates from 1999 and 2000 are likely to more accurately reflect the actual costs of solids handling at the Guelph WWTP.

Table 7-1 shows the estimated quantity of solids handled by each unit process from 1998 to 2000 based on the method described in Section 6.

Table 7-1: Estimated Quantity of Solids Processed at Guelph WWTP

Solids Processing (dry tonnes/year)	1998	1999	2000
Total Dewatered Cake Produced (dt/d at 18% TS)	9.0	8.1	8.1
Total Dewatered Cake Produced (dt/y at 18% TS)	**3,298**	**2,968**	**2,963**
Dewatered Cake to Landfill (dt/y)	52	0	0
Dewatered Cake to Land Application (dt/y)	616	1,830	1,369
Dewatered Cake to Composting (dt/y)	2,630	1,138	1,594

The estimated quantity of solids data was taken from the dewatered cake production, calculated from the plant data, as discussed previously. The dewatered cake to landfill and land application was taken from the plant recorded data, and summarized in the annual reports to the MOE. The dewatered cake composted was calculated as the difference between the total and that landfilled and land applied.

7.1 Digestion

As the WWTP does not have data specific to digestion, the cost of digestion was determined by estimating electrical consumption, and annualized costs for digester clean-out and equipment maintenance. No costs were included for digester gas processing / utilization. A summary of estimated costs of digestion is shown in Table 7-2. The assumptions used are shown in Table 7-3.

Table 7-2: Annual Costs of Digestion

	1998	1999	2000
Electricity	$41,279	$42,311	$43,369
Labour	$20,845	$21,366	$21,900
Maintenance & Repairs	$25,080	$25,707	$26,350
Total	**$87,204**	**$89,384**	**$91,619**
Solids Produced (dry tonnes/year)	3,298	2,968	2,963
Cost Per Dry Tonne Produced	**$26**	**$30**	**$31**

Table 7-3: Digestion Cost Assumptions

Assumptions:							
Labour: 1.5 man hrs/day @ $40/hr							
Electricity (2000 $)							
	Number of units	Total kW	$/kWh	hrs	service factor	$/day	$/yr
Primary Sludge Mixers	12	67.2	0.08	24	0.75	$96.77	$35,320
Recirc. Pump	3	11.25	0.08	24	0.75	$16.20	$5,913
Raw Sludge Pumps	6	22.5	0.08	4	0.75	$5.40	$1,971
Sludge Transfer Pump	1	3.75	0.08	2	0.75	$0.45	$164
Maintenance & Repairs (2000 $)							
	Number	Cap. Cost	Life	$/yr			
Heat Exchanger	3	$40,000	20	$6,000			
Digester Cleanout	0.8	$20,000	1	$16,000			
Recirc. Pump	3	$12,000	10	$3,600			
Sludge Transfer Pump	1	$15,000	20	$750			
Inflation	2.5 %						

7.2 Dewatering

For the years 1998 to 2000, the WWTP provided costs specific to the dewatering facility. Electrical consumption costs were not included in the historical data, and were therefore estimated by determining the dewatering facility electrical consumption and using an assumed cost of $0.08/kWh. A summary of costs of dewatering is shown in Table 7-4. Assumptions are shown in Table 7-5.

Table 7-4: Annual Operating Costs of Dewatering

	1998	1999	2000
Regular Wages	$30,042	$31,277	$48,779
Hourly Overtime	$24,505	$23,617	$20,028
Fringe Benefits	$24,155	$23,604	$29,570
Electricity	$47,229	$48,410	$49,620
Electrical Supplies	$0	$1,117	$6,600
Other Operating Supplies	$7,893	$6,767	$4,689
Parts	$5,112	$19,567	$56,310
Pumps	$0	$0	$5,547
Polymer	$123,781	$152,084	$163,163
Sodium Hypochlorite	$0	$500	$0
Air Compressors	$0	$411	$379
Equipment Repairs & Maintenance	$1,457	$40,950	$25,945
Other Material & Supplies	$0	$874	$313
Equipment & Operator	$0	$303	$10
Other Professional Services	$0	$0	$13
Other Purchased Services	$0	$950	$0
Total	$264,175	$350,432	$410,965
Cake Produced (dry tonnes/year)	3,298	2,968	2,963
Cost of Dewatering ($/Dry Tonne Cake Produced)	**$80**	**$118**	**$139**

Table 7-5: Dewatering Operating Cost Assumptions

Assumptions:					
% Capture of BFP = 88%					
1996 - all solids composted					
Electricity (2000 $)	Number of units	Total kW	$/kWh	service factor	$/yr
Belt Filter Presses 1&2	2	9	0.08	0.5	$3,154
Belt Filter Presses 3&4	2	8.25	0.08	0.5	$2,891
Exhaust Fan (2)	1	0.55	0.08	0.5	$193
Exhaust Fan (5,6,7&8)	4	1.5	0.08	0.5	$526
Polymer Mixer	2	1.5	0.08	0.5	$526
Air Compressor	1	11	0.08	0.5	$3,854
Sludge Feed Pumps 1&2	2	7.5	0.08	0.5	$2,628
Sludge Feed Pumps 3&4	2	11	0.08	0.5	$3,854
Filtrate Sump Pump 1&2	2	4.4	0.08	0.5	$1,542
Filtrate Sump Pump 3	1	4	0.08	0.5	$1,402
Strainer	1	1.1	0.08	0.5	$385
Backwash Valve	1	0.75	0.08	0.5	$263
Supply Fan (1)	1	1.5	0.08	0.5	$526
Supply Fan (4,5,6&7)	4	1.5	0.08	0.5	$526
Cross Screw Conveyor	1	2.2	0.08	0.5	$771
Lift Screw Conveyor	1	2.2	0.08	0.5	$771
Horizontal Screw Conveyor (1)	1	2.2	0.08	0.5	$771
Horizontal Screw Conveyor (2)	1	3.75	0.08	0.5	$1,314
Filtrate Feed Pump 1&2	2	44	0.08	0.5	$15,418
Unit Heater	5	25	0.08	0.5	$8,760
Drainage Sump Pump	1	0.75	0.08	0.5	$263

7.3 Composting

For the years 1998 to 2000, the WWTP provided costs specific to the composting facility. Electrical consumption was determined by records from Guelph Hydro for the meter located in the composting building for the year 2000, and the cost was estimated, based on $0.08/kWh. The estimated cost for 2000 was discounted at a rate of 3% annually. A summary of costs of composting is shown in Table 7-6.

Table 7-6: Annual Costs of Composting

	1998	1999	2000
Regular Wages	$55,358	$51,080	$51,631
Seasonal Wages	$0	$0	$0
Part-time Wages	$0	$0	$0
Hourly Overtime	$11,627	$7,344	$12,811
Fringe Benefits	$30,003	$25,122	$27,692
Electricity (1998 & 1999 estimated from 2000 data)	$31,376	$33,286	$34,285
Oil	$0	$633	$3,565
Lubricants	$0	$3,359	$535
Small Tools & Equipment	$0	$1,642	$1,233
Fuel	$213	$0	$0
Plumbing Supplies	$0	$3,548	$0
Electrical Supplies	$0	$12,721	$16,935
Other Operating Supplies	$238	$760	$0
Parts	$0	$42,882	$26,875
Wood Chips	$144,332	$121,069	$234,903
Tipping Fees	$17,739	$407	$0
Contracted Repairs & Maintenance	$59,611	$39,262	$0
Equipment	$27,431	$10,040	$19,093
Equipment & Operator	$62,067	$57,465	$52,381
Other Supplies, Repairs & Maintenance	$0	$71,219	$80,487
Total	$439,995	$481,839	$562,426
Dry Tonnes of Solids Composted	2,630	1,138	1,594
Cost of Composting per Dry Tonne Composted	**$167**	**$423**	**$353**

7.4 Land Application

The costs of the land application program have been documented by the WWTP for the past 3 years. A summary of costs of the land application program is shown in Table 7-7.

Table 7-7: Annual Costs of Land Application

	1998	1999	2000
Weight to Land Application (Wet Tonnes)	3,104	9,148	6,665
Estimated Weight to Land Application (Dry Tonnes)	616	1,830	1,369
Average Transport Rate/Wet Tonne	$8.05	$9.00	$9.00
Cost of Transport	$24,987	$82,332	$59,985
Land Apply Rate/Wet Tonne	$10.60	$10.60	$10.60
Cost of Land Application	$32,902	$96,969	$70,649
Total Cost of Land Application	**$57,890**	**$179,301**	**$130,634**
Cost per Dry Tonne Land Applied	**$94**	**$98**	**$95**

7.5 Landfilling

In January and February of 1998, a total of 52 dry tonnes of biosolids was directly landfilled.

Compost is used as daily cover at the local landfill. The costs of landfilling have been documented by the WWTP for the past 3 years. A summary of costs of landfilling is shown in Table 7-8.

It should be noted that compost, to date, which has been used as landfill cover at the City's Eastview landfill and has not been subject to tipping fees. However, this landfill is scheduled to be closed in 2003 and after this the compost material would likely be subject to increased transportation costs and market tipping fees.

Table 7-8: Annual Costs of Landfilling

	1998	1999	2000
Weight to Landfill (dry tonnes biosolids)	2,682	1,138	1,594
Transport Cost	$58,340	$41,966	$66,100
Tipping Fee	$0	$0	$0
Total Cost of Landfilling	**$58,340**	**$41,966**	**$66,100**
Cost per Tonne Landfilled	**$22**	**$37**	**$41**

7.6 Summary of Costs

A summary of the total solids handling costs for the Guelph WWTP is shown in Table 7-9.

Table 7-9: Summary of Annual Costs

	1998	1999	2000
Digestion	$87,204	$89,384	$91,619
Dewatering	$264,175	$350,432	$410,965
Composting	$439,995	$481,839	$562,426
Land Application	$57,890	$179,301	$130,634
Landfilling	$58,340	$41,966	$66,100
Total Solids Handling Cost	$907,604	$1,142,922	$1,261,744
Total dry tonnes produced	**3,298**	**2,968**	**2,963**
Total cost per dry tonne	$275	$385	$426

It should be noted that the accounted method used to record costs was modified by the City in early 1999, and the costs shown for 1999 and 2000 more accurately reflect the actual solids handling costs than previously recorded data.

Attachment A: Project Initiation Workshop Meeting Summary

City of Guelph Biosolids Management Plan, Task 1

ATTENDEES:

Terry Hearn	City of Guelph
Wayne Key	City of Guelph
Ron Turner	City of Guelph
Trevor Barton	City of Guelph
Bob Hook	CG&S
Peter Burrowes	CG&S
Warren Saint	CG&S
Sally Baldwin	CG&S

FROM: Sally Baldwin

DATE: October 12, 2000

Please advise the writer of any errors or omissions within one week of the date of issue of this meeting summary.

The City of Guelph Biosolids Management Plan project initiation and chartering meeting was held in the City's Engineering Department meeting room on October 11 at 2pm.

1. Introductions and Expectations

As not all the attendees had previously met, introductions and project expectations were made by each party. The project expectations are:

- To meet the City's objectives in a co-operative manner
- To find a beneficial use for the biosolids compost
- To find a direction which will meet everyone's needs
- To address current and future needs for biosolids and the City
- To formulate a plan which meets the City's biosolids and residuals issues whilst also meeting government standards and public scrutiny
- To use the wet/dry facility's experiences as a resource

2. Overview of Project

An overview of the project was given by Bob Hook and the major tasks and work plan were agreed upon by the City. The major tasks are:

- Task 1 - Management Plan Definition
- Task 2 - Compost Utilization
- Task 3 - Compost Process Optimization
- Task 4 - Biosolids Management options
- Task 5 - Biosolids Management Plan

3. Roles and Responsibilities

The project roles and responsibilities of the City and CG&S staff were agreed upon as:

CG&S

- Bob Hook - Project Director
- Peter Burrowes - Project Manager
- Warren Saint - Senior Project Engineer
- Sally Baldwin - Junior Project Engineer

City of Guelph

- Terry Hearn - Project Director
- Wayne Key - Assistant Project Director
- Ron Turner - Project Manager
- Rob Latford - Project Assistant
- Trevor Barton - Project Support

4. Critical Success Factors

The attendees agreed upon the project's critical success factors, which were determined as:

- Providing value (Capital and O&M)
- Completing the project within budget and on schedule
- Ensuring the solutions are forward looking
- Ensuring the solutions are integrated with the WWTP processes
- Ensuring the project is consistent with the community's values and environmental focus
- Meeting or exceeding regulatory requirements, including the EA
- Endorsed, as the preferred approach, by the public and other stakeholders
- Completion with an enthusiastic, co-operative, communicative, interactive team approach

5. Wet/Dry Experience

Trevor Barton, marketing manager at the City's wet/dry facility, gave the project team a summary of the wet/dry facility's composting management experiences:

Marketing

A market analysis for the wet/dry facility's compost was completed in 1995. Compost is generated in 1000 cubic yard (cu yd) batches and sold to three core buyers (soil blenders, landscapers [including City Parks & Rec.] and large scale gardeners) for $12/cu yd excluding PST and GST. The maximum workable travel distance for bulk sales is approximately 60 km. The compost is not currently marketed to golf courses or bagged due to the small glass fractions and C:N variablity. The facility is planning on introducing grinding to alleviate this problem. The sale cost of a bagged material is approximately equivalent to $250/ton. The bulk of compost is sold primarily in January and February as blenders gear-up production for the spring market, which begins May 24th.

Compost Production

The final product is 6 months old (from reception on tipping floor to stable and saleable). It is stored outside on a concrete pad, which has a total capacity for 2000 cu yds of material. The concrete pad also holds the bulking materials of suitable yard waste and purchased wood chips. The facility recieves some bedding material from U of G and is considering using stomach paunchresiduals from Better Beef due to it's relatively high carbon valve.

Regulatory Issues
Each batch of compost, both in channel and after screening, is sampled to ensure it meets the regulatory requirements. Wastewater streams discharged to the sewers are also sampled to ensure they do not exceed the sewer-use by-law regulations. The Wet/Dry facility is prohibited from blending with sewage biosolids by their C of A.

Trevor is optimistic about finding a market for the WWTP's compost and suggested discussing possible demonstration projects with his industry and University of Guelph contacts, and exploring possible environmental grants to help off-set the costs of the project.

6. Project Scope and Schedule

Peter Burrowes outlined CG&S's suggested project scope, which was agreed upon by the City. The phased approach will allow decisions to be made as each Task proceeds and the decisions will allow the direction of the management plan to develop.

The schedule was determined as:

- Task 1 - to be completed by December 31, 2000.
- Task 2 - to be completed by April 30, 2001. This date may not include the completion of demonstration projects which may occur with this task.
- Task 3 - to be completed no later than December 31, 2001.

The schedule will be further refined as the phased approach as decisions determine the project direction.

7. Project Administration

Correspondence
The City will send e-mail to Peter, and copy all to Warren

CG&S will send e-mail to Ron, copy to Wayne and Trevor as appropriate, and copy to Terry if concerning budget or schedule. Ron will forward correspondence to Terry as necessary.

Reporting
CG&S reporting and invoicing will be the same method and procedures to the City as for the current Plant 4 project.

Change Management
The change management process will be the same as that used for Plant 4.

8. Project Statement

The project will result in:

A long-term biosolids management plan that provides value, is endorsed by the public and other stakeholders, and meets or exceeds regulatory requirements.

9. Next Steps

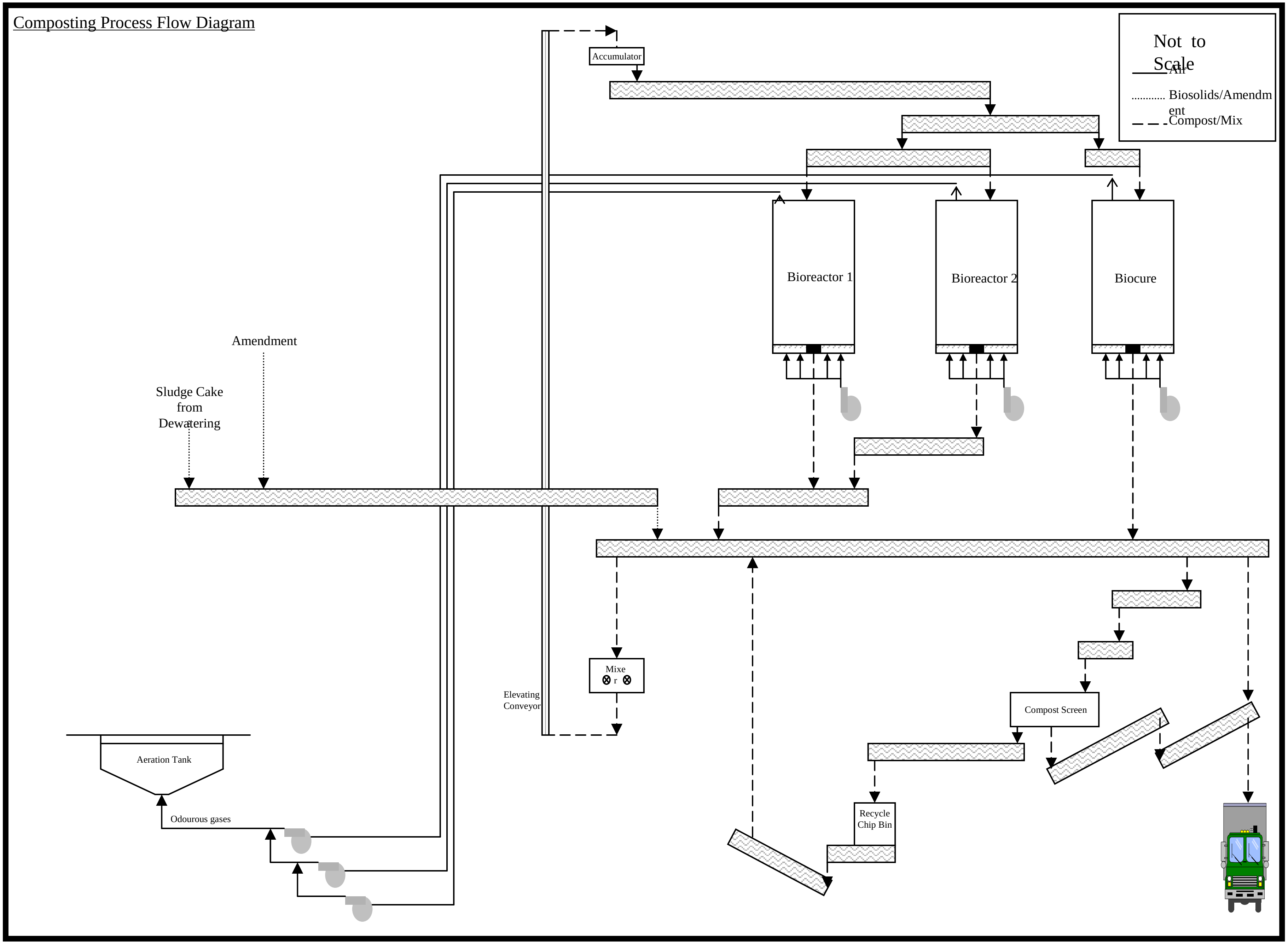
Task 1 Initial Tasks and Responsibilities:

What?	By Whom?	To Who?	By When?
WWTP compost quality data	Wayne	Trevor & Warren	Oct. 16
Plant data (including costs) for past 5 years	Ron	Warren	Oct 31
Initial contacts with industry and UofG	Trevor		Nov. 7th
Stockpile compost (2 loads unscreened, 2 loads screened)	Ron		

Next Meetings and Required Participants:

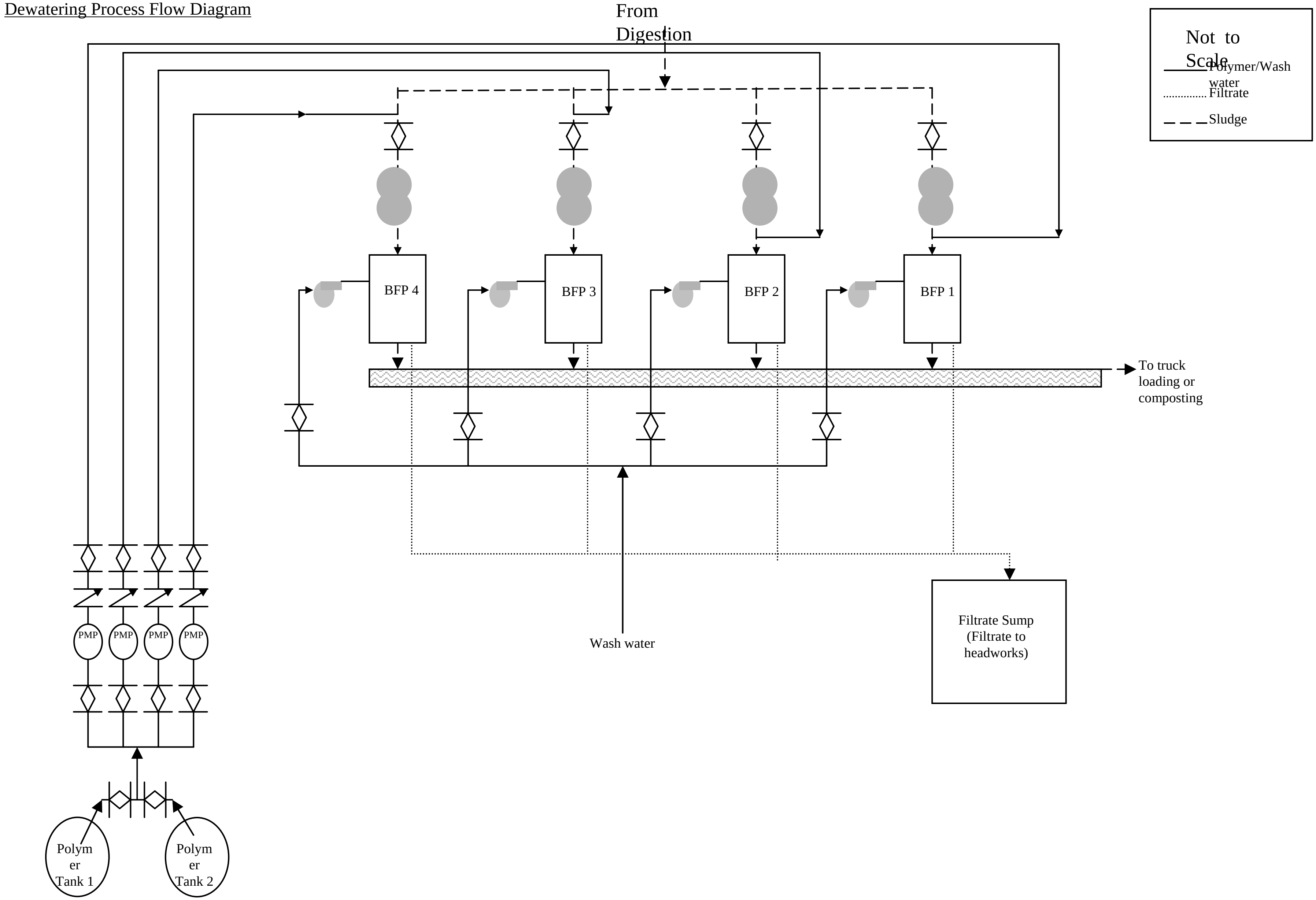
- Tuesday 7th November at WWTP - Wayne, Ron, Trevor, Peter, Warren
- Week of November 21-24th - Terry, Wayne, Ron, Peter, Warren. Date and location to be confirmed by Ron. Project progress meeting to review draft Technical Memorandum for Task 1.

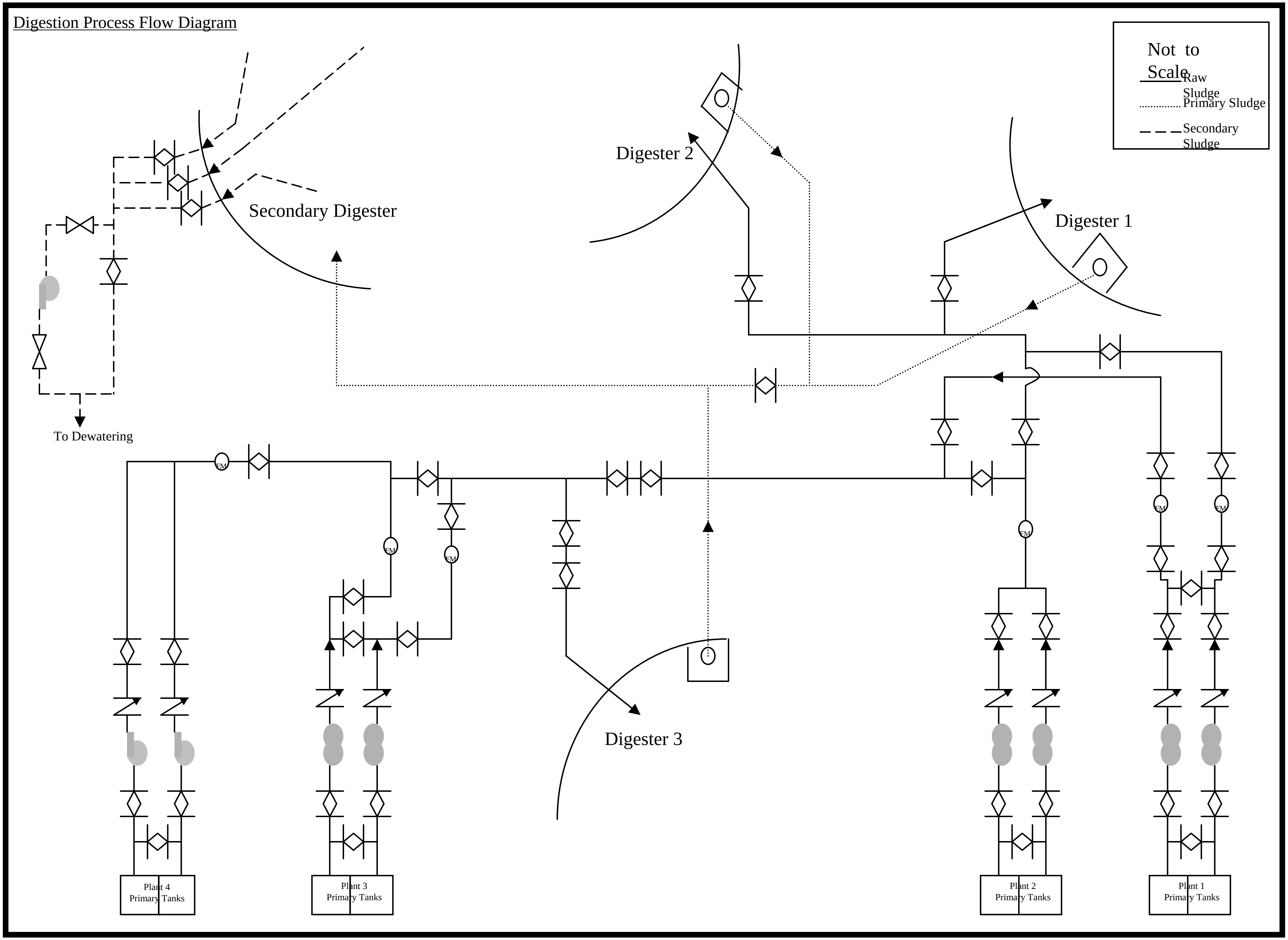
Attachment B: Process Flow Diagrams



Composting Process Flow Diagram
Not to Scale
Air
Biosolids/Amendment
Compost/Mix
Accumulator
Bioreactor 1
Bioreactor 2
Biocure
Amendment
Sludge Cake from Dewatering
Mixer
Elevating Conveyor
Compost Screen
Aeration Tank
Odourous gases
Recycle Chip Bin

Dewatering Process Flow Diagram





Digestion Process Flow Diagram
Not to Scale
Raw Sludge
Primary Sludge
Secondary Sludge
Secondary Digester
Digester 2
Digester 1
Digester 3
To Dewatering
FM
Plant 4 Primary Tanks
Plant 3 Primary Tanks
Plant 2 Primary Tanks
Plant 1 Primary Tanks

Attachment C: Solids Handling Equipment List

	Units				
Raw Sludge					
Raw Sludge Pumps		**Plant 1**	**Plant 2**	**Plant 3**	**Plant 4**
Date Installed		1998	2001	1980	2002
Number		2	2	2	2
		P1-RSP-101	P2-RSP-103	P3-RSP-105	4-PS-111 4-
Tag Number		P1-RSP-102	P2-RSP-104	P3-RSP-106	PS-121
Type		Double Disc	Rotary Lobe	Double Disc	Centrifugal
Tag Number					
Capacity - each	L/s	5	5	5	5
Installed Capacity	L/s	10	10	10	10
at TDH	m	15.2			
Total Firm Capacity	L/s	35			
Condition		Satisfactory	Satisfactory	Req.'s Replac'nt	
Reliability		Satisfactory	Satisfactory	Poor	
Digestion					
Anaerobic Digesters		**Primary (1, 2 & 3)**		**Secondary (4)**	
Date Installed		1958, 1968 (#3)		1968	
Number		3		1	
Type		Circular with fixed roof		Circular with fixed roof	
Diameter - each	m	19.88		19.88	
Side Wall Depth - each	m	7.92		7.62	
Capacity - each	m3	2440		2350	
Installed Capacity	m3	7320		2350	
Total Firm Capacity					
Condition	Satisfactory	Recond. 1995, 1998(#3)		Recond. 1995	
Sludge Recirculation Pumps		**Digesters 1 & 2**		**Digesters 3 & 4**	
Date Installed		1998		1968	
Number		2		2	
Tag Number		D2-SRP-419	D2-SRP-420	D3-SRP-422	D3-SRP-423
Type		Horizontal/Centrifugal		Horizontal/Centrifugal	
Tag Number					
Capacity - each	L/s	25.2		19.4	
Installed Capacity	L/s	50.4		38.8	
at TDH	m	6.1			
Total Firm Capacity	L/s	64			
Condition		Good		Good	
Reliability		Good		Good	
Sludge Heat Exchangers		**Digesters 1 & 2**		**Digester 3**	
Date Installed		1998		1968	
Number		2		1	
Tag Number		D2-SHX-424	D2-SHX-425	D3-SHX-426	
Type		Alfa Laval Spiral		Napier Shell & Tube	
Tag Number					
Capacity - each	MBTU/hr	1.5		1	
Installed Capacity	MBTU/hr	3		1	
Condition		Satisfactory		Req.'s Replac'nt	
Reliability		Req.'s Replac'nt		Satisfactory	

Sludge Transfer Pumps		**Digesters 1 & 2**	**Digesters 3 & 4**
Date Installed		1958	1968
Number		1	1
Tag Number		D2-STP-417	D2-STP-421
Type		Horizontal/Centrifugal	Horizontal/Centrifugal
Tag Number			
Capacity - each	L/s	18.9	15.8
Installed Capacity	L/s	18.9	15.8
at TDH	m	10.7	11.6
Firm Capacity	L/s	0	0
Condition		Req.'s Replac'nt	Satisfactory
Reliability		Satisfactory	Satisfactory

Mechanical Mixers on Primary Digesters 1, 2 and 3				
Number (each digester)	1 centre, 3 peripheral			
Date Installed		1995	1995	1998
Tag Number		*Digester 1*	*Digester 2*	*Digester 3*
	Centre	D1-MX-401	D2-MX-405	D3-MX-409
	Peripheral	D1-MX-402	D2-MX-406	D3-MX-410
	Peripheral	D1-MX-403	D2-MX-407	D3-MX-411
	Peripheral	D1-MX-404	D2-MX-408	D3-MX-412
Rating, each mixer	7.5	kW		
Tank Turnover Rate	30-45	minutes		
Condition		Satisfactory	Satisfactory	Satisfactory
Reliability		Satisfactory	Satisfactory	Satisfactory

Dewatering

Belt Filter Press		**Press 1**	**Press 2**	**Press 3**	**Press 4**
Date Installed		1983	1983	1992	1992
Number		1	1	1	1
Manufacturer		K-S	K-S	Pheonix	Pheonix
Tag Number		M-041	M-042	M-043	M-044
Belt Width	m	2	2	2.5	2.5
Installed Capacity	L/s	7.5	7.5	9.5	9.5
Operating Capacity	L/s	3.3	3.3	6.3	6.3
Condition		Req Rplcmnt	Req Rplcmnt	Satisfactory	Satisfactory
Reliability		Poor	Poor	Satisfactory	Satisfactory

Sludge Feed Pumps		**Press 1**	**Press 2**	**Presses 3 & 4**	
Date Installed		1999	1983	1992	1992
Number		1	1	1	1
Type		Diaphragm	Lobe	Diaphragm	(all variable speed)
Tag Number		M-031	M-032	M-033	M-034
Capacity- each	L/s	9.5	9.5	9.5	9.5
Installed Capacity	L/s	9.5	9.5	9.5	9.5
Total Firm Capacity	L/s	28.5			
Condition		Satisfactory	Req Rplcmnt	Satisfactory	Satisfactory
Reliability		Satisfactory	Satisfactory	Satisfactory	Satisfactory
Notes:		VFD's req. replacement, controls require upgrading			

Washwater Feed Pumps			
Date Installed		1992	(not new equip.,unknown manufacture date
Number		2	
Type		Vertical Turbine	
Tag Number			
Capacity - each	L/s	25	
Installed Capacity	L/s	50	
Total Firm Capacity	L/s	25	
Condition		Require Replacement or Repair	
Reliability		Satisfactory	

Polyelectrolyte (Polymer) Pumps		**Press 1**	**Press 2**	**Press 3**	**Press 4**
Date Installed		1992	1992	1992	1992
Number		1	1	1	1
Type	All:	Progressing Cavity variable speed			
Tag Number		CP-004	CP-006		
Capacity - each	L/s	0.57	0.57	0.57	0.57
Firm Capacity	L/s	0	0	0	0
TDH	m	17.4			
Condition		Satisfactory	Satisfactory	Satisfactory	Satisfactory
Reliability		Satisfactory	Satisfactory	Satisfactory	Satisfactory
Notes:		Hot water flush required			

Polymer Mixing Tanks			
Date Installed		1983	
Number		2	
Tag Number of Mixers		M-004	M-006
Capacity - each	L	8,800	
Installed Capacity	L	17,600	
Diameter	m	2.5	
Depth	m	2.1	
Firm Capacity	L	8,800	
Condition	Mixers require replacement, System upgrading should be investgated		

Filtrate Sump Pumps					
Date Installed		From 1983 facility, relocated in 1992			
Number		1	1	1	
Type	All:	Submersible Centrifugal			
Tag Number					
Capacity - each	L/s				
Firm Capacity	L/s				
Discharge Size	mm	50	50	100	
Condition		Satisfactory	Satisfactory	Satisfactory	Satisfactory
Reliability		Satisfactory	Satisfactory	Satisfactory	Satisfactory
Notes:		Additional Pumping Capacity required			

Air Compressors:		
Date Installed		1992
Number		1
Tag Number		M-103
Type		Screw
Installed Capacity	m^3/min	1.87
Firm Capacity	m^3/min	0
Condition	Satisfactory	
Reliability	Satisfactory	
Notes:	Additional Capacity Required	

Composting

Compost Reactors		Bioreactor 1	Bioreactor 2	Biocure
Date Installed		1994	1994	1994
Number		1	1	1
Type	All:	cylindrical welded steel tank, concrete floor		
Tag Number		C-RT-510	C-RT-520	C-SC-564
Installed Capacity	m3	1500	1500	1500
Operating Capacity	m3	1250	1250	1250
Total Firm Capacity	m3	2500		
Condition		Satisfactory	Satisfactory	Satisfactory

Reactor Infeed		
Number		1 per reactor
Type		hydraulic slide gate and rotary distubuter
Hydraulic Drive	kW	11
Condition		Satisfactory
Reliability		Satisfactory

Reactor Outfeed		Bioreactor 1	Bioreactor 2	Biocure
Number		1	1	1
Type		variable speed, rotating, single screw with hydraulic and electric drives		

Tag Number		C-DS-516	C-DS-526	C-DS-536
Drives:				
outfeed screw rotation with VFD		56	kW	
rotary collector		4	kW	
hydraulic drive		4	kW	
Condition		Satisfactory	Satisfactory	Satisfactory
Reliability		Poor	Poor	Poor

Amendment Storage Silo

Date Installed		1994
Number		1
Type		cylindrical steel vessel, bolted construction, supported on concrete base
Tag Number		C-SA-341
Installed Capacity	m3	800
Condition		Satisfactory
Reliability		Satisfactory

Amendment Storage Silo Outfeed System

Number		1
Max. Outfeed Rate	m³/h	42
Outfeed Screw Drives:		
outfeed screw rotation	kW	37
outfeed screw advance	kW	0.75
Discharge Conveyor:		
screw conveyor diameter	mm	400
speed control		variable
drive	kW	6
Condition		Satisfactory
Reliability		Satisfactory

Amendment Storage Silo Baghouse

Date Installed		1994
Number		1
Type		enclosed, silo exhaust air filter
Tag Number		C-BH-342
Vent Fan	kW	4
Compressed Air Requirement:		
Flow	m³/h	8.8 - 27.2
Pressure	kPa	620 - 690
Condition		Satisfactory
Reliability		Satisfactory

Amendment Receiving Bin

Date Installed		1994
Number		1
Tag Number		C-HA-311
Installed Capacity	m³	12
Dischage Capacity using 4 screws:		
Flow	m³/h	0-12
Solids	kg/h	12,200
Discharge Screw Drives	kW (total)	22
Condition		Satisfactory
Reliability		Satisfactory

Hammermill

Date Installed		1994
Number		1
Tag Number		C-HM-331
Drive	kW	112
Installed Capacity	kg/h	12000
Condition		Satisfactory
Reliability		Satisfactory

Amendment Bin Transfer Fan

Date Installed		1994
Number		1
Tag Number		C-FA-332
Drive	kW	56
Installed Capacity	kg/h	12000
Condition		Satisfactory
Reliability		Satisfactory

Amendment Bin Transfer Conveyor

Date Installed		1994
Number		1
Tag Number		C-SSC-422
Size	400 mm diameter screw conveyor	
Drive	kW	6
Installed Capacity	kg/h	12200
Condition		Satisfactory
Reliability		Satisfactory

Sludge Bin

Date Installed		1994
Number		1
Tag Number		C-HS-411
Installed Capacity	m3	100
Discharge Capacity for 4 Screws:		
Flow	m^3/h	0 - 18
Solids	kg/h	72000
Discharge Screw Drives		2 @ 11 kW
Levelling Screw Drives		2 @ 4 kW
Condition		Satisfactory
Reliability		Satisfactory

Sludge Bin Feed Conveyor

Date Installed		1994
Number		1
Tag Number		C-SC-421
Size	350 mm diameter screw conveyors	
Drive	kW	6
Installed Capacity	m^3/h	20
Condition		Satisfactory
Reliability		Satisfactory

Sludge Transfer Conveyor

Date Installed		1994
Number		1
Tag Number		C-SC-422
Size	400 mm diameter screw conveyor	
Drive	kW	15
Installed Capacity	m^3/h	36
Condition		Satisfactory
Reliability		Satisfactory

Amendment/Sludge Transfer Conveyor

Date Installed		1994	
Number		1	
Tag Number		C-SC-351	
Size	450 mm diameter screw conveyor		
Drive	kW	19	
Installed Capacity	m³/h	75	
Condition		Satisfactory	
Reliability		Satisfactory	

Bio/Cure Reactor Transfer Conveyor

Date Installed		1994	
Number		1	
Tag Number		C-SC-552A&B	
Size	2 @ 600 mm diameter screw conveyor		
Drive	2 x 19 kW, reversing		
Installed Capacity	m³/h	150	
Condition		Satisfactory	(drop zone wear from SC-550 discharge)
Reliability		Satisfactory	

Bio Reactor No. 2 Transfer Conveyor

Date Installed		1994	
Number		1	
Tag Number		C-SC-551	
Size	600 mm diameter screw conveyor		
Drive	kW	19	
Installed Capacity	m³/h	135	
Condition		Satisfactory	
Reliability		Satisfactory	

Bio Reactor No. 1 Transfer Conveyor

Date Installed			
Number		1	
Tag Number		C-SC-500	
Size	600 mm diameter screw conveyor		
Drive	kW	19	
Installed Capacity	m³/h	135	
Condition		Satisfactory	(drop zone wear from SC-551 discharge)
Reliability		Satisfactory	

Mixer

Date Installed			
Number		1	
Tag Number		C-MX-571	
Type	twin paddle		
Size	2 x 22 kW		
Installed Capacity	kg/h	110000	
Condition		Satisfactory	
Reliability		Satisfactory	(Pluggage rate is high)

Elevating Conveyor

Date Installed		1994	
Number	1		
Tag Number		C-EC-554	
Type	sandwich belt		
Drive	2 x 19 kW		
Installed Capacity	m³/h	150	
Condition		Satisfactory	(Belts require replacement)
Reliability		Satisfactory	

Accumulator

Date Installed	1994	
Number	1	
Tag Number	C-AR-561	
Type	two 300 mm diameter screws	
Drive	11 kW	
Installed Capacity	m³/h 20	
Condition	Satisfactory	
Reliability	Satisfactory	

Bio/Cure Reactor Fill Conveyor

Date Installed	1994	
Number	1	
Tag Number	C-SC-562	
Type	600 mm diameter screw conveyor	
Drive	19 kW, reversing	
Installed Capacity	m³/h 150	
Condition	Satisfactory	(Stress cracks on motor mounting plates)
Reliability	Satisfactory	

Bio Reactor Fill Conveyor

Date Installed	1994	
Number	1	
Tag Number	C-SC-563	
Type	600 mm diameter screw conveyor	
Drive	19 kW, reversing	
Installed Capacity	m³/h 150	
Condition	Satisfactory	(Stress cracks on motor mounting plates)
Reliability	Satisfactory	

Cure Reactor Fill Conveyor

Date Installed	1994	
Number	1	
Tag Number	C-SC-564	
Type	600 mm diameter screw conveyor	
Drive	kW 11	
Installed Capacity	m³/h 150	
Condition	Satisfactory	
Reliability	Satisfactory	

Final Discharge Conveyor

Date Installed	1994	
Number	1	
Tag Number	C-SC-553	
Type	600 mm diameter screw conveyor	
Drive	kW 19	
Installed Capacity	m³/h 150	
Condition	Satisfactory	(drop zone wear from SC-552 discharge,
Reliability	Satisfactory	gearbox requires replacement)

Compost Screen

Date Installed	1994	
Number	1	
Tag Number	C-SN-621	
Type	flexible perforated mat over 16 agitator assemblies	
Drive	two, 6 kW motors with VFDs	
Installed Capacity	m³/h 42.8	
	(25,400 kg/h at bulk density of 593 kg/m³)	
Condition	Satisfactory	
Reliability	Unknown	

Screen Infeed Conveyor

Date Installed		1994	
Number		No. 1	No. 2
Tag Number		C-SC-610	
Size	400 mm diameter screw conveyor		
Drive	kW	6	6
Installed Capacity	m³/h	21.5	21.5
Installed Firm Capacity	m³/h	0	0
Condition		Satisfactory	
Reliability		Unknown	

Fines Transfer Conveyor

Date Installed		1994
Number		1
Tag Number		C-SC-632
Size	400 mm diameter screw conveyor	
Drive	kW	6
Installed Capacity	m³/h	25
Installed Firm Capacity	m³/h	0
Condition		Satisfactory
Reliability		Unknown

Recycle Chip (Oversize Woodchips) Transfer Conveyor

Date Installed		1994
Number		1
Tag Number		C-SC-641 / C-SC-642 / C-SC-643
Size	400 mm diameter screw conveyor	
Drive	kW	7.5
Installed Capacity	m³/h	25
Installed Firm Capacity	m³/h	0
Condition		Satisfactory
Reliability		Unknown

Recycle Chip Bin

Date Installed		1994
Number		1
Tag Number		C-SB-651
Installed Capacity	m³/h	50
Installed Firm Capacity	m³/h	0
Operating Capacity		
Discharge Capacity:	m³/h	0 to 20
Flow	kg/h	10,000
Solids		
Drives:		
Spreader screw	kW	4
Levelling screw	kW	2
Discharge Screw Drive	11 kW hydraulic power pack with 6 kW VFD	
Condition		Satisfactory
Reliability		Unknown

Recycle Chip Bin Discharge Conveyor

Date Installed		1994
Number		1
Tag Number		C-SC-656
Size	400 mm diameter screw conveyor	
Drive	kW	7.5
Installed Capacity	m³/h	30
Installed Firm Capacity	m³/h	0
Condition		Satisfactory
Reliability		Unknown

Aeration Blowers		Bioreactor 1	Bioreactor 2	Biocure	Standby
Date Installed		1994	1994	1994	1994
Number		1	1	1	1
Tag Number		C-AB-721	C-AB-722	C-AB-723	C-AB-724
Type	rotary lobe, positive displacement				
	85 m³/min, 125 Hp each				
Installed Capacity	m³/min	340			
Installed Firm Capacity	m³/min	255			
Operating Capacity	m³/min				
Inlet Filter	dry, washable, synthetic media type filter with 98% capture efficiency at 10 micron and above particle size				
Condition		Satisfactory	Satisfactory	Satisfactory	Req. Repair
Reliability		Satisfactory	Satisfactory	Satisfactory	Satisfactory

Exhaust Blowers		Bioreactor 1	Bioreactor 2	Biocure	Standby
Date Installed		2000	Rebuilt 1996	Rebuilt 1999	Rebuilt 1996
Number		1	1	1	1
Tag Number		C-EB-741	C-EB-742	C-EB-743	C-EB-744
Type	eight-stage, centrifugal				
Drive	kW	187			
Installed Capacity	m³/min	440			
Installed Firm Capacity	m³/min	330			
Condition		Satisfactory	Satisfactory	Satisfactory	Satisfactory
Reliability		Satisfactory	Satisfactory	Satisfactory	Satisfactory

Attachment D: Pro2D Summary Spreadsheet

		Existing Conditions 1998	Existing Conditions 1999	Existing Conditions 2000	Stage I Expansion max load	Stage I Expansion ave. load	Stage I Expansion comp. load	Stage 2 Expansion max load	Stage 2 Expansion ave. load	Stage 2 Expansion comp. load	Design Stage 1 Expansion design. load	Design Stage 2 Expansion design. load
1 GENERAL												
1 Population												
					110,909	110,909	110,909					
1 Flow												
Average	m^3/d	49,414	50,430	56,202	64,000	64,000	64,000	73,300	73,300	73,300	64,000	73,300
Peak process flow (95%ile)	m^3/d	74,615	76,149	84,865	96,000	96,000	96,000	110,683	110,683	110,683	96,640	110,683
Peak instantaneous flow	m^3/d	98,492	100,517	112,022	128,000	128,000	128,000	146,102	146,102	146,102	127,565	146,102
1 Raw Sewage Characteristics												
Concentrations												
BOD	mg/L	249	237	182	240	223	151	226	223	148	200	200
SS	mg/L	346	280	226	364	284	205	339	284	201	275	275
TKN	mg/L	30	32	30	30	30	30	30	30	30	30	30
TP	mg/L	5.0	4.9	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Loadings												
BOD	kg/d	12,304	11,949	10,229	15,345	14,249	9,645	16,532	16,320	10,832	12,800	14,660
SS	kg/d	17,097	14,114	12,702	23,269	18,173	13,147	24,851	20,814	14,730	17,600	20,158
TKN	kg/d	1,482	1,602	1,686	1,920	1,920	1,920	2,199	2,199	2,199	1,920	2,199
TP	kg/d	247	248	281	320	320	320	367	367	367	320	367
1 Required Plant Effluent Quality												
Compliance Limits												
*April 1 to October 31 (**Summer**)*												
TOD	mg/L	30	30	30	30	30	30	30	30	30	30	30
SS	mg/L	12	12	12	12	12	12	12	12	12	12	12
TP	mg/L				0.4	0.4	0.3	0.4	0.4	0.4	0.4	0.4
*November 1 to March 31 (**Winter**)*												
BOD_5	mg/L	12	12	12	12	12	12	12	12	12	12	12
SS	mg/L	12	12	12	12	12	12	12	12	12	12	12
NH3-N	mg/L	6	6	6	6	6	6	6	6	6	6	6
TP	mg/L	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Design Objectives												
*April 1 to October 31 (**Summer**)*												
TOD	mg/L	22	22	22	15	15	15	15	15	15	15	15
SS	mg/L	8	8	8	7	7	10	7	7	7	7	7
TP	mg/L	0.50	0.50	0.50	0.3	0.3	0.7	0.3	0.3	0.3	0.3	0.3
Cl_2 Residual	mg/L	0.50	0.50	0.50	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
*November 1 to March 31 (**Winter**)*												
BOD_5	mg/L	8	8	8	5	5	5	5	5	5	5	5
SS	mg/L	8	8	8	7	7	7	7	7	7	7	7
NH3-N	mg/L	3.0	3.0	3.0	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
TP	mg/L	0.50	0.50	0.50	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2 HEADWORKS												
2 Inlet Sewers												
Number		2	2	2	2	2	2	2	2	2	2	2
Size 1 x	mm	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
1 x	mm	1650	1650	1650	1650	1650	1650	1650	1650	1650	1650	1650

			Existing Conditions 1998	Existing Conditions 1999	Existing Conditions 2000	Stage I Expansion max load	Stage I Expansion ave. load	Stage I Expansion comp. load	Stage 2 Expansion max load	Stage 2 Expansion ave. load	Stage 2 Expansion comp. load	Design Stage 1 Expansion design. load	Design Stage 2 Expansion design. load
2 Plant Influent Pumping Station													
Number of pumps			2	2	2	3	3	3	3	3	3	3	3
Type			Screw	Screw	Screw	Screw	Screw	Screw	Screw	Screw	Screw	Screw	Screw
Capacity	Each	m^3/d	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000
	Total	m^3/d	130,000	130,000	130,000	195,000	195,000	195,000	195,000	195,000	195,000	195,000	195,000
	Firm	m^3/d	65,000	65,000	65,000	130,000	130,000	130,000	130,000	130,000	130,000	130,000	130,000
2 Screen Building													
Number of Screens			2	2	2	3	3	3	3	3	3	3	3
Type			Bar	Bar	Bar	Bar	Bar	Bar	Bar	Bar	Bar	Bar	Bar
Width		mm	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300
Openings		mm	20	20	20	20	20	20	20	20	20	20	20
Capacity	Each	m^3/d	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000
	Total	m^3/d	130,000	130,000	130,000	195,000	195,000	195,000	195,000	195,000	195,000	195,000	195,000
	Firm	m^3/d	65,000	65,000	65,000	130,000	130,000	130,000	130,000	130,000	130,000	130,000	130,000
2 Grit Removal													
Type						Aerated	Aerated	Aerated					
Number of Tanks			2	2	2	2	2	2	2	2	2	2	2
Tank volume	Each	m^3	240	240	240	240	240	240	240	240	240	240	240
	Total	m^3	480	480	480	480	480	480	480	480	480	480	480
Tank area	Each	m^2	60	60	60	60	60	60	60	60	60	60	60
	Total	m^2	120	120	120	120	120	120	120	120	120	120	120
HRT	Average	min	14.0	13.7	12.3	10.8	10.8	10.8	9.4	9.4	9.4	10.8	9.4
	Pea 1.5 Qavg	min	9.3	9.1	8.2	7.2	7.2	7.2	6.3	6.3	6.3	7.2	6.3
	2.0 Qavg	min	7.0	6.9	6.1	5.4	5.4	5.4	4.7	4.7	4.7	5.4	4.7
3 PRIMARY TREATMENT													
3 Primary Treatment Flow Capacity													
Total													
Average flow		m^3/d	49,414	50,430	56,202	64,000	64,000	64,000	73,300	73,300	73,300	64,000	73,300
Peak flow		m^3/d	74,615	76,149	84,865	96,000	96,000	96,000	110,683	110,683	110,683	96,640	110,683
Plant no. 1			44%	43%	39%	25%	25%	25%	25%	25%	25%	25%	25%
Plant no. 2			35%	34%	30%	20%	20%	20%	20%	20%	20%	20%	20%
Plant no. 3			33%	32%	29%	20%	20%	20%	20%	20%	20%	20%	20%
Plant no. 4 (New)						*34%*	*34%*	*34%*	*34%*	*34%*	*34%*	*34%*	*34%*
3 Primary Settling Tanks													
Plant no. 1													
Number of tanks			2	2	2	2	2	2	2	2	2	2	2
Surface area	Each		366	366	366	366	366	366	366	366	366	366	366
	Total		732	732	732	732	732	732	732	732	732	732	732
Overflow rate	Average	m^3/m^2.	30	30	30	22	22	22	25	25	25	22	25
	Peak	m^3/m^2.	45	45	45	33	33	33	38	38	38	33	38
	Peak Inst.	m^3/m^2.	59	59	59	44	44	44	50	50	50	44	50

			Existing Conditions 1998	Existing Conditions 1999	Existing Conditions 2000	Stage I Expansion max load	Stage I Expansion ave. load	Stage I Expansion comp. load	Stage 2 Expansion max load	Stage 2 Expansion ave. load	Stage 2 Expansion comp. load	Design Stage 1 Expansion design. load	Design Stage 2 Expansion design. load
Plant no. 2													
Number of tanks			2	2	2	2	2	2	2	2	2	2	2
Surface area	Each		286	286	286	286	286	286	286	286	286	286	286
	Total		571	571	571	571	571	571	571	571	571	571	571
Overflow rate	Average	m^3/m^2.	30	30	30	23	23	23	26	26	26	23	26
	Peak	m^3/m^2.	45	45	45	34	34	34	39	39	39	34	39
	Peak Inst.	m^3/m^2.	60	60	60	46	46	46	52	52	52	45	52
Plant no. 3													
Number of tanks			2	2	2	2	2	2	2	2	2	2	2
Surface area	Each		271	271	271	271	271	271	271	271	271	271	271
	Total		541	541	541	541	541	541	541	541	541	541	541
Overflow rate	Average	m^3/m^2.	30	30	30	24	24	24	28	28	28	24	28
	Peak	m^3/m^2.	45	45	45	36	36	36	42	42	42	36	42
	Peak Inst.	m^3/m^2.	60	60	60	48	48	48	55	55	55	48	55
Plant no. 4 (New)													
Number of tanks						2	2	2	2	2	2	2	2
Surface area	Each					300	300	300	300	300	300	300	300
	Total					600	600	600	600	600	600	600	600
Overflow rate	Average	$m^3/m^2.d$				37	37	37	42	42	42	37	42
	Peak	$m^3/m^2.d$				55	55	55	63	63	63	55	63
	Peak Inst.	$m^3/m^2.d$				73	73	73	84	84	84	73	84
Total													
Number of tanks			6	6	6	8	8	8	8	8	8	8	8
Total Surface Area			1,844	1,844	1,844	2,444	2,444	2,444	2,444	2,444	2,444	2,444	2,444
Overflow rate	Average	m^3/m^2.	27	27	30	26	26	26	30	30	30	26	30
	Peak	m^3/m^2.	40	41	46	39	39	39	45	45	45	40	45
	Peak	m^3/m^2.	53	55	61	52	52	52	60	60	60	52	60
3 Primary Sludge Pumps													
Plant No. 1													
Number of Pumps			2	2	2	2	2	2	2	2	2	2	2
Type			Double Disk	Double Disk	Double Disk	Double Disk	Double Disk	Double Disk	Double Disk	Double Disk	Double Disk	Double Disk	Double Disk
Capacity	Each	m^3/d	605	605	605	605	605	605	605	605	605	605	605
	Total	m^3/d	1210	1210	1210	1210	1210	1210	1210	1210	1210	1210	1210
	Firm	m^3/d	605	605	605	605	605	605	605	605	605	605	605
Plant No. 2													
Number of Pumps			2	2	2	2	2	2	2	2	2	2	2
Type			Lobe	Lobe	Lobe	Lobe	Lobe	Lobe	Lobe	Lobe	Lobe	Lobe	Lobe
Capacity	Each	m^3/d	492	492	492	492	492	492	492	492	492	492	492
	Total	m^3/d	985	985	985	985	985	985	985	985	985	985	985
	Firm	m^3/d	492	492	492	492	492	492	492	492	492	492	492
Plant No. 3													
Number of Pumps			2	2	2	2	2	2	2	2	2	2	2
Type			Lobe	Lobe	Lobe	Lobe	Lobe	Lobe	Lobe	Lobe	Lobe	Lobe	Lobe
Capacity	Each	m^3/d	492	492	492	492	492	492	492	492	492	492	492
	Total	m^3/d	985	985	985	985	985	985	985	985	985	985	985
	Firm	m^3/d	492	492	492	492	492	492	492	492	492	492	492

			Existing Conditions 1998	Existing Conditions 1999	Existing Conditions 2000	Stage I Expansion max load	Stage I Expansion ave. load	Stage I Expansion comp. load	Stage 2 Expansion max load	Stage 2 Expansion ave. load	Stage 2 Expansion comp. load	Design Stage 1 Expansion design. load	Design Stage 2 Expansion design. load
Plant No. 4 (New)													
Number of Pumps						2	2	2	2	2	2	2	2
Type						Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal
Capacity	Each	m^3/d				682	682	682	682	682	682	682	682
	Total	m^3/d				1,363	1,363	1,363	1,363	1,363	1,363	1,363	1,363
	Firm	m^3/d				682	682	682	682	682	682	682	682
Total Plant													
Capacity	Total	m^3/d	3,180	3,180	3,180	4,165	4,165	4,165	4,165	4,165	4,165	4,165	4,165
	Firm	m^3/d	1,590	1,590	1,590	2,082	2,082	2,082	2,082	2,082	2,082	2,082	2,082
3 Primary Effluent Loadings													
Primary Removal Efficiencies													
	BOD		36%	36%	36%	35%	35%	35%	35%	35%	35%	35%	35%
	SS		65%	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%
	TKN		10%	10%	10%	0%	0%	0%	0%	0%	0%	0%	0%
	TP		20%	20%	20%	10%	10%	10%	10%	10%	10%	10%	10%
Primary Sludge production													
	Primary sludge	kg/d	11,113	9,174	8,256	15,125	11,813	8,545	16,153	13,529	9,574	11,440	13,102
	Waste Activated Sludge	kg/d	8,586	8,361	7,356	11,759	10,994	7,776	12,740	12,591	8,757	9,981	11,431
	Total Mass	kg/d	19,699	17,536	15,612	26,884	22,806	16,322	28,893	26,120	18,331	21,421	24,534
	%TS	%	3.3%	3.3%	3.3%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%
	Flow	m^3/d	589	525	473	768	652	466	826	746	524	612	701
Primary Effluent Loadings													
	BOD	kg/d	7,875	7,647	6,546	9,974	9,262	6,269	10,746	10,608	7,041	8,320	9,529
	SS	kg/d	5,984	4,940	4,446	8,144	6,361	4,601	8,698	7,285	5,155	6,160	7,055
	TKN	kg/d	1,334	1,442	1,517	1,920	1,920	1,920	2,199	2,199	2,199	1,920	2,199
	TP	kg/d	198	198	225	288	288	288	330	330	330	288	330
4 SECONDARY TREATMENT													
4 Secondary Treatment Flow Capacity													
Total													
Average flow		m^3/d	49,414	50,430	56,202	64,000	64,000	64,000	73,300	73,300	73,300	64,000	73,300
Peak flow		m^3/d	74,615	76,149	84,865	96,000	96,000	96,000	110,683	110,683	110,683	96,640	110,683
Plant no. 1			44%	43%	39%	25%	25%	25%	25%	25%	25%	25%	25%
Plant no. 2			35%	34%	30%	20%	20%	20%	20%	20%	20%	20%	20%
Plant no. 3			33%	32%	29%	20%	20%	20%	20%	20%	20%	20%	20%
Plant no. 4 (New)						*34%*	*34%*	*34%*	*34%*	*34%*	*34%*	*34%*	*34%*
4 Aeration Tanks													
Plant no.1													
Number of tanks			2	2	2	2	2	2	2	2	2	2	2
Volume	Each	m^3	2,173	2,173	2,173	2,173	2,173	2,173	2,173	2,173	2,173	2,173	2,173
	Total	m^3	4,346	4,346	4,346	4,346	4,346	4,346	4,346	4,346	4,346	4,346	4,346
HRT (nominal)	Average	hours	4.8	4.8	4.8	6.5	6.5	6.5	5.7	5.7	5.7	6.5	5.7
	Peak	hours	3.2	3.2	3.2	4.3	4.3	4.3	3.8	3.8	3.8	4.3	3.8
BOD Loading		kg/m^3.d	0.8	0.8	0.6	0.6	0.5	0.4	0.6	0.6	0.4	0.5	0.5
MLSS		mg/L	2,169	2,070	1,960	4,735	4,427	3,131	5,130	5,070	3,526	4,019	4,603
SRT		days	2.5	2.5	3.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0

Client: Guelph WPCP \\Waterloo\proj\GuelphCityof\120703BMP\Task 1 Existing & Future\[PRO2d_historical.xls]Plant Summary

Project#:

			Existing Conditions 1998	Existing Conditions 1999	Existing Conditions 2000	Stage I Expansion max load	Stage I Expansion ave. load	Stage I Expansion comp. load	Stage 2 Expansion max load	Stage 2 Expansion ave. load	Stage 2 Expansion comp. load	Design Stage 1 Expansion design. load	Design Stage 2 Expansion design. load
Plant no.2													
Number of tanks			2	2	2	2	2	2	2	2	2	2	2
Volume	Each	m^3	2,490	2,490	2,490	2,490	2,490	2,490	2,490	2,490	2,490	2,490	2,490
	Total	m^3	4,980	4,980	4,980	4,980	4,980	4,980	4,980	4,980	4,980	4,980	4,980
HRT (nominal)	Average	hours	7.0	7.0	7.0	9.2	9.2	9.2	8.0	8.0	8.0	9.2	8.0
	Peak	hours	4.6	4.6	4.6	6.1	6.1	6.1	5.3	5.3	5.3	6.1	5.3
BOD Loading		$kg/m^3.d$	0.5	0.5	0.4	0.4	0.4	0.3	0.4	0.4	0.3	0.3	0.4
MLSS		mg/L	2,387	2,277	2,022	2,398	2,242	1,586	2,598	2,568	1,786	2,035	2,331
SRT		days	4.0	4.0	4.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Plant no.3													
Number of tanks			2	2	2	2	2	2	2	2	2	2	2
Volume	Each	m^3	2,038	2,038	2,038	2,038	2,038	2,038	2,038	2,038	2,038	2,038	2,038
	Total	m^3	4,076	4,076	4,076	4,076	4,076	4,076	4,076	4,076	4,076	4,076	4,076
HRT (nominal)	Average	hours	6.0	6.0	6.0	7.5	7.5	7.5	6.6	6.6	6.6	7.5	6.6
	Peak	hours	4.0	4.0	4.0	5.0	5.0	5.0	4.4	4.4	4.4	5.0	4.4
BOD Loading		$kg/m^3.d$	0.6	0.6	0.5	0.5	0.5	0.3	0.5	0.5	0.4	0.4	0.5
MLSS		mg/L	2,417	2,306	2,081	2,930	2,739	1,938	3,174	3,137	2,182	2,487	2,848
SRT		days	3.5	3.5	4.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Plant no.4 (New)													
Number of tanks						2	2	2	2	2	2	2	2
Volume	Each	m^3				6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500
	Total	m^3				13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000
HRT (nominal)	Average	hours				14.2	14.2	14.2	12.4	12.4	12.4	14.2	12.4
	Peak	hours				9.5	9.5	9.5	8.2	8.2	8.2	9.4	8.2
BOD Loading		$kg/m^3.d$				0.26	0.24	0.17	0.28	0.28	0.19	0.22	0.25
MLSS		mg/L				2,954	2,762	1,953	3,200	3,163	2,200	2,507	2,872
SRT		days				9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5
Total													
Number of tanks			6	6	6	8	8	8	8	8	8	8	8
Volume	Total	m^3	13,402	13,402	13,402	26,402	26,402	26,402	26,402	26,402	26,402	26,402	26,402
HRT	Average	hours	6.5	6.4	5.7	9.9	9.9	9.9	8.6	8.6	8.6	9.9	8.6
	Peak	hours	4.3	4.2	3.8	6.6	6.6	6.6	5.7	5.7	5.7	6.6	5.7
BOD Loading		$kg/m^3.d$	0.59	0.57	0.49	0.38	0.35	0.24	0.41	0.40	0.27	0.32	0.36
MLVSS %			75%	82%	75%	67%	67%	67%	67%	67%	67%	67%	67%
MLSS (mg/L)			2,325	2,219	2,020	3,139	2,934	2,076	3,400	3,361	2,337	2,664	3,051
Chemical Solids		% of MLSS	8.3%	8.5%	11.0%	8.8%	9.4%	13.3%	9.3%	9.4%	13.6%	10.4%	10.4%
F/Mv	@ ave. flow	d^{-1}	0.34	0.31	0.32	0.18	0.18	0.17	0.18	0.18	0.17	0.18	0.18
Temperature		°C	12	12	12	12	12	12	12	12	12	12	12
SRT		d	3.6	3.6	3.7	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0

			Existing Conditions 1998	Existing Conditions 1999	Existing Conditions 2000	Stage I Expansion max load	Stage I Expansion ave. load	Stage I Expansion comp. load	Stage 2 Expansion max load	Stage 2 Expansion ave. load	Stage 2 Expansion comp. load	Design Stage 1 Expansion design. load	Design Stage 2 Expansion design. load
Waste Activated Sludge (WAS):													
Total Solids	Biological	kg/kgBODa	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
	Chemical	kg/kg Pa	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
	Total	kg/kgBODa	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
	Biological	kg/d	7,875	7,647	6,546	10,722	9,957	6,740	11,552	11,404	7,569	8,944	10,244
	Chemical	kg/d	712	714	809	1,037	1,037	1,037	1,187	1,187	1,187	1,037	1,187
	Total	kg/d	8,586	8,361	7,356	11,759	10,994	7,776	12,740	12,591	8,757	9,981	11,431
Solids Content		% TS	0.47%	0.44%	0.40%	0.63%	0.59%	0.42%	0.68%	0.67%	0.47%	0.53%	0.61%
Volume		m^3/d	1,846	1,884	1,821	1,873	1,873	1,873	1,873	1,873	1,873	1,873	1,873
Design Oxygen		kg O_2/kg BOD	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
		kg O_2/kg TKN	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
		kg O2/d	14,012	14,280	13,527	18,806	18,094	15,101	20,861	20,723	17,156	17,152	19,644
Plant no. 1													
Oxygen requirement		kg/d	6,153	6,145	5,223	4,702	4,524	3,775	5,215	5,181	4,289	4,288	4,911
AOTE			11.3%	11.3%	11.3%	11.3%	11.3%	11.3%	11.3%	11.3%	11.3%	11.3%	11.3%
Air requirement		Sm^3/hr	8,436	8,424	7,160	6,446	6,202	5,176	7,150	7,103	5,880	5,879	6,733
Diffusers	Number	#	4,698	4,603	4,131	2,675	2,675	2,675	2,675	2,675	2,675	2,675	2,675
	Loading	Nm^3/hr.diffus	1.80	1.83	1.73	2.41	2.32	1.94	2.67	2.66	2.20	2.20	2.52
Blowers	Number	#	3	3	3	2	2	2	2	2	2	2	2
	Capacity ea.	Sm^3/hr	7,646	7,646	7,646	7,646	7,646	7,646	7,646	7,646	7,646	7,646	7,646
	Firm Capacity	Sm^3/hr	15,292	15,292	15,292	7,646	7,646	7,646	7,646	7,646	7,646	7,646	7,646
Plant no. 2													
Oxygen requirement		kg/d	4,849	4,842	4,116	3,820	3,675	3,067	4,237	4,209	3,485	3,484	3,990
AOTE			9.7%	9.7%	9.7%	9.7%	9.7%	9.7%	9.7%	9.7%	9.7%	9.7%	9.7%
Air requirement		Sm^3/hr	7,713	7,702	6,546	6,076	5,846	4,879	6,740	6,696	5,543	5,542	6,347
Diffusers	Number	#	3,702	3,628	3,255	2,173	2,173	2,173	2,173	2,173	2,173	2,173	2,173
	Loading	Nm^3/hr.diffus	2.08	2.12	2.01	2.80	2.69	2.25	3.10	3.08	2.55	2.55	2.92
Plant no. 3													
Oxygen requirement		kg/d	4,594	4,587	3,899	3,820	3,675	3,067	4,237	4,209	3,485	3,484	3,990
AOTE			9.7%	9.7%	9.7%	9.7%	9.7%	9.7%	9.7%	9.7%	9.7%	9.7%	9.7%
Air requirement		Nm^3/hr	7,307	7,296	6,202	6,076	5,846	4,879	6,740	6,696	5,543	5,542	6,347
Diffusers	Number	#	3,507	3,437	3,084	2,173	2,173	2,173	2,173	2,173	2,173	2,173	2,173
	Loading	Nm^3/hr.diffus	2.08	2.12	2.01	2.80	2.69	2.25	3.10	3.08	2.55	2.55	2.92
Plants no. 2 and no.3													
Air requirement		Sm^3/hr	15,019	14,998	12,748	12,152	11,692	9,758	13,480	13,391	11,086	11,083	12,694
Blowers	Number	#	3	3	3	3	3	3	3	3	3	3	3
	Capacity ea.	Sm^3/hr	5,076	5,076	5,076	5,076	5,076	5,076	5,076	5,076	5,076	5,076	5,076
	Firm Capacity	Sm^3/hr	10,152	10,152	10,152	10,152	10,152	10,152	10,152	10,152	10,152	10,152	10,152

			Existing Conditions 1998	Existing Conditions 1999	Existing Conditions 2000	Stage I Expansion max load	Stage I Expansion ave. load	Stage I Expansion comp. load	Stage 2 Expansion max load	Stage 2 Expansion ave. load	Stage 2 Expansion comp. load	Design Stage 1 Expansion design. load	Design Stage 2 Expansion design. load
Plant no. 4 (New)													
Oxygen requirement		kg/d				6,465	6,220	5,191	7,171	7,124	5,898	5,896	6,753
AOTE						11.3%	11.3%	11.3%	11.3%	11.3%	11.3%	11.3%	11.3%
Air requirement		Sm^3/hr				8,863	8,528	7,117	9,832	9,767	8,086	8,083	9,258
Diffusers	Number	#				3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
	Loading	Nm^3/hr.diffuser				2.95	2.84	2.37	3.28	3.26	2.70	2.69	3.09
Blowers	Capacity ea.	Sm^3/hr				7,646	7,646	7,646	7,646	7,646	7,646	7,646	7,646
	Capacity ea.	Sm^3/hr				10,100	10,100	10,100	10,100	10,100	10,100	10,100	10,100
	Firm Capacity	Sm^3/hr				7,646	7,646	7,646	7,646	7,646	7,646	7,646	7,646
4 Final Settling Tanks													
Plant no. 1													
Number of tanks			2	2	2	2	2	2	2	2	2	2	2
Surface area	Each		563	563	563	563	563	563	563	563	563	563	563
	Total		1,125	1,125	1,125	1,125	1,125	1,125	1,125	1,125	1,125	1,125	1,125
Overflow rate	Average	$m^3/m^2.d$	19	19	19	14	14	14	16	16	16	14	16
	Peak	$m^3/m^2.d$	29	29	29	21	21	21	25	25	25	21	25
	Peak Inst.	$m^3/m^2.d$	38	38	38	28	28	28	32	32	32	28	32
Solids Loading	Average	$kg/m^2.d$	63	60	57	101	94	67	125	124	86	86	112
(@50% RAS)	Peak	$kg/m^2.d$	84	80	76	135	126	89	168	166	115	115	151
	Peak Inst.	$kg/m^2.d$	104	100	94	168	157	111	208	206	143	143	187
Plant no. 2													
Number of tanks			2	2	2	2	2	2	2	2	2	2	2
Surface area	Each		271	271	271	271	271	271	271	271	271	271	271
	Total		542	542	542	542	542	542	542	542	542	542	542
Overflow rate	Average	$m^3/m^2.d$	32	32	32	24	24	24	27	27	27	24	27
	Peak	$m^3/m^2.d$	48	48	48	36	36	36	41	41	41	36	41
	Peak Inst.	$m^3/m^2.d$	63	63	63	48	48	48	55	55	55	48	55
Solids Loading	Average	$kg/m^2.d$	113	108	96	86	81	57	107	106	74	73	96
(@50% RAS)	Peak	$kg/m^2.d$	151	144	128	115	108	76	143	142	99	98	129
	Peak Inst.	$kg/m^2.d$	188	179	159	144	134	95	178	176	122	122	160

			Existing Conditions 1998	Existing Conditions 1999	Existing Conditions 2000	Stage I Expansion max load	Stage I Expansion ave. load	Stage I Expansion comp. load	Stage 2 Expansion max load	Stage 2 Expansion ave. load	Stage 2 Expansion comp. load	Design Stage 1 Expansion design. load	Design Stage 2 Expansion design. load
Plant no. 3													
Number of tanks			2	2	2	2	2	2	2	2	2	2	2
Surface area	Each		339	339	339	339	339	339	339	339	339	339	339
	Total		678	678	678	678	678	678	678	678	678	678	678
Overflow rate	Average	$m^3/m^2.d$	24	24	24	19	19	19	22	22	22	19	22
	Peak	$m^3/m^2.d$	36	36	36	29	29	29	33	33	33	29	33
	Peak Inst.	$m^3/m^2.d$	48	48	48	38	38	38	44	44	44	38	44
Solids Loading	Average	$kg/m^2.d$	87	83	75	84	79	56	105	103	72	72	94
(@50% RAS)	Peak	$kg/m^2.d$	116	111	100	112	105	74	140	138	96	96	126
	Peak Inst.	$kg/m^2.d$	144	137	124	140	131	93	174	172	119	119	156
Plant no.4 (New)													
Number of tanks						2	2	2	2	2	2	2	2
Surface area	Each					600	600	600	600	600	600	600	600
	Total					1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Overflow rate	Average	$m^3/m^2.d$				18	18	18	21	21	21	18	21
	Peak	$m^3/m^2.d$				28	28	28	32	32	32	28	32
	Peak Inst.	$m^3/m^2.d$				37	37	37	42	42	42	37	42
Solids Loading	Average	$kg/m^2.d$				108	101	72	134	133	92	92	121
(@100% RAS)	Peak	$kg/m^2.d$				135	127	90	169	167	116	115	151
	Peak Inst.	$kg/m^2.d$				162	152	107	201	199	138	138	180
Total													
Total Surface Area			2,345	2,345	2,345	3,545	3,545	3,545	3,545	3,545	3,545	3,545	3,545
Overflow rate	Average	$m^3/m^2.d$	21	22	24	18	18	18	21	21	21	18	21
	Peak	$m^3/m^2.d$	32	32	36	27	27	27	31	31	31	27	31
	Peak Inst.	$m^3/m^2.d$	42	43	48	36	36	36	41	41	41	36	41
Solids Loading	Average	$kg/m^2.d$	73	72	73	113	106	75	141	139	97	96	126
(@100% RAS)	Peak	$kg/m^2.d$	123	120	122	142	132	94	176	174	121	121	158
	Peak Inst.	$kg/m^2.d$	147	143	145	170	159	112	210	208	145	144	189
5 Return Activated Sludge Pumps													
Plant No. 1													
Number of Pumps			3	3	3	3	3	3	3	3	3	3	3
Type			Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal
Capacity	Each	m^3/d	13,100	13,100	13,100	13,100	13,100	13,100	13,100	13,100	13,100	13,100	13,100
	Total	m^3/d	39,300	39,300	39,300	39,300	39,300	39,300	39,300	39,300	39,300	39,300	39,300
	Firm	m^3/d	26,200	26,200	26,200	26,200	26,200	26,200	26,200	26,200	26,200	26,200	26,200
		% Q avg.	121%	121%	121%	164%	164%	164%	143%	143%	143%	164%	143%

			Existing Conditions 1998	Existing Conditions 1999	Existing Conditions 2000	Stage I Expansion max load	Stage I Expansion ave. load	Stage I Expansion comp. load	Stage 2 Expansion max load	Stage 2 Expansion ave. load	Stage 2 Expansion comp. load	Design Stage 1 Expansion design. load	Design Stage 2 Expansion design. load
Plant No. 2													
Number of Pumps			3	3	3	3	3	3	3	3	3	3	3
Type			Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal
Capacity	Each	m^3/d	3,900	3,900	3,900	3,900	3,900	3,900	3,900	3,900	3,900	3,900	3,900
	Total	m^3/d	11,700	11,700	11,700	11,700	11,700	11,700	11,700	11,700	11,700	11,700	11,700
	Firm	m^3/d	7,800	7,800	7,800	7,800	7,800	7,800	7,800	7,800	7,800	7,800	7,800
		% Q avg.	46%	46%	46%	60%	60%	60%	52%	52%	52%	60%	52%
Plant No. 3													
Number of Pumps			3	3	3	3	3	3	3	3	3	3	3
Type			Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal
Capacity	Each	m^3/d	4,600	4,600	4,600	4,600	4,600	4,600	4,600	4,600	4,600	4,600	4,600
	Total	m^3/d	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800	13,800
	Firm	m^3/d	9,200	9,200	9,200	9,200	9,200	9,200	9,200	9,200	9,200	9,200	9,200
		% Q avg.	57%	57%	57%	71%	71%	71%	62%	62%	62%	71%	62%
Plant No. 4 (New)													
Number of Pumps						3	3	3	3	3	3	3	3
Type						Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal
Capacity	Each	m^3/d				11,000	11,000	11,000	12,598	12,598	12,598	11,000	12,598
	Total	m^3/d				33,000	33,000	33,000	37,795	37,795	37,795	33,000	37,795
	Firm	m^3/d				22,000	22,000	22,000	25,197	25,197	25,197	22,000	25,197
		% Q avg.				100%	100%	100%	100%	100%	100%	100%	100%
5 TERTIARY TREATMENT													
5 Tertiary Treatment Flow Capacity													
Average flow		m^3/d	49,414	50,430	56,202	64,000	64,000	64,000	73,300	73,300	73,300	64,000	73,300
Peak process flow (95%ile)		m^3/d	74,615	76,149	84,865	96,000	96,000	96,000	110,683	110,683	110,683	96,640	110,683
Peak instantaneous flow		m^3/d	98,492	100,517	112,022	128,000	128,000	128,000	146,102	146,102	146,102	127,565	146,102
5 Influent Characteristics													
Concentrations	*November 1 to March 31 (**Winter**)*												
BOD_5		mg/L	9	9	9	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
BOD soluble		mg/L	3	3	3	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
BOD_{20}		mg/L	23	23	23	23	23	23	23	23	23	23	23
TOD		mg/L	101	110	113	103	108	118	105	108	118	110	110
SS		mg/L	15	15	15	15	15	15	15	15	15	15	15
NH3-N		mg/L	17.2	19.2	19.8	17.5	18.6	20.9	18.1	18.6	21.0	19.2	19.2
NO3-N		mg/L	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
TKN		mg/L	19.4	21.5	21.9	19.6	20.6	22.9	20.1	20.6	23.0	21.2	21.2
TP		mg/L	0.35	0.36	0.46	0.37	0.39	0.56	0.39	0.39	0.57	0.43	0.43

			Existing Conditions 1998	Existing Conditions 1999	Existing Conditions 2000	Stage I Expansion max load	Stage I Expansion ave. load	Stage I Expansion comp. load	Stage 2 Expansion max load	Stage 2 Expansion ave. load	Stage 2 Expansion comp. load	Design Stage 1 Expansion design. load	Design Stage 2 Expansion design. load
Concentrations	*April 1 to October 31 (**Summer**)*												
BOD_5		mg/L	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
BOD soluble		mg/L	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
BOD_{20}		mg/L	19	19	19	19	19	19	19	19	19	19	19
TOD		mg/L	27	27	27	27	27	27	27	27	27	27	27
SS		mg/L	15	15	15	15	15	15	15	15	15	15	15
NH3-N		mg/L	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
TKN		mg/L	3	3	3	3	3	3	3	3	3	3	3
TP		mg/L	0.35	0.36	0.46	0.37	0.39	0.56	0.39	0.39	0.57	0.43	0.43
5 Secondary Effluent Pumps													
Number of pumps			2	2	2	2	2	2	2	2	2	2	2
Type			Propeller, VS	Propeller, VS	Propeller, VS	Propeller, VS	Propeller, VS	Propeller, VS	Propeller, VS	Propeller, VS	Propeller, VS	Propeller, VS	Propeller, VS
Capacity	Each	m^3/d	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000
	Total	m^3/d	110,000	110,000	110,000	110,000	110,000	110,000	110,000	110,000	110,000	110,000	110,000
Number of pumps			1	1	1	1	1	1	1	1	1	1	1
Type			Propeller, VS	Propeller, VS	Propeller, VS	Propeller, VS	Propeller, VS	Propeller, VS	Propeller, VS	Propeller, VS	Propeller, VS	Propeller, VS	Propeller, VS
Capacity	Each	m^3/d	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000
	Total	m^3/d	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000
Number of pumps			0	0	0	1	1	1	1	1	1	1	1
Type			Submersible	Submersible	Submersible	Submersible	Submersible	Submersible	Submersible	Submersible	Submersible	Submersible	Submersible
Capacity	Each	m^3/d	-	-	-	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000
	Total	m^3/d				40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000
Capacity	Total	m^3/d	179,000	179,000	179,000	219,000	219,000	219,000	219,000	219,000	219,000	219,000	219,000
	Firm	m^3/d	110,000	110,000	110,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000
5 Rotating Biological Contactors													
Number of Contactors			4	4	4	4	4	4	4	4	4	4	4
Tank volume	Each	m^3	507	507	507	507	507	507	507	507	507	507	507
	Total	m^3	2028	2028	2028	2028	2028	2028	2028	2028	2028	2028	2028
Contactors			32	32	32	32	32	32	32	32	32	32	32
Contactors per tank			8	8	8	8	8	8	8	8	8	8	8
Media Area per contactor		m^2	13,750	13,750	13,750	13,750	13,750	13,750	13,750	13,750	13,750	13,750	13,750
Media Area per tanks	Each	m^2	110,000	110,000	110,000	110,000	110,000	110,000	110,000	110,000	110,000	110,000	110,000
	Total	m^2	440,000	440,000	440,000	440,000	440,000	440,000	440,000	440,000	440,000	440,000	440,000
Blowers Number			3	3	3	3	3	3	3	3	3	3	3
Type			centrifugal	centrifugal	centrifugal	centrifugal	centrifugal	centrifugal	centrifugal	centrifugal	centrifugal	centrifugal	centrifugal
Capacity	Each	Nm^3/hr	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
	Total	Nm^3/hr	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4
	Firm	Nm^3/hr	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3
HRT	Average	min	59	58	52	46	46	46	40	40	40	46	40
	Peak	min	39	38	34	30	30	30	26	26	26	30	26

			Existing Conditions 1998	Existing Conditions 1999	Existing Conditions 2000	Stage I Expansion max load	Stage I Expansion ave. load	Stage I Expansion comp. load	Stage 2 Expansion max load	Stage 2 Expansion ave. load	Stage 2 Expansion comp. load	Design Stage 1 Expansion design. load	Design Stage 2 Expansion design. load
*November 1 to March 31 (**Winter**)*													
Loadings													
Ammonia Loading		$g/m^2.d$	1.9	2.2	2.5	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
BOD_5 loading		$g/m^2.d$	0.3	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Ammonia Removal		mg/L	16.6	16.2	14.6	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
Effluent													
BOD_5		mg/L	8.4	8.4	8.4	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
BOD soluble		mg/L	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
BOD_{20}		mg/L	21	21	21	19	19	19	19	19	19	19	19
TOD		mg/L	24.0	34.7	44.8	62.4	67.2	77.6	64.8	67.2	78.1	69.9	69.9
SS		mg/L	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
NH3-N		mg/L	0.7	3.0	5.2	9.4	10.5	12.8	10.0	10.5	12.9	11.1	11.1
TKN		mg/L	2.8	5.2	7.3	11.4	12.5	14.8	12.0	12.5	14.9	13.1	13.1
TP		mg/L	0.3	0.4	0.5	0.37	0.39	0.56	0.39	0.39	0.57	0.43	0.43
*April 1 to October 31 (**Summer**)*													
Loadings													
Ammonia Loading		$g/m^2.d$	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
BOD_5 loading		$g/m^2.d$	0.8	0.9	1.0	0.7	0.7	0.7	0.8	0.8	0.8	0.7	0.8
Ammonia Removal		mg/L	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Effluent													
BOD_5		mg/L	8.4	8.4	8.4	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
BOD soluble		mg/L	3.0	3.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
BOD_{20}		mg/L	21	21	21	17	17	17	17	17	17	17	17
TOD		mg/L	24.7	24.7	24.7	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2
SS		mg/L	13.5	13.5	13.5	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1
NH3-N		mg/L	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
TKN		mg/L	1.9	2.0	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
TP		mg/L	0.3	0.4	0.5	0.4	0.4	0.6	0.4	0.4	0.6	0.4	0.4
6 Tertiary Filters													
Number			2	2	2	2	2	2	2	2	2	2	2
Type			Low Head	Low Head	Low Head	Low Head	Low Head	Low Head	Low Head	Low Head	Low Head	Low Head	Low Head
Area	Each	m^2	263	263	263	263	263	263	263	263	263	263	263
Number						2	2	2	2	2	2	2	2
Type						Low Head	Low Head	Low Head	Low Head	Low Head	Low Head	Low Head	Low Head
Area	Each	m^2				170	170	170	170	170	170	170	170
	Total	m^2	526	526	526	866	866	866	866	866	866	866	866

				Existing Conditions 1998	Existing Conditions 1999	Existing Conditions 2000	Stage I Expansion max load	Stage I Expansion ave. load	Stage I Expansion comp. load	Stage 2 Expansion max load	Stage 2 Expansion ave. load	Stage 2 Expansion comp. load	Design Stage 1 Expansion design. load	Design Stage 2 Expansion design. load
Hydraulic Loading	Average		$L/m^2.s$	1.09	1.11	1.24	0.86	0.86	0.86	0.98	0.98	0.98	0.86	0.98
All units in service	Peak Process		$L/m^2.s$	1.64	1.68	1.87	1.28	1.28	1.28	1.48	1.48	1.48	1.29	1.48
	Peak Instantaneous		$L/m^2.s$	2.17	2.21	2.46	1.71	1.71	1.71	1.95	1.95	1.95	1.70	1.95
Hydraulic Loading	Average		$L/m^2.s$	2.17	2.22	2.47	1.23	1.23	1.23	1.41	1.41	1.41	1.23	1.41
1x 263 m2 out of	Peak Process		$L/m^2.s$	3.28	3.35	3.73	1.84	1.84	1.84	2.12	2.12	2.12	1.85	2.12
service	Peak Instantaneous		$L/m^2.s$	4.33	4.42	4.93	2.46	2.46	2.46	2.80	2.80	2.80	2.45	2.80
*November 1 to March 31 (**Winter**)*														
Effluent														
BOD_5			mg/L	6.2	6.2	6.2	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
BOD soluble			mg/L	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
BOD_{20}			mg/L	16	16	16	12	12	12	12	12	12	12	12
TOD			mg/L	18.5	29.2	39.3	54.9	59.8	70.2	57.3	59.8	70.6	62.4	62.4
SS			mg/L	8.0	8.0	8.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
NH3-N			mg/L	0.7	3.0	5.2	9.4	10.5	12.8	10.0	10.5	12.9	11.1	11.1
TKN			mg/L	2.4	4.8	6.9	10.9	11.9	14.2	11.4	11.9	14.3	12.5	12.5
TP			mg/L	0.29	0.29	0.35	0.26	0.27	0.33	0.27	0.27	0.33	0.28	0.28
*April 1 to October 31 (**Summer**)*														
Effluent														
BOD_5			mg/L	6.2	6.2	6.2	4.5	4.5	5.5	4.5	4.5	4.5	4.5	4.5
BOD soluble			mg/L	3.0	3.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
BOD_{20}			mg/L	16	16	16	11	11	14	11	11	11	11	11
TOD			mg/L	19.2	19.2	19.2	15.0	15.0	17.6	15.0	15.0	15.0	15.0	15.0
SS			mg/L	8.0	8.0	8.0	7.0	7.0	10.0	7.0	7.0	7.0	7.0	7.0
NH3-N			mg/L	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
TKN			mg/L	1.5	1.6	1.5	1.4	1.4	1.6	1.4	1.4	1.4	1.4	1.4
TP			mg/L	0.29	0.29	0.35	0.28	0.30	0.45	0.29	0.30	0.38	0.32	0.32
5 .6 Chlorine Contact Chamber														
Type				4 pass rectang	4 pass rectang	4 pass rectangular								
Volume			m^3	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100
HRT	Peak flow		min	21	21	19	17	17	17	14	14	14	16	14
6 SLUDGE TREATMENT														
6 Anaerobic Digesters														
Number	Primary			3	3	3	3	3	3	3	3	3	3	3
	Secondary			1	1	1	1	1	1	1	1	1	1	1
Volume	Primary	Each	m^3	2,440	2,440	2,440	2,440	2,440	2,440	2,440	2,440	2,440	2,440	2,440
		Total	m^3	7,320	7,320	7,320	7,320	7,320	7,320	7,320	7,320	7,320	7,320	7,320
	Secondary	Each	m^3	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350
		Total	m^3	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350

			Existing Conditions 1998	Existing Conditions 1999	Existing Conditions 2000	Stage I Expansion max load	Stage I Expansion ave. load	Stage I Expansion comp. load	Stage 2 Expansion max load	Stage 2 Expansion ave. load	Stage 2 Expansion comp. load	Design Stage 1 Expansion design. load	Design Stage 2 Expansion design. load
6 Sludge Loadings													
Raw Sludge	Flow	m^3 /d	589	525	473	815	691	495	876	792	555	649	743
	Solids	% ds	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%
	Mass	kg/d	19,699	17,536	15,612	26,884	22,806	16,322	28,893	26,120	18,331	21,421	24,534
	Volatile solids	% VS	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%
		kg/d	14,381	12,801	11,397	19,625	16,649	11,915	21,092	19,068	13,382	15,637	17,909
Primary	HRT	days	12.4	14.0	15.5	9.0	10.6	14.8	8.4	9.2	13.2	11.3	9.8
	Loading	kg $VSS/m^3.d$	2.0	1.7	1.6	2.7	2.3	1.6	2.9	2.6	1.8	2.1	2.4
Total	HRT	days	16.4	18.4	20.4	11.9	14.0	19.6	11.0	12.2	17.4	14.9	13.0
	Loading	kg $VSS/m^3.d$	1.5	1.3	1.2	2.0	1.7	1.2	2.2	2.0	1.4	1.6	1.9
VSS destruction		%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%
		kgVS des/d	8,341	7,425	6,610	11,383	9,656	6,911	12,233	11,059	7,761	9,070	10,387
Digested Sludge		m^3 /d	589	525	473	815	691	495	876	792	555	649	743
		kg/d	11,359	10,111	9,002	15,501	13,150	9,411	16,660	15,061	10,570	12,351	14,146
		% ds	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%
		% VS	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%
6 Sludge Dewatering													
Type													
Number			2	2	2	2	2	2	2	2	2	2	2
Size		m width	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Operating Capacity	Each	L/s	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
	Total	L/s	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
Number			2	2	2	2	2	2	2	2	2	2	2
Size		m width	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Operating Capacity	Each	L/s	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
	Total	L/s	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6
Capacity	Total	L/s	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
	Firm	L/s	12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.9
Operation		Days/wk	5	5	5	5	5	5	5	5	5	5	5
All units in service		hours/d	11.9	10.6	9.6	16.5	14.0	10.0	17.7	16.0	11.3	13.1	15.1
1 x 2.5 m press out of service		hours/d	17.8	15.8	14.3	24.6	20.8	14.9	26.4	23.9	16.7	19.6	22.4
Dewatered sludge													
(Assuming 100%	Volume	m^3 /d	63.1	56.2	50.0	86.1	73.1	52.3	92.6	83.7	58.7	68.6	78.6
capture)	Dry solids	% ds	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
6 Composting Facility													
Design Capacity		kg/d	15,100	15,100	15,100	15,100	15,100	15,100	15,100	15,100	15,100	15,100	15,100
Required Capacity		kg/d	11,359	10,111	9,002	15,501	13,150	9,411	16,660	15,061	10,570	12,351	14,146
Cake Production (88% capture)		kg/d	9,996	8,898	7,922	13,641	11,572	8,282	14,661	13,254	9,301	10,869	12,448
ACTUAL CAKE PRODUCTION		kg/d	9,830	7,373	9,101								
capture													
BOD20/BOD5	2.5					4,979	4,224	3,023	5,351	4,838	3,395	3,967	4,544
		-	1.68 -	20.69	12.96								
		p	198.93	146.19	161.94								
		m	229.87	200.50	160.17								

Attachment E: Calculation of System Capacity Requirements

Compost system HRT was calculated from plant data as follows for 1999:

$$HRT = \frac{\text{(Reactor Volume) x (Average Density)}}{[\text{(infeed wet weight)} + \text{(outfeed wt weight)}]/2} \text{ x } \frac{\text{7 days/week}}{\text{5 operating days/week}}$$

Where:

Reactor Volume = reactor volume, m^3

Average Density = average density of the reactor contents, kg/m^3

Infeed Wet Weight = total wet weight of sludge, carbon and recycle introduced into the reactors, kg/operating day

Outfeed Wet Weight = total wet weight of the final product (including recycle) discharged from the reactors, kg/operating day

The compost system HRTs shown in Table 6-3 were scaled linearly from the 1999 parameters, for the ProD projected solids production rates, that is the same proportion of recycle, amendment and dewatered cake were assumed, as well as the same average density of the reactor contents.

Attachment F: Predictions of Future Solids Quantities

Guelph WWTP - Predictions of Future Sludge Quantities

PREPARED FOR: City of Guelph
Attention: Mr. Terry Hearn

PREPARED BY: Steve Black
Sally Baldwin

COPIES: Wayne Key, Guelph WWTP

DATE: April 22, 2001

This memorandum develops predictions of future sludge quantities generated by the Guelph WWTP. Scenarios evaluated include Sleeman at current, average and bylaw limits; Better Beef at current and bylaw limits; and all other industries at current and bylaw limits for BOD and TSS concentrations.

In order to predict the solids quantities produced at Guelph WWTP at the 64 MLD and to the 73.3 MLD planning horizon, it is necessary to look at the influence of industrial wastewater characteristics and flows to the treatment plant's raw wastewater influent.

The monthly and annual average raw wastewater $cBOD_5$ and TSS concentrations of raw sewage received at the Guelph WWTP over the period 1990 to 2000 are plotted in Figures 1 and 2. It can be seen that the raw wastewater characteristics have been somewhat variable over the past 10 years, with a peaking in raw wastewater $cBOD_5$ and TSS concentrations in 1997-1998.

The domestic, industrial and septage flows and characteristics largely determine raw wastewater characteristics. Industrial flows and characteristics are regularly monitored by the Guelph WWTP operations staff at the connecting sewers for each major industrial water user in the City of Guelph. This data is gathered to determine each industry's compliance with the City's sewer use by-law compliance limits and to assist WWTP staff in the operation of the plant. From this data we can determine the potential maximum (current) industrial wastewater $cBOD_5$ and TSS loadings. Furthermore, we can demonstrate the potential industrial wastewater $cBOD_5$ and TSS loadings, if it is assumed that Sleeman and Better Beef and all industries are brought into, or remain within the City's sewer use by-law compliance limits.

Domestic and septage characteristics, whilst not individually recorded at Guelph WWTP can be fairly accurately estimated from empirical data. The total plant loadings recorded historically can then be compared to the recorded industrial plant loadings to assess the level of accuracy of the available data.

In order to determine the potential maximum and compliance limit $cBOD_5$ and TSS loadings to the plant, the data from each industry were examined. Table 1 provides predictions of WWTP influent $cBOD_5$ and TSS concentrations and loadings under various scenarios of Sleeman, Better Beef and total industry compliance. In the table, current "maximum" concentration as taken as the maximum day composite for samples collected during the 1st 6 months of 2000 for Sleeman and Better Beef, while concentrations for all other industries are taken as average values of samples collected over the same period. Similarly, "average" concentrations for Sleeman and Better Beef are taken as the average of composite samples collected over that same period.

Comparison of predicted loading with Stage 1 and Stage 2 design loadings indicates the following:

- Stage 1 design loadings for $cBOD_5$ are exceeded in 2002 with both Sleeman and Better Beef at current "maximum" $cBOD_5$ concentrations, and also in 2003 with Sleeman effluent at current "average" $cBOD_5$ concentration (1200 mg/L BOD) and Better Beef at current "maximum" $cBOD_5$ concentration.
- Stage 2 design loadings for $cBOD_5$ are exceeded in 2002 with both Sleeman and Better Beef at current "maximum" $cBOD_5$ concentrations.
- Stage 1 design loadings for TSS are exceeded in 2001 with both Sleeman and Better Beef at current "maximum" TSS concentrations.
- Stage 2 design loadings for TSS are exceeded in 2003 with both Sleeman and Better Beef at current "maximum" TSS concentrations.

The solids production relates directly to the wastewater influent flow and the influent TSS and $cBOD_5$ loadings. Table 2 shows the plant recorded and Pro2D estimated solids production for 1998, 1999 and 2000. Pro2D model estimated solids production is within 10% of the plant recorded data. This is within the expected accuracy of the model. Table 2 also shows Pro2D predicted solids production for the 64 MLD (Stage1) and 73.3 MLD (Stage 2) expansions, for potential maximum, expected average, and compliance limit loadings. This assumes that the maximum $cBOD_5$ and TSS concentration grab samples at each industry to date are the maximum concentration for that industry and that the only industry to significantly increase its wastewater flow is Sleeman. The expected average data are compiled from current (1st 6 months of 2000) average loading data, and assumes that average discharge concentrations from the various industries will remain the same.

Table 2 shows that industries in Guelph have a significant impact on the solids production rate at the Guelph WWTP. If all industries were in compliance with the City's by-law limits, the solids production at the plant would be approximately 45% less than under current "maximum" conditions.

Table 3 shows some examples of the operating considerations over the planning period, depending on the predicted solids production rates.

As indicated by the lightly shaded areas in the table, the total operating digester capacity is inadequate under the current "maximum" load at both Stage 1 and Stage 2 design conditions. Firm capacity is exceeded under Stage 1 maximum and average conditions and under all conditions in Stage 2. Dewatering operation time is also a concern under a number of conditions.

The capacity of the compost facility is exceeded under maximum loading conditions under both Stage 1 and Stage 2 as indicated by the darker shaded areas on the table.

The design criteria for the solids handling facilities (digestion, dewatering & composting) are therefore highly dependent upon the $cBOD_5$ and TSS concentrations and flow of wastewater from industries in Guelph, and their sewer by-law compliance. If the industries do not comply with the City's sewer by-law compliance limits, significant capital expenditures will be necessary to enable the WWTP to effectively manage the biosolids produced.

Year	Daily Aver Flow MLD	Annual Average BOD mg/L	TSS mg/L	Actual Cake Prod dt/y	Pro2D Total Sludge Prod dt/y	Actual sludge at 88% Capture dt/y
1993		168	300			
1994		165	311			
1995		178	320			
1996		212	283			
1997		256	258			
1998	49.414	249	326	3,588	4,332	4,077
1999	50.430	237	280	2,691	2,793	3,058
2000	56.202	182	226	3,322	3,433	3,775
Max	64.000	240	364		6,328	
Average	64.000	214	233		4,787	
Compliance	64.000	151	205		3,598	
Max	73.300	226	339		6,522	
Average	73.300	203	225		4,980	
Compliance	73.300	148	201		4,315	

Figure 1

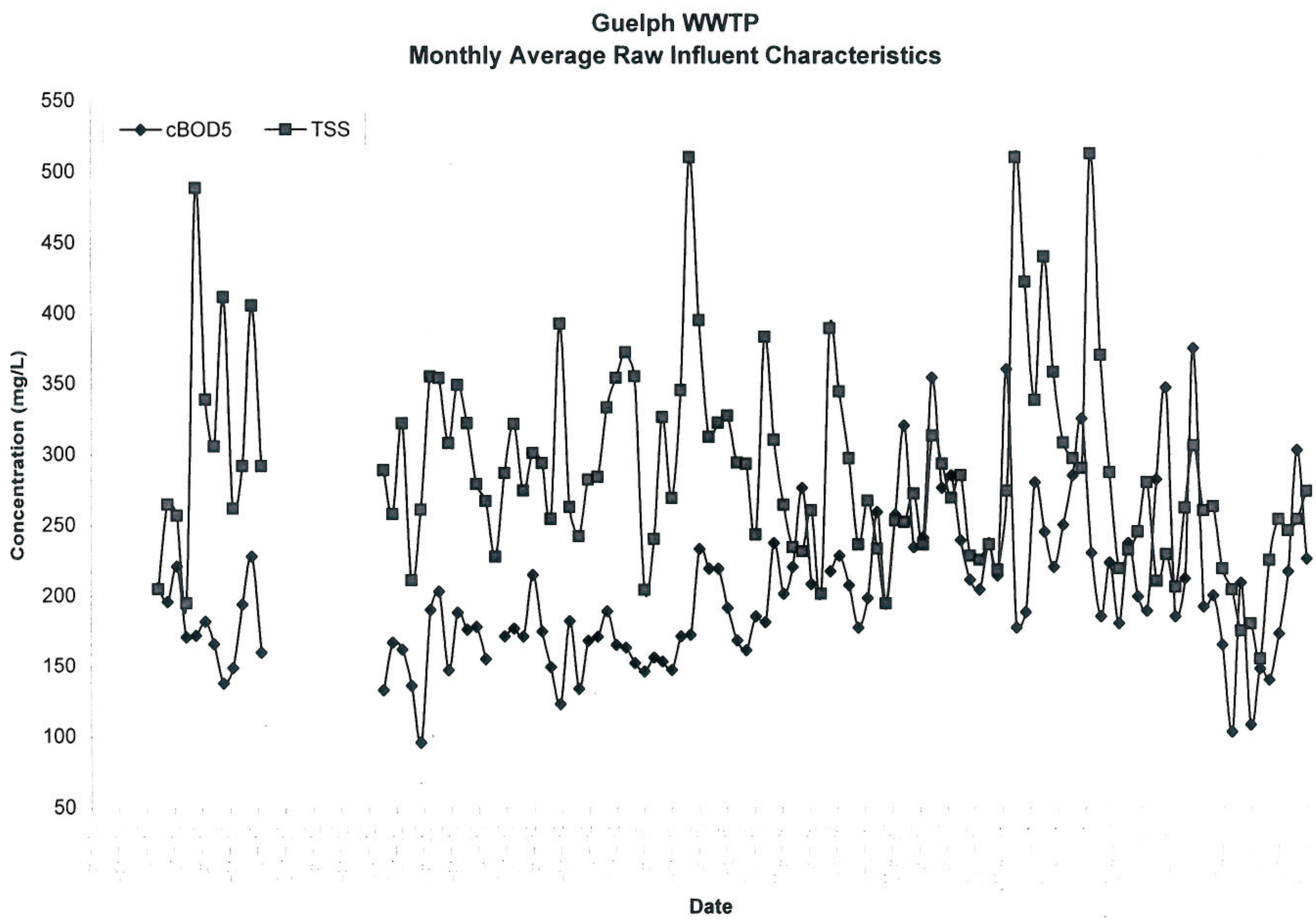
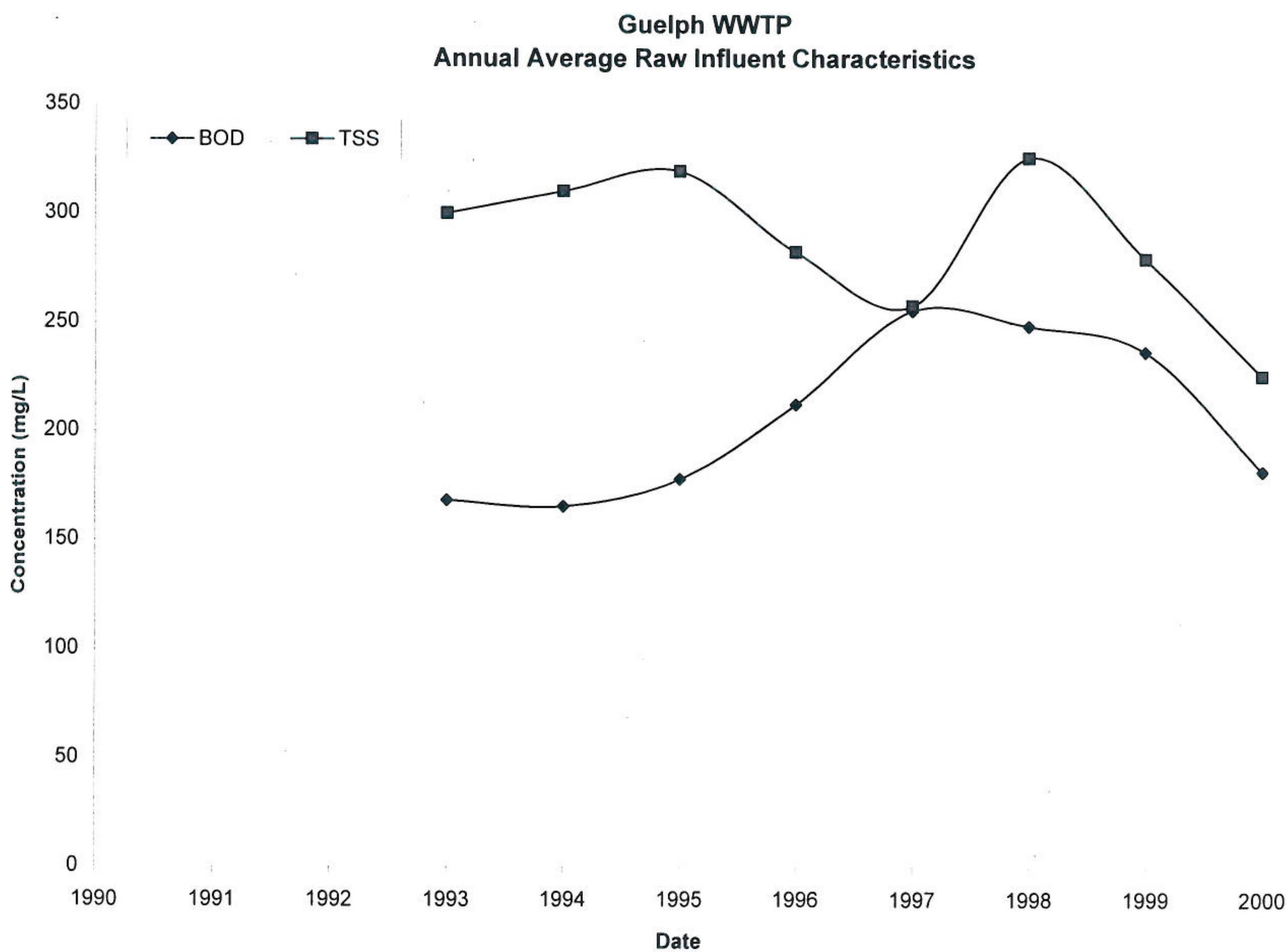

Guelph WWTP
Monthly Average Raw Influent Characteristics
cBOD5
TSS
Concentration (mg/L)
550
500
450
400
350
300
250
200
150
100
50
Date

Figure 2



Guelph WWTP
Annual Average Raw Influent Characteristics
BOD
TSS
Concentration (mg/L)
350
300
250
200
150
100
50
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
Date

Predicted BOD Loadings

Year	Predicted Population	Total Flow	Sleeman's Production	Domestic	Septage	Sleeman's @ 2100 mg/L	Sleeman's @ 1200 mg/L	Sleeman's @ 300 mg/L	Better Beef @ 3634 mg/L	Better Beef @ 300 mg/L	All other industrial	Total at Max Sleeman & BB	Max	Total at Average Sleeman (max BB)	Average	Total at Compliance	Compliance
		MLD	hL/yr	kg/d	kg/d	(max) kg/d	(ave) kg/d	(compliance) kg/d	(max) kg/d	(compliance) kg/d	(ave) kg/d	kg/d	mg BOD / L inflow	kg/d	mg BOD / L inflow	kg/d	mg BOD / L inflow
2000	114,941	56,208	360,800	6,896	32	1,818			3,155		208	12,110	215	10,291	183		
2001	117,975	56,888	425,000	7,079	32	2,142	1,224	306	3,155	695	208	12,616	222	11,698	206	8,320	146
2002	121,075	57,005	550,000	7,265	32	2,772	1,584	396	3,155	695	208	13,432	236	12,244	215	8,596	151
2003	124,290	58,475	750,000	7,457	32	3,780	2,160	540	3,155	695	208	14,632	250	13,012	223	8,932	153
Stage 1	136,170	64,000	750,000	8,170	32	3,780	2,160	540	3,155	695	208	15,345	240	13,725	214	9,645	151
Stage 2	155,957	73,300	750,000	9,357	32	3,780	2,160	540	3,155	695	208	16,532	226	14,912	203	10,832	148

Predicted TSS Loadings

Year	Predicted Population	Total Flow	Sleeman's Production	Domestic	Septage	Sleeman's @ 2900 mg/L	Sleeman's @ 588 mg/L	Sleeman's @ 350 mg/L	All Other Industry @ max	All Other Industry @ ave	All other industrial @ compliance	Total at Max	Max	Total at Average	Average	Total at Compliance	Compliance
		MLD	hL/yr	kg/d	kg/d	(max) kg/d	(ave.) kg/d	(compliance) kg/d	(max) kg/d	(ave.) kg/d	(compliance) kg/d	kg/d	mg TSS / L inflow	kg/d	mg TSS / L inflow	kg/d	mg TSS / L inflow
2000	114,941	56,208	360,800	9,195		2,504	508	302	3,312	2,206	1,316	15,012	267	11,909	212	10,813	192
2001	117,975	56,888	425,000	9,438		5,135	1,041	531	3,312	2,206	1,316	17,886	314	12,685	223	11,285	198
2002	121,075	57,005	550,000	9,686		6,646	1,348	688	3,312	2,206	1,316	19,644	345	13,239	232	11,689	205
2003	124,290	58,475	750,000	9,943		9,063	1,838	938	3,312	2,206	1,316	22,318	382	13,986	239	12,196	209
Stage 1	136,170	64,000	750,000	10,894		9,063	1,838	938	3,312	2,206	1,316	23,269	364	14,937	233	13,147	205
Stage 2	155,957	73,300	750,000	12,477		9,063	1,838	938	3,312	2,206	1,316	24,851	339	16,520	225	14,730	201

APPENDIX D
TECHNICAL MEMORANDUM 2

Compost Utilization Assessment

(Final Draft)

For

City of Guelph
Guelph Wastewater Treatment Plant

February 2002

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1. Introduction

The City of Guelph currently utilizes the composted biosolids from the Guelph Wastewater Treatment Plant (WWTP) as cover material at the landfill. Dewatered biosolids are also applied on agricultural land during parts of the year.

The Guelph WWTP currently generates about 54 m^3/d (20,000 m^3/yr) of unscreened compost. The characteristics of the compost are shown in Table 1.1.

Table 1.1: Guelph WWTP Compost Characteristics

Parameter	Composted Biosolids Characteristics	
	Current (2000)	Stage 1 (2010?)
Generation Rate		
Volume (m^3/d)	54.2	66.3
Mass (tonnes/d total)	32.5	39.8
Compost Quality		
Moisture (%, w/w)	45[1]	
VS (% of TS)	81[1]	
Organic Matter (%)		
pH (pH units)	6.5 - 8.1[2]	
Salts (%)	< 6[1]	
TKN (mg/kg dry wt.)	19,100	
Ammonia (NH_3-N) (mg/kg dry wt.)	6,740	
Phosphorus (total) (mg/kg dry wt.)	12,600	
Potassium (as P) (mg/kg dry wt.)	711	
Bulk Density (kg/m^3)	600[1]	

[1] estimate based on typical value
[2] based on past operating data

2. Compost Marketing Survey

This memo summarizes the results from a telephone survey of potential end users and other stakeholders, with a summary of the following:

- Types of uses for the compost
- Potential demand for compost
- Potential revenues
- Regulatory Issues
- Quality Issues

Telephone conversations and meetings were also held with the MOE and Agriculture Canada to discuss approval issues for the different end uses.

2.1. Potential End Users and Uses

2.11 End Uses

One of the objectives of compost utilization marketing analysis is to identify types of end uses for the composted biosolids and the potential end users.

A diagram of different biosolids markets, including markets other than dewatered biosolids application on agricultural land, that are to be considered in this memo are shown in Figure 2.1.

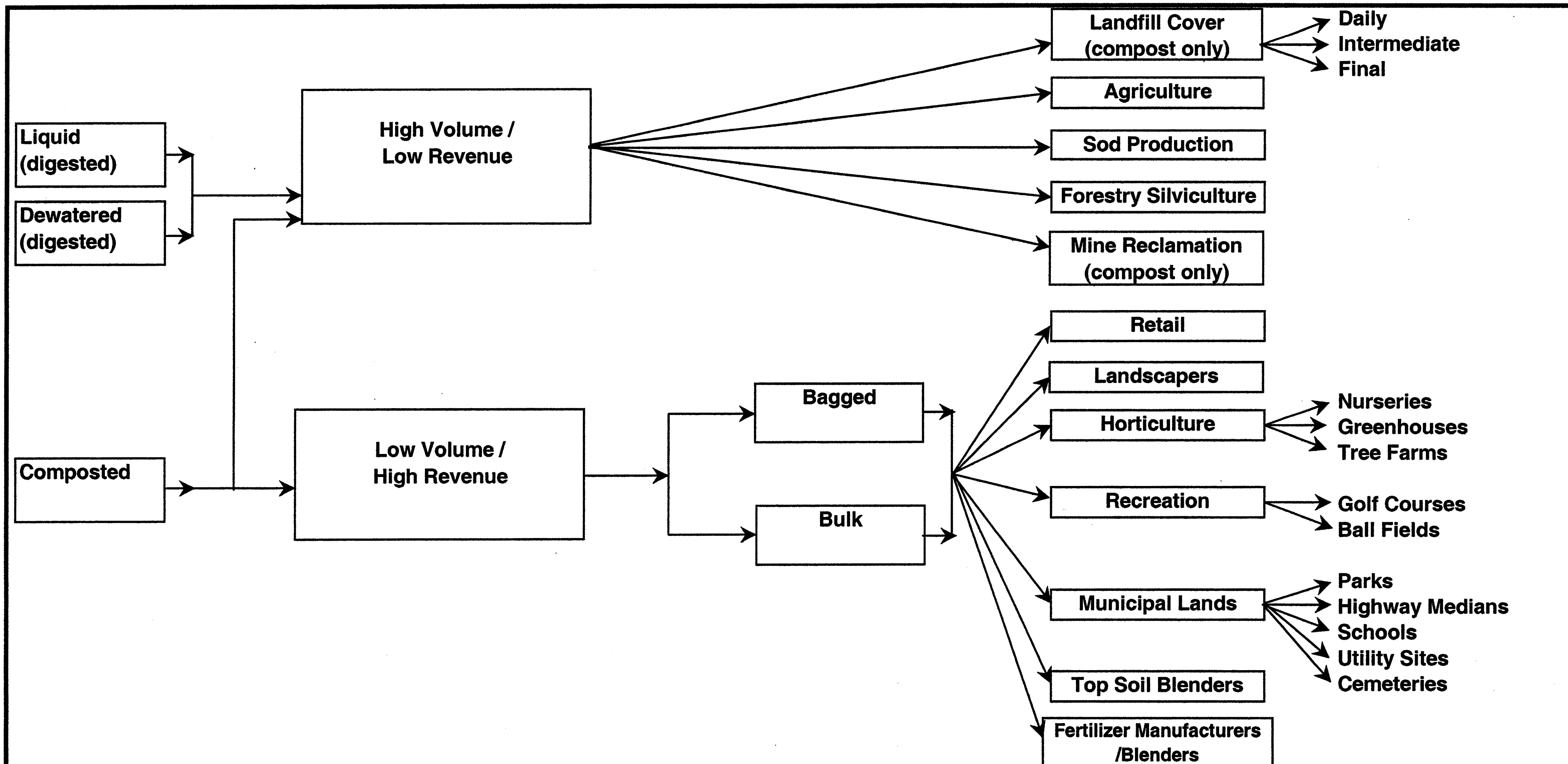
Types of end uses include:

- Agricultural Land Application
  - Low nitrogen crops
  - Tree farms
  - Sod Farms
- Recreational Sites (ie: golf courses, ball parks)
- Topsoil Market (identify suppliers; blenders and determine; quality and quantity requirements)
- Soil Conditioner (blending with poor quality topsoil and improving the fertility of existing topsoils)
  - Bulk sales from the WWTP to: 1) the public and to 2) brokers and blenders
  - Bagging/Sales
- Landfill: - Use of material for cover material

Land Reclamation. Reclamation of quarries, mined areas, gravel pits.

2.1.2. Potential End Users

A list of potential end users and other stakeholders that may have input into the end use of composted biosolids is included in Appendix B. The list includes several stakeholders in the



DATE 08/30/01	**Figure 2.1: Biosolids Product Markets**	FILE No.
SCALE: N.T.S.		DWG/FIGURE No.

industry including regulatory agencies (ie: OMAFRA, MOE, Agriculture Canada (AAFC), CFIA), agricultural organizations, as well as local compost and topsoil distributors.

A list of some of the potential end users and other stakeholders contacted in the telephone survey are included in Appendix B . The list includes the following types of markets:

Table 2.1: Telephone Survey of Compost End Users and Regulatory Agencies

Compost Market / Stakeholder	# of Users Surveyed[1]
Regulatory agencies	3
Landscapers	3
Topsoil blenders and distributors	9
Landfill operators	1
Mining and Quarry Operators	1
Agricultural (sod farms)	3
Golf Courses	1
Public Works	2

[1] sample of potential users in the Guelph area

The types of questions included in the survey and the survey records are included in Appendix C. Each of these end use markets is discussed below.

2.2. Market Survey Results

2.2.1. Landscapers

Landscapers purchase small quantities of compost and topsoil as required. Typical quantities purchased are about 400 to 800 m^3/yr (500 – 1,000 yd^3/yr), in truck loads of 10 to 30 m^3. Important compost characteristics identified by landscapers are as follows:

- No odours
- Neutral pH (ie: pH range of 7.0 to 7.2 pH units)
- Low soluble salt content
- A consistent quality
- Black colour
- Screening to remove woodchips in some cases
- Regulatory approval
- Public education material to change public perception of the material

Most of the topsoil and compost is purchased from topsoil blenders.

Landscapers may be interested in using the compost; however, quantities are small and landscapers would not likely pay for the composted biosolids without long term experience in using the compost. Also, usage must be free from any approval or application restrictions.

2.2.2. Topsoils Blenders and Distributors

Topsoil blenders and distributors represent the largest market for the compost. Topsoil blenders could utilize much of the compost.

Issues of concern and desired characteristics for topsoil are as follows:

- Salts (TDS less than 6%)
- Organic matter (less than 10% after blending)
- Regulatory approval required
- Metals, organics and pathogens must not be a concern in the topsoil after blending

The market for topsoil is approximately as follows:

- 25% general public
- 60% landscaping contractors
- 15% municipal government and public works

2.2.3. landfill Operators

The Guelph Eastview sanitary landfill is being closed in the near future. The landfill has significant topsoil material for a final cover. Composted biosolids could be used as a component in the final cover material to provide increased organic matter and nutrients. Large quantities of compost could be utilized in the April – May 2001 period for topsoil blending to produce material for the final capping of the landfill. The final closure of the landfill is expected in August 2001.

In the past the landfill has purchased topsoil at a cost of about $3/m^3.

2.2.4. Land Reclamation

2.2.4.1 Mining and Quarry Operators

The Guelph area contains several closed quarries and gravel pits. The Aggregate Producers Association of Ontario (APAO) has identified several sites in the Guelph area that are to be reclaimed in the future

The APAO's Management of Abandoned Aggregate Properties (MAAP) program provides expertise and a small amount of funding for reclamation of its member's sites. A few reclamation projects are tendered each year in Ontario. Typical reclamation site projects are about 2 ha in size, with costs of about $30,000 ($15,000/ha). Some topsoil is purchased for some of the projects, with topsoil costs representing about 20% of the total costs or about $6,000 per site. Topsoil usage usually represents about 700 m^3/ha (7 cm depth). Often topsoil is excavated from other areas on the site and no topsoil is purchased.

The potential for usage of composted biosolids depends on the contractor, site characteristics, the location and the costs.

The APAO would consider demonstrating the use of composted biosolids if the City offsets any costs from the use and evaluation of the use of the compost.

2.2.4.2 Other Sites

Other sites include industrial park developments (ie: Lafarge site) and other industrial lands.

2.2.5. Agricultural (Sod Farms)

Sod farms could utilize compost for topsoil replacement and for nutrients. Three sod farms currently operate in the Guelph area, including:

- Compact Sod
- Fairlawn Sod
- Manderly Turfgrass

The total area used in sod production is about 1,300 ha. At application rates of 20 tonnes(total wt.)/ha.yr, sod farms could utilize about 26,000 tonnes(total wt.)/yr of compost.

Sod farms would try the compost if it were available free of charge and delivered to their sites.

Requirements and compost characteristics required for usage by sod farms are as follows:

- MOE approval
- Consistent quality from batch-to-batch, in terms of nutrients
- No safety concerns

2.2.6. Golf Courses

Golf courses have very stringent criteria for topsoil and soil amendments. Some golf courses purchase topsoil for course reconstruction. The Ariss Valley G&CC has no need for topsoil amendments or compost and would not consider using composted biosolids at this time. Ariss Valley has excess topsoil on-site from excavations from pond construction.

2.2.7. Guelph Municipal Works/Provincial Works

Guelph's public works department is responsible for the landscaping and maintenance of all of Guelph's municipally-owned sites, parks and some road medians and rights of way.

Guelph currently purchases about 700 m^3/yr of topsoil from topsoil distributors.

Compost is not purchased. The City's leaf and yard waste are composted off-site at a private composting facility (All Treat Farms) that produces a triple mix topsoil using the compost.

Guelph may consider purchasing topsoil blended with composted biosolids if available through the topsoil distributors.

Provincial highway medians and facility landscaping, as well as industrial areas are also potential end-users of the compost.

2.3. Potential Demand for Biosolids Compost

The potential demand for compost in the Guelph Region (~ 40 km radius) is up to approximately 107,000 m^3/yr, as shown in Table 2.2. Most of the demand is seasonal, with peak demands in early spring. Biosolids quality issues are most important the potential users. Government approval and demonstration trials would be needed before the potential users would consider purchasing biosolids compost.

Table 2.2: Potential Demand and Revenue from the Sale of Compost

Compost Market	Potential Demand and Revenues for Compost		
	Demand (m^3/yr)	Revenue	
		($/$m^3$)	($/yr)
Landscapers	26,000[1]		
Topsoil blenders and distributors	40,000[2]	$10	$400,000[3]
Landfill operators	0[4]	-[5]	-
Mining and Quarry Operators		-[5]	-
Agricultural (sod farms)	40,000[6]	-[5,7]	-[5,7]
Golf Courses	-[8]	-	-
Public Works	1,000	-	-
Total	107,000	$0 - $10	$0 - $400,000

[1] landscapers assumed toutilize 65% of topsoil from distributors
[2] surveyed topsoil distributors assumed to represent 30% of local topsoil market
[3] concerned with composted biosolids quality
[4] sufficient construction soil wastes and topsoil available on site
[5] users would take compost at no cost
[6] generator would pay for transportation costs to the site
[7] at 20 tonnes (33 m^3) per hectare per year
[8] no interest due to quality concerns

2.4. Potential Revenue from the Sale of Compost

Potential revenues from the sale of the compost could be up to $400,000 per year. Regulatory and biosolids quality issues must be addressed before potential users are willing to pay for the composted biosolids. Also, demonstration trials and sample lots are needed to let the potential users become familiar with the use of the composted biosolids and encourage future usage.

2.5. Compost Marketing Issues

Compost quality, public perception and government approval is a major barrier to the use of compost in the different markets. The compost quality areas of concern are generally metals, pathogens, toxic organics and the uncertainty that sufficient monitoring and quality control is in place.

Other issues:

- Perception of the public and the effect on their business
- Lack of experience in using composted biosolids
- Concerns with safety risks with public contact

2.6. Co-Marketing with Wet-Dry Compost

Marketing issues for biosolids compost are similar to the issues for marketing the City's wet-dry compost. Combined marketing efforts with the wet-dry composting operation is recommended.

2.7. Summary of the Marketing Survey

Conclusions from the marketing survey are as follows:

C.1. Sale to topsoil blenders and distributors, as well as sod farms, represents the largest market for composted biosolids. The topsoil blending market has the greatest potential for revenue.

C.2. Revenues could be as high as $400,000 per year; however, several years of demonstrations would be required to generate a demand for composted biosolids.

C.3. Composted biosolids sales into the topsoil blending market could affect the supply-demand balance and reduce the potential revenues from the sale of the compost. Composted biosolids from the Guelph WWTP represent more than 50% of the total compost usage in topsoil blending in the Guelph area.

C.4. Product specifications differ for each end use (and end users). A screened compost may be useful for some end uses.

C.5. Regulatory and quality issues must be addressed before potential end users will consider using (and buying) the composted biosolids.

Recommendations from the marketing survey are as follows:

R1. Complete demonstrations with topsoil blenders in partnership with regulatory authorities

- Demonstrate blending operations and quality controls to produce a safe, consistent topsoil product
- Demonstrate the product with willing end users

- Complete additional monitoring and identify further processing requirements (ie: screening, curing) for the different end uses
- Develop public education materials to improve the public perception of the material

R2. Construct a storage facility for the storage and curing of the compost

R3. Monitor the composted biosolids for the following additional parameters:

- Bulk density
- Soluble Salts

R4. Combined marketing efforts with the wet-dry composting operation is recommended.

3. Regulations

Regulatory requirements for the different uses of the composted biosolids are as follows:

- Application on Land: Certificate of Approval and compliance with MOE regulations and the "**Guidelines for the Application of Biosolids and Other Wastes on Agricultural Land"**. MOE/OMAFRA, 1996.
- Sale to the Public or Distributors: Compliance with the AAFC and CFIA fertilizer criteria as well as any conditions identified by the MOE

A comparison of the composted biosolids quality with existing regulations is shown in Appendix A. Cadmium, copper, mercury and zinc are the metals of most concern that may restrict the types of end uses for the compost. Copper and zinc are considered micro-nutrients, that may be allowed to exceed the criteria for some unrestricted use applications.

3.1. Regulatory Support

The support of regulatory agencies is critical for a successful composted biosolids marketing program (Brown (1990)). Demonstrations of alternative end uses for the compost, in partnership with government agencies, is needed to develop the new markets.

3.2. MOE Policies

The MOE requires approval for the compost usage on lands, unless it is approved for sale (and sold) under the CFIA fertilizer regulations. For MOE site application approval, the following would be required:

- Certificate of Approval
- Hydrogeological assessment of site
- Agronomic and environmental assessment to determine appropriate application rates and methods
- Soil analysis

3.3. OMAFRA Policies

The Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) provides guidelines for nutrient applications for turf grass and agricultural crops. The proposed nutrient management regulation would require wastes to be applied at agronomic rates.

3.4. Agriculture and Agri-Food Canada (AAFC) (and Canadian Food Inspection Agency (CFIA) Policies

The Canadian Food Inspection Agency (CFIA) regulates the sale of fertilizers and soil supplements (ie: compost) through the Agriculture and Agri-Food Canada (AAFC) fertilizer regulations act.

The fertilizer criteria specify maximum concentrations and/or loadings of metals, pathogens and toxic organics. The MOE may apply more stringent criteria than the fertilizer criteria. The CFIA recommends that generators intending to sell biosolids products submit detailed processing and product quality information to the CFIA. The CFIA would review the information and may provide additional criteria (ie: annual metal loading rates) for each generator.

To date, several biosolids generators in Canada have submitted information to the CFIA, including:

- Nviro Systems Canada (Leamington (ON) Facility) – Alkaline Biosolids
- Smith Falls (ON) – Pelletized (Dried) Biosolids
- Azurix North America (Windsor (ON) facility) – Pelletized (Dried) Biosolids
- US Filter (Toronto (ON) facility) – Pelletized (Dried) Biosolids

The status of CFIA's evaluation of each generator is confidential. Also, the CFIA does not have a list of generators of composted biosolids (or any other type of biosolids) that have been reviewed and approved for sale.

3.5. Other Standard and Guidelines

The Canadian Council of the Ministers of the Environment (CCME) and the Bureau de Normalization du Quebec (BNQ) have also developed voluntary standards for the distribution of compost in Canada, including metal and pathogen criteria. The standards have two tiers of criteria ("A" and "B") for unrestricted use and controlled uses (ie: use on industrial lands only). The metal criteria are shown in Table A.1, Appendix B.

4. Demonstration Projects

The recommended demonstration projects for end uses for the composted biosolids to be pursued include the following:

- Sod Farms
- Land Reclamation
- Top Soil Production

The demonstration projects are expected to have a capacity to utilize a small fraction of the compost produced.

4.1. Implementation Plan for Demonstration Projects

The implementation plan includes the following activities:

- Objectives
- Approval Requirements
- Demonstration Project Descriptions
- Implementation Plan Costs
- Schedule
- Demonstration Program Participation

4.2. Objectives

The objectives of the demonstration projects are to develop new markets for the use of the compost. The objectives of each demonstration project are included in each of the three project descriptions.

The general objectives and goals of the demonstration trials are to determine the following:

- Best practices for preventing any potential environmental impacts.
- Optimum application rates for soil improvement and fertilizer benefit
- Timing of application and storage requirements.
- Familiarize public/end users with the benefits and methods of utilizing compost.
- Equipment and logistic requirements.
- Labour requirements.
- Capital and operating costs.
- Compost specifications

4.3. Approval Requirements

The approval requirements for each demonstration project are as follows:

Demonstration Project	Approval Type
Sod Farm Application	Waste Disposal Site (Organic Soil Conditioning)
Land Reclamation	Waste Disposal Site (Organic Soil Conditiong)
Topsoil Production	Waste Disposal Site (Processing)[1]

[1] or approved as an amendment to the existing C of A (sewage)

Comments on the approvals are as follows:

4.3.1. Sod Farms and Reclamation Sites:

- Application rates on sod farms and reclamation sites exceeding 8 tonnes/ha would need to be supported with agronomic and environmental impact assessments. Also, demonstration projects may require groundwater analysis to confirm environmental impacts (ie: nitrogen leaching) is not occurring.
- Application rates may also be limited by metal loadings (on an annual or lifetime basis)

4.3.2. Topsoil Production:

- Processing at either the Guelph WPCP is preferred by the MOE.
- Blending at the Wet-Dry Composting Site is not preferred by the City. Prevention of odours at the Wet-Dry Composting site would be a significant factor in any approvals for blending.
- Blending at the Eastview Landfill site is preferred by the City.
- Compost blending for topsoil production at a private topsoil blender (ie: Prior Construction) is not recommended by the MOE. A new CofA for the private topsoil blender's facility would be required for off-site blending. The existing CofA for the WPCP or Wet-Dry facility could be amended for on-site topsoil blending.

The application forms for the Certificates of Approval (CofA) required for the demonstration projects are included in Appendices D and E.

The following information would be necessary for further developing demonstration plans for the compost:

4.3.3. Sod Farm Applications:

- Site Assessment (soil report, soil sampling and analysis, aerial photos, topographic maps, etc.)

- Agronomic Assessment (ie: nutrient content of compost; estimate rate of mineralization of organically bound nutrients)
- Type of turf grasses grown on sod farms (ie: Kentucky Bluegrass)

4.3.4. Land Reclamation:

- Site Assesment (soil report, soil sampling and analysis, aerial photos, topographic maps, etc.)
- Characteristics and costs of top soil available.
- Site characteristics (ie: topography, depth to groundwater, groundwater flow patterns, proximity to surface water and potable wells).
- Future use of the site.
- Precipitation records.

4.3.5. Topsoil Production:

- Characteristics of soil used in topsoil blend.
- End users of the topsoil and topsoil specifications.
- Equipment and operating procedures for soil blending.

4.4. Demonstration Project Descriptions

4.4.1. Sod Farm:

4.4.1.1 Introduction

Compost would be spread and incorporated into soils on the sod farm sites. Four half (0.5) to one (1) hectare plots at a sod farm site are proposed for the demonstration trials, with compost volumes of 186 m^3 to 371 m^3 required. Actual plot dimensions depend on the sites available. Potential sites include Fairlawn Sod, Blue Grass Sod Farms and Compact Sod.

The objectives of the sod farm trials are to develop appropriate application rates, obtain regulatory acceptance and develop interest from other sod farm operators for the compost. Future sod farm applications will depend on the success of the demonstration trial. The trials may also identify methods of application that produce the best improvements in sod production.

4.4.1.2 Demonstration Program Participation

The government, industry and non-government agencies that are proposed for participation in the project are shown in Figure 4.1.

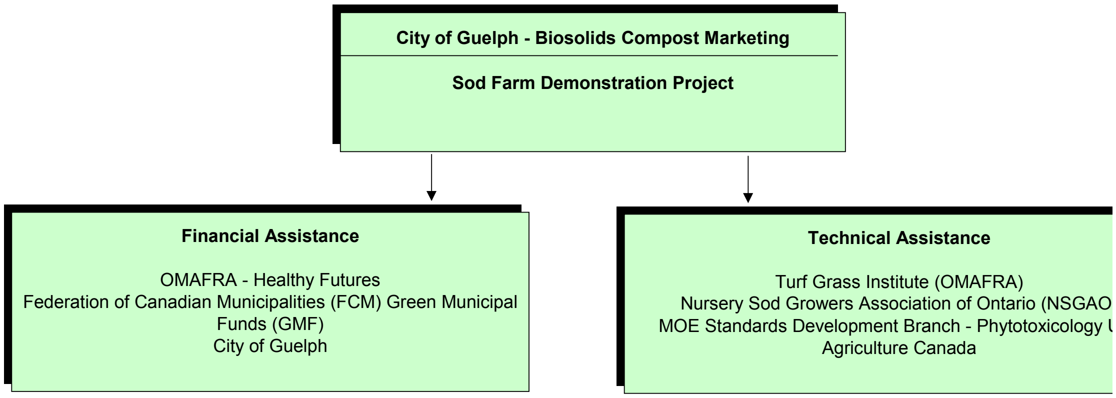


Figure 4.1: Participation in the Sod Farm Demonstration Project

4.4.1.3. Application Rates:

Application rates would range from 0 to 175 dry tonnes of solids per hectare, based on U.S. Department of Agriculture (USDA) recommendations (see Appendix F) and up to 75 dry tonnes/ha based on nutrient loading rates in Guelph's biosolids compost. Application rates are based on the nutrients provided by compost and rates that result in soil improvement. The trials would be used to show sod farm operators the benefits of compost application, and provide sufficient information to justify application rates higher than 8 dry tonnes/ha/5 years. Proposed application rates are shown in Table 4.1. Metal loadings, shown in Table 4.2 are less than the cumulative lifetime loading limits.

4.4.1.4. Applications Method:

Compost would be spread at the beginning of the sod growing season before seeding. Application on the land at a controlled rate using calibrated application equipment. After application, the compost would be immediately (within 6 hours) disced into the soil. Application requirements for the trials are shown in Table 4.1.

4.4.1.5. Equipment Requirements:

A tractor with a solid-type manure spreader and discing equipment would be suitable for spreading and incorporating the compost into the soil (see Appendix G). A front end loader may also be required for loading the compost into the manure spreader.

4.4.1.6. Sod Farm Area Requirements

Land area requirements based on an application rate of 75 dry tonnes/ha would be up to x ha. If the applications are limited to once per 4 years, the total land area required for

Table 4.1: Sod Farm Demonstration Trial Requirements

Trial Plot #	Compost Application Rate: tonne/ha dry wt.	Compost Application Rate: total tonnes mass, total	Compost Application Rate: total tonnes dry wt.	Compost Application Rate: Volume (m^3)	Application Site: Requirements Truck Loads #	Application Site: Requirements Application days	Application Site: Depth (cm)	Application Site: Depth (inch.)	Application Site: Application Area ha	Nutrient Addition: Nitrogen total (kg/ha)	Nutrient Addition: Nitrogen available (kg/ha)	Nutrient Addition: OM (tonnes/ha)
Half (0.5) Hectare Plots												
1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0
2	8	6.7	4.0	11.2	0.7	0.1	0.1	0.0	0.5	144.0	36.0	6.4
3	50	41.7	25.0	69.8	4.7	0.6	0.7	0.3	0.5	900.0	225.0	40.0
4	75	62.5	37.5	104.7	7.0	0.9	1.0	0.4	0.5	1350.0	337.5	60.0
Total		110.8	66.5	185.7	12.4	1.5			2.0			
One (1.0) Hectare Plots												
1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
2	8	13.3	8.0	22.3	1.5	0.2	0.2	0.1	1.0	144.0	36.0	6.4
3	50	83.3	50.0	139.6	9.3	1.2	1.4	0.5	1.0	900.0	225.0	40.0
4	75	125.0	75.0	209.4	14.0	1.7	2.1	0.8	1.0	1350.0	337.5	60.0
Total		221.7	133.0	371.4	24.8	3.1			4.0			

Sod Farm Demonstration Trials

application in a 4 year cycle would be x ha. Also note that additional land area may be required to allow for setbacks from watercourses, wells, residences and roads.

4.4.1.7. Minimum Compost

An uncured compost (or 2 – vessel compost) would be acceptable for use on sod farms.

4.4.2. Land Reclamation Site

Small mined aggregate pits would be remediated by covering the sites with a blend of soil and compost. A list of potential reclamation sites in the Guelph area is shown in Appendix H.

Compost would be applied on the reclamation site using the same methods as application on sod farms and other agricultural land, however, the application rates may be much higher.

The objectives of the trials are to develop appropriate application rates, obtain regulatory acceptance and develop interest from aggregate producers to use the compost on other sites.

4.4.2.1. Demonstration Program Participation

The government, industry and non-government agencies that are proposed for participation in the project are shown in Figure 4.2.

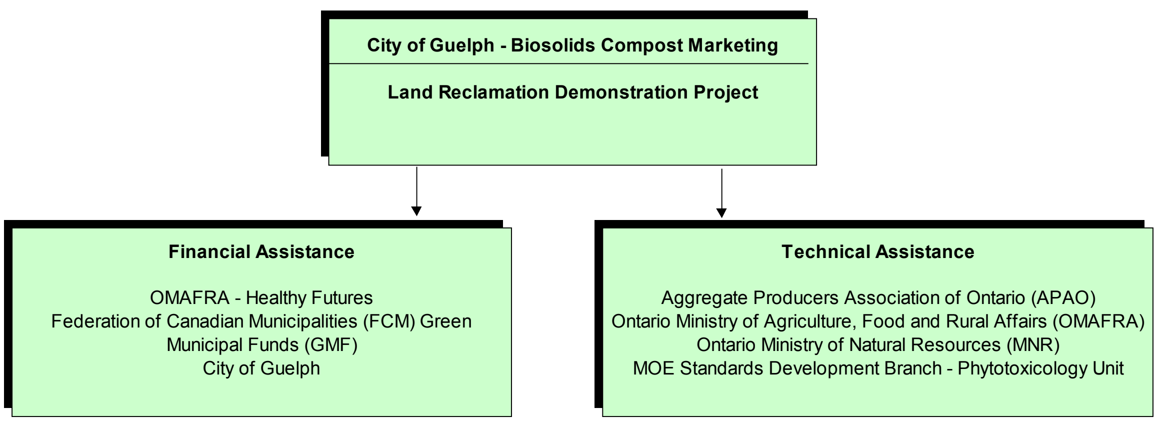


Figure 4.2: Participation in the Land Reclamation Demonstration Project

4.4.2.2. Compost Application:

Compost would be spread at a controlled rate on the site along with topsoil and then immediately (within 6 hours) disced into the soil.

4.4.2.3. Application Rates:

Application rates would range from 0 to 400 dry tonnes of solids per hectare, based on typical land reclamation practices. Application rates are based on achieving a topsoil organic content of 5% to 10% to support vegetative growth. The rates may also be based on the available nutrients provided by compost that can be removed by vegetative growth. Application rates and requirements to achieve a range of topsoil organic matter contents are included in Table 4.3. Metal loadings, shown in Table 4.2 are less than the cumulative lifetime loading limits.

4.4.2.4. Minimum Compost Quality:

A well-cured compost (3 – vessel compost) would be required to reduce the available ammonia content of the compost product. Uncured composts may be acceptable on some sites at reduced application rates.

4.4.2.5. Equipment Requirements:

Equipment requirements would be similar to the equipment used for compost application on sod farms (see Appendix G).

4.4.2.6. Site Preparation:

The demonstration site may require barriers to control storm runoff and a liner and drains to collect leachate. Monitoring wells may be required for groundwater monitoring in the area. Crops grown on the site after compost application would be selected to maximize nutrient and moisture removal.

4.4.2.7. Land Area Requirements:

Four quarter (0.25) to half (0.5) hectare plots at a reclamation site are proposed for the demonstration trials, with compost volumes of 262 m^3 to 524 m^3 required. Actual plot dimensions depend on the sites available.

4.4.2.8. Site Selection:

The preferred site would contain soils with medium to low permeability, a level topography, a high cation exchange capacity (CEC), a low groundwater level and a site that is a long distance from surface waters, potable wells, and residential areas.

4.4.3. Topsoil Blending

Composts may be suitable for use as a component in topsoil production to improve the physical, nutrient and microbiological characteristics of the topsoil.

The objectives of the topsoil blending trials are to determine appropriate blending methods, blend ratios and to obtain regulatory acceptance.

4.4.3.1. Demonstration Program Participation

The government, industry and non-government agencies that are proposed for participation in the project are shown in Figure 4.3.

Table 4.2: Metal Loadings to Soil at Compost Application Rates for Sod Farms and Land Reclamation Sites

Parameter	Compost Concentration mg/kg TS	Metal Loadings (kg/ha) / Application Rate (dry tonnes/ha)					
						Ontario Limits[1]	
		8	50	75	250	Annual	Lifetime
Arsenic (As)	4.9	0.04	0.24	0.36	1.2	1.4	14
Cadmium (Cd)	6.0	0.05	0.30	0.45	1.5	0.27	1.6
Cobalt (Co)	2.8	0.02	0.14	0.21	0.7	2.7	30
Chromium (Cr)	120	0.96	6.0	9.0	30.0	23.3	210
Copper (Cu)	506	4.0	25.3	38.0	126.5	13.6	150
Mercury (Hg)	0.8	0.01	0.04	0.06	0.19	0.09	0.8
Molybdenum (Mo)	7.3	0.06	0.37	0.55	1.83	0.8	4
Nickel (Ni)	10.2	0.08	0.51	0.77	2.55	3.56	32
Lead (Pb)	45	0.36	2.25	3.4	11.2	9	90
Selenium (Se)	1.2	0.01	0.06	0.09	0.31	0.27	2.4
Zinc (Zn)	932	7.5	46.6	69.9	233.1	33	330

[1] from the "Guidelines for the Utilization of Biosolids and Other Wastes on Agricultural Land". OMAFRA/MOEE, March 1996.

Table 4.3: Land Reclamation Demonstration Trial Requirements

Trial Plot #	Land Reclamation Demonstration Trials												
	Compost Application Rate				Application Site						Nutrient Addition		
					Requirements		Depth		Application	OM	Nitrogen		OM
	tonne/ha dry wt.	total tonnes mass, total	dry wt.	Volume (m^3)	Truck Loads #	Application days	(cm)	(inch.)	Area ha	(%)	total (kg/ha)	available (kg/ha)	(tonnes/ha)
Quarter (0.25) Hectare Plots													
1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.25	0.0	0.0	0.0	0.0
2	50	20.8	12.5	34.9	2.3	0.3	1.4	0.5	0.25	2.0	900.0	225.0	40.0
3	75	31.3	18.8	52.4	3.5	0.4	2.1	0.8	0.25	3.0	1350.0	337.5	60.0
4	250	104.2	62.5	174.5	11.6	1.5	7.0	2.7	0.25	10.0	4500.0	1,125.0	200.0
Total		156.3	93.8	261.8	17.5	2.2			1.0				
Half (0.5) Hectare Plots													
1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0
2	50	41.7	25.0	69.8	4.7	0.6	1.4	0.5	0.5	2.0	900.0	225.0	40.0
3	75	62.5	37.5	104.7	7.0	0.9	2.1	0.8	0.5	3.0	1350.0	337.5	60.0
4	250	208.3	125.0	349.1	23.3	2.9	7.0	2.7	0.5	10.0	4500.0	1,125.0	200.0
Total		312.5	187.5	523.6	34.9	4.4			2.0				

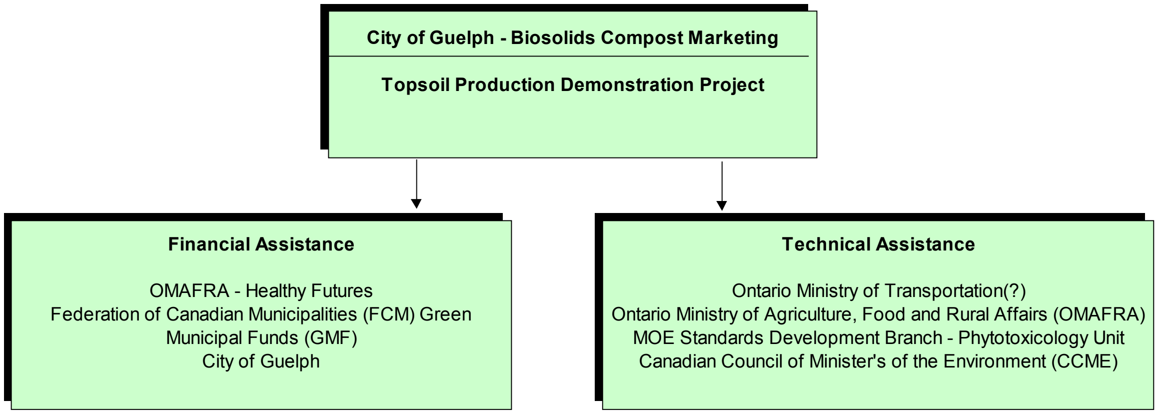


Figure 4.3: Participation in the Topsoil Production Demonstration Project

4.4.3.2. Topsoil Characteristics:

The desired characteristics of compost material for producing topsoil includes low odours, minimal dust generation, supports vegetative growth (not phytotoxic) and good physical stability.

Compost would be blended with soil and then formed into windrows. The topsoil blend would be cured for a period of 60 days to reduce any residual odours, as well as provide time for each lot of topsoil to be analyzed.

Compost would be blended with soils to obtain a topsoil organic matter content in the range of 5% to 10%. Compost usage would also be controlled to produce topsoil with metal concentrations less than the maximum criteria allowable. Compost, topsoil and blended topsoil compositions are shown in Table 4.4 and 4.5. Metal concentrations in the topsoil blend, based on a 2.3:1 topsoil/compost blend, would meet the MOE's unrestricted controlled use compost guidelines.

4.4.3.3. Topsoil Blending Site:

The blended topsoil windrows would have dimensions similar to windrow composting. Dimensions are typically in the range of 2.4 to 6.1m (8'-20') wide by 1 to 2m (3'-7') high. The windrow dimensions depend on the equipment used to blend the compost and soil. The windrow length would be constructed to suit the dimensions of the disposal site.

For a demonstration with five windrows, each 4.8m wide by 1.5 m high by 20m in length, approximately 150 m^3 of compost would be required and 500 m^3 of topsoil mix would be produced.

A blending site area of approximately 0.2 ha would be required.

4.4.3.4. Topsoil Blending Requirements:

Soil/compost ratios of 2:1 to 4:1 are typical.

4.4.3.5. Minimum Compost Quality:

A well-cured compost (3 – vessel compost) would be required to reduce the odour potential and the available ammonia content of the compost product.

Table 4.4: Topsoil Demonstration Trial Requirements

Component	Topsoil Demonstration Trial							
	Topsoil Blending			Topsoil Blend		Nutrient Availability (% of total mass)		
	Weight total tonnes mass, total	dry wt.	Volume (m^3)	Truck Loads #	Bulk Density kg/m^3	Nitrogen total	available	OM
Compost	89.5	53.7	150.0	10.0	596.8	1.8	0.3	48.0
Topsoil	626.7	532.7	350.0	23.3	1790.5	0.0	0.0	0.0
Blend	716.2	586.4	500.0	33.3	1432.5	0.2	0.04	6.0

lbs/yd3	kg/m3	TS (%,w/w)
1000	596.83819	60
3000	1790.5146	85

Table 4.5: Metal Concentrations in Compost and Topsoil Blend

Parameter	Concentration (mg/kg TS)				
	Compost	Topsoil	Blend	Ontario Limits[2]	
			(2.3:1)[1]	Unrestrict.	Controlled Use
Arsenic (As)	4.86	7.00	6.8	10	20
Cadmium (Cd)	5.96	0.80	1.3	3	4
Cobalt (Co)	2.82	5.00	4.8	25	25
Chromium (Cr)	119.93	15.00	24.6	50	50
Copper (Cu)	506.07	25.00	69.1	60	100
Mercury (Hg)	0.77	0.10	0.2	0.15	0.5
Molybdenum (Mo)	7.33	2.00	2.5	2	3
Nickel (Ni)	10.20	16.00	15.5	60	60
Lead (Pb)	44.95	15.00	17.7	150	500
Selenium (Se)	1.23	0.40	0.5	2	2
Zinc (Zn)	932.32	55.00	135.3	500	500

[1] topsoil-to-compost volume ratio

[2] from the "Interim Guidelines for the Production and Use of Aerobic Compost in Ontario". MOE, November 1991.

4.4.3.6. Equipment Requirements:

Windrow turning equipment and/or a front end loader suitable for moving and blending compost and topsoil material, and constructing windrows would be required.

4.4.3.7. Land Area Requirements:

The land area required for a topsoil blending operation is expected to be in the range of approximately 0.2 – 0.3 ha . Additional area for storage and a buffer zone may also be required.

4.5. Costs

Costs for the demonstration projects are summarized in Table 4.6.

4.6. Schedule

The schedule for completing the three demonstration projects are summarized in Table 4.7. The typical processing and land application schedule for the different end uses is shown in Table 4.8.

4.7. Compost Curing and Blending Site

The asphalt pad on the southwest corner of the Guelph WPCP site could be used for curing and topsoil blending. The 0.8 ha area, has a capacity for curing up to 3,100 m^3 of compost, as shown in Figure 4.4.

The demonstration trials could utilize up to about 1,400 m^3 of cured compost, thereby requiring up to about 50% of the asphalt pad for curing.

4.8. Compost Analyses

The list of analyses for the compost marketing demonstration projects is shown in Table 4.9. Also, the WWTP is required, by the C of A for the compost facility, to analyze the compost for several additional parameters, some of which will also be used in the demonstration projects.

4.9. Demonstration Program Participation

Funding:

Two sources of funding are the OMAFRA Healthy Futures Program and the Federation of Canadian Municipalities (FCM) Green Municipal Funds (GMF) Program. Application forms for funding are included in Appendices I and J, respectively.

Technical Assistance:

Several organizations have indicated interest in participating and providing technical assistance in the compost marketing demonstration programs, including:

- Aggregate Producers Association of Ontario (APAO)

Table 4. Breakdown of Costs for the Demonstration Projects

Item	Cost ($) / Demonstration Project		
	Sod Farm[1]	Land Reclamation[1]	Topsoil Production[2]
Demonstration Work Plan	3,000	3,000	3,000
Agronomic Assessment	4,000	4,000	
Site Assessment / Approvals	5,000	5,000	5,000
Site Preparation / Equipment Rental	10,000	10,000	10,000
Transportation (@ $10/wet tonne)	2,000	3,000	9,000
Application (@ $20/wet tonne)	4,000	6,000	
Pre and Post Application Sampling & Analyses	9,000	9,000	9,000
Demonstration Report	10,000	10,000	10,000
Total	47,000	50,000	46,000

[1] based on installation of 4 monitoring wells, with well water and soil samples collected before and after (3X) application

[2] based on rental of windrow turner and front end loader for 1 week

Table 4.7: Compost Marketing Demonstration Project Proposed Schedule

City of Guelph Compost Marketing Demonstration Projects

Task	November			December				January					February					March				April					May				
	12	19	26	5	12	19	26	2	9	16	23	30	1	2	3	4	5	5	12	19	26	1	2	3	4	5	1	2	3	4	5
Approvals																															
• Develop Demonstration Plan	■	■	■	■	■	■	■																								
• Application for Approvals	■	■	■	■	■	■	■																								
• Application for Funding	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Site Preparation / Processing																															
• Site Preparation (ie: monitoring wells)																		■	■	■	■										
• Contracts for Processing, Application													■	■	■	■	■	■	■	■	■										
Processing / Application (End Use)																															
• Transportation, Application																						■	■	■	■	■	■	■	■	■	■
Post Application Monitoring																															
• Soil, Crop and Groundwater Testing																															
Report Preparation																															
• Demonstration Report																															

Task	June					July					August					September					October					November					December					January				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	2	9	16	23	30
Approvals																																								
• Develop Demonstration Plan																																								
• Application for Approvals																																								
• Application for Funding																																								
Site Preparation / Processing																																								
• Site Preparation (ie: monitoring wells)																																								
• Contracts for Processing, Application																																								
Processing / Application (End Use)																																								
• Transportation, Application																																								
Post Application Monitoring																																								
• Soil, Crop and Groundwater Testing	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■										
Report Preparation																																								
• Demonstration Report																								■	■	■	■	■	■	■	■	■	■	■	■					

Table 4.8: Compost Processing an Land Application Schedule for Different End Uses

End Use Market	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Notes
Sod Farms				Application	Application								Uncured (2-vessel) compost acceptable
Land Reclamation			Application	Application	Application	Application	Application	Application	Application	Application	Application	Application	Cured (3-vessel) compost required, with low ammonia content
Topsoil Production	Blending	Blending	Blending	Application	Application				Application	Application			Cured (3-vessel) compost required, with low odour and ammonia content

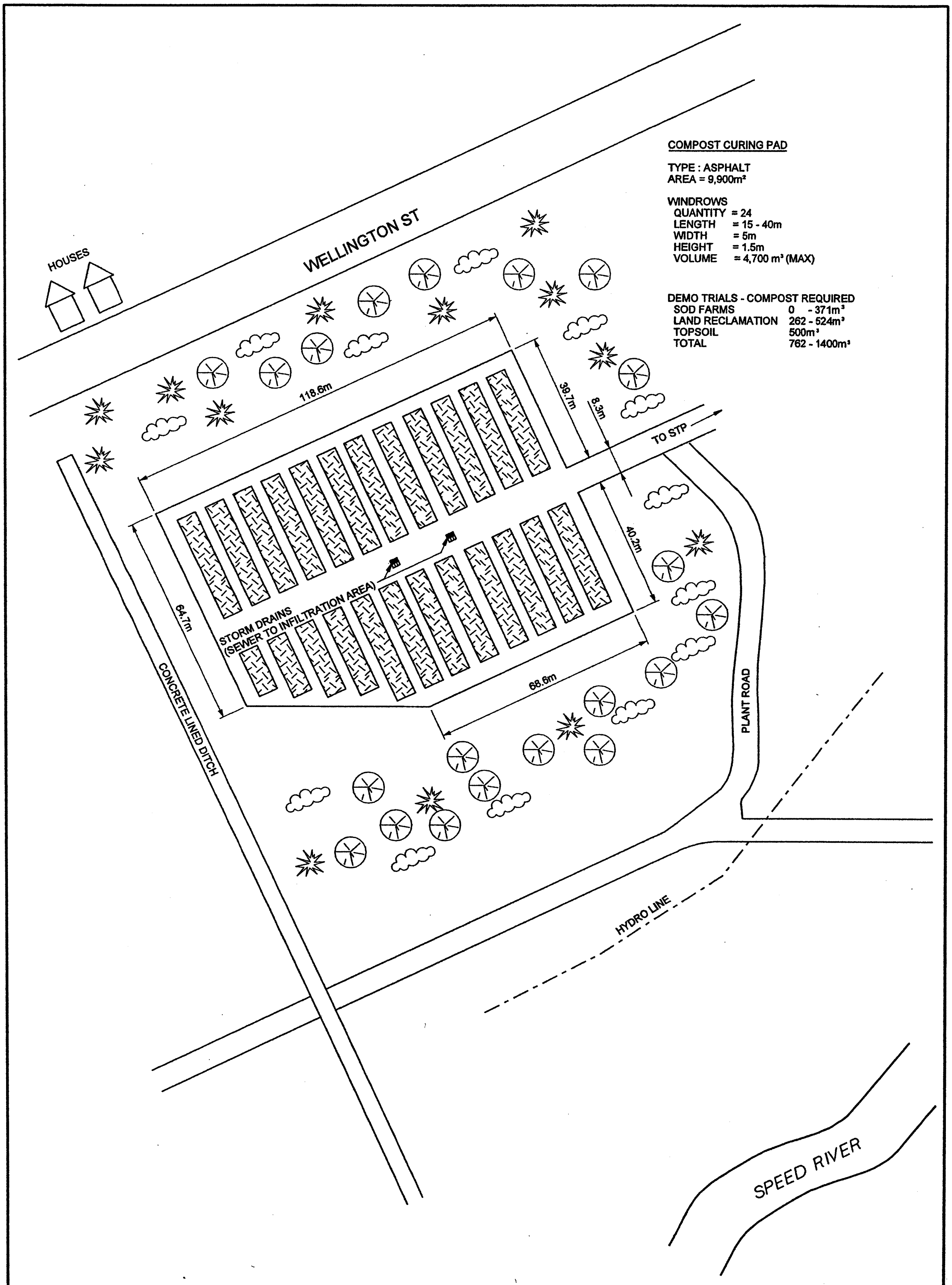


FIGURE 4-4
COMPOST CURING AND BLENDING
GUELPH WPCP STORAGE PAD

C:\WIP\figure4.dgn

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Table 4.9: List of Analysis for the Compost Marketing Demonstration Projects

Parameter	Parameter / Location	
	Compost (Windrow Cured)	Monitoring Wells
Field Monitoring		
Temperature	X	
Colour	X	
Odour Level	X	
Chemical Analyses		
Conventional:		
BOD_5		X
COD		
Conductivity (EC)	X	X
pH	X	X
Suspended Solids (SS)		X
Total solids (TS)	X	
Volatile Solids (VS)	X	
Nutrients:		
Ammonia	X	X
Nitrate & Nitrite	X	X
TKN	X	
Total phosphorus (TP)	NR[1]	
Metals (ICP, As, Hg, Se)	NR[1]	
Other:		
Chlorides (Cl)		X
Sodium (Na)		X
Soluble Salts (total)	X	
Germination Tests	NR[2]	
Microbiological:		
E. coli	X	X
Faecal coliform	X	X
Salmonella	X	X

[1] not required (data available from monthly analysis of compost (prior to storage))

[2] not required unless requested by potential end user

- Agriculture and Agri-Food Canada
- Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA)
- Ontario MOE Standards Development Branch - Phytotoxicology Unit
- Ontario Ministry of Natural Resources (MNR)
- Turf Grass Institute (OMAFRA)

Other organizations that may have interest include:

- Nursery Sod Growers Association of Ontario (NSGAO)
- Canadian Council of Minister's of the Environment (CCME)
- Ontario Ministry of Transportation

4.10. Outcomes from Compost Use Demonstration Projects

The expected results from the compost use demonstration projects are as follows:

- Determine appropriate application rates
- Identify best management practices to mitigate any potential impacts
- Obtain regulatory approval to use the compost for the demonstrated end uses
- Identify the most promising markets for the compost
- Determine compost specifications required for the different end uses
- Identify barriers must be addressed before selling the biosolids products
- List steps to be completed to further develop a compost marketing plan, such as:
    - Complete longer term demonstrations
    - Obtain price guarantees for sale of the compost
    - Complete additional monitoring of the compost quality
    - Demonstrate the use of the compost with other willing end users

5. REFERENCES

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17. Tyler R. "**Diversification at the Compost Factory**", in Biocycle, August 1993.
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19. Williams TO, Epstein E. "**Are There Markets for Compost?**", in Waste Age, April 1991.
20. Wilson C. **"Boosting Compost Sales"**, Operators' Exchange, in Biocycle, September 1996.

21. Wohlgemuth GJ, Davis PA. “**Broward County Uses Distribution and Marketing for Biosolids Management**”.

APPENDIX A

COMPOST QUALITY

Table A.1: Comparison of Guelph's Composted Biosolids Quality with Compost Guidelines

Parameter	Concentration (mg/kg dry wt.)														
	Guelph WWTP Compost (mg/kg dry wt.?)							Compost Utilization Guidelines							
								Restricted Use	Unrestricted / Controlled Uses						
								Agricultural Land[2]	Ontario[1]		CCME[3]		BNQ[4]		Agriculture Canada[5,6]
	1995	1996	1997	1998	1999	2000	Ave. (overall)		Unrestrict.	Controlled Use	"A"	"B"	"AA" & "A"	"B"	
Arsenic (As)	6.4	5.4	5.4	4.8		3.8	4.9	170	10	20	13	50	13	75	20
Cadmium (Cd)	7.6	6.3	6.1	5.1	4.2	6.3	6.0	34	3	4	3	20	3	20	5.2
Cobalt (Co)	1.1	1.2	3.2	3.2			2.8	340	25	25	26	300	34	150	39
Chromium (Cr)	130	121	98	104	130	152	120	2,800	50	50	210	800	210	1,060	
Copper (Cu)	400	639	557	445	450	412	506	1,700	60	100	100	500	100	757	
Mercury (Hg)	3.0		0.2	0.7		1.1	0.8	11	0.15	0.5	0.8	10	0.8	5	1.3
Molybdenum (Mo)	5.0	8.7	7.4	7.8	8.5	6.8	7.3	94	2	3	5	40	5	20	5.2
Nickel (Ni)	10.0	11.7	10.3	8.2	8.6	10.8	10.2	420	60	60	60	500	62	180	47
Lead (Pb)	45	56	78	27	16	21	45	1,100	150	500	150	1,000	150	500	130
Selenium (Se)	1.5	1.3	1.7	1.2		0.8	1.2	34	2	2	2	10	2	14	3.6
Zinc (Zn)	1,000	980	904	815	830	1,026	932	4,200	500	500	500	1,500	500	1,850	481

1 from the "Interim Guidelines for the Production and Use of Aerobic Compost in Ontario". MOE, November 1991.

2 from the "Guidelines for the Utilization of Biosolids and Other Wastes on Agricultural Land". OMAFRA/MOEE, March 1996.

3 from the "CCME Discussion Paper for the Regulation of Concentrations of Trace Elements in Compost". Canadian Council of the Ministers of the Environment. Rev. #1, September 1993

4 from the "National Standard of Canada. Organic Soil Conditioners - Composts". Bureau De Normalisation Du Quebec (BNQ), 1996

5 from "Metal Concentrations in Processed Sewage and By-Products". Trade Memorandum T-4-93, Agriculture Canada, July 1995.

6 at 1.3% nitrogen

APPENDIX B

LIST OF CONTACTS

B. List of Contacts

Companies and organizations surveyed for their comments on the market for composted biosolids in the Guelph area include:

Regulatory:

- Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA)
- Ontario Ministry of the Environment (Guelph District)
- Ontario Ministry of the Environment (Approvals)

Landfill and Quarry Operators:

- One (1) Landfill

City of Guelph Public Works:

- Two (2) public works departments

Landscapers:

- Four (4) landscapers

Topsoil Blenders:

- Nine (9) topsoil blenders and suppliers

Sod Farmers:

- Three (3) sod farms

Golf Courses:

- One (1) golf course

APPENDIX C

TELEPHONE SURVEY

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TELEPHONE CALL SURVEY – LIST OF QUESTIONS

Party Called:
of: **Tele #:**

Email: **Fax #:**

Date: **Call Initiated By:**

Subject: Composted Biosolids Product Market Assessment

Questions included in the biosolids marketing telephone marketing survey are as follows:

A list of issues and questions to be addressed in the end user survey are outlined below:

Product Quality:

- What are the product specifications (ie: stability, odour, dust content, texture, size uniformity (granulometry), composition (metals, micro-nutrients, nutrients, pathogens, water insoluble nitrogen, TDS, pH, TS, OM)?

Product Distribution:

- In what form would the product best be sold (bagged, bulk, filler material in product)?
- Would the distributor provide a market development plan? Would a guarantee be provided on the quantity of biosolids to be purchased per year?
- Would the distributor provide transportation and storage for the biosolids products?
- What are the expected product retail demand variations on a monthly basis?
- How much storage capacity should be provided by the generator?
- How is the product typically applied and what are the typical application equipment?
- What is the typical transportation distance to the end users?

Product Markets:

- What is the potential size (ie: # tonnes/yr) and stability of the market?
- What would be the impact of Guelph's biosolids products (~ 8,000 to 15,000 tonnes (wet wt.) per year of product) on the price for similar products?

- How would the product best be sold (ie: directly to end-user; through topsoil blender; to wholesaler or retailer)?
- What competition would be expected from other similar organic and inorganic-based products (ie: synthetic fertilizers, peat, animal manure composts, Aglime, topsoil blenders)?
- Who are the major manufacturers, and suppliers of similar products?
- Who are the actual end users of the products?
- What are the major barriers to selling the biosolids products?
- What additional information is needed before considering the distribution of biosolids products?

What organizations should be involved in developing the biosolids product markets (ie:

OMAFRA seal of approval?)?

TELEPHONE CALL CONFIRMATION

Party Called:
of: **Ariss Valley Golf Course** **Tele #:**

Email: **Fax #:**

Date: **Sept 5/01** **Call Initiated By: ISO**

Subject: Composted Biosolids Product Market Assessment

Comments on the biosolids marketing telephone survey are as follows:

Product Quality:

- Compost quality very specific depending on the use.

Compost Usage:

- Not much compost usage expected at the golf course for the forseeable future
- 1 – 2 truckloads/yr of compost at the most would be used for flowerbeds or possibly reconstruction. Mostly sand used for top dressing greens.
- Ariss Valley is under construction and have too much topsoil from digging ponds, etc.

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TELEPHONE CALL CONFIRMATION

Party Called: **Peter Ferguson**
of: **Canadian Food Inspection Agency** **Tele #:** **613/225-2342X4365**
59 Camelot Drive, Napean, ON K1A 0Y9
Email: **Fax #:**

Date: **Sept 11/01** **Call Initiated By: ISO**

Subject: Composted Biosolids Product Market Assessment

Comments on the biosolids marketing telephone survey are as follows:

Product Quality:

- Compost must meet the requirements of the fertilizer act and the Trade Memorandums
- Compost must be safe and adequately labelled
- Guelph can submit a package of information to the CFIA for review. The submission is voluntary and not required for registration.
- A letter of “no objection” is not provided by CFIA
- CFIA does not have a list of biosolids products, such as compost or pelletized biosolids, that are registered for sale or are under consideration.

TELEPHONE CALL CONFIRMATION

Party Called:
of: **Complete Landscaping** **Tele #:**

Email: **Fax #:**

Date: **Sept 8/01** **Call Initiated By: ISO**

Subject: Composted Biosolids Product Market Assessment

Comments on the biosolids marketing telephone survey are as follows:

Product Quality:

- No metals or odours in compost product
- Screened, with no wood chips desirable.

Product Distribution:

- About 1 truckload/wk of triple mix used. Amount varies with most of demand in the spring (April – June)

Product Markets:

- Willing to consider marketing biosolids compost, depending on price and quality
- Only triple mix is currently sold. Compost not used.

TELEPHONE CALL CONFIRMATION

Party Called:
of: **DMEX Excavating**
also Fairlawn Sod
Tele #:
Email:
Fax #:

Date: **Sept 8/01**
Call Initiated By: ISO

Subject: Composted Biosolids Product Market Assessment

Comments on the biosolids marketing telephone survey are as follows:

Product Quality:

- Used wet-dry facility compost in the past and did not like. Would not use biosolids compost
- Would rather pay for manure

Product Distribution:

- Use about 1,000 yd3 /yr of compost?
- About 90% goes to landscapers

Product Markets:

- Contact Fred Prior Excavating for topsoil blenders
- About 2,000 ac of sod under production

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TELEPHONE CALL CONFIRMATION

Party Called:
of: **Earth Works Landscaping** **Tele #:**

Email: **Fax #:**

Date: **Sept 8/01** **Call Initiated By: ISO**

Subject: Composted Biosolids Product Market Assessment

Comments on the biosolids marketing telephone survey are as follows:

Product Quality:

- Metals and public perception are a concern in using biosolids compost
-

Product Distribution:

- Triple mix (compost, peat, sand) purchased from RM Adams in Kitchener or All Treat
- Two loads/wk of triple mix purchased, mostly in spring
- Only triple mix is used. Compost not purchased to use or blend with other materials

Product Markets:

- Most of triple mix sold to homeowners
- No market for biosolids compost

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TELEPHONE CALL CONFIRMATION

Party Called: **John Monbly**
of: **Evergreen Farms** **Tele #:** **519/658-6279**

Email: **Fax #:**

Date: **Sept 8/01** **Call Initiated By: ISO**

Subject: Composted Biosolids Product Market Assessment

Comments on the biosolids marketing telephone survey are as follows:

Product Quality:

- Salt content less than 3.5% in compost (greenhouse test less than 1%). Poultry manures high in salts
- pH content 6.3 – 7.0 desired
- product must be odourless

Product Distribution:

- 120,000 – 150,000 yd3 composted, bagged and sold all over Ontario. Retails at up to $9/bag
- bags sold to retail store chains and garden centres
- Evergreen would bag Guelph's compost for $1/bag + pallet and wrapping costs. Add $1/yd3 for screening.
- Bagged in 30 L (~ 16 kg) bags
- Sold in bulk to landscapers at $18 - $28/tonne
- Most of compost demand is in March to June period.

Product Markets:

- composted turkey manure, composted leaves and other composts produced under different labels, such as Utopia Gold
-

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TELEPHONE CALL CONFIRMATION

Party Called: **Ian Milne**
of: **Guelph Parks and Recreation** **Tele #:**

Email: **Fax #:**

Date: **Sept 8/01** **Call Initiated By: ISO**

Subject: Composted Biosolids Product Market Assessment

Comments on the biosolids marketing telephone survey are as follows:

Product Quality:

- No metals or odours in compost product
- Screened compost desirable to prevent injury from wood chip slivers if compost used on ball fields; wood chips in compost acceptable for other uses
- Concerned with potential health risks if used on sports (ball) fields. Likely would be tried on low public contact areas (ie: flower gardens).

Product Usage:

- No compost purchased. About 600 yd3 to 700 yd3 of Triple mix purchased each year from Prior Construction. City leaves composted by All Treat Farms in Arthur.
- Usage is throughout the April – October season, but mostly April – May, when there is no grass cutting.

Product Markets:

- Triple mix used for shrub beds, tree planting (~ 200 yd3/yr) and sports fields
- Only triple mix is currently sold. Compost not used.
- Guelph area has poor, gravelly topsoil. In most cases the topsoil depth is less than 9”. Increasing the topsoil depth would be a benefit.

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TELEPHONE CALL CONFIRMATION

Party Called: Bob Miller, Wendy
of: MOE – Guelph District Office **Tele #:**
1 Stone Road, Guelph, ON
Email: **Fax #:**

Date: Sept 23/01 **Call Initiated By: ISO**

Subject: Composted Biosolids Product Market Assessment

Comments on the approvals for biosolids end uses as follows:

Approval Requirements:

- Applications that deviate from the Guidelines (March 1996) would need to be reviewed by the Biosolids Utilization Committee (BUC)
- Topsoil blending is best done on the WWTP site or at the wet-dry facility site. The existing CofAs for either site could then be amended for the blending operation. A new CofA for the blending facility would be required if blending occurs at an off-site location.
- Minimizing odours are a concern at the wet-dry composting facility site. Odour complaints have occurred in the past.
- Applications for approval should be submitted before approval conditions can be determined.
- Discussion with MOE Approvals also suggested.

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TELEPHONE CALL CONFIRMATION

Party Called: Brian Pierce / Paul Shell
of: Nugro Corporation **Tele #: 519/757-0077**
519/770-3181
Email: **Fax #: 519/757-0080**

Date: Sept 13/01 **Call Initiated By: ISO**

Subject: Composted Biosolids Product Market Assessment

Comments on the biosolids marketing telephone survey are as follows:

Product Quality:

- Screened compost preferred
- Topsoil-compost blend about 4:1 ratio
- Nugro could cure the material at the Woodstock site if MOE approves a demonstration

Product Distribution:

- All topsoil bagged (18 L, 30L bags) and sold through retail outlets. Cost for bagging unknown. Topsoil sold across Canada. Guelph area sales unknown.
- Most of topsoil demand is in spring (up to 150 – 200 truck loads/d during the March to June 1 period. Demand is about 95% in the spring with some demand in the fall.
- Topsoil bagging operation begins in January with 3 shifts/d
- Twenty (20) ac of paved storage at Woodstock processing site

Product Markets:

- Topsoil markets are not growing (1-2%/yr growth), while available supply of organics is increasing
- A "green" topsoil product produced with compost from recycling municipal organics is marketed; however demand is low
- Improved marketing for compost from recycling is needed to improve public perception
- Composted animal manure was a good selling product. Walkerton may have changed the public perception and reduced the demand for composted manure.

- Animal manure availability varies from year to year depending on transport costs, weather and nitrogen fertilizer costs. Many farmers are looking into on-farm composting.
- Nugro may participate in a demonstration study with Guelph's compost. A sample of the compost should be sent to Nugro before further discussions take place.

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TELEPHONE CALL CONFIRMATION

Party Called:
of: **RM Adams** **Tele #:**

Email: **Fax #:**

Date: **Sept 10/01** **Call Initiated By: ISO**

Subject: Composted Biosolids Product Market Assessment

Comments on the biosolids marketing telephone survey are as follows:

Product Quality:

- Salt content a concern (high in yard waste composts)
- pH of 7.2 ideal
- Animal manure composts usually cured for a while

Product Distribution:

- Yard waste and leaf compost purchased for $4/yd3 (delivered).
- Topsoil demand in early spring and late fall (September/October)
- Compost could be picked up or delivered to RM Adams site, depending on price.

Product Markets:

- About 5,000 to 10,000 yd3/yr of compost used to produce triple mix topsoil. Topsoil is about a third compost.

APPENDIX D

MOE CERTIFICATE OF APPROVAL ORGANIC SOIL CONDITIONING SITE

Ontario Ministry of the Environment

Ce formulaire est disponible en français

Application for Approval of a Hauled Sewage (septage) or Processed Organic Waste (biosolids) Disposal Site

For Office Use Only			
Reference Number	Payment Received $	Date *(y/m/d)*	Initials

General Information and Instructions

General:

Information requested in this form is collected under the authority of the *Environmental Protection Act*, R.S.O. 1990 (EPA) and will be used to evaluate applications for approval of waste management systems under Section 27, EPA.

Instructions:

1. When completing this form, please refer to the "Guide for Applying for Approval of Waste Management Systems, Section 27, EPA" (referred to as the Guide) and "Guide - Application Cost for Waste Management, S. 27, EPA." Questions regarding completion and submission of the application should be directed to your local District Office of the Ministry of the Environment.
2. This form must be completed with respect to all requirements identified in the Guide in order for it to be considered as an application for approval. INCOMPLETE APPLICATIONS WILL BE RETURNED TO THE APPLICANT.
3. A complete application consists of:
   (1) a completed and signed application form, including the attached "Costs for EPA S. 27 Applications - Supplement to Application for Approval";
   (2) all required supporting information identified in this form and the Guide, and
   (3) a certified cheque or money order, in Canadian funds, made payable to the *Minister of Finance* for the applicable application fee.
   The Ministry may require additional information during the technical review of any application accepted as complete.
4. The application, along with the supporting information and application fee, must be submitted to the local Ministry District.
5. Information contained in this application is not considered confidential and will be made available to the public upon request. Information submitted as supporting information may be claimed as confidential but will be subject to the *Freedom of Information and Protection of Privacy Act* (FOIPPA). If you do not claim confidentiality at the time of submitting the information, the Ministry may make the information available to the public without further notice to you.
6. If the Client submits with the application a copy of their Master Business Licence (MBL) obtained from the Ministry of Consumer and Commercial Relations, the **shaded sections within this form do not need to be completed.** For additional information on the MBL please refer to the "Guide."

1. Client Information *(owner of waste management system, or owner or lessee of land)*

Client Name *(legal name of individual or organization as evidenced by legal documents)*	Business Identification Number
Business Name *(the name under which the entity is operating or trading if different from the Client Name - also referred to as trade name)*	
Client Type: ☐ Corporation ☐ Individual ☐ Partnership ☐ Sole Proprietor ☐ Federal Government ☐ Municipal Government ☐ Provincial Government ☐ Other *(describe)*:	Activity Classification Code/Standard Industrial Classification Code *(if unknown please complete Business Activity Description)*
Business Activity Description *(a narrative description of the business endeavour, this may include products sold, services provided or machinery/equipment used, etc.)*	

2. Client Physical Address - *Complete A, C, and D* **or** *B, C and D*

A. Civic Address- Street information *(applies to an address that has civic numbering and street information includes street number, name, type and direction)*				Unit Identifier *(identifies type of unit, such as suite & number)*
B. Survey Address *(used for a rural location specified for a subdivided township, an unsubdivided township or unsurveyed territory)*				
Lot and Conc.: used to indicate location within a subdivided township and consists of a lot number and a concession number.	Lot / Conc.	Part and Reference: used to indicate location within an unsubdivided township or unsurveyed territory, and consists of a part and a reference plan number indicating the location within that plan. Attach copy of the plan.		Part / Reference
C. Municipality/Unorganized Township	County/District	Province/State	Country	Postal Code
D. Telephone Number *(including area code & extension)*	Fax Number *(including area code)*	E-mail Address		

3. Client Mailing Address - Complete A and C or B and C

A. Civic Address - Street information (includes street number, name, type and direction) ☐ Same as Client Physical Address			Unit Identifier (identifies type of unit, such as suite & number)	
B. Delivery Designator: ☐ Rural Route ☐ Suburban Service ☐ Mobile Route ☐ General Delivery			Delivery Identifier (a number identifying a Rural Route, Suburban Service or Mobile Route delivery mode)	
C. Municipality	Postal Station	Province/State	Country	Postal Code

4. Site Information

(Location where activity/works applied for is to take place. Please attach a sketch of the Site showing relevant features, structures, setback areas, sensitive uses and spreading locations. Also include a topographical map (1:10,000 scale), showing Site location.)

Site Name	MOE District Office	Legal Description*(attach copy of a legal survey)*

A. Civic Address- Street information *(applies to an address that has civic numbering and street information includes street number, name, type and direction)*	Unit Identifier *(identifies type of unit, such as suite & number)*

B. Survey Address *(used for a rural location specified for a subdivided township, an unsubdivided township or unsurveyed territory) NOTE:* Do not complete "B" if you completed "A."

Lot and Conc.: used to indicate location within a subdivided township and consists of a lot number and a concession number.	Lot	Conc.	Part and Reference: used to indicate location within an unsubdivided township or unsurveyed territory, and consists of a part and a reference plan number indicating the location within that plan. Attach copy of the plan.	Part	Reference

Non Address Information *(includes any additional information to clarify clients' physical location)*

Geo Reference

Map Datum	Zone	Accuracy Estimate	Geo Referencing Method	UTM Easting	UTM Northing

Municipality/Unorganized Township	County/District	Postal Code

Adjacent Land Use

☐ Industrial ☐ Residential ☐ Commercial ☐ Agricultural ☐ Recreational

☐ Other*(specify)*:

Is the Client the owner or lessee of the site? ☐ Yes ☐ No

5. Landowner Information *(if not the client) -Complete A, B, and D* **or** *A, C, and D*

☐ Same as Client Mailing Address

A. Landowner Name

B. Civic Address - Street information *(includes street number, name, type and direction)*			Unit Identifier *(identifies type of unit, such as suite & number)*	
C. Delivery Designator: ☐ Rural Route ☐ Suburban Service ☐ Mobile Route ☐ General Delivery			Delivery Identifier *(a number identifying a Rural Route,*	
D. Municipality	Postal Station	Province/State	Country	Postal Code

6. Lessee Information *(if applicable) - Complete A, B, and D* **or** *A, C, and D*

☐ Same as Client Mailing Address

A. Lessee Name

B. Civic Address - Street information *(includes street number, name, type and direction)*			Unit Identifier *(identifies type of unit, such as suite & number)*	
C. Delivery Designator: ☐ Rural Route ☐ Suburban Service ☐ Mobile Route ☐ General Delivery			Delivery Identifier *(a number identifying a Rural Route,*	
D. Municipality	Postal Station	Province/State	Country	Postal Code

7. Project Information

Type of Application:

☐ New Certificate of Approval ☐ Amendment to current Certificate of Approval

Current Certificate of Approval Number

Date of Issue *(y/m/d)*

Project Description Summary *(If EBR is applicable, this summary will be used in the EBR posting notice)*

Project Name *(Project identifier to be used as a reference in correspondence)*

Project Type

☐ Hauled Sewage*(septage)* Disposal Site ☐ Processed Organic Waste *(biosolids)* Disposal Site

Source of Hauled Sewage/Processed Organic Waste

☐ Municipal ☐ Provincial ☐ Private

☐ Other*(specify)*:

Type of Hauled Sewage/Processed Organic Waste

☐ Residential ☐ Commercial ☐ Institutional ☐ Industrial

☐ Other*(specify)*:

Amount of Hauled Sewage/Processed Organic Waste Proposed to be Spread, Stored or Disposed at the Site based on a single application: (cubic inches)

Total Site Area*(hectares (ha))*:

Total Usable Area*(hectares(ha))*:

Type of Soil:

Soil Permeability:

Average slope: ☐ 0 - 3% (flat) ☐ 3 - 6% (gentle slope) ☐ 6 - 9% (moderate slope) ☐ > 9% (steep slope)

Depth to water table: ☐ < one metre ☐ > one metre

Average depth to bedrock: ☐ 0 - 1.5 metres ☐ over 1.5 metres

Is the Site tile drained? ☐ Yes ☐ No

Distance to nearest water course*(metres)*:

Distance to nearest well*(metres)*:

Distance to closest house on-site*(metres)*:

Well Type:

Distance to closest house off-site*(metres)*:

Distance to other sensitive users*(metres)*:

Distance to nearest residential development*(two or more houses in a cluster)(metres)*:

Proposed Winter Spreading/Storage

☐ Yes ☐ No If Yes, ○ Storage ○ Injection ○ Spreading

Rate of application

(litres/square metre/seven day period)

8. Processed Organic Waste Source

Estimated Volume Handled on an annual basis: tonnes: cubic metres:

Plant/Facility Name

Plant/Facility Owner

Plant/Facility Type

Civic Address- Street information *(applies to an address that has civic numbering and street information includes street number, name, type and direction)*

Unit Identifier *(identifies type of unit, such as suite & number)*

Survey Address *(used for a rural location specified for a subdivided township, an unsubdivided township or unsurveyed territory)*

Lot and Conc.: used to indicate location within a subdivided township and consists of a lot number and a concession number.

Lot	Conc.

Part and Reference: used to indicate location within an unsubdivided township or unsurveyed territory, and consists of a part and a reference plan number indicating the location within that plan. Attach copy of the plan.

Part	Reference

Municipality/Unorganized Township	County/District	Province/State	Country	Postal Code

Telephone Number *(including area code & extension)*	Fax Number *(including area code)*	E-mail Address

9. Other Approvals

List the Certificate of Approval number(s) for the Waste Management System associated with this application *(if available at the time of the application)*

10. Supporting Information Checklist - *This is a list of all supporting information to this application and is subject to the FOIPOPA.*

Supporting Information	Attached	Reference	Can be disclosed
Proof of Legal Name of Client	☐ Yes ☐ No		☐ Yes ☐ No
Sketch of the site showing relevant features, structures, setback areas, sensitive uses and spreading areas	☐ Yes ☐ No		☐ Yes ☐ No
Topographical map showing site location	☐ Yes ☐ No		☐ Yes ☐ No
Other Attached Information	☐ Yes ☐ No		☐ Yes ☐ No

11. Application Fee *(check appropriate categories)*

Category Code	Category Description	Amount	Quantity	Sub Total

Total:

12. Statement of Client

I, the undersigned hereby declare that, to the best of my knowledge, the information contained herein and the information submitted in support of this application is complete and accurate in every way and that the Project Technical Information Contact identified in section 5 of this form is authorized to act on my behalf for the purpose of obtaining approval under Section 27 of the EPA for the waste disposal site identified herein.

Client Name	Signature	Date *(y/m/d)*

13. Statement of Landowner *(if not the client)*

I, the landowner of the property identified herein, hereby consent to the use of the property as described in this application for approval.

Client Name	Signature	Date *(y/m/d)*

14. Statement of Lessee *(if applicable)*

I, the lessee of the property identified herein, hereby consent to the use of the property as described in this application for approval.

Client Name	Signature	Date *(y/m/d)*

APPENDIX E

MOE CERTIFICATE OF APPROVAL
WASTE PROCESSING SITE

Ontario Ministry of the Environment

Application for a Provisional Certificate of Approva[l] for a Waste Disposal Sit[e]

Ce formulaire est disponible en français

For Office Use Only			
Reference Number	Payment Received $	Date (y/m/d)	Initials

General Information and Instructions

General:

Information requested in this form is collected under the authority of the *Environmental Protection Act*, R.S.O. 1990 (EPA) and the *Environmental Bill of Rights*, C. 28, Statues of Ontario, 1993, (EBR) and will be used to evaluate applications for approval of waste disposal sites under Section 27, EPA.

Instructions:

1. When completing this form, please refer to the "Guide for Applying for Certificate of Approval of Waste Disposal Sites, Section 27, 30, 31 and 32, EPA," (referred to as the Guide) and "Guide - Application Cost for Waste Management, S. 27, EPA." Questions regarding completion and submission of the application should be directed to the Environmental Assessment & Approvals Branch, 2 St. Clair Avenue West, Floor 12A, Toronto, Ontario, M4V 1L5, telephone number 1-800-461-6290 or (416) 314-8001 or to your local District Office of the Ministry of the Environment.

2. This form must be completed with respect to all requirements identified in the Guide in order for it to be considered as an application for approval. INCOMPLETE APPLICATIONS WILL BE RETURNED TO THE APPLICANT.

3. A complete application consists of:
   (1) a completed and signed application form; including the attached "Costs for EPA S. 27 Applications - Supplement to Application for Approval";
   (2) all required supporting information identified in this form and the Guide, and
   (3) a certified cheque or money order, in Canadian funds, made payable to the *Minister of Finance* for the applicable application fee.
   The Ministry may require additional information during the technical review of any application accepted as complete.

4. The original application, along with the supporting information and the application fee, must be sent to:
   The Ministry of the Environment,
   Director, Environmental Assessment and Approvals Branch,
   2 St. Clair Avenue West, Floor 12A, Toronto, Ontario, M4V 1L5
   A copy of the application and the supporting information must be sent to the local Ministry District Office which has jurisdiction over the area where the facilities are located.

5. Information contained in this application is not considered confidential and will be made available to the public upon request. Information submitted as supporting information may be claimed as confidential but will be subject to the *Freedom of Information and Protection of Privacy Act* (FOIPPA) and *EBR*. If you do not claim confidentiality at the time of submitting the information, the Ministry may make the information available to the public without further notice to you.

6. If the Client submits with the application a copy of their Master Business Licence (MBL) obtained from the Ministry of Consumer and Commercial Relations, the **shaded sections within this form do not need to be completed.** For additional information on the MBL please refer to the "Guide"

1. Client Information

Client Name *(legal name of individual or organization as evidenced by legal documents)*	Business Identification Number
Business Name *(the name under which the entity is operating or trading if different from the Client Name - also referred to as trade name)*	

Client Type:

- ☐ Corporation
- ☐ Individual
- ☐ Partnership
- ☐ Sole Proprietor
- ☐ Federal Government
- ☐ Municipal Government
- ☐ Provincial Government
- ☐ Other *(describe)*:

Activity Classification Code/Standard Industrial Classification Code *(if unknown please complete Business Activity Description)*

Business Activity Description *(a narrative description of the business endeavour, this may include products sold, services provided or machinery/equipment used, etc.)*

2. Client Address - *Complete A, C and D or B, C and D*

A. Civic Address- Street information *(applies to an address that has civic numbering and street information includes street number, name, type and direction)*	Unit Identifier *(identifies type of unit, such as suite & number)*

B. Survey Address *(used for a rural location specified for a subdivided township, an unsubdivided township or unsurveyed territory)*

Lot and Conc.: used to indicate location within a subdivided township and consists of a lot number and a concession number.	Lot	Conc.	Part and Reference: used to indicate location within an unsubdivided township or unsurveyed territory, and consists of a part and a reference plan number indicating the location within that plan. Attach copy of the plan.	Part	Reference

C. Municipality/Unorganized Township	County/District	Province/State	Country	Postal Code

D. Telephone Number *(including area code & extension)*	Fax Number *(including area code)*	E-mail Address

3. Client Mailing Address - *Complete A and C or B and C*

A. Civic Address - Street information *(includes street number, name, type and direction)*	☐ Same as Client Physical Address	Unit Identifier *(identifies type of unit, such as suite & number)*
B. Delivery Designator: ☐ Rural Route ☐ Suburban Service ☐ Mobile Route ☐ General Delivery		Delivery Identifier *(a number identifying a Rural Route, Suburban Service or Mobile Route delivery mode)*

C. Municipality	Postal Station	Province/State	Country	Postal Code

4. Site Information - *(location where activity/works applied for is to take place - not applicable to mobile facilities)* **Mobile Facility:** ☐ Yes ☐ No

Site Name	MOE District Office	Legal Description*(attach copy of a legal survey)*

Site Address - Street information *(applies to an address that has civic numbering and street information - includes street number, name, type and direction)* ☐ Same as Client Physical Address | Unit Identifier *(identifies type of unit, such as suite & number)*

Survey Address *(used for a rural location specified for a subdivided township, an unsubdivided township or unsurveyed territory)*

Lot and Conc.: used to indicate location within a subdivided township and consists of a lot number and a concession number.	Lot	Conc.	Part and Reference: used to indicate location within an unsubdivided township or unsurveyed territory, and consists of a part and a reference plan number indicating the location within that plan. Attach copy of the plan.	Part	Reference Plan

Non Address Information *(includes any additional information to clarify clients' physical location)*

Geo Reference

Map Datum	Zone	Accuracy Estimate	Geo Referencing Method	UTM Easting	UTM Northing

Municipality/Unorganized Township	County/District	Postal Code

Adjacent Land Use

☐ Industrial ☐ Commercial ☐ Recreational

☐ Residential ☐ Agricultural ☐ Other*(specify)*:

Is the Site located in an area of development control as defined by the Niagara Escarpment Planning & Development Act (NEPDA)?

☐ Yes (If Yes, attach copy of NEPDA permit for the proposed activity/work) ☐ No

Is the Client the operating authority? ☐ Yes ☐ No

If No, attach the operating authority name, address and phone number.

Is the Client the owner of the land (site)? ☐ Yes ☐ No

If No, attach the owner's name, address and consent for the installation and operation of the facilities.

5. Project Technical Information Contact - *Complete A, B, D and E or A, C, D, and E*

A. Name	Company	☐ Same as Client Name

Contact Address

B. Civic Address - Street information *(includes street number, name, type and direction)* ☐ Same as Client Mailing Address | Unit Identifier *(identifies type of unit, such as suite & number)*

C. Delivery Designator: ☐ Rural Route ☐ Suburban Service ☐ Mobile Route ☐ General Delivery | Delivery Identifier *(a number identifying a Rural Route, Suburban Service or Mobile Route delivery mode)*

D. Municipality	Postal Station	Province/State	Country	Postal Code

E. Telephone Number *(including area code & extension)*	Fax Number *(including area code)*	E-mail Address

6. Project Information

Type of Application: ☐ New Certificate of Approval ☐ Amendment to current Certificate of Approval	Current Certificate of Approval Number	Date of Issue *(y/m/d)*

Project Description Summary *(If EBR is applicable, this summary will be used in the EBR posting notice)*

Project Name *(Project identifier to be used as a reference in correspondence)*

Project Schedule

Estimated date for start of construction/installation	Estimated date for start of operation

3. Client Mailing Address - *Complete A and C or B and C*

A. Civic Address - Street information *(includes street number, name, type and direction)* ☐ Same as Client Physical Address | Unit Identifier *(identifies type of unit, such as sui... & number)*

B. Delivery Designator: ☐ Rural Route ☐ Suburban Service ☐ Mobile Route ☐ General Delivery | Delivery Identifier *(a number identifying a Rural Route, Suburban Service or Mobile Route delivery mode)*

C. Municipality	Postal Station	Province/State	Country	Postal Code

4. Site Information - *(location where activity/works applied for is to take place - not applicable to mobile facilities)*

Mobile Facility: ☐ Yes ☐ No

Site Name	MOE District Office	Legal Description *(attach copy of a legal survey)*

Site Address - Street information *(applies to an address that has civic numbering and street information - includes street number, name, type and direction)* ☐ Same as Client Physical Address | Unit Identifier *(identifies type of unit, such as suite & number)*

Survey Address *(used for a rural location specified for a subdivided township, an unsubdivided township or unsurveyed territory)*

Lot and Conc.: used to indicate location within a subdivided township and consists of a lot number and a concession number.	Lot	Conc.	Part and Reference: used to indicate location within an unsubdivided township or unsurveyed territory, and consists of a part and a reference plan number indicating the location within that plan. Attach copy of the plan.	Part	Reference Plan

Non Address Information *(includes any additional information to clarify clients' physical location)*

Geo Reference

Map Datum	Zone	Accuracy Estimate	Geo Referencing Method	UTM Easting	UTM Northing

Municipality/Unorganized Township	County/District	Postal Code

Adjacent Land Use

☐ Industrial ☐ Commercial ☐ Recreational

☐ Residential ☐ Agricultural ☐ Other*(specify)*:

Is the Site located in an area of development control as defined by the Niagara Escarpment Planning & Development Act (NEPDA)?

☐ Yes (If Yes, attach copy of NEPDA permit for the proposed activity/work) ☐ No

Is the Client the operating authority? ☐ Yes ☐ No

If No, attach the operating authority name, address and phone number.

Is the Client the owner of the land (site)? ☐ Yes ☐ No

If No, attach the owner's name, address and consent for the installation and operation of the facilities.

5. Project Technical Information Contact - *Complete A, B, D and E or A, C, D, and E*

A. Name	Company	☐ Same as Client Name

Contact Address

B. Civic Address - Street information *(includes street number, name, type and direction)* ☐ Same as Client Mailing Address | Unit Identifier *(identifies type of unit, such as suite & number)*

C. Delivery Designator: ☐ Rural Route ☐ Suburban Service ☐ Mobile Route ☐ General Delivery | Delivery Identifier *(a number identifying a Rural Route, Suburban Service or Mobile Route delivery mode)*

D. Municipality	Postal Station	Province/State	Country	Postal Code

E. Telephone Number *(including area code & extension)*	Fax Number *(including area code)*	E-mail Address

6. Project Information

Type of Application: ☐ New Certificate of Approval ☐ Amendment to current Certificate of Approval	Current Certificate of Approval Number	Date of Issue *(y/m/d)*

Project Description Summary *(If EBR is applicable, this summary will be used in the EBR posting notice)*

Project Name *(Project identifier to be used as a reference in correspondence)*

Project Schedule

Estimated date for start of construction/installation	Estimated date for start of operation

10. Environmental Bill of Rights Requirements

Is this a proposal for a Prescribed treatment under EBR?	If "Yes," is it excepted from public participation?	If it is excepted from public participation provide reason:	
		☐ Equivalent Public Participation	☐ Environmentally Insignificant Amendment or Revocation
☐ Yes ☐ No	☐ Yes ☐ No	☐ Emergency	☐ EAA or Tribunal Decision

Documentation is support of the above noted exception must be provided (refer to "Guide")

11. Environmental Assessment Act (EAA) Requirements

☐ The works are not subject to EAA for the reason specified below:

☐ The works are proceeding in accordance with the Environmental Assessment Process Approval Notice specified below:

12. Supporting Information Checklist - *This is a list of all supporting information to this application and is subject to the FOIPPA and EBR.*

Supporting Information	Attached	Reference	Can be disclosed
General			
Proof of Legal Name of Client	☐ Yes ☐ No		☐ Yes ☐ No
Copy of NEPDA Permit	☐ Yes ☐ No		☐ Yes ☐ No
Name, Address and Phone Number of the Operating Authority	☐ Yes ☐ No		☐ Yes ☐ No
Name, Address and consent of land/site owner for the installation/construction and operation of the works/facility	☐ Yes ☐ No		☐ Yes ☐ No
Verification of EBR Public Participation Exception	☐ Yes ☐ No		☐ Yes ☐ No
Proof of Public Consultation/Notification	☐ Yes ☐ No		☐ Yes ☐ No
Technical			
Site Plan/Location Map	☐ Yes ☐ No		☐ Yes ☐ No
Hydrogeolocial Assessment Report	☐ Yes ☐ No		☐ Yes ☐ No
Design and Operations Report	☐ Yes ☐ No		☐ Yes ☐ No
Drainage Study	☐ Yes ☐ No		☐ Yes ☐ No
Financial Assurance	☐ Yes ☐ No		☐ Yes ☐ No
Other Attached Information	☐ Yes ☐ No		☐ Yes ☐ No

13. Application Fee

Category Code	Category Description	Amount	Quantity	Sub Total

Total:

14. Statement of Client

I, the undersigned hereby declare that, to the best of my knowledge, the information contained herein and the information submitted in support of this application is complete and accurate in every way and that the Project Technical Information Contact identified in section 5 of this form is authorized to act on my behalf for the purpose of obtaining approval under Section 27 of the EPA for the waste disposal site identified herein.

Name *(please print)*	Title
Signature	Date *(y/m/d)*

Ministry of the Environment

Ministère de l'Environnement

Ontario

COSTS FOR EPA s. 27 APPLICATIONS - SUPPLEMENT TO APPLICATION FOR APPROVAL

Until new application forms and guides are available, this form is to be completed for all applications under the Environmental Protection Act, s. 27 received by the Approvals Branch on or after October 1, 1998. The purpose of this supplement is to reflect the new costs for applications, as per Regulation 363.

The attached table is a summary of the applicable costs and categories. Please refer to the table when completing this form. A document, entitled "GUIDE - Application Costs for Waste Management, s. 27, Environmental Protection act", with detailed information is available by contacting the Ministry at 1-800- 461-6290 or (415) 314-8001 or by e-mail at the following address GetGuide@ENE.GOV.ON.CA , in the subject line type GUIDES-EPA..

The attached summary table should be retained for future use and the supplement attached to the application form

Company Name:____

Application No. (if known)____________________________________

Application Cost: Indicate the type of application and complete the corresponding section.

___ **Section 1:** **Approvals (Table 1)**

___ **Section 2:** **Amendment to existing approval:**

  ___ **Administrative amendments(Table 2(a))**

  ___ **Amendments requiring a technical review (Table 2(b))**

___ **Section 3:** **Revocations (Table 3)**

___ **Section 4:** **Preliminary Review(Table 4)**

(A) APPROVALS

Table 1: **Approvals**

(✔)	Category	COST
	Category 1 - Administrative processing (applies to all except sites for hauled sewage and sites for biosolids)	$200
	From the attached summary table, under the section entitled "Approvals", indicate the categories for the site or system applied for and the corresponding costs (Categories 2 to 26). Category applied for —— Cost $ —— —— Cost $ —— —— Cost $ —— *(Indicate all categories of sites and systems applied for and the corresponding cost.)* Total Cost: ________	$
	Category 27- If the hearing is mandatory, $18,000 must be included with the application. If there are discretionary hearing requirements and a hearing is necessary, the $18,000 must be submitted before the hearing commences	$
TOTAL COST		$

Section 2: AMENDMENT TO EXISTING APPROVAL

Table 2(a) Administrative Amendments

(✔)	Category	COST
	Category 28 - If the amendment is considered as administrative (no technical review is required), the total cost of the application is $100. (Refer to the Guide for information as to what is considered an administrative amendment)	$100
	Category 29 -For administrative amendments related to a hauled sewage or biosolids waste management system, the total cost of the application is $50.	$50
	Category 100 - Amendments necessary as a result of action that the applicant has been required to take by the Director pursuant to a condition contained in a certificate..	$0
TOTAL COST		$

Table 2(b): Amendments Requiring a Technical Review

(✔)	Category	COST
	Category 1 - Administrative processing **(applies to all applications except sites for hauled sewage and sites for biosolids)**	$ 200
	From the attached summary table, under the section entitled **"Amendments - Technical"**, indicate the categories for the site or system applied for and the corresponding costs (Categories 30 to 65). Category applied for —— Cost $ —— —— Cost $ —— —— Cost $ —— *(Indicate all categories of sites and systems applied for and the corresponding cost.)* Total Cost: ________	$
	Category 27 - If the hearing is mandatory, $18,000 must be included with the application. If there are discretionary hearing requirements and a hearing is necessary, the $18,000 must be submitted before the hearing commences. .	$
	Category 100 - Amendments necessary as a result of action that the applicant has been required to take by the Director pursuant to a condition contained in a certificate.	$0
TOTAL COST		$

APPENDIX F

SOD FARM – COMPOST APPLICATION RATES

Various uses and application rates of sewage sludge compost to achieve fertilizer benefits and soil improvement.

Use	Compost lbs. per 1,000 square feet†	Remarks
Turfgrasses:		
Establishment		
Soil incorporated	2,000 to 6,000	Incorporate into top 4 to 6 inches of soil. Use lower rate on relatively fertile soil and higher rate on infertile soil.
Surface mulch	600 to 700	Broadcast uniformly on surface before seeding small seeded species (bluegrass) or after seeding large seeded species (fescues).
Maintenance	400 to 800	Broadcast uniformly on surface. On cool-season grasses apply higher rate in fall or lower rate in fall and again in early spring.
Sod production when—		
Incorporated with soil	3,000 to 6,000	Incorporate into top 4 to 6 inches of soil.
Unincorporated with soil	6,000 to 18,000	Apply uniformly to surface. Irrigate for germination and establishment.

†1,500 lbs. per 1,000 square feet is approximately equal to 1/2 inch depth of compost. Compost has a bulk density of about 1,000 lbs. per cubic yard at 40% moisture. Source: based on USDA publication ARM-NE-6, August 1979.

Compost Use	Compost Application Rates						
	lbs/1000 ft2	kg/m2	tonne/ha mass, total	tonne/ha dry wt.	Volume (m3)	Depth (cm)	Depth (inch.)
Turfgrass:							
Maintenance	400	2.0	19.5	11.7	32.7	0.3	0.1
	800	3.9	39.1	23.4	65.4	0.7	0.3
Surface Mulch	600	2.9	29.3	17.6	49.1	0.5	0.2
	700	3.4	34.2	20.5	57.3	0.6	0.2
Establishment	2,000	9.8	97.6	58.6	163.6	1.6	0.6
(Soil Incorporated)	6,000	29.3	292.9	175.8	490.8	4.9	1.9
Sod Production:							
Soil Incorp.	3,000	14.6	146.5	87.9	245.4	2.5	1.0
	6,000	29.3	292.9	175.8	490.8	4.9	1.9
No soil Incorp	6,000	29.3	292.9	175.8	490.8	4.9	1.9
	18,000	87.9	878.8	527.3	1,472.5	14.7	5.8
Example	1,500	7.3	73.2	43.9	122.7	1.2	0.5

Density	lbs/yd3	kg/m3	TS (%,w/w)
	1000	596.8382	60

APPENDIX G

COMPOST APPLICATION EQUIPMENT

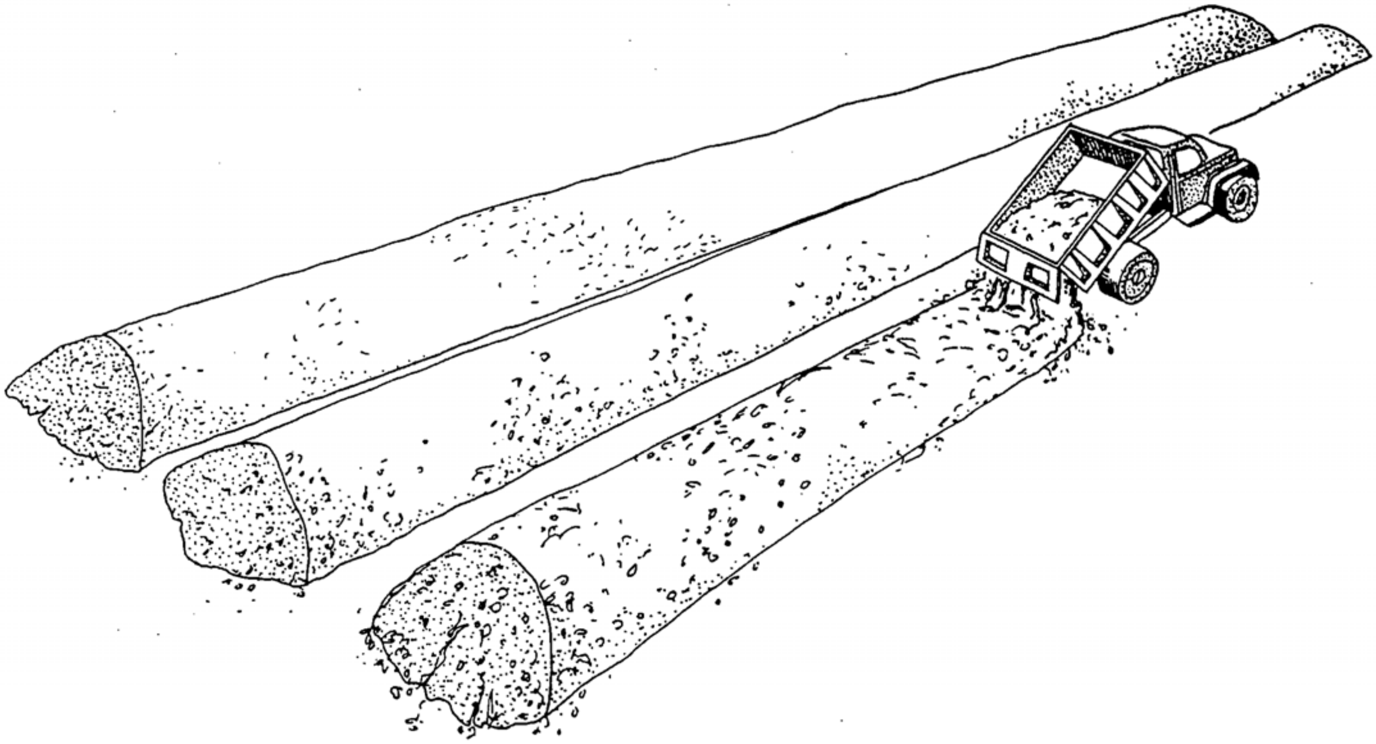


Figure 5.7
Move the dump truck forward slowly to form the windrow.

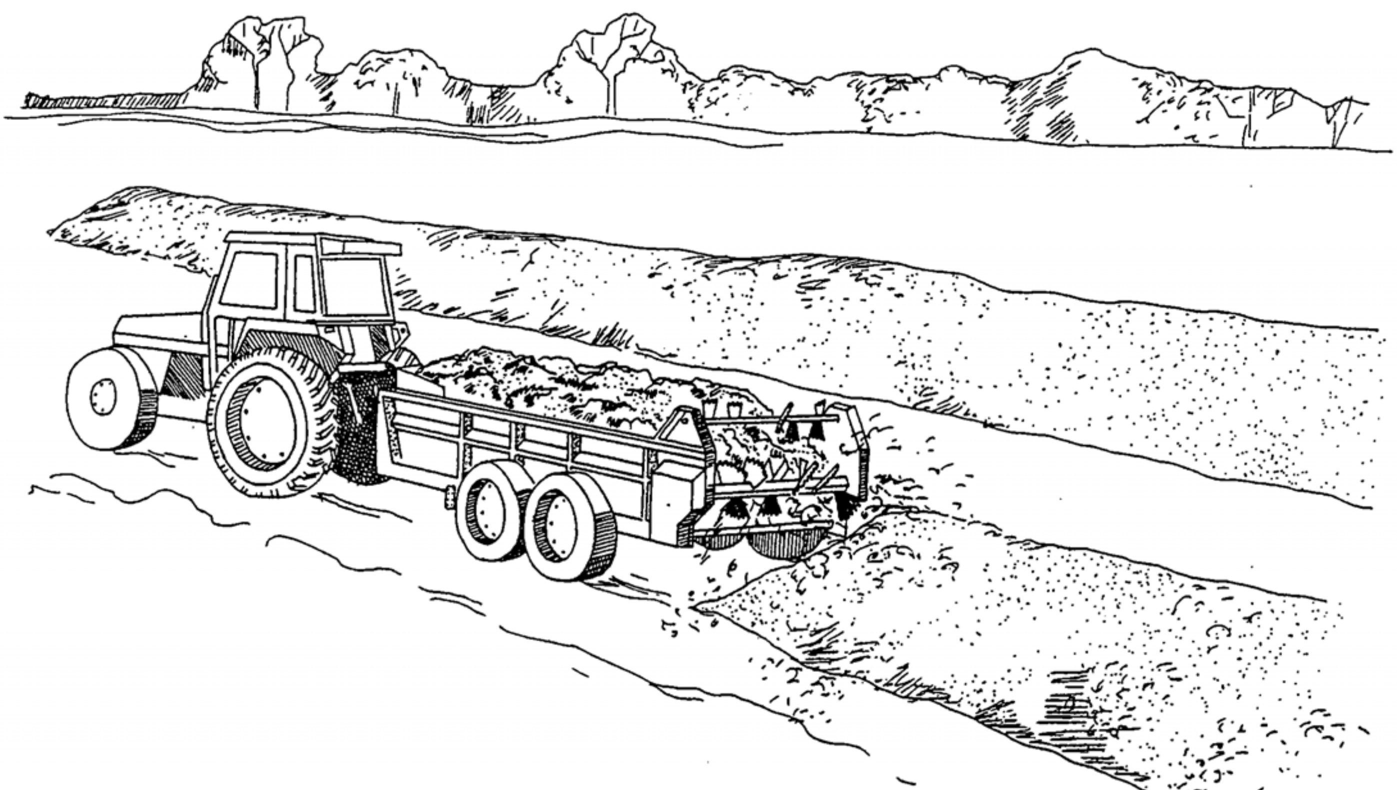


Figure 5.8
Forming windrows with a manure spreader.

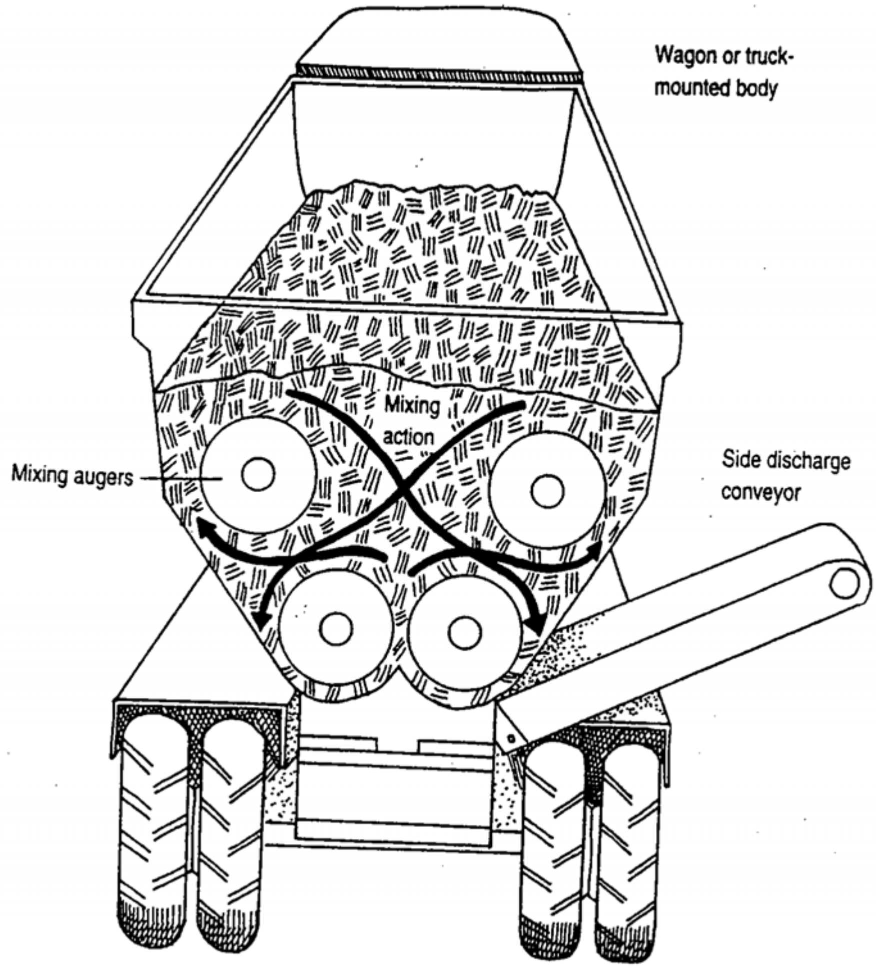


Figure 5.9
Mobile batch mixers can also be used to form windrows.
Adapted with permission from Sludge Systems International, Inc.

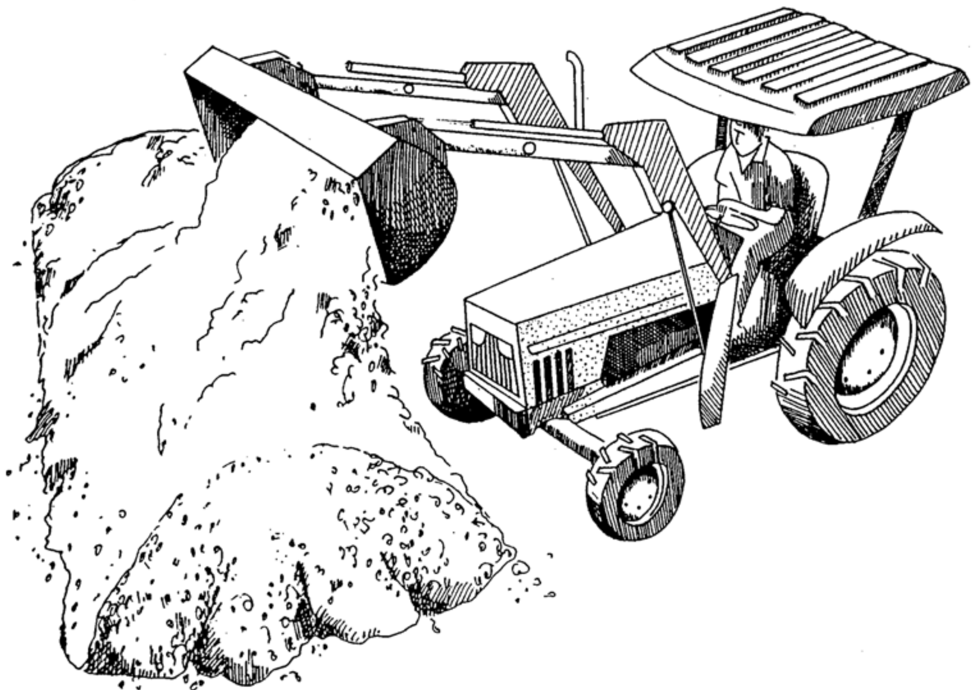
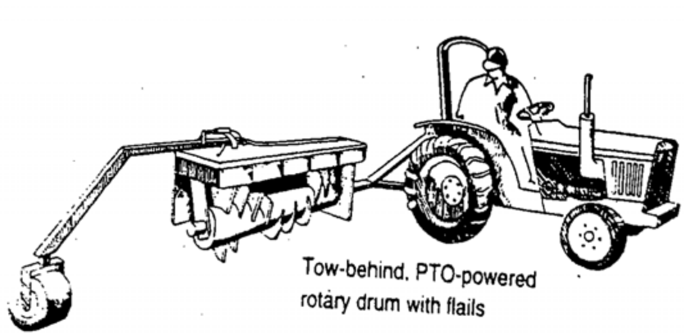


Figure 4.3
Turning windrows using a bucket loader.



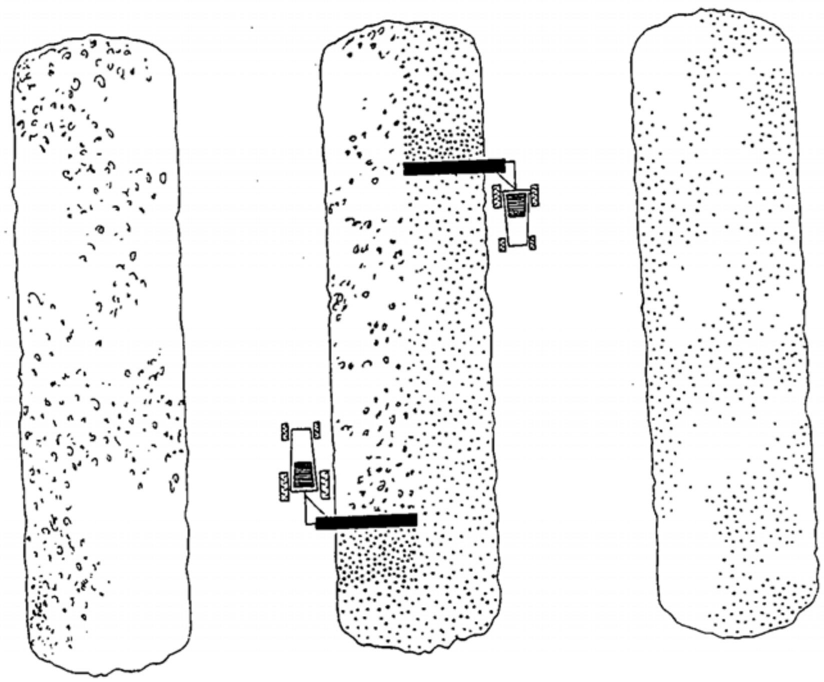


Figure 4.5
Two passes are necessary for most tractor-drawn turners.

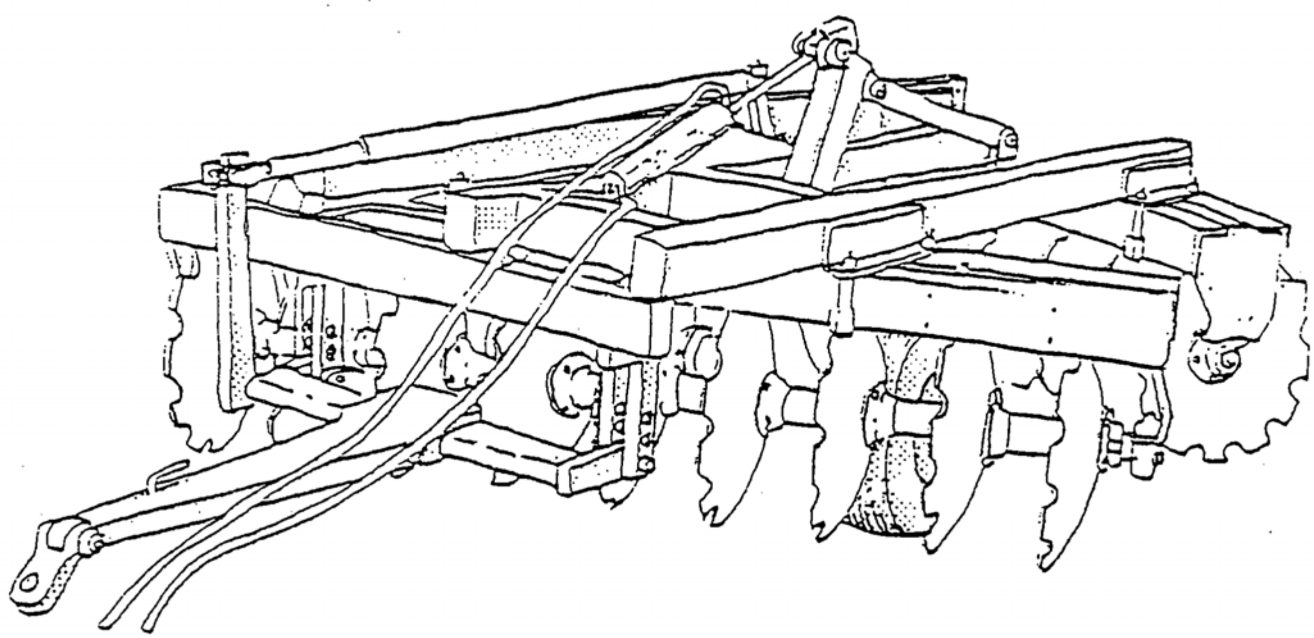


Figure 10-15. Example of disc tiller.

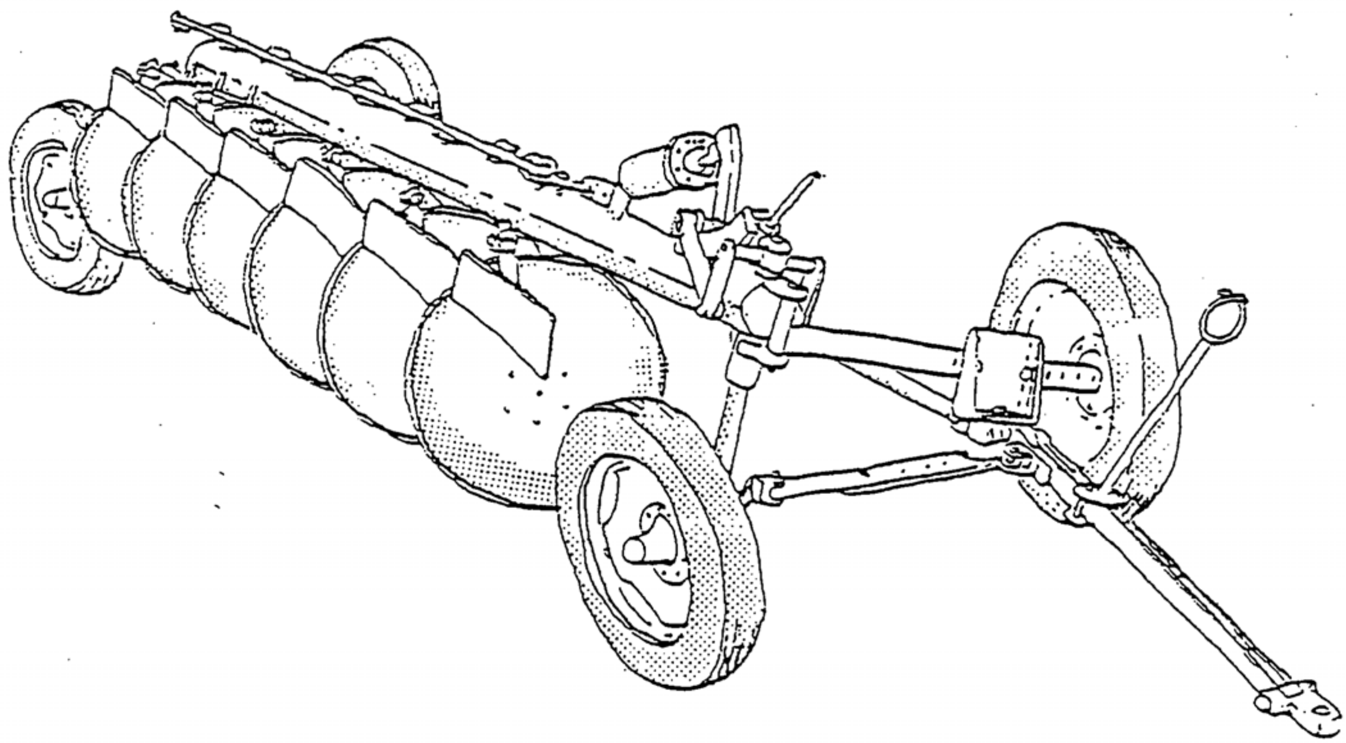
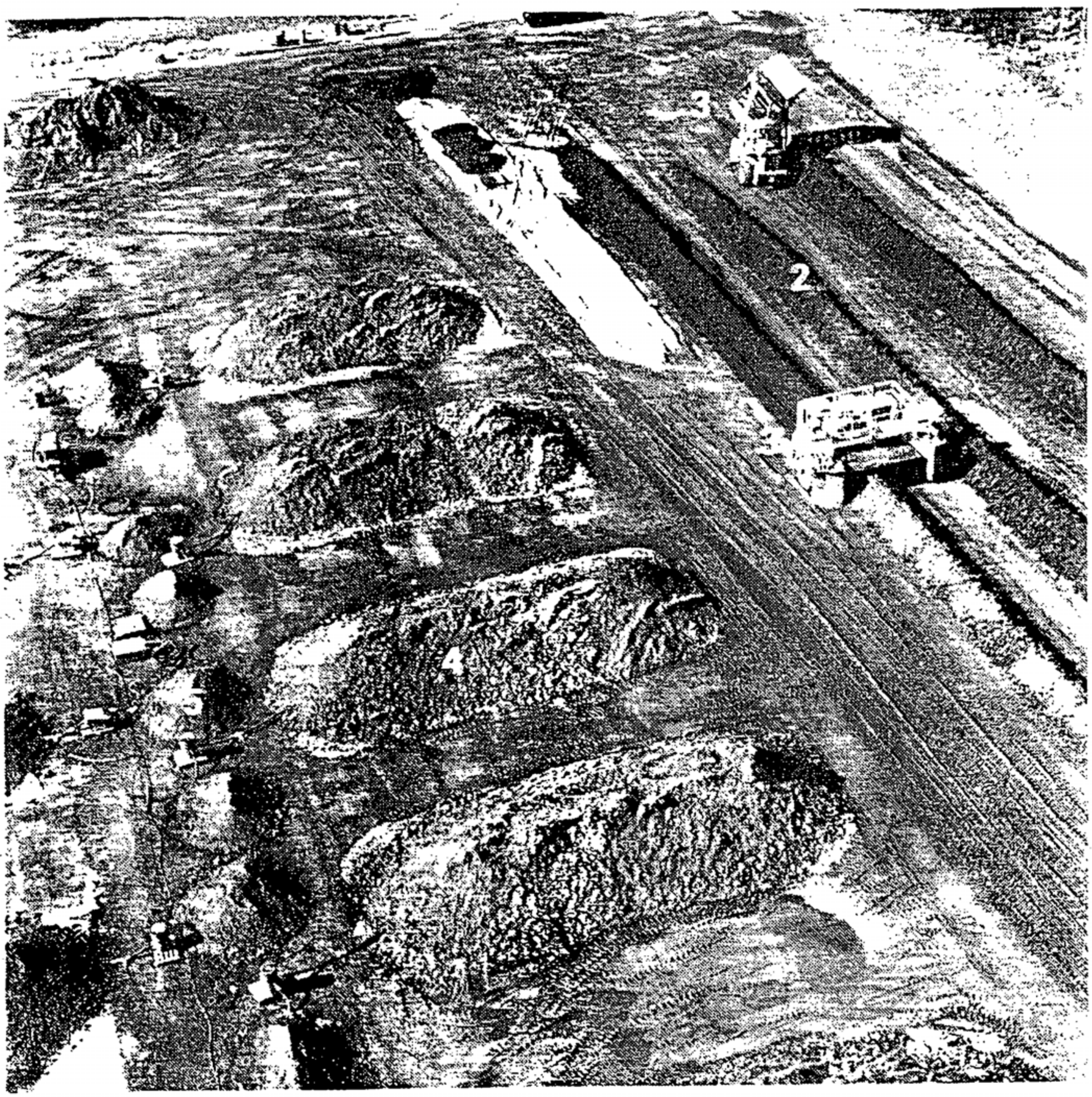


Figure 10-16. Example of disc plow.


3
2
4

APPENDIX H

AGGREGATE MINING SITES – WELLINGTON COUNTY

Ministry of Natural Resources / Ministère des Richesses naturelles — Ontario

Ministry of Natural Resources

Aggregate Resources Licence List Sheets

District: Guelph District
Area: WELLINGTON AREA
Year: 2000

Active Licences Only

Upper Tier Municipality: WELLINGTON CO
Lower Tier Municipality: ERAMOSA TP
Geographic Township: ERAMOSA

Licencee Legal Name / Billing Address	Licence ID	Trust Acct.	Lot and Concession /Section	P Q	Licence Area (ha)	Tonnage Limit (tonne)
Sterling Packers Limited 250 Summerlea Road BRAMPTON ONTARIO L6T 3V6	5551	P720533	Pt. 8 3	P	11.75	20,000
Sterling Packers Limited 250 Summerlea Road BRAMPTON ONTARIO L6T 3V6	5552	P720534	Pt. 10 2	P	4.94	20,000
HANS VAN WISSELINGH, RODERICK VAN WISSELINGH C/O Robert Grant, Kearns, Mckinnon 265 Bridge Street, P.O. Box 128 Fergus ONTARIO N1M2W7	5578	P720767	27 3	P	19.12	20,000
OUSTIC SAND & GRAVEL c/o Laverne and William Hartung R. R. #1 GUELPH ONTARIO N1H 6H7	5579	P720768	Pt. 28 4	P	20.25	25,000
Roger Knapp R. R. #1 No. 8066, Highway 24 GUELPH ONTARIO N1H 6H7	5665	P722703	Pt. NE 1/2 of 13 1	P	16.20	100,000
George W. Leslie and Marion Shirley Leslie R.R. #1 ROCKWOOD ONTARIO N0B 2K0	5702	P723058	West half Lots 15 & 16 6	P	56.60	250,000

Pg 1 of 220

Oct 18, 2001

APPENDIX I

MINISTRY OF AGRICULTURE, FOOD AND RURAL AFFAIRS HEALTHY FUTURES PROGRAM

healthy futures
FOR ONTARIO AGRICULTURE

Project Summary Format

Pre-Proposal - Stage 1 (Continued)

Applicants are required to complete a project summary that includes answers to the following items <u>in the order specified:</u>

1. **Overview:** Give a brief overview of the project, including it's title, location, start date, an estimated completion date and a brief description. Indicate if this is a new project or an existing project being enhanced. If it is an enhancement, please explain how it is being enhanced. **Indicate if any contact has been made with any ministry personnel and who the contact was made with.**

2. **Objectives:** Describe how your project relates to the Healthy Futures for Ontario Agriculture objectives of enhancing the safety and quality of Ontario food products; capitalizing on marketing and export opportunities; and improving rural water quality and making efficient use of water resources.

3. **Relevance**: Relevance of and need for the work and its appropriateness for support by the Healthy Futures for Ontario Agriculture program. Be sure to indicate the urgency of the work and impact of it not occurring.

4. **Partnership**: List the partners (including organization name) involved in the project. Describe the nature of the partnership(s) (new, established, permanent, temporary, etc.). For each of the partners, describe the key roles and responsibilities, experience which demonstrates ability to attain project results and the nature of each of their financial contributions to the project.

5. **Work Plan:** Submit a summary of the expected project work plan, including major activities, activity locations, timelines, milestones and measurable deliverables. *Milestones will be used to determine the timelines for payments from the Healthy Futures for Ontario Agriculture program.*

6. **Benefits:** Summarize the benefits which will result. Project benefits can be direct, indirect, short term or long term. Beneficiaries may include:
   (a) project partners/applicants;
   (b) other identified stakeholders in rural Ontario and/or sector;
   (c) the agri-food sector and rural municipalities; and
   (d) Ontario.
   Provide details of how the project results will be shared with others in the agri-food sector, if you plan to share them.

7. **Budget:** A project budget summary (sources and uses of funds) must include the total cost of the project; all sources of funding and details on how the contribution from the Healthy Futures for Ontario Agriculture program will be used. Please format the budget as shown in Schedule 4 from the application package.

8. **Other:** Include information relevant to the project, e.g. list of the required approvals and permits.

Please submit one (1) stapled or unbound copy of the project summary and a copy of the project registration form to the Healthy Futures for Ontario Agriculture Secretariat (address listed on page 1 and page 16). Keep a copy of the pre-proposal for your records.

healthy futures FOR ONTARIO AGRICULTURE

Project Registration Form

Pre-Proposal - Stage 1

Applicants are required to complete a project registration form and a project summary as part of stage 1 of the application process.

Title of Project:	
Lead Applicant ☐Mr. ☐Ms. ☐Dr. Name of Project Leader/Contact Person:	
Position:	
Organization or Business:	
Mailing Address (street):	
City/Town:	
Province:	Postal Code:
Telephone:	Fax:
E-mail:	

Names of all Partners/Co-Applicants (List additional partners on a separate sheet):

Names of all Co-applicants	Organization Name	Phone Number	Fax Number
1.			
2.			
3.			
4.			
5.			

CONFIDENTIALITY

Application forms and supporting material submitted to the Ontario Ministry of Agriculture, Food and Rural Affairs will be subject to the *Freedom of Information and Protection of Privacy Act*. Any information submitted in confidence should be clearly marked "CONFIDENTIAL" by the applicant. Inquiries about confidentiality should be directed to the Healthy Futures for Ontario Agriculture Secretariat.

CERTIFICATION

By submitting this application the lead applicant hereby certifies to the Ontario Ministry of Agriculture, Food and Rural Affairs that the application and supporting documentation are true and complete in all respects.

Lead Applicant Name (print): ______________________________

Position: ______________________________

Signature: ______________________________ Date: ______________

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Schedule 1

Contact Information for Applicants

Eligible applicants will include not-for-profit formally organized groups (e.g. associations, marketing boards) in the agri-food sector and rural municipalities and agencies. Partnerships/strategic alliances of two or more companies having an arm's length relationship will be eligible to apply. It is not necessary for all entities to be incorporated. Educational institutions may partner with commercializing entities. Individuals and individual businesses are **not** eligible under the program. Under the Healthy Futures for Ontario Agriculture program all applicants must share in the risks of the project, invest cash, and have a vested interest in completing the project. ***All applicants for approved projects must sign a Letter of Agreement*** (i.e., contract with OMAFRA) which specifies the terms and conditions of funding. A copy of the Letter of Agreement is available from the Healthy Futures for Ontario Agriculture Secretariat upon request. *Applicants are strongly advised to have all partners review the Letter of Agreement.* Additional details on each co-applicant (e.g., mailing addresses) must be provided in your Project Business Case as part of the full application.

Lead Applicant:

Contact Name: ____________________
Organization: ____________________
Address: ____________________
____
Postal Code: ____________________
Telephone: ____________________
Facsimile: ____________________
Email: ____________________

Project Representative (if different):

Contact Name: ____________________
Organization: ____________________
Address: ____________________
____
Postal Code: ____________________
Telephone: ____________________
Facsimile: ____________________
Email: ____________________

Other Applicants (list on back if necessary):

Contact Name: ____________________
Organization: ____________________
Address: ____________________
____
Postal Code: ____________________
Telephone: ____________________
Facsimile: ____________________
Email: ____________________

Contact Name: ____________________
Organization: ____________________
Address: ____________________
____
Postal Code: ____________________
Telephone: ____________________
Facsimile: ____________________
Email: ____________________

Contact Name: ____________________
Organization: ____________________
Address: ____________________
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Postal Code: ____________________
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Contact Name: ____________________
Organization: ____________________
Address: ____________________
____
Postal Code: ____________________
Telephone: ____________________
Facsimile: ____________________
Email: ____________________

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FOR ONTARIO AGRICULTURE

Schedule 3

Measurable Outcomes

The following are some desired outcomes of the Healthy Futures for Ontario Agriculture program:

- Ontario benefits from increased sales of Ontario products in the domestic market.
- Continued growth of agri-food exports.
- Ontario agri-food sector be a leader in the development and adoption of new technologies.
- Maintain safety and quality of Ontario's food supply.
- Improved water quality in rural Ontario from improved agricultural practices.

Please complete the following information (where applicable) on the anticipated results of your project:

Anticipated Result	**Describe how you are going to measure your project's success (include values where appropriate)**
Estimated value and volume of increased exports as a result of project investment.	
Estimated value and volume of increased domestic sales as a result of project investment.	
Estimated number of jobs created, upgraded or retained by the project.	
Value in new investment in industry/sector as a result of this project.	
Number of new industry partnerships/linkages created by the project.	
Number of industry/sector issues resolved by project.	
Number of new innovative products/services or technologies as a result of this project.	
Number of introductions/adoptions of new technology to agri-food industry/sector as a result of this project.	
Number of industry/sector barriers to growth overcome as a result of this project.	
Number of markets accessed (domestic, international and import replacement) as a result of project investment.	

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Schedule 3

Measurable Outcomes Continued

Anticipated Result	**Describe how you are going to measure your project's success (include values where appropriate)**
Adoption rate of food safety or quality management programs (% /commodity) such as HACCP*, ISO* and BMPs*.	
Volume/value of food products produced under quality assurance programs.	
Number of food safety/ quality management programs implemented or expanded at provincial level.	
Rural water use and waste-water efficiency.	
Private sector investment to improve rural water quality or food safety.	
Combined number of water quality or food safety improvements made (Best Management Practices and Good Manufacturing Practices).	
Number of rural municipalities or commodities with improved practices.	
Measurable reduction in water quality parameters related to agricultural practices.	
Other:	
Other:	
Other:	

* Quality Assurance Programs: Hazard Analysis Critical Control Points (HACCP); International Standards Organization (ISO); and Best Management Practices (BMPs)

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Schedule 4

Sources and Uses of Funds

Under the Healthy Futures for Ontario Agriculture program, applicants must share the costs. Projects may receive up to 70 per cent government funding of eligible costs under the program in extenuating circumstances. Most cost sharing will be up to 50 per cent. Funding from other provincial or federal government programs will be considered in calculating the level of investment from the Healthy Futures for Ontario Agriculture program. In determining contributions for cost-sharing, in-kind contributions will **not** be recognized. *Failure to disclose all funding or possible funding sources may be grounds for termination of the application or contract.*

Investment by the applicant will amount to at least 50 per cent of the eligible costs of the project in most cases. Applicants who are applying for the maximum level of government funding (70 per cent) should provide compelling justification for their request. Costs for equipment critical to the success of the project will be considered up to 25 per cent of the project's eligible costs. The Healthy Futures for Ontario Agriculture program reserves the right to determine awards on a case-by-case basis.

Sources of Funds

Partners/Applicants (list)	Eligible Project Costs ($)	Total Project Costs ($)
Other Private Sources		
Other Government Programs (Indicate all program names)	(B)	
Requested from Healthy Futures for Ontario Agriculture program	(C)	
TOTAL	(D)	

Per cent of Government Investment in Eligible Costs $= \frac{(B) + (C)}{\text{Cell (D)}} \times 100 =$ _______ %

The per cent of government investment (federal / provincial) in eligible costs cannot exceed 70 per cent for projects under the Healthy Futures for Ontario Agriculture program.

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FOR ONTARIO AGRICULTURE

Schedule 4

Sources and Uses of Funds Continued

Uses of Funds

Eligible expenditures must be directly related to the project and would not have otherwise been incurred by the applicant. Expenditures must be actual cash outlays to third parties that can be documented through paid invoices and/or receipts. Evidence of payment (e.g., cancelled cheques and/or bank statements) and supporting documentation must be maintained and submitted to the Healthy Futures for Ontario Agriculture Secretariat with requests for payment. Claims for travel for applicants must adhere to the Provincial Government guidelines (available upon request). Costs must not exceed fair market value. Satisfactory evidence demonstrating that the cost of services does not exceed fair market value may be required. Where the value of sub-contracts for work or services exceeds $25,000, applicants must demonstrate that a competitive process has been used. At least three written tenders must be obtained, unless the supplier has previously been chosen through a competitive process, or the supplier is expected to provide specialized expertise that is not otherwise readily available. The Province has the final word in determining expenditure eligibility and valuation.

Description of Eligible Expenditures	Amount ($)
1.	$
2.	$
3.	$
4.	$
5.	$
6.	$
7.	$
8.	$
9.	$
10.	$
11.	$
12.	$
Total	$

Additional expenditures should be listed on a separate sheet.

Eligible expenditures could include, but are not limited to the following:

- the development and distribution of marketing and promotional materials
- travel costs incurred by applicants/contractors
- specialized equipment leases necessary for project
- business plan preparation
- skill enhancement costs (specialized training)
- consultants/sub-contractors
- legal, accounting or other professional fees
- bank fees and charges for the project
- equipment related to the project – up to 25% of total

The Healthy Futures for Ontario Agriculture program will not invest in:

- Projects from an individual or individual business
- Direct wage subsidies
- Costs of normal business and production practices, operations (including startups)
- Recurring costs such as reprinting
- Costs of normal business enhancements
- Fixed capital assets (land, buildings, storage facilities)
- Debt restructuring, fundraising or debt financing
- Project costs incurred prior to signing a Letter of Agreement
- Projects replacing discontinued government programs
- Costs incurred in preparing an application (including the business case)

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FOR ONTARIO AGRICULTURE

Schedule 5

Projected Milestone

Projected Milestone Dates / Costs / Results Anticipated*

Description of Eligible Project Costs for Milestone #________ Date Completed: __________	Projected Eligible Cost	HFOA Contribution (Based on ______%)
TOTALS		

EXPECTED RESULTS AS OF THIS MILESTONE (List on back if necessary):

WHAT HURDLES OR EVENTS CAN AFFECT THE PROJECT'S SUCCESS?

*Use one (1) form per milestone. Make additional copies as required.

APPENDIX J

FEDERATION OF CANADIAN MUNICIPALITIES (FCM)
GREEN MUNICIPAL FUNDS (GMF)

GREEN MUNICIPAL INVESTMENT FUND

Return to Support Index

Support for Projects and Initiatives : Green Municipal Investment Fund: Eligibility Guidelines

GMIF Eligibility Guidelines

en français

FCM must be satisfied that a GMIF project proposal meets the following basic requirements:

1. The applicant is a Canadian municipality or its duly authorized partner. If the partner is applying, a letter from the municipal government must demonstrate its commitment to the project.

2. The project falls under one of the eligible categories:

- energy
- buildings
- water
- waste
- transportation

3. The project will implement at least one environmentally innovative approach.

4. There is potential for a significant improvement over "business as usual." Energy, building, water and

About the GMIF

Overview
Eligibility Guidelines
Selection Process
Selection Criteria
Application Deadlines
Contact Information
Updates

Possible Projects
Approved Projects

How to Apply

performance by at least 35 per cent. Waste projects must improve performance by at least 50 per cent. See the applicants' guide for more information about ways to measure performance improvement.

GMIF can only lend up to 15 per cent of eligible capital costs (exceptionally, 25 per cent).

Eligible Expenses

- the capital costs (as defined in the Canadian Institute of Chartered Accountants Handbook) associated with project implementation
- professional, technical personnel, consultants and contractor costs directly involved in the project's design, engineering, manufacturing, or construction, but not employed by the recipient
- the cost of construction, renovation or modernization of facilities and structures essential for the installation of the project

Ineligible Expenses

- the recipient's general overhead costs or commitment in-kind, including operating costs related to the general maintenance, repair and overhead cost of the project
- the cost to purchase or lease real property
- office space for project administrative staff
- administrative costs not specifically listed as eligible expenses

feasibility studies

- conference travel
- office supplies
- Provincial Sales Tax and the Goods and Services Tax for which the recipient is eligible for a tax rebate and any other costs eligible for rebates

top of page

APPENDIX E

TECHNICAL MEMORANDUM 3

Task 3: Compost Optimization

Final Draft

TO: Wayne Key

COPIES: Ron Turner, Rob Latford, Jim Lilley, James Etienne, Trevor Barton, Bob Hook, Peter Burrowes, Irwin Osinga, Diana Vangelisti

FROM: Warren Saint, Sally Baldwin

DATE: July 31, 2002

1. Introduction

The City of Guelph are currently addressing their wastewater treatment requirements by expanding the capacity of the Guelph Wastewater Treatment Plant (WWTP), to ultimately enable the City to treat wastewater flows up to 73,300 m^3/d. This biosolids management study project has been initiated to ensure that the solids handling systems at the wastewater treatment plant are sufficient to deal with the increased residuals that will inevitably result from the increased wastewater flow, and that the solids handling systems are cost-effective with respect to capital, operations and maintenance (O&M).

Task 1 of the project included analyzing the condition and capacities of existing equipment, estimating existing operational costs and determining existing and future processing capacity and potential equipment needs. This task provided a baseline for the following project tasks.

The objective of Task 2 was to determine whether there are viable end-uses for compost and what product quality is required. Task 2 has been presented in a TM.

The findings of Task 3 are presented herein.

2. Purpose

The City is concerned with the cost and resources required to operate and maintain the composting facility. This task investigated alternatives for optimizing the composting operations. Utilizing cost information from Task 1 and product quality requirements from Task 2, areas where optimization may provide cost savings and process optimization have been identified and evaluated.

3. Background

The compost facility was constructed and placed into service in 1995. Prior to this, the dewatered biosolids cake was loaded into dump trucks and transported to the municipal landfill. The purpose of installation of the composting system was to remove cake disposal difficulties encountered with landfilling and to ultimately provide a more beneficial use for the biosolids. Composting allows for a drier end product to be produced, with a significant reduction in the concentration of pathogens and other microorganisms.

The compost facility was designed to process 15,100 dry kg per operating day of biosolids, dewatered to 20% total solids with an operating range of 17% to 23%. The system is designed to operate as a three-vessel system, with composting occurring in two vessels and in the third cure vessel.

In 2001, during periods when all dewatered cake was composted, the system processed an average of 8.7 dry tonnes per day of dewatered biosolids at approximately 18% average solids content, and a total of approximately 2,600 dry tonnes of biosolids throughout the year. The remainder of the dewatered biosolids was utilized by PowerGrow in Niagara Region. In other years, when composting all of the biosolids was not achieved, the biosolids were directly land applied. Landfilling of the dewatered biosolids at the Eastview Landfill is maintained as an emergency contingency option, however, the landfill is scheduled to close in 2002/03 and so this option will then be no longer available.

Usually the system is forced to operate as a two-vessel system due to unscheduled reactor shutdowns. This results in a compost product that contains approximately 5% greater moisture content, due to the decreased material residence time.

The composting system can effectively reduce pathogens in the dewatered biosolids and produce a chemically and biologically stable end product that has a number of potential end uses. With the current health and environmental focuses on nutrient management and potential effects of land applying materials which contain high numbers of pathogens, processes which produce stable, pathogen-free biosolids end-produced are becoming increasing important.

3.1. Task 1 Review

The Task 1 report found that the average dewatered cake production rate was, during steady state conditions (when all biosolids are composted), approximately 8.5 dry tonnes/day (dt/d) from 1998 to 2000 and the average raw water influent flow for the same period was about 52,000 m^3/d. The report also projected solids production data for the Stage 1 and Stage 2 expansion capacities of 64,000 m^3/d and 73,300 m^3/d raw influent respectively and for three different organic loading scenarios.

The estimated dewatered cake production ranges from 8.3 dt/d to 13.6 dt/d at 64,000 m^3/d of raw influent flow, and from 9.3 dt/d to 14.7 dt/d at 73,300 m^3/d of raw influent flow, based on industrial contaminant loads based on sewer use by-law compliance and projected maximum rates. The estimated dewatered cake production at current average industrial contaminant loading rates are 11.6 dt/d at 64,000 m^3/d raw influent and 13.3 dt/d at 73,300 m^3/d raw influent.

3.2. Biosolids Processing Requirements at the Guelph WWTP

The 2001 plant data was briefly reviewed to ensure that the Task 1 projections remain valid with the additional data available. A summary of the data is displayed in Appendix A.

The data suggests that there was a slight decrease in solids production in 2001 from 2000, but the long-term trend remains consistent. Therefore, the Task 1 projections are considered appropriate. See Appendix A.

The costs of operating and maintaining the composting facility were approximately 35% greater in 2001 than in the year 2000. The increased costs reflected unscheduled non-reoccurring costs associated with containing and cleaning up after a fire in the cure reactor in December 2001. Furthermore, unscheduled maintenance costs increased, partly due to physical contaminants in the amendment material such as metal, stones and oversize material and partly due to the increasing age and wear of the equipment, particularly the outfeed devices.

4. Compost Process Overview

Composting is essentially an aerobic biological process in which a variety of organisms feed on the biodegradable organic material in the composting mixture. The mixture must therefore provide the essential food ('nutrients') and conditions for activity and growth of microorganisms, including:

- Biodegradable organic material as a carbon food source;
- Sufficient nitrogen as a nutrient for cell growth
- Sufficient phosphorus as a nutrient for cell growth;
- Sufficient amounts of trace nutrients required for the optimum growth of a widely varied microbiological population within the compost mixture;
- A porous compost structure, so that air can travel through it to provide oxygen for the aerobic organisms;
- Sufficient moisture to support the life and growth of microorganisms.

Composting biological activity is characterized by the generation of a significant amount of heat: enough to raise the temperature of the composting mix to roughly 55 – 65 °C. Production of heat gives two important benefits:

- Most pathogenic bacteria, viruses and parasites are inactivated during at least three days at a temperature of ≥55°C;
- A large amount of water evaporates and is carried away in the off-gas, this in turn causes drying of the composting mix improving the physical characteristics of the resulting product.

The in-vessel system at the Guelph WWTP includes three large steel reactors; two bioreactors and one cure reactor. These three large vessels house the composting mix; generally the majority of the biological reactions take place in the two bioreactors and the mix is then transferred to the cure reactor for additional stabilization.

In-vessel composting is a continuous batch mix process that proceeds in a number of consecutive phases, and is designed so that each operating day a calculated volume of cured compost is removed and, under a three rector operating scenario, a similar volume of compost is transferred from the bioreactor(s) to the cure reactor, and a new batch of feed is added to the bioreactor.

5. Compost System Overview

The compost system consists of the following major equipment components:

- Amendment Receiving
  - Amendment receiving hopper
  - Transfer conveyor
  - Hammermill (optional unit process)
  - Pneumatic conveyor
  - Storage silo
  - Discharge screw
- Sludge Storage
  - Infeed conveyor from dewatering
  - Sludge storage bin
  - Sludge transfer screw conveyor
- Mixer & Reactor Infeed Conveyors
  - Twin auger mixer
  - Elevating sandwich belt conveyor
  - Reactor infeed screw conveyor
- Composting
  - Infeed rotary distributor
  - Bioreactor vessels
  - Cure reactor vessel
  - Outfeed device
  - Reactor air distribution grids
  - Transfer screw conveyors
- Finished Compost Loading
  - Screw conveyors
  - Compost Screen (optional unit process)
  - Misc. conveyor
  - Screen recycle (optional unit process)
- Aeration System
  - Compost Aeration blowers
  - Exhaust blowers
- Compost exhaust air heat recovery
  - Exhaust piping/diffusers to WWTP aeration tank
  - Ventilation
- Instrumentation and Controls

A process flow diagram is shown in Attachment A.

5.1. Amendment Receiving/Storage

Inclusion of amendment in the compost feed is essential. Amendment increases the porosity and solids content of the mix as well as providing a source of biodegradable carbon to maintain the correct carbon to nitrogen ratio of the initial compost mixture.

Amendment is brought to the plant in truckloads. It is off-loaded into the amendment bin and pneumatically conveyed into a large amendment silo, which can store up to $800m^3$ of amendment. The Hammermill, located between the bin and silo, is not currently required for size reduction of the current amendment, which is used .

5.2. Sludge Storage

Sludge cake is produced in the dewatering facility and is immediately transported via a series of enclosed screw conveyors to the compost building. The cake is deposited into the sludge bin, which is completely enclosed and continuously weighed.

The sludge bin is a rectangular steel tank 3m wide, 9m long, and with a variable working depth of up to 4m. The bin can hold up to $100m^3$ of cake. The sludge bin functions as an intermediate storage reservoir so that the shift-to-shift operation of dewatering and composting do not need to be synchronized.

5.3. Mixer

The mixer blends the bioreactor infeed materials which consist of dewatered sludge cake, wood chip amendment and recycled compost. Additionally the mixer homogenizes the intermediate compost product during the transfer process from the bioreactor to the cure reactor. The mixer discharges onto the vertical double belt sandwich conveyor and the mixed material is subsequently discharged to the top conveyors and routed to the selected reactor.

5.4. Transport Systems

Various equipment components are connected with screw conveyors and the sandwich belt conveyor. To sustain the biological process and make the daily operating routines possible, these transport mechanisms are essential. They provide the means of transporting and rough metering of the various raw, intermediate and finished compost materials.

The screw conveyors are fabricated of steel round bottom troughs. Electric motors and associated speed reducers are provided to slowly rotate the helical ‘screws’ that run in the troughs, and thus continuously auger the material from inlet to discharge points.

Some 20 conveyors of various sizes, lengths and orientation are installed in the compost facility to transport material. They are viewed as essential equipment units. Most have no standby units or alternate material routing.

5.5. Composting

After the correct feed mix is blended in the mixer, the feed is conveyed to the selected bioreactor and is spread over the top view area of the reactor by the use of an internal rotating spreading mechanism (“distributor”). Once that operation is completed, no further operator control is needed to transport the compost from the top to the bottom (exit) of the reactor. With the correct compost mixture and operating conditions, biological activity in the reactors is autogenous and self-sustaining. The inclusion of "cured" compost in the initial compost mixture aids in the inoculation with the required biomass.

The two bioreactors are designed to provide sufficient time, and the correct environment, for the first stage of composting. Maximum compost temperatures are generally achieved in the bioreactors and is sustained long enough (i.e. at least three days) to give a very high degree of pathogen kill. As the compost gradually travels downwards in the bioreactors, the predominant organisms change. Each type flourished in its own best environmental regime of temperature, food supply, and system pH. Many different types act on the composting mix, and gradually the texture and characteristics of the compost are modified.

When approximately 75% of the total composting time has expired, the compost is transferred from the bioreactors to the cure reactors. A large percentage of the rapid biological activity has taken place, but polishing of the product is still needed. The air demand is generally lower, and it is therefore necessary to complete the process in a separated regime.

5.6. Loading

Transfer from the bioreactors to the cure reactor is accomplished in batch operation. Compost is removed from the bottom of each bioreactor by a slowly rotating outfeed device which cuts horizontal "disks" of compost, pulls the material towards a central discharge chute, and discharges it onto the conveyor below. The material then goes through the mixer and up via the vertical sandwich belt. The top conveyors bring it to the top of the cure where the rotary distributor distributes it as a fresh top layer in the cure reactor.

5.7. Aeration System

Compost aeration is achieved by injecting a controlled stream of compressed air into each reactor. Air flow to each reactor is almost continuous; it is only interrupted when the outfeed system for that given reactor is in service.

Aeration air is injected into the bottom of the composting reactors in one quadrant at a time. That injection method makes it possible to achieve a relatively high air-flow-per-unit-area on an intermittent basis. A system of perforated pipe, together with a coarse gravel bottom bed, distributes air over each complete quadrant area.

The air is delivered by four positive displacement aeration blowers driven by 93 kW electric motors. The air is normally discharged at a working pressure of about 5 – 15 kPa.

The compost reactors are kept under a very small negative pressure (-20 Pa) to prevent escape of compost exhaust into the atmosphere. Four exhaust blowers are installed to draw exhaust air from the compost reactors, through the air to air heat exchangers and discharge the compost off-gas via a 750 mm stainless steel header pipe to the Plant 1 aeration tanks.

5.8. Instrumentation and Controls

The SCADA control system automatically controls gates, conveyors, process equipment, and ensures all safety interlocks. The operator selects which sequence is to occur and the length of time for that sequence, to ensure that all cyclic operation goals are met. Examples of sequences include outfeed from the cure reactor to the truck, transfer from a bioreactor to the cure reactor, and the feeding dewatered cake, amendment and recycled compost, at different rates, to the mixer.

The system is designed to employ the SCADA-controlled sequences for specific tasks under normal operations. Under maintenance or unusual operating conditions, manual stops and starts for individual pieces of equipment may be made at the local control panels, or from the MCC breakers.

6. Compost System Process

6.1. Feed Materials

One of the most important operating and process controls connected with composting is the preparation (blending) of the individual batches of compost feed. Once they have been blended and loaded in to the first reactor, there are minimal process controls that staff can operate. This means that in order to optimize the composting process, it is essential to prepare and blend a feed which contains a good ratio of C to N, is dry enough (36-41% TS) and is porous enough to allow passage of air.

Dewatered cake cannot be composted by itself. It is too wet, not porous enough and lacks sufficient biodegradable carbon. It is therefore necessary to produce a blended feed consisting of dewatered cake, amendment (wood chips) and recycled compost. The amendment is added to act as a source of carbon, increase feed porosity and reduce feed moisture content. The recycled compost is added to provide active biological seed, increase feed porosity and reduce feed moisture content.

6.1.1. Biosolids

The consistency of the biosolids cake is determined by the raw wastewater characteristics and the processes upstream of the compost facility, including primary and secondary wastewater treatment processes, digestion and dewatering.

The sludge bin is enclosed and continuously weighed. However, as the sludge bin provides capacity for about 1.25 days of dewatered cake, the compost facility must be able to consume cake on each day the dewatering units are producing cake. As the wastewater flow, and therefore, residuals production, increases over time, and the dewatering facility produces more cake, possibly over a longer period of time per operating day and/or more days per week, the compost facility will require increased operator attendance time.

6.1.2. Amendment

Currently, approximately 20 tonnes/day, over a five-day week, of amendment is purchased from Woodwaste Solutions. The amendment costs approximately $57/wet tonne, delivered.

Some contaminants have been found in the amendment material, such as larger pieces of 2" x 4" wood planks and pieces of metal. Damage has occurred to the augers at the bottom of the amendment bin and materials handling fan when the operators have been unable to remove the contaminants as they monitor the amendment discharge from the suppliers transport trucks. The supplier has been informed that these contaminants are unacceptable and has been making efforts to perform better quality control on their product.

Previous suppliers have been more successful in providing contaminant-free amendment material, but at a higher price. Woodwaste Solutions bid to a tender specification that required a material free of oversize material and inorganic contaminants.

6.1.3. Recycle

Compost discharged from the reactors is recycled back to the reactor vessels, and mixed with the feed biosolids and amendment material. This not only provides a dryer feed material and improves the characteristics for infeed operations and porosity of the mix, but also provides biological seed material for composting.

6.2. Composting

The reactors each have a maximum capacity of about 1,500m^3 and a working volume of approximately 1200 m^3. Each metre of operating depth represents a volume of approximately 200m^3.

6.2.1. Compost Bioreactor

After the feed mix is blended in the mixer, the feed is conveyed to the selected bioreactor and is spread by use of an internal rotating spreading mechanism (infeed distributor). The bioreactor feed rate is limited by the capacity of the mixer (150m^3/hr maximum) and conveying systems.

6.2.2. Curing

The compost is transferred from the bioreactors, where the majority of biological conversion generally occurs, to the cure reactor, where additional stabilization of the compost product occurs

The cure reactor can function as a bioreactor, if one vessel is out of service. This may be the preferred mode of operation if determined the end product use specifications.

6.3. Auxiliary Components

6.3.1. Conveyors

The various components of the compost feed loop, transfer loop, screening system and compost discharge are connected with screw conveyors and the “sandwich belt” vertical transport conveyor. To sustain the biological processes and make the daily operating routines possible, these transport mechanism are essential. They provide the only means of transporting and roughly metering the various composting materials.

The screw conveyors are all made as steel round bottom troughs. Electric motor and associated speed reducers are provided to slowly rotate the helical screws that run in the troughs, and thus continuously auger the material from inlet to discharge points.

About twenty conveyors of various sizes, lengths and inclinations are installed in the compost facility to transport material. They are essential equipment units; most have no standby units or alternative material routing.

Operations and maintenance staff perform effective preventative maintenance to keep the conveyors serviceable and to minimize disruptive conveyor breakdowns.

6.3.2. Aeration System

Aerobic conditions are essential for composting, and therefore aeration blowers and exhaust blowers are must be kept operational and controlled.

Aeration is achieved by injecting a controlled stream of compressed air into each reactor. Air flow to each reactor is almost continuous; it is only interrupted when the outfeed system is in service. Aeration air is injected into the bottom of the composting reactors in one quadrant at a time, and the system of internal nozzles and coarse gravel bed distributes the air over each quadrant area.

One of the four aeration blowers is normally dedicated to each one of the reactors. The fourth blower is normally a standby unit.

The compost reactors are kept under a very small negative pressure to prevent escape of exhaust air, and the associated dust and odour. Four (4) exhaust blowers are installed to withdraw the exhaust air from the compost reactors and discharged to a dedicated coarse bubble aeration header, in the Plant 1 aeration tanks.

6.3.3. Instrumentation and Controls

The day-to-day operation of the whole composting facility relies heavily on the SCADA control system. It would be extremely difficult for staff to operate the facility without the use of the programmed SCADA system. The local controls are not meant to replace automated and interlocked controls from the SCADA composting sequences.

Each sequence is selected by the operator, and allowed to function for a selected length of time. All the conveyor and equipment stops, starts, speed control, direction of rotation, etc, then occur in the predetermined order.

All the important equipment conditions are monitored during sequence operations. If equipment failure, overload, pluggage, or other potentially harmful conditions occur, the sequence is automatically halted. The SCADA system indicates which conditions caused the alarm and shutdown. Human intervention is then required to correct the situation.

6.3.4. Building HVAC

Building air exchange depends, in part, on using the vessel aeration blowers. This creates a problem when one or more reactor is out of service, as this results insufficient building air exchange.

7. Compost System Maintenance

7.1. System Outages

The Compost Facility at the Guelph WWTP has experienced a number of equipment outages since its start-up in 1995. Equipment maintenance logs are maintained by the operations staff, which indicate the scheduled and unscheduled equipment outages.

The reactor outages recorded by the plant staff since commissioning are summarized in the table below.

Date	Bioreactor 1	Bioreactor 2	Cure Reactor	Bypass Necessary?
August-95		X		
September-95		X		

Date	Bioreactor 1	Bioreactor 2	Cure Reactor	Bypass Necessary?
October-95		X		
November-95	X			
December-95	X			
January-96	X			
February-96				Yes
March-96				Yes
December-96		X		
January-97		X		
March-97	X			
April-97	X			
May-97			X	
June-97			X	
July-97	No data			
August-97	No data			
September-97	X	X	X	Yes
October-97	X	X	X	Yes
November-97	X	X	X	Yes
December-97	X	X	X	Yes
January-98	No data			
February-98	No data			
March-98	No data			
April-98				Yes
May-98	X			Yes
June-98	X			Yes
July-98	X			
August-98	X			Yes
September-98	X			Yes
October-98	X			
November-98	X			
December-98	X			
January-99	X			
February-99	X			
March-99	X			
April-99	X			Yes
May-99	X	X	X	Yes
June-99	X	X	X	Yes
July-99	X	X	X	Yes
August-99	X	X	X	Yes
September-99	X	X	X	Yes
October-99	X	X	X	Yes
November-99	X	X	X	Yes
December-99		X	X	Yes
January-00		X		
February-00		X		
March-00		X		
April-00		X		
May-00		X		Yes
June-00		X		Yes
July-00		X		Yes
August-00		X		Yes
September-00			X	Yes
October-00				Yes
November-00		X		Yes
December-00	X			
January-01	X			Yes
February-01	X			Yes
March-01	X			Yes
April-01	X			Yes

Date	Bioreactor 1	Bioreactor 2	Cure Reactor	Bypass Necessary?
May-01	X			Yes
June-01	X			Yes
July-01	X			Yes
August-01	X		X	
September-01			X	
October-01			X	
November-01			X	

Notes:

X denotes Out of Service

The reactor outages shown in the table refer to some period or outage during the month, which may or may not involve the entire period.

7.2. Maintenance History

Comprehensive maintenance records are kept by the compost facility operations staff. These include all scheduled and unscheduled maintenance items performed both by the compost operation staff, as well as WWTP and external maintenance personnel.

Other compost facility equipment typically does not have as demanding maintenance unscheduled requirements as the reactors outfeed devices. Scheduled checks and lubrication are extensive, and equipment reliability is less of an issue than that of reactor outfeed device reliability. Major maintenance is achieved when the whole facility is taken out of service in the summer months, when the biosolids is able to be land applied. The plant maintains detailed records of equipment maintenance, and a review of these has shown that few reoccurring incidents have been evident due to the success of the scheduled maintenance activities, other than reactor vessel issues.

A summary of the reactor maintenance history, derived from the compost facility records, is displayed in Appendix B. The most common reactor maintenance issues appear to arise from the outfeed devices. The staff have reported that the most common fault is that seals typically fail, allowing compost fines to damage the bearings and resulting in failure of the gear-box clutch. This results in the requirement to take the reactor off-line, empty the vessel and remove and repair the clutch mechanism. This process typically takes at least two months, as often spare parts have to be ordered and delivered from Germany.

7.2.1. Scheduled and Emergency Maintenance

The scheduled maintenance program is extensive, and generally includes scheduled inspections, lubrications and repairs. However, it can be seen from the plant records that scheduled maintenance is sometimes delayed. This is typically due to staffing issues, and may result from the relocation of resources to deal with emergency maintenance issues. The composting facility employs two full time staff, and has maintenance assistance when required and available from the WWTP maintenance staff, also consisting of two employees. External services are called in for maintenance assistance when special skills and/or extra assistance are required.

Scheduled maintenance is generally preformed by in-house employees, but can be delayed when unscheduled issues arise. Emergency, or unscheduled, maintenance is performed as necessary to limit process upset due to equipment failure. Due to the tight schedule and low level of staff contingency time available, delays of scheduled maintenance can cause further unscheduled requirements, resulting in a cycle of unscheduled maintenance and reduced scheduled maintenance.

8. Compost System Operations

8.1. Staffing

The compost facility is usually manned 5 days per week, from 7:00 am to 5:00 pm. Each of the two full-time employees dedicated to the facility is scheduled to work 5 days per week, for 8 hours each day. The total budgeted raw salary burden for the compost facility $56,300 per year. Overtime is budgeted at $12,000 per year, and fringe benefits are accounted for separately.

Over the past four years the salary budget has been exceeded somewhat, particularly in 2001 when significant overtime was required to control and clean up after the fire in the cure reactor. Excluding major non-reoccurring events such as the cure fire, the salary and overtime budget for the compost facility generally remain within 10% of the annual budget.

In addition, the WWTP's two full-time maintenance employees assist with the compost facility maintenance when requested and required, although this must be balanced with the demands of the rest of the plant. The amount of time and effort spent in the compost facility is not recorded separately for the maintenance staff, so the actual maintenance staffing costs are not included in the compost facility budget.

The manufacturer's design manual recommends that four full-time dedicated employees are required to operate and maintain the facility.

8.2. Daily Operations Review

During the operating hours, some compost is removed from the bottom of each vessel in service, and new biosolids, amendment and recycled compost mixture is added to the top. A number of operations are required to do this, and to remove the compost product from the facility. The necessary equipment operation, sequencing and controls requires the attention of one operator, primarily from the control room. Equipment inspections and scheduled maintenance during the operating day requires the attention of the second operator.

When unscheduled maintenance is required, equipment inspections and scheduled maintenance is postponed and operator attention is refocused.

Composting operations must occur, as a minimum, on the same days as dewatering, as the sludge bin excess capacity is not great enough for two days of dewatered cake storage.

8.3. Housekeeping

Housekeeping is generally the least important operational issue on the operators task list. Due to the amount of time required to operate and maintain the facility, only a few hours per week can normally be dedicated to housekeeping. During periods of major unscheduled maintenance, housekeeping efforts must be reduced even further.

9. Operation and Maintenance Costs

Historical operation and maintenance costs were addressed in Task 1 and have been included in Appendix A, for reference.

9.1. Amendment

The amendment costs, including a breakdown per dry tonne of biosolids composted, for 1998 to 2001 are shown in the table below.

Year	Total Cost	Delivered Amendment Cost Per Wet Tonne	Total Annual Quantity (Dry Tonnes) of Biosolids Composted (to closest 100)	Amendment Cost per Dry Tonne of Biosolids Composted (to closest $1)
1998	$202,222			
1999	$300,307		2,300	$131
2000	$365,537	$57 + GST	1,600	$228
2001	$443,872	$57 + GST	2,600	$171

9.1.1. Amendment Quality and Price

The City is currently producing a Request for Quotations for amendment suppliers. This will have the effect of ensuring bids are competitive within the market place.

A number of potential suppliers that may be willing to bid on the contract have been identified in a preliminary investigation. The potential suppliers identified to date include:

- JR Simpson Lumber, Cambridge – local sawmill producing lumber
- Penguin Pole Inc., Wallenstein – local sawmill producing hydro poles
- Pestell's, New Hamburg – suppliers to agricultural applications (animal bedding) and the University of Guelph
- SEL Recycling, Elmira – suppliers to the Wet-Dry Facility biofilters

When the Request for Quotations is released by the City, other potential suppliers may be identified.

Initial contact via e-mail, was also made with the Rocky Stone Corp., who represents a group of biomass power plant owners with forest industry contacts. The contact suggested that wood chips could be purchased further afield, possibly in larger sawmills in Northern Ontario or New York, and transported by train, in railcars carrying approximately 40 tonnes of wood chips for a transport cost of approximately $22 per tonne. It may be prudent to pursue this further if unloading at a rail siding is feasible for the Guelph WWTP in the future, although at this time it may not be cost effective. One advantage could be that the emptied amendment rail car could be used to transport compost back to mine sites in Northern Ontario, for land reclamation use.

9.1.2. Amendment Quantity

The plant recorded data suggests that approximately 1.9 to 3.3 times more amendment than compost is added to the bioreactors, in terms of weight (dry tonnes). For example, if 1 dry tonne of biosolids is added, 1.9 to 3.3 dry tonnes of amendment are added.

According to Taulman's performance tests, shown in Appendix C, the suggested weight ratio for bioreactor feed is approximately 1:0.25:1 (biosolids:amendment:recycle).

The suggested volume ratio, in the same order, is approximately 1:1.25:2.7. The actual volume ratio, taken from plant records, is approximately 1:2:9 for bioreactor 1 and 1:2:6 for bioreactor 2.

This suggests that the facility currently uses a much greater amount of amendment and recycles, than was found necessary in the performance test. The greater volumes of amendment and recycle, not only increases the cost of the compost produced but may decrease the quality due to the lower retention time in the reactors. Gradually decreasing the amount of recycle and amendment should be attempted to determine and document the limiting process and operational factors. In conjunction with this, the method of measurement and calibration should be recorded and compared to the performance test, to determine any differences and related product weight and volume ratio considerations.

The manufacturer's operations and maintenance manual lists the advantages and disadvantages of a number of amendment sources, including sawdust and tree trimmings and leaves. Aged or kiln-dried sawdust, and milled yard waste are listed as two of the preferred sources.

9.2. Maintenance

Maintenance costs were not recorded by the WWTP for the compost system, as a separate item in the WWTP's annual accounting data. Maintenance items for the facility, in the plant's accounts, can be identified by the plant's maintenance manager, but this is a time-consuming task. Starting in 2001, the WWTP has integrated an accounting system that will help identify maintenance items by process, excluding WWTP maintenance labour.

Total compost facility maintenance costs, excluding WWTP staff maintenance labour costs, ranged from about $87,000 to about $184,000 per year between 1997 and 2000, representing from 19% to 29% of the total compost facility operating costs, excluding electricity, or about $50 to $220 per dry tonne of biosolids processed.

9.3. Operations

The total operating costs ranged from about $380,000 to $510,000 per year between 1997 and 2000, representing about 71% to 81% of the compost facility total costs, excluding electricity, or about $216 to $525 per dry tonne of biosolids processed.

9.4. Transportation & Disposal

Transportation and disposal costs, included in the above calculation of operating costs, ranged from about $52,000 to $80,000 per year, or about $27 to $67 per dry tonne of biosolids processed from 1997 to 2000. The largest costs involved were the equipment and operator fees for transport of the compost to the landfill and for the contracting of a backhoe.

While not all operating costs were provided for 2001, the compost transport and disposal costs and backhoe contracting costs for the year were about $150,000 and $25,000, respectively, excluding taxes. These represented a significant increase in costs over previous years.

10. Experiences from other Plants

There are seven operating Taulman composting facilities in North America. These are located in:

- Springfield, MA
- Binghampton,NY
- Endicott, NY
- Geneva NY
- East Richland County, SC
- Musconetcong Sewer Authority
- Bristol, TN

The Endicott, East Richland, Musconetcong and Bristol facilities all have Weiss outfeed devices, but of a different design to the VFD-style at the Guelph WWTP.

The Springfield, Binghampton and Geneva facilities were all built with Laidig outfeed devices. Operational staff at these facilities were contacted to gain perspective on the operation of their systems, with particular reference to their outfeed devices.

10.1. Springfield

Contact Information: Marty Greeny, telephone # 413-731-1532, e-mail rcci1@altavista.com, pager # 413-785-3359.

The Springfield plant operates two vessels, each 38ft in height, with a capacity of 1,400m^3. The facility has been in operation for 12 years, and was the first facility to be constructed with the Laidig outfeed devices. The compost product is either land applied at no cost to the receiver, or sold. The market is still being developed with the aim of selling all the compost product in the future.

The facility processes solids at approximately 50% total solids infeed, and they run at about 70% vessel capacity, typically resulting in a 21 day HRT, compared to the design of 35 days HRT. The biosolids is approximately 22% total solids and ¾" wood chips (reclaimed pallets) are used for amendment. They do not screen the product and recycle the wood chips through the system. Previously, the facility accepted Zimpro-treated biosolids, and due to the high solids content, recycle of compost was not necessary. In the future, the facility plans to install an indirect dryer and mix the 22% solids dewatered cake with the dried product to increase the infeed solids content and again eliminate the need to recycle compost through the system.

Some failures experienced during the first few years of operation were related to the lack of a high pressure relief on the outfeed devices. Initially the operators spent time learning about the operating pressures, and then they retrofitted bypasses, so that only a maximum pressure could be reached. Now the system operates continuously, excluding a scheduled shutdown for maintenance in the summer. The annual maintenance generally costs between $5,000 and $15,000 (US) per vessel, each year.

Since the bypasses have been installed, there has only been one unscheduled shutdown. During the scheduled maintenance the amount of wear on the trailing arm in one vessel was underestimated, and due to corrosion caused by leachate, the trailing arm broke during operation. With this in mind, Springfield recommends that any outfeed device retrofit is of stainless steel construction.

Springfield do not use the spinner plate infeed device. They like the loading pattern produced without this; greater solids loading in the centre and less loading at the edges. They feel this provides them with a preferred loading pattern.

The Springfield operator would be happy to arrange a site visit by Guelph WWTP staff, to be set up at a mutually agreeable time.

10.2. Binghampton

Contact Information: Harry Derra, telephone #607-729-0483

The Binghampton facility operates a three vessel system. The two bioreactors have dimensions of 33ft diameter and the cure has a 46ft diameter. The facility was built in 1988 and started up in 1989/90. It was the second facility to be constructed with the Laidig outfeed devices. The compost product is given away for beneficial reuse as no market has ever been set up for it. The plant maintains that this is cheaper than land filling.

The amendment material used is fine sawmill sawdust. The use of this type of amendment material has resulted in an optimum operating level of approximately 60% in the vessels. The plant was previously receiving ¼" sawdust, and at that time they normally filled to the 100% level. As amendment availability changed, the plant optimized operations to match the available material.

In the past 12 operating years there have been no emergency facility or unscheduled shutdowns; however, a fire in one of the reactors reduced the operation to a two vessel system for a period of time. The auger in the effected reactor had to be replaced at that time, as it was warped in the fire.

The operator reports no unusual or excessive wear of the Laidig outfeed devices. In one vessel the outboard bearing in the auger has been changed, and scheduled inspections have shown that, in each vessel, the shoe on the track on which the auger sits is wearing out.

The operator also suggested that the shadow cast by the spinner plate arm and uneven filling of the vessel is not an issue. While they were concerned with this when first operating, over the longer term operating cycle, they determined that the varying feed solids, density and mix tends to result in even vessel loading.

The Binghampton operator would be happy to arrange a site visit by Guelph WWTP staff, to be set up at a mutually agreeable time.

10.3. Geneva

Contact Information: Will Czapiak, telephone #315-789-8040

The Geneva facility has one vessel, with dimensions of 30ft diameter and 38 ft height. The system produces 20 to 25 cubic yards of compost per operating day, and has an invessel HRT of 20 to 30 days. Additional curing is achieved on an outdoor aerated holding area, where the compost is cured for approximately 30 days. The cured compost is sold for $8 to

$10 US per cubic foot, and fine sawmill sawdust is used for amendment material. The system has been in operation since 1995/6.

Scheduled maintenance is performed on the system once every two years, when the system is taken out of service for up to 4 months and dewatered biosolids is sent to a land application program.

To date, there has only been one period of emergency maintenance necessary, which resulted in facility shutdown. This occurred when an internal part broke and it was necessary to empty the reactor to make repairs. This emergency maintenance was performed quickly and the period of forced shutdown was short.

The Laidig outfeed devise has shown no unusual wear when examined during the scheduled inspections; track wear on the screw conveyor at the bottom of the silo tends to be the most prolific wearing part. The auger is scheduled to be replaced in 2002/3 due to age and wear.

The plant operators report that Laidig provide good customer service, and have not only ensured that problems have been effectively solved, but have also performed some work at a reduced price.

The Geneva operator would be happy to arrange a site visit by Guelph WWTP staff, to be set up at a mutually agreeable time.

11. Conclusions

11.1. Summary Table of Issues

Refer to Table 1:

Item	Comment	Potential Reliability/Operations Improvement	Potential Action	"Headache Factor"[1]
Equipment				
Amendment Receiving	• Good condition; equipment may fail if amendment quality is poor	• Amendment source control • Ability to screen incoming amendment – may require dry storage facility to reduce time of truck unloading and for efficient operation	• Issue RFP for amendment • Have contract with amendment supplier(s) with penalties for non-performance • Review costs and benefits of dry storage area	5
Hammermill	• Not used • Takes 3 ½ to 4 hours to unload one truck of amendment through hammermill	• Needs to be inspection prior to testing & use • If required for daily operation dry storage facility may be necessary, as discussed above	• Inspection and testing of equipment • Cost/benefit analysis of dry storage area & hammermill use	0
Amendment handling fan	• Newly rebuilt, good condition	• Contaminant free amendment extends fan life	• Maintain scheduled inspections and maintenance	0
Amendment storage silo	• Under extreme cold weather conditions, amendment freezes in ring around the silo, can cause blockages if frozen lumps are knocked to bottom of silo	• Insulate silo • Heat silo	• Insulate silo • Heat silo	1
Amendment discharge screw	• Good condition	• None	• Maintain scheduled inspections and maintenance	0
Sludge (day) bin	• Capacity not great enough for current operations – dewatering operates 16 hours per day and 'day' bin can never be fully emptied	• Increase operations time of composting facility, requires more staff		1
Discharge screw conveyor (sludge bin)	• Condition unkown, inspection scheduled	• To be determined	• Maintain scheduled inspections and maintenance	0
Mixer and Controls	• Top access hatch doors too big and heavy, hinges don't work • Mixer paddles need to be replaced summer 2002 • Mixer paddles 'fling' material onto far side of funnel feeding belt and stick to side, eventually plugging funnel; must be cleaned out 2 to 3 times per day (10 – 45 mins per clean)	• Replace doors with removable light weight covers, replace hinges • Perform scheduled maintenance • Line interior of funnel with HDMWPE coating system • Remove last few paddles and replace with short screw	• Maintain scheduled inspections and maintenance • Assess efficiency of HDMWPE coating – take equipment off line and coat, before retrofitting with short screw	3 0 5+
Accumulator	• Good condition	• None	• Maintain scheduled inspections and maintenance	0
Slide plates	• Material builds up in grooves and eventually slide gate cannot close properly; difficult to clean; results in blowers overworking and tripping out	• Redesign for self-cleaning (preferred) or manual cleaning	• Redesign and maintain scheduled inspections and maintenance	5
Bioreactors/Cure Infeed	• A shadow is cast by the distributor supports and the feed mix is unevenly distributed • Spinner plate difficult to adjust, at slow speeds does not work well • Access to reactors difficult	• Need better adjustment for spinner plate • Control for spinner plate direction through PLC from SCADA • Redeisgn spinner plate as cone-shaped and improve attachment to vessel • Need cage for each reactor • Need better way to put access cage into reactor – beam and power hoist preferred	• Design and obtain budget quotation for new spinner plate and pilot test in one reactor • Conceptually design and obtain budget quotation for cage and beam and pilot test in one reactor	5 5
Bioreactors/Cure	• Good condition	• None	• Maintain scheduled inspections and maintenance	0
Bioreactors/Cure Outfeed	• Poor reliability due to excessive bearings wear and clutch breakdown (must be replaced every 2 months) and 6 to 10 week wait for replacement parts	• Test different operating scenarios • Replace outfeed device	• Run outfeed devices at slower rate for longer periods; ensure Taulman operating instructions are reviewed (eg. run outfeeds at same time as filling) • Contact other composting facilities in US to determine preferred outfeed device alternatives • Visit US facilities • Request proposals for preferred new outfeed devices	5
Air Distribution	• Good condition	• None	• Maintain scheduled inspections and maintenance	0
Screen	• Current status unknown • Past experience suggests that feed to screen exceeds capacity of screen and %TS range is specific	• Run screen tests • Test different operating scenarios • Screen part of compost product only	• When at least two reactors are running, inspect and run screen tests • Review costs & benefits of running screen	0
Screen recycle	• Current status unknown	• Run screen tests • Test different operating scenarios	• When at least two reactors are running, inspect and run screen tests	0
Aeration blower	• Air flow rate may be limiting.	• Adjustable output may be beneficial	• Install VFDs	1
Heat recovery	• Does not work effectively; difficult to clean, high maintenance – if filter plugs, ducting collapses • Condensate presents problems (more prevalent in winter) in the heat exchanger units themselves	• Install vacuum relief valve • Install ability to bypass • Determine efficiency of equipment • Install condensate traps	• Design & install vacuum relief valve, ability to bypass and condensate traps • Request proposal by manufacturer to overhaul or retrofit to improve efficiency	3
Exhaust blowers	• Good condition	• None	• Maintain scheduled inspections and maintenance	0
Wide band diffuser	• Since retrofit, previous problem of blower backpressure not a concern	• None	• Maintain scheduled inspections and maintenance	0
Ventilation	• Heat relief and ventilation poor; in summer 2001, 4 large fans were purchased to reduce temperature	• Place exhaust fan on building exterior • Provide (fixed) safe access to	• Assess building HVAC and air flow to determine best location of exterior fan and any necessary	5

	• Some exhaust fan motors have failed to be accessed for maintenance	motors • Ensure louvre screens are clean	ducting retrofits • Design and request budget quotations for access ladders to motors • Maintain scheduled inspections and maintenance	
Instrumentation	• SCADA computer outdated	• Update SCADA computer	• Update to windows based system compatible with WWTP operating system • Instrumentation: SCADA ladder logic / operation sequences - process narratives have been documented for several process sequence enhancements - implement new logic and SCADA screens during computer upgrade	5
Conveyors 422	• Good condition	• None	• Maintain scheduled inspections and maintenance	0
351	• Requires replacement	• Replacement is scheduled	• Maintain scheduled inspections and maintenance	0
552 A	• Good condition	• None	• Maintain scheduled inspections and maintenance	0
552 B	• Requires replacement	• Replacement to be scheduled	• Maintain scheduled inspections and maintenance	0
550	• Requires new endplate	• Endplate replacement to be scheduled	• Maintain scheduled inspections and maintenance	0
551	• Requires inspection of bearings and plates	• Inspection to be scheduled	• Maintain scheduled inspections and maintenance	0
553 (final discharge)	• Requires replacement	• Replacement is scheduled	• Maintain scheduled inspections and maintenance	0
554	• Safety cages and rollers on doors require redesign and replacement	• Redesign and replacement to be scheduled	• Maintain scheduled inspections and maintenance	0
561	• Good condition	• Stock spare parts	• Maintain scheduled inspections and maintenance	0
562	• Requires new endplate	• Endplate replacement is scheduled	• Maintain scheduled inspections and maintenance	0
563	• Good condition	• None	• Maintain scheduled inspections and maintenance	0
564	• Good condition	• None	• Maintain scheduled inspections and maintenance	0
Process				
Feed mix	• C:N ratio may not be optimum • Moisture content difficult to control and maintain with one reactor system	• Measure mix C:N of feed and moisture regularly • Use Taulman 'recipe' as guideline	• Discuss with other facilities any scientific approaches used	1
Level and temperature monitoring	• 1 level sensor per reactor system ineffective with current infeed distribution problems • 3 temperature probes per reactor are insufficient to provide an accurate reactor profile	• Retrofit additional level sensors • Mount IR camera, radar or ultrasonic sensor to show profile of top • Retrofit additional 2 or 3 temperature probes at each level	• Determine preferred alternative • Obtain budget quotation • Install in one reactor to pilot test • Determine preferred alternative • Obtain budget quotation • Install in one reactor to pilot test	3 2
Amendment Quality	• Quality of amendment from current supplier has been an issue in 2001/2002	• Amendment source control • Ability to screen incoming amendment – would require dry storage facility to reduce time of truck unloading and for efficient operation	• Issue RFP for amendment • Have contract with amendment supplier(s) with penalties for non-performance • Review costs and benefits of dry amendment storage area	5
Operations and Maintenance				
Maintenance Scheduling	• Emergency maintenance predominant	• Work towards preventative maintenance	• Employ dedicated maintenance worker(s)	4
Annual Costs	• Amendment • Operations overtime • Maintenance costs	• Screen & recycle • Issue amendment contract RFP to maintain competitiveness of suppliers • Employ maintenance and cleaning staff • Maintain scheduled inspections and maintenance rather than emergency • Correct continuous outfeed device problems	• Review effectiveness of screening, hammermill, etc • Produce amendment RFP for competitiveness of suppliers • Review costs & benefits of amendment types and suppliers • Employ dedicated maintenance worker(s) and cleaners/labours • Employ dedicated maintenance worker(s)	5 5 5

Notes:

1 "Headache Factor" of 5 is high, 1 is low, and 0 is currently unimportant due to existing operations and maintenance schedules. Current "Headache Factor" of each item will change as improvements to the system are made and scheduled inspections and maintenance are performed. This table reflects existing conditions, on January 9 2002.

11.2. Process

The composting process works most effectively when all three vessels are operating. When a 2-vessel composted product is produced, additional curing outside of a test pile has indicated that pathogen re-growth does not appear to be an issue, as shown in the test-pile analytical results, displayed in Appendix ____. However, while no offensive odours were observed at the curing site, plant staff noted that if larger amounts were cured outside, odour issues should be addressed during design of the curing facility.

The in-vessel system produces a composted product that stakeholders have shown some interest in determining the potential benefits of use. When sample bags of the compost were taken to a community open-house event, attendees noted that the product was aesthetically pleasing and appeared to have no malodours.

11.3. Operations

11.3.1. Staffing

The compost facility has been operating with fewer than the manufacturer's recommended staff of two operators and two dedicated maintenance personnel. It is difficult for the plant maintenance staff to schedule maintenance in the compost facility, as they are generally busy with the wet-side of the WWTP operations. Furthermore, overtime tends to be a regular occurrence for the operators, and housekeeping duties are not a priority activity.

In order to determine the costs and benefits of dedicating more staff to the compost facility, it is important to baseline the current efforts of the staff. This should include both operations and maintenance staff, and could be achieved by all staff working in the compost facility keeping a daily log of the time spent on each task. If it is found, for example, that scheduled maintenance duties are regularly postponed for housekeeping duties, it may be more prudent to employ housekeeping staff rather than dedicated maintenance staff.

11.3.2. Process

The most apparent operations deviance from the pilot testing is the biosolids-amendment-recycle mix ratio. While it is understood that this mix has been adjusted to prevent clogging of equipment and conveyors, and maintain a suitably porous mix in the reactors, the adjustments were made some time ago, and decisions have primarily been introduced as retroactive problem-solving measures.

In order to determine the optimum mix and range of mix ratios required to handle the biosolids stream, the operating staff should try adjusting amendment and recycle stream flows, in conjunction with vessel operating levels. Record keeping during this process would be an essential component. Experience at other facilities has shown that keeping the vessels at no more than 50 to 66% full reduces pressure, increases porosity, and helps to prevent clogging of the outfeed devise. Furthermore, while reducing the level to which the reactors are filled will not effect residence time, reducing the amount of amendment will increase biosolids residence time, and reduce the demand for (and total cost of) amendment. Clogging of conveyors could also be reduced as a decreased volume of material would be moved, even though moisture content may increase slightly.

11.3.3. Outfeed Mechanisms

The outfeed devices currently require a significant amount of resources to maintain. From the plant maintenance records, summarized in Appendix ___, it can be seen that with regular (weekly) attention to the outfeed device, they have been maintained in operating condition for periods of time extending for over a year. However, as the equipment becomes older, the frequency of failure of the outfeed devices increases.

No other composting facilities have the same type of outfeed device as Guelph's. In order to determine potential solutions to enable the outfeeds to operate for a minimum of 8 months continuously, so that either one vessel can be taken out of service at any time, with minimal risk of losing another, or all vessels can be taken out of service in the summer, it is recommended that Peter Hain, the German design engineer for the outfeeds, be contacted. (E-mail: p.hain@omnical.de, telephone: +49 2774 81-0, fax: +49 2774 81 349.) Initial contact with Mr. Hain has been initiated by CH2MHILL, and he has expressed an interest to provide assistance for the outfeed issues.

If no reasonable solutions can be found, the outfeed devices could be replaced with the Laidig-type, which has proven to work well in other facilities. Installation of new outfeeds would not reduce scheduled maintenance for this item of equipment. However, the period between emergency unscheduled maintenance events could be greatly increased. A budget quotation from Laidig is included in Appendix ___.

11.3.4. Infeed Mechanisms

The vessel infeed devices are also regarded as problematic by the Guelph staff, due to breakdowns and uneven loading. Other facilities contacted noted similar issues, but stated that by reducing the level of compost in the vessel, the infeed devices were not essential components of the system, and could even be removed if desired. When adjusting the biosolids-amendment-recycle mix ratio and fill level, the importance of even feeding should also be recorded. It may be found that uneven feeding on a daily basis is unimportant, as over a period of time the compost profile will even out, and even if it does not, filling only to 50 to 66% of the total capacity may render this unimportant.

11.3.5. Control Systems

Operational controls, primarily temperature and level sensors, could also be improved to provide a better profile of the compost in each vessel. In order to assist the staff, an additional sensor could be provided for each vessel, to give a profile of the top of the compost. A radar sensor, for example, with an output through the electronic control system, could provide a view of the top profile of compost. This would enable staff to see loading patterns, and better predict vessel temperatures throughout the vessel. The fire in the cure reactor in 2001 was likely caused by uneven loading, resulting in a buildup of compost in locations not accessible to the three temperature probes. An alternative, or additional measure could be to provide additional temperature probes.

The existing computerized controls (SCADA system) is an outdated DOS based system and incompatible with remaining plant. It does meet the minimal operating requirements, but replacement of the system should be considered, as there is currently no backup. When the system is replaced, there is opportunity for a much improved program, which could be integrated with the rest of the plant SCADA system.

11.4. Maintenance

It is important for the facility to move towards a proactive, preventative, scheduled maintenance program, rather than emergency maintenance. This will help the plant to produce good quality compost at all times. The first step in this program will be to comprehensively document maintenance activities and effort spent in the compost facility, as discussed previously, to assist in the determination of maintenance staffing requirements. This information will also help determine which activities require most effort and where the potential for efficiencies exist.

11.5. Costs

11.5.1. Amendment

Pursuing the Request for Quotations for amendment, which has been initiated by the City, is the first recommended step in an effort to improve the quality and decrease the cost of amendment material.

A number of in-vessel composting facilities successfully use sawdust as an amendment material. It is recommended that the City contact other in-vessel biosolids composting facilities to discuss operational issues relating to the use of sawdust, and investigate the local potential sawdust suppliers. If a more cost-effective, reliable supply is found, it is recommended that the City conduct trials to determine the feasibility of using sawdust as an alternative amendment material.

There may also be potential to reducing the amount of amendment required, which should be investigated when reviewing the biosolids-amendment-recycle ratio, as discussed previously.

Trials on the compost screening facility should also be conducted, to determine the feasibility of using this to recycle amendment through the system. Removing some larger amendment material from the product will affect the product quality, and this should be considered as part of the screen trials.

11.5.2. Compost Transportation and Backhoe Charges

If the volume of compost produced can be reduced, there is potential for savings in the transportation of the product. It may be possible to reduce the compost volume by optimizing the biosolids-amendment-recycle ratio, as discussed previously. The use of sawdust, of a finer amendment material may also help to reduce compost volume.

Screening of the compost, also as discussed previously, could also reduce the final compost volume, as reusable the larger amendment particles can be recycled through the system rather than discarded in the compost.

A backhoe operation log should be kept at the compost facility. It is understood that not all backhoe charges relate to the compost facility, and in order to better track composting costs, a more comprehensive record of backhoe operations should be maintained.

11.5.3. Maintenance

Not all maintenance costs are recorded for the compost facility, as maintenance labour for the facility is not separated out from other maintenance duties. Maintenance staff logs would help to define the time spent on maintenance duties in the facility, and enable management staff to understand the scheduled and emergency maintenance duties of the staff.

If a substantial amount of maintenance labour effort is concentrated on any particular items, this will further identify the potential benefits of any capital upgrades.

11.6. Reliable Firm Capacity

The firm capacity of the system is defined as two vessels.

Two preferred modes of operation are available, depending on the compost quality required, and the availability of compost and other biosolids product markets.

The facility could be maintained as a three vessel system for the majority of the year, with an annual facility shut-down in the summer months, when either liquid or dewatered biosolids could be land applied, if the digester HRT is maintained at 15 days or greater, or the dewatered cake could be landfilled as a contingency. As the Guelph Eastview landfill is expected to close in late 2002, transportation to an alternative landfill would have to be factored into the cost. Furthermore, depending on the compost product required quality, additional curing of the compost may be necessary, in the event of an unscheduled reactor failure. This could be provided on the existing outside pad, assuming stormwater issues are properly addressed.

The advantages of this mode of operation include that compost could be produced throughout the fall, winter and early spring, for the heavy spring demand period, and that if required, the dewatering system could also be shutdown, if liquid land application of biosolids in the summer occurs. Furthermore, a stable, well-cured three-vessel compost would be the normal product.

The second alternative mode of operation, is as a two vessel system, with each vessel being scheduled for an annual shut-down and maintenance period each year. It is likely that additional curing on the existing outside pad would be required to meet product quality expectations. Storage of the product would also be required year-round as the normal compost market demand is in the spring.

The actual outside curing and storage area required should be addressed when the optimum biosolids-amendment-recycle ratio has been tested, and when the feasibility of using the compost screen facility has been determined. Furthermore, the compost market must be identified, so that product quality and quantity requirements can be assessed.

12. Recommendations

The following items are recommended:

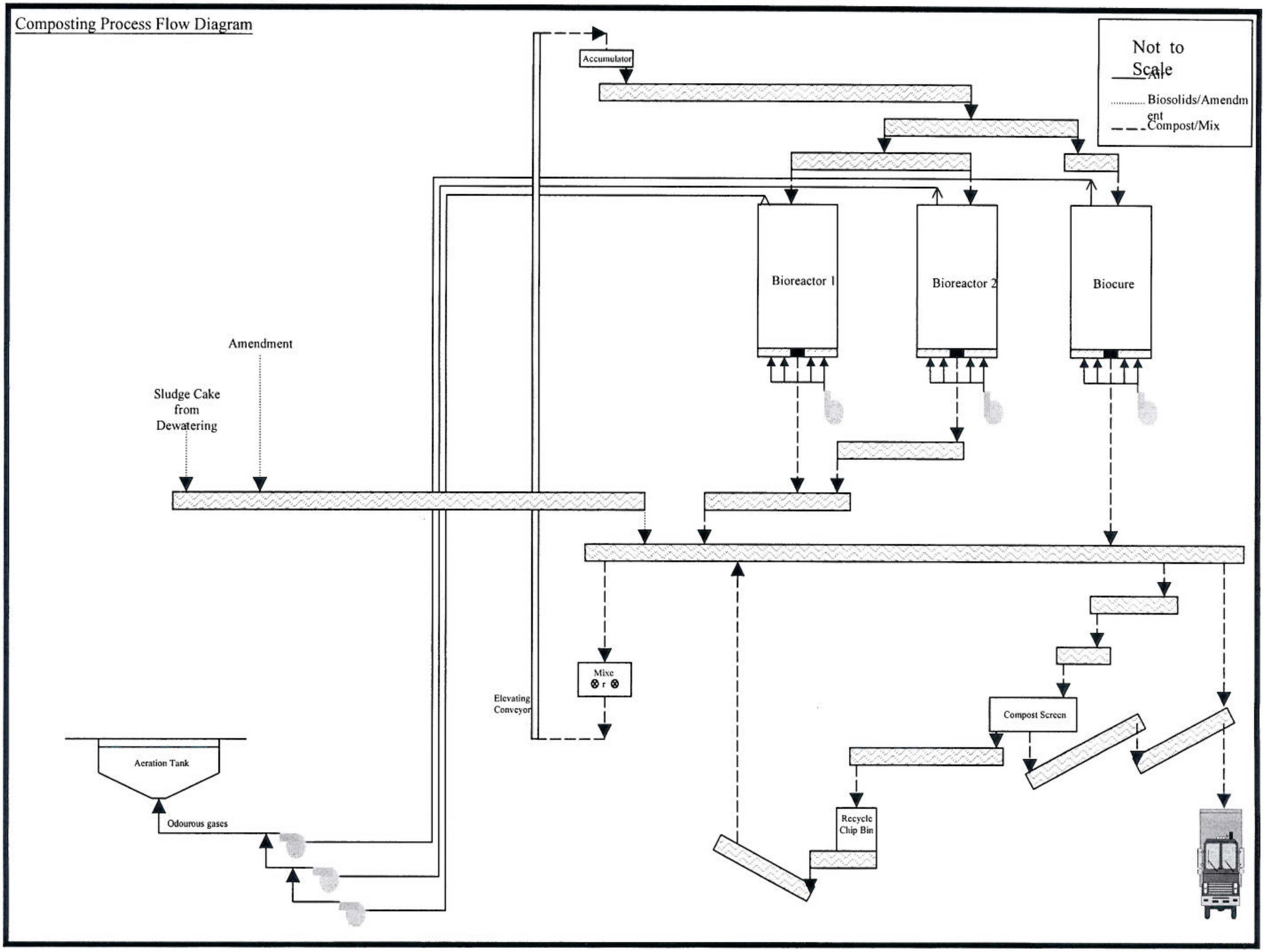
- Operation staff daily activity logs should include time spent each day on each activity. This will help to determine where additional assistance is needed, and when cost saving measures could be employed, possibly by capital expenditure.
- Maintenance staff compost facility activity logs should include time spent each day on each compost facility activity. This will help to determine where additional assistance is needed, and when cost saving measures could be employed, possibly by capital expenditure.

- Distribute an amendment request for quotations
- Distribute a transportation request for quotations for compost
- Research the availability and cost of sawdust
- Arrange and visit the Binghampton, Geneva, and Springfield facilities
- Contact Peter Hain for outfeed device operational review and retrofit opportunities.
- Adjust and record amendment, biosolids and recycle quantities to determine ranges and optimum mix ratios
- Adjust and record issues surrounding the level of fill in the reactor, from 50% to full. This will likely include infeed and outfeed operational assessments.
- Perform compost screening trials, on at least a portion of the compost.
- Create a scheduled maintenance log, and ensure all scheduled maintenance is performed in a timely manner. For example, on a weekly, monthly and annual basis, determine which activities should be preformed and when. While this may be difficult to achieve at first, the more schedule maintenance performed, the less likely emergency maintenance will occur. Cost savings are also likely to result.
- SCADA: the plant is currently in the process of upgrading the existing compost DOS based control system. Ultimately, this system should be tied in with the WWTP SCADA system so that operations can also be monitored from the main administration building.
- Additional temperature sensors could be added to each reactor, and the cost and feasibility of this should be further investigated. However, it may be more cost effective to install a level sensor in each reactor. This would not only provide a profile of the compost in each vessel, but from this any potential temperature related and uneven loading issues could be identified. The effectiveness of this method of operational control could be first piloted with a level sensor that could be moved from one vessel to another.
- Maintain records of all work carried out, that has been traditionally credited to the compost facility, but actually occurs elsewhere in the plant, such as contracted backhoe operations. This will help to better define the actual compost facility costs.
- HVAC ?????

As outlined above, a number of activities are recommended to ensure that any potential capital expenditures for the plant will create the most cost effective solutions. Not only does the actual capital cost have to be considered, but also the maintenance requirements of any new or retrofitted equipment. This should be balanced with the existing costs of the equipment in order to determine potential benefits. Detailed effort and expenditure logs are therefore required to make these comparisons. While it is recognized that researching these opportunities will take effort, the payback could be significant.

Furthermore, a number of opportunities exist to potentially reduce operations costs, and it is recommended that each of these is systematically investigated. Some of these opportunities involve actual operational tasks, while others required efforts to obtain better rates on outside contracts.

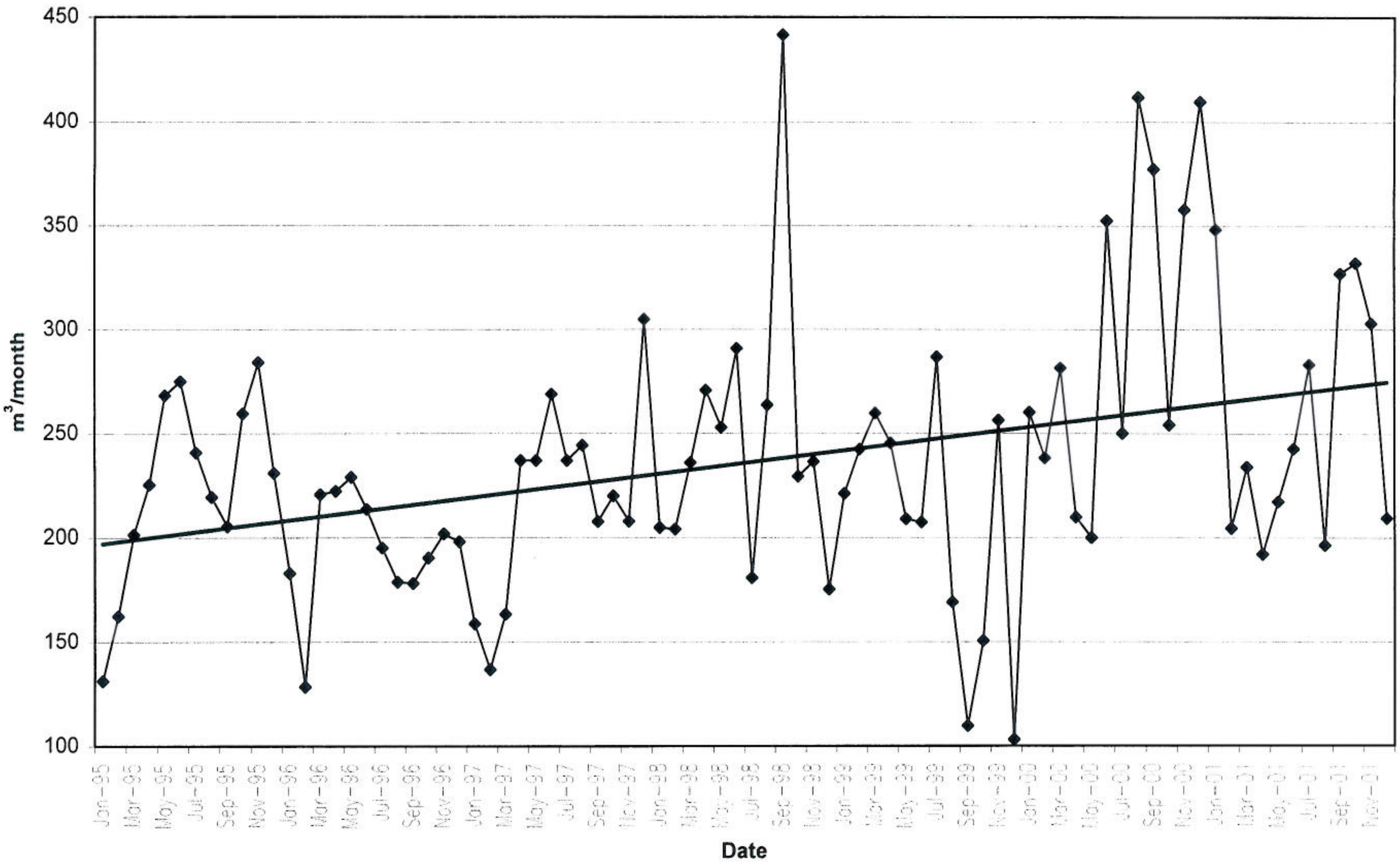
Attachment A: Compost System Process Flow Diagram

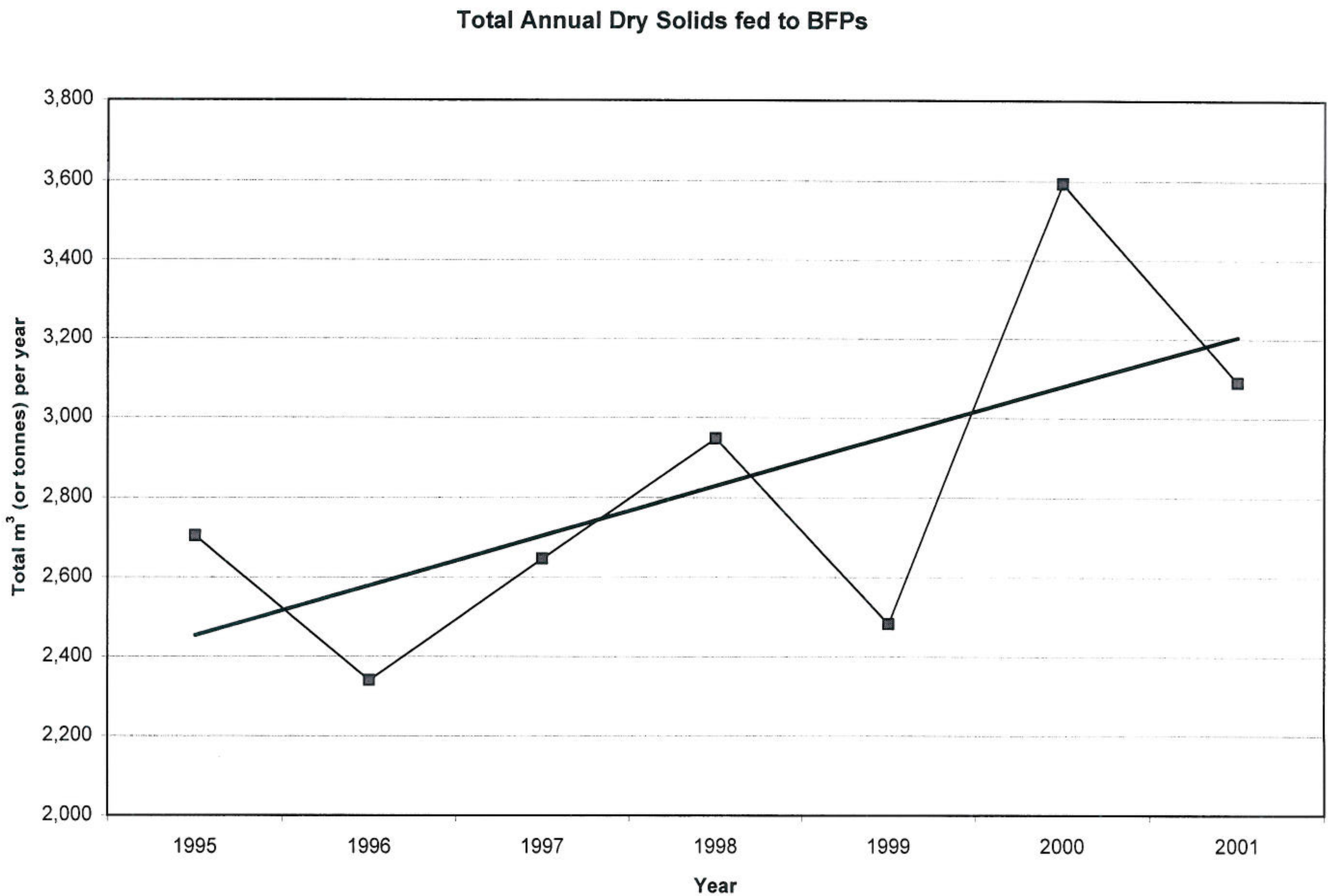


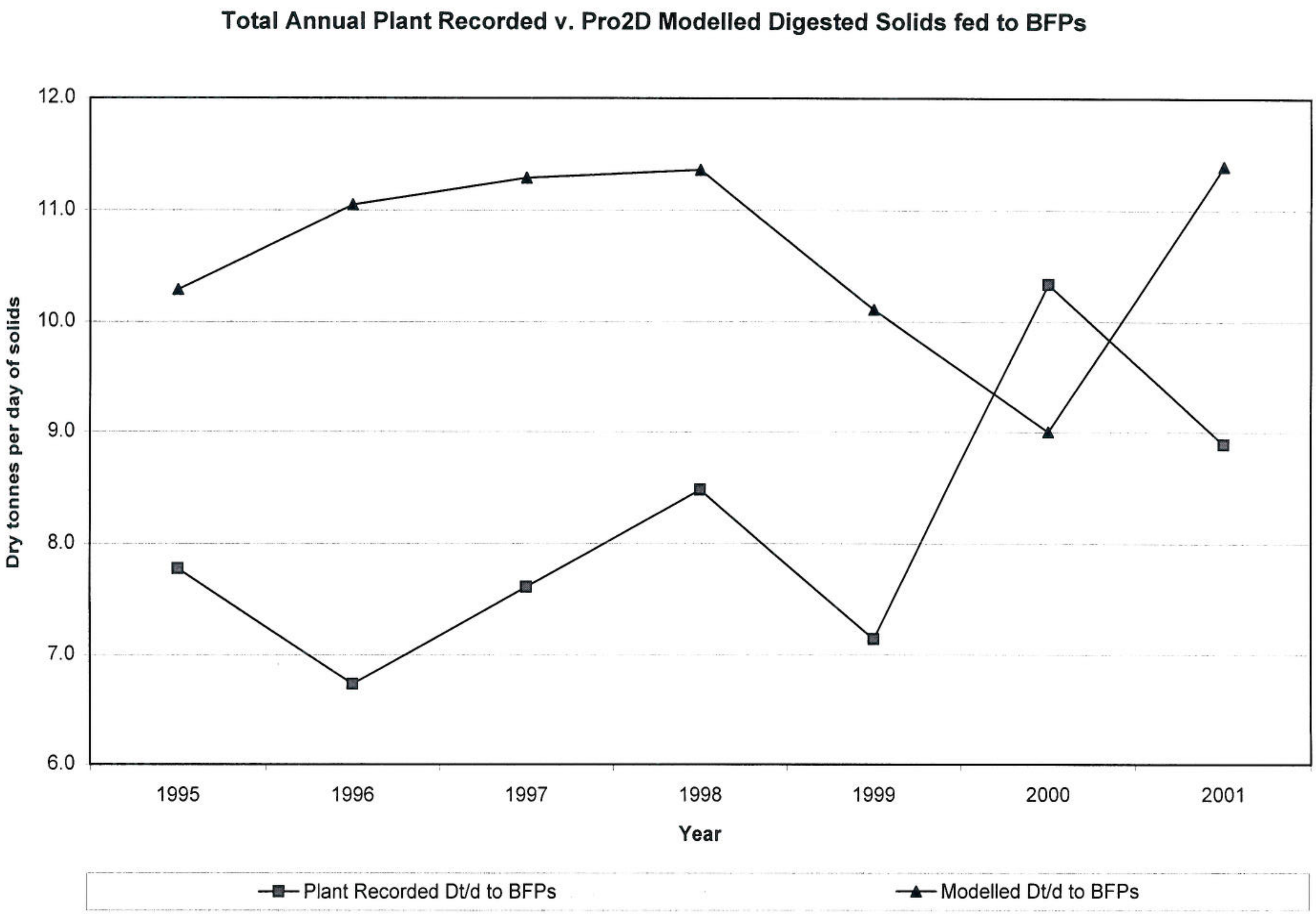
Composting Process Flow Diagram
Not to Scale
Air
Biosolids/Amendment
Compost/Mix
Accumulator
Bioreactor 1
Bioreactor 2
Biocure
Amendment
Sludge Cake from Dewatering
Mixer
Elevating Conveyor
Compost Screen
Recycle Chip Bin
Aeration Tank
Odourous gases

Appendix A: Task 1 Update

Total Solids fed to BFPs (m^3/month)




Total Annual Dry Solids fed to BFPs
3,800
3,600
3,400
3,200
3,000
2,800
2,600
2,400
2,200
2,000
Total m3 (or tonnes) per year
1995
1996
1997
1998
1999
2000
2001
Year


Total Annual Plant Recorded v. Pro2D Modelled Digested Solids fed to BFPs
12.0
11.0
10.0
9.0
8.0
7.0
6.0
Dry tonnes per day of solids
1995
1996
1997
1998
1999
2000
2001
Year
Plant Recorded Dt/d to BFPs
Modelled Dt/d to BFPs

Appendix B: Reactor Maintenance History

Date	Maintena-nce	Type	Unit	Equipment	Comments
22-Mar-95	Scheduled	Mechanical	Bio 1	Outfeed	Replaced flow splitter (old style)
16-Mar-95	Emergency	Mechanical	Bio 1	Outfeed	Replaced belts
04-Apr-95	Scheduled	Mechanical	Bio 1	Outfeed	Installed new flow splitter (new style)
04-Jul-95	Scheduled	Mechanical	Bio 1	Outfeed	Partial greasing
07-Dec-95	O/S	Cleaning	Bio 1	Vessel	Removed dust from Bio 1
18-Dec-95	O/S	Mechanical	Bio 1	Outfeed	Installed new grease nipples in main shaft
20-Dec-95	Scheduled	Mechanical	Bio 1	Outfeed	Changed gear box oil, lubricated bearings, changed center column greasers
17-Jan-96	O/S	Mechanical	Bio 1	Outfeed	Drained oil from main gear box
18-Jan-96	O/S	Mechanical	Bio 1	Outfeed	Rensch installed new breather for gear box
19-Jan-96	O/S	Mechanical	Bio 1	Vessel	Rensch installed new skirting on center column
22-Jan-96	O/S	Mechanical	Bio 1	Outfeed	Hardfacing of augers and teeth repairs
11-Mar-96	Emergency	Mechanical	Bio 1	Outfeed	Tighten belts
12-Mar-96	Emergency	Mechanical	Bio 1	Outfeed	Change belts
25-Apr-96	Emergency	Mechanical	Bio 1	Outfeed	Buildup of compost on auger, fed 2"x4"'s through auger
28-May-96	Scheduled	Mechanical	Bio 1	Outfeed	Modified greasers
28-Jun-96	Scheduled	Mechanical	Bio 1	Outfeed	Greased main shaft, cylinders and chain
03-Jul-96	Scheduled	Mechanical	Bio 1	Outfeed	Greased main shaft, cylinders, chain and screw shaft bearings
08-Jul-96	Scheduled	Mechanical	Bio 1	Outfeed	Tightened extend/retract hydraulic lines
30-Jul-96	Emergency	Electrical & Mechanical	Bio 1	Outfeed	Outfeed/PLC interface repairs
06-Sep-96	Emergency	Mechanical	Bio 1	Outfeed	Reapired broken support arm
20-Sep-96	Emergency	Mechanical	Bio 1		Taken o/s for inspection
07-Oct-96	Scheduled	Mechanical	Bio 1	Outfeed	Greased bearing, main shaft, feed cylinders chain and screw shaft bearings
07-Oct-96	Scheduled	Mechanical	Bio 1	Outfeed	Greased outer bearings of outfeed augers
05-Feb-97	Scheduled	Mechanical	Bio 1	Outfeed	Greased main shaft and lower bearings
21-Feb-97	Emergency	Mechanical	Bio 1	Outfeed	Replaced belts
24-Feb-97	Scheduled	Mechanical	Bio 1	Outfeed	Greased main shaft and bearings
25-Mar-97	O/S	Cleaning	Bio 1	Vessel	Removed dust from Bio 1
10-Apr-97	Scheduled	Mechanical	Bio 1	Outfeed	Changed seal & bearings on outfeed augers
24-Apr-97	Emergency	Mechanical	Bio 1	Outfeed	Removed main shaft to inspect possible faulty bearing
12-May-97	Emergency	Mechanical	Bio 1	Outfeed	Rensch replaced clutch assembly and top bearing modified
19-Jun-97	Emergency	Mechanical	Bio 1	Outfeed	Auger and trailing arm broken, repaired by 17-Jul-97
06-Nov-97	O/S	Mechanical	Bio 1	Outfeed	Centre column removed, back in service 4-Dec-97
11-Nov-97	O/S	Mechanical	Bio 1	Outfeed	Outfeed auger removed, back in service 4-Dec-97
01-Dec-97	O/S	Mechanical	Bio 1	Outfeed	End bearings changed, back in service 4-Dec-97

Date	Maintenance	Type	Unit	Equipment	Comments
09-Dec-97	Emergency	Mechanical	Bio 1	Infeed	Modular Fluid repaired spinner plate to evenly distribute feed
15-Jan-98	Emergency	Mechanical	Bio 1	Outfeed	Replaced end cap of auger
19-Jan-98	Scheduled	Mechanical	Bio 1	Outfeed	Greased clutch and chain
20-Jan-98	Scheduled	Mechanical	Bio 1	Outfeed	Installed shields over outfeed bindicators
03-Mar-98	Scheduled	Mechanical	Bio 1	Outfeed	Greased clutch
26-Mar-98	Emergency	Mechanical	Bio 1	Outfeed	Replaced broken shear plates, noted top bearings worn
30-Mar-98	Emergency	Mechanical	Bio 1	Outfeed	Changed sealed bearings
31-Mar-98	Emergency	Mechanical	Bio 1	Outfeed	Removed main shaft, noted lower bearings worn
02-Apr-98	O/S	Mechanical	Bio 1	Outfeed	Changed out main drive unit, greased main shaft, lower bearing and clutch assembly
02-Apr-98	O/S	Mechanical	Conveyor 550	Lining	Lining repaired
13-Apr-98	O/S	Mechanical	Bio 1	Outfeed	Replace bull gear, completed 24-Apr-98
18-Aug-99	Emergency	Mechanical	Bio 1	Outfeed	Installed new packing material around main bearing
23-Aug-99	Emergency	Mechanical	Bio 1	Outfeed	Installed/modified seals in main drive/clutch
25-Aug-99	Scheduled	Mechanical	Bio 1	Outfeed	Changed outboard bearing and seals in outfeed auger
10-Sep-99	Scheduled	Mechanical	Bio 1	Outfeed	Replaced outfeed auger bearings
20-Dec-99	Scheduled	Mechanical	Bio 1	Outfeed	Greased clutch
07-Jan-00	Scheduled	Mechanical	Bio 1	Outfeed	Greased clutch bearings
11-Jan-00	Emergency	Mechanical	Bio 1	Outfeed	Changed clutch assembly and greased clutch
13-Jan-00	Emergency	Mechanical	Bio 1	Outfeed	Greased clutch
10-Feb-00	Scheduled	Mechanical	Bio 1	Outfeed	Greased clutch
30-Mar-00	Scheduled	Mechanical	Bio 1	Outfeed	Greased outfeed auger and outboard bearing, greased clutch and bearing
10-Apr-00	Scheduled	Mechanical	Bio 1	Outfeed	Changed belts
15-May-00	Scheduled	Mechanical	Bio 1	Outfeed	Greased clutch, upper bearings and outboard auger bearing
29-May-00	Scheduled	Mechanical	Bio 1	Outfeed	Replaced both sets of shear plates
12-Jun-00	Scheduled	Mechanical	Bio 1	Outfeed	Raised collector arms 1"; replaced lower shear plate hubs and 3 missing bolts
12-Jun-00	Scheduled	Mechanical	Bio 1	Aeration valve	Replaced west zone aeration valve
28-Jun-00	Scheduled	Mechanical	Bio 1	Outfeed	Greased clutch and upper bearings
11-Sep-00	Scheduled	Mechanical	Bio 1	Outfeed	Greased clutch
28-Sep-00	Emergency	Mechanical	Bio 1	Outfeed	Removed, rebuilt and replaced clutch assembly, greased clutch and new belts installed
03-Oct-00	Emergency	Mechanical	Bio 1	Outfeed	Bindicator replaced
27-Oct-00	Scheduled	Mechanical	Bio 1	Outfeed	Greased clutch
20-Nov-00	Scheduled	Mechanical	Bio 1	Outfeed	Greased clutch
28-Nov-00	Scheduled	Mechanical	Bio 1	Outfeed	Greased clutch

Date	Maintena-nce	Type	Unit	Equipment	Comments
15-Dec-00	Emergency	Mechanical	Bio 1	Outfeed	Clutch assembly breakdown, replaced with new Sept-01
16-Oct-01	Emergency	Mechanical	Bio 1	Outfeed	Hydraulic oil leak, new parts not available, replaced from Cure
19-Oct-01	Emergency	Mechanical	Bio 1	Infeed	Replaced inline filter in hydraulic unit
27-Nov-01	Emergency	Mechanical	Bio 1	Outfeed	Rensch hard faced auger
04-Dec-01	Emergency	Mechanical	Bio 1	Outfeed	Removed outfeed main drive; installed new improved high speed bearing seals; shaft gun drilled

Date	Maintena-nce	Type	Unit	Equipment	Comments
31-Mar-95	Scheduled	Mechanical	Bio 2	Outfeed	Installed flow splitter (new style)
28-Jun-95	Emergency	Mechanical	Bio 2	Outfeed	Centre column bearing cover ripped off, vessel taken o/s, repairs completed 27-Oct-95
11-Jul-95	O/S	Mechanical	Bio 2	Outfeed	Modified auger track dogs
07-Feb-96	Scheduled	Mechanical	Bio 2	Outfeed	Greased main shaft, cylinders and chain
11-Mar-96	Emergency	Mechanical	Bio 2	Outfeed	Straigntened belts
15-Mar-96	Scheduled	Mechanical	Bio 2	Outfeed	Changed belts
23-Mar-96	Scheduled	Mechanical	Bio 2	Outfeed	Replaced belts
18-Apr-96	Emergency	Mechanical	Bio 2	Outfeed	Belts broken, replaced by 24-Apr-96
08-Jul-96	Scheduled	Mechanical	Bio 2	Outfeed	Bearings lubricated, hydraulic leak tightened
16-Oct-96	Emergency	Mechanical	Bio 2	Outfeed	Auger outboard bearing replaced
10-Jan-97	Scheduled	Mechanical	Bio 2	All	Annual inspection; gear box oil changed, greased outer bearings and hydraulic cylinders, replaced greasers in centre column, greased lower main shaft bearings
27-Mar-97	Emergency	Mechanical	Bio 2	Outfeed	Noisy outfeed inspected
02-Apr-97	Emergency	Mechanical	Bio 2	Outfeed	Replaced lower shear hubs (temporary)
03-Apr-97	Emergency	Mechanical	Bio 2	Outfeed	Temporary shear hubs broken, replaced with solid unit (temporary)
12-Apr-97	Emergency	Mechanical	Bio 2	Outfeed	Temporary shear plates broken and damaged bottom hubs; repaired
03-Jun-97	Emergency	Mechanical	Bio 2	Outfeed	Replaced hydraulic hose
06-Aug-97	Emergency	Mechanical	Bio 2	Outfeed	Temporary shear plates broken and repaired
21-Aug-97	Emergency	Mechanical	Bio 2	Outfeed	Augers out of step; repaired
11-Sep-97	Emergency	Mechanical	Bio 2	Outfeed	Replaced belts, greased clutch, extended hydraulic hose
15-Oct-97	Scheduled	Mechanical	Bio 2	Outfeed	Work completed to outfeed inspection platform
05-Nov-97	O/S	Mechanical	Bio 2	Infeed	New bearings in spinner plate installed
25-Nov-97	O/S	Mechanical	Bio 2	Outfeed	Removed centre column, ready for service 23-Feb-98, in service 27-mar-98
05-Mar-98	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch
09-Apr-98	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch and main bearing
25-May-98	Emergency	Mechanical	Bio 2	Outfeed	Blew off belts, repaired
28-May-98	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch
10-Jun-98	Emergency	Mechanical	Bio 2	Outfeed	Changed bearing, outboard of discharge auger
18-Jun-98	Emergency	Mechanical	Bio 2	Bindicator	Installed shields for bindicator paddles
25-Jun-98	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch
27-Jul-98	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch and bearings
13-Aug-98	Scheduled	Mechanical	Bio 2	Outfeed	Greased outside bearing of auger, clutch and main shaft bearing
18-Sep-98	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch
13-Oct-98	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch
22-Oct-98	Scheduled	Mechanical	Bio 2	Outfeed	Greased outboard bearing of auger
05-Nov-98	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch
16-Nov-98	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch and bearings
18-Nov-98	Scheduled	Mechanical	Bio 2	Outfeed	Replaced belts
26-Nov-98	Scheduled	Mechanical	Bio 2	Outfeed	Greased outboard bearing of auger

Date	Maintena-nce	Type	Unit	Equipment	Comments
04-Dec-98	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch and outboard auger bearing
14-Dec-98	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch
17-Dec-98	Scheduled	Mechanical	Bio 2	Outfeed	Greased outboard bearing of auger
12-Jan-99	Emergency	Mechanical	Bio 2	Outfeed	Upper shaft bearings worn, shaft assmebly replaced from spare; replaced both shear plates and both upper double bearings; greased clutch
08-Feb-99	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch
14-Jun-99	Scheduled	Mechanical	Bio 2	Outfeed	Changed out outfeed device, all bearings replaced
28-Jun-99	Scheduled	Mechanical	Bio 2	Outfeed	Removed/installed clutch assmebly
16-Aug-99	Scheduled	Mechanical	Bio 2	Outfeed	Installed new packing material around main bearing of drive unit
23-Aug-99	Scheduled	Mechanical	Bio 2	Outfeed	Installed/modified seals in main drive/clutch
24-Aug-99	Scheduled	Mechanical	Bio 2	Outfeed	Changed outfeed auger outboard bearing and seals
10-Sep-99	Scheduled	Mechanical	Bio 2	Outfeed	Replaced outboard bearing of outfeed auger
16-Aug-00	Scheduled	Mechanical	Bio 2	Outfeed	Replaced shear plates
23-Aug-00	Scheduled	Mechanical	Bio 2	Outfeed	Cleaned out compost buildup from gear box control; changed gear box oil
11-Sep-00	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch
02-Oct-00	Emergency	Mechanical	Bio 2	Infeed	Hydraulic lines to spinner motor and spinner bearings removed and replaced
28-Nov-00	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch
01-Dec-00	Emergency	Mechanical	Bio 2	Outfeed	Greased outboard bearing of auger; replaced grease nipple
17-Jan-01	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch and upper bearing
29-Jan-01	Scheduled	Mechanical	Bio 2	Outfeed	Changed oil filter (hydraulic)
06-Feb-01	Emergency	Mechanical	Bio 2	Outfeed	Blew off upper hydraulic hose in hopper, repaired
12-Feb-01	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch
20-Feb-01	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch and lower bearing
24-Feb-01	Scheduled	Mechanical	Bio 2	Outfeed	Replaced clutch assembly with high speed
06-Mar-01	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch
19-Mar-01	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch and low speed bearing
07-Apr-01	Emergency	Mechanical	Bio 2	Outfeed	Replaced belts
30-Apr-01	Emergency	Mechanical	Bio 2	Outfeed	Replaced outfeed with new central shaft
17-May-01	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch and low speed bearing
31-May-01	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch
28-Jun-01	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch, replaced belts, aligned sleaves
12-Jul-01	Scheduled	Mechanical	Bio 2	Outfeed	Greased clutch
21-Sep-01	Emergency	Mechanical	Bio 2	Outfeed	Replaced clutch assembly; drilled out centre shaft and greased upper bearings and new seal installed
03-Oct-01	Emergency	Mechanical	Bio 2	Outfeed	Straigntened broken collector arm; removed and replaced broken liner

Date	Maintena-nce	Type	Unit	Equipment	Comments
10-Oct-01	Emergency	Mechanical	Bio 2	Outfeed	Repaired clutch assembly, broken due to broken collector arm
16-Oct-01		Mechanical	Bio 2	Outfeed	Replaced auger outboard bearing
18-Oct-01		Mechanical	Bio 2	Outfeed	Replaced hydraulic hoses inside hopper, bypassed splitter box
06-Nov-01		Mechanical	Bio 2	Outfeed	Removed/replaced outfeed auger

Date	Maintena-nce	Type	Unit	Equipment	Comments
31-Mar-95	Scheduled	Mechanical	Cure	Outfeed	Installed new flow splitter (new style)
21-Jul-95		Mechanical	Cure	Outfeed	Modified dogs for track
10-Aug-95	Emergency	Mechanical	Cure	Outfeed	Repair oil leak
21-Nov-95	Scheduled		Cure	Outfeed	Changed out amplifier card
22-Feb-96	Emergency	Mechanical	Cure	Outfeed	Unplugged auger discharge screw
11-Mar-96	Scheduled	Mechanical	Cure	Outfeed	Changed greasers in centre column
28-May-96		Mechanical	Cure	Outfeed	Modified greasers
08-Jul-96	Scheduled	Mechanical	Cure	Outfeed	Greased main shaft, cylinders, collection chain and screw shaft bearings
17-Jul-96	Emergency	Mechanical	Cure	Outfeed	Replaced belts
24-Jul-96	Emergency	Mechanical	Cure	Outfeed	Adjusted pulleys
10-Sep-96	Scheduled	Mechanical	Cure	Outfeed	Greased main shaft, cylinders, collection chain and screw shaft bearings
04-Apr-97	Emergency	Mechanical	Cure	Outfeed	Replaced shear plates, repaired and ireinstalled broken collector arms
07-Apr-97	Emergency	Mechanical	Cure	Outfeed	Replaced belts
30-May-97	Emergency	Mechanical	Cure	Outfeed	Replaced main shaft, modified clutch and double bearings
21-Jun-97	Scheduled	Mechanical	Cure	Outfeed	Changed gear box oil, greased bearings
28-Aug-97	Emergency	Mechanical	Cure	Outfeed	Clutch broken & repaired, seals replaced,belts replaced, back in service 03-Sep-97
04-Sep-97	Emergency	Mechanical	Cure	Outfeed	Centre column bolts snapped, 2 guide wires broken, back in serivce 30-Jan-98
02-Oct-97	Emergency	Mechanical	Cure	Outfeed	Hydraulic line damaged & repaired, back in serivce 30-Jan-98
05-Nov-97	Emergency	Mechanical	Cure	Infeed	New spinner plate installed, back in serivce 30-Jan-98
05-Mar-98	Scheduled	Mechanical	Cure	Outfeed	Greased clutch
09-Apr-98	Scheduled	Mechanical	Cure	Outfeed	Greased clutch and main shaft lower bearing
14-Apr-98	Emergency	Mechanical	Cure	Outfeed	Main shaft upper bearings replaced; greased clutch
19-May-98	Emergency	Mechanical	Cure	Outfeed	Replaced belts and realigned pulley
24-Jun-98	Scheduled	Mechanical	Cure	Outfeed	Greased clutch
02-Jul-98	Emergency	Mechanical	Cure	Outfeed	Replaced clutch
13-Aug-98	Scheduled	Mechanical	Cure	Outfeed	Greased auger outside bearing
18-Sep-98	Scheduled	Mechanical	Cure	Outfeed	Greased clutch
09-Oct-98	Scheduled	Mechanical	Cure	Outfeed	Greased clutch
14-Oct-98	Scheduled	Mechanical	Cure	Outfeed	Greased auger outside bearing
05-Nov-98	Scheduled	Mechanical	Cure	Outfeed	Greased clutch
16-Nov-98	Scheduled	Mechanical	Cure	Outfeed	Greased clutch and bearings
04-Dec-98	Scheduled	Mechanical	Cure	Outfeed	Greased clutch and outboard auger bearing
14-Dec-98	Scheduled	Mechanical	Cure	Outfeed	Greased clutch
08-Feb-99	Scheduled	Mechanical	Cure	Outfeed	Greased clutch
09-Mar-99	Scheduled	Mechanical	Cure	Outfeed	Greased clutch and bearings
24-Aug-99		Mechanical	Cure	Outfeed	Replaced auger outboard bearing and seal
10-Sep-99		Mechanical	Cure	Outfeed	Replaced auger outboard bearing and seal
13-Jan-00	Scheduled	Mechanical	Cure	Outfeed	Greased clutch

Date	Maintenance	Type	Unit	Equipment	Comments
05-May-00		Mechanical	Cure	Outfeed	Replaced outboard bearing and spindle of auger
28-Jun-00	Scheduled	Mechanical	Cure	Outfeed	Greased clutch and upper bearings
16-Sep-00	Emergency	Mechanical	Cure	Outfeed	Sucked in HRU203 discharge vent
27-Sep-00	Scheduled	Mechanical	Cure	Outfeed	Outboard bearing discharge auger greased to break up crust
27-Oct-00	Scheduled	Mechanical	Cure	Outfeed	Greased clutch
20-Nov-00	Scheduled	Mechanical	Cure	Outfeed	Greased clutch
12-Jan-00	Emergency	Mechanical	Cure	Outfeed	Replaced main drive, repaired collectors, change out clutch assembly
18-Jan-01	Emergency	Mechanical	Cure	Outfeed	Replaced upper bearings
31-Jan-01	Scheduled	Mechanical	Cure	Outfeed	Greased clutch
12-Feb-01	Scheduled	Mechanical	Cure	Outfeed	Greased clutch
20-Feb-01	Scheduled	Mechanical	Cure	Outfeed	Greased clutch and lower bearings
06-Mar-01	Scheduled	Mechanical	Cure	Outfeed	Greased clutch
19-Mar-01	Scheduled	Mechanical	Cure	Outfeed	Greased clutch and lower bearings
12-May-01	Scheduled	Mechanical	Cure	Outfeed	Greased clutch and lower bearings
09-Jul-01	Emergency	Mechanical	Cure	Outfeed	Replaced shaft, clutch and bearings
17-Jul-01	Scheduled	Mechanical	Cure	Outfeed	Greased clutch
09-Aug-01	Emergency	Mechanical	Cure	Outfeed	Bolt broken on anti-reversing level, frame bent on plate; outfeed auger failure, flights off from shaft
23-Oct-01	Emergency	Mechanical	Cure	Vessel	Fire; material in cure could not be removed as auger had failed in August

Appendix C: Taulman Performance Test Data

#1

PRESENT OPERATING MASS BALANCE - WORK DAY BASIS April 10, 1995

120 MINUTES FILLING/DAY

	SLUDGE	AMENDMENT	RECYCLE	TO MIX	TO BIO	TO CURE	CURE DISCHARGE	PRODUCT
DENSITY KG M^3	1055.6*	224.3*	416.5*	496.7	488.0*	416.5*	384.4*	
WET WEIGHT KG	58015.8	147863.3	66281.8	139083.9	139083.9	41965.1	36978.0	
DRY WEIGHT	10442.9	12198.7	33140.9	55782.4	55782.4	20968.0	20339.	
VOLUME M^3	54.96	65.92	159.14	280.02	280.02	100.7	96.2	
WATER KG	47573.0	2587.6	33140.9	83301.5	83301.5	20968.0	16639	
DRY SOLIDS %	18	82.5	50	40	40	50	55	
VOLUME RATIO	.2	24	56					
RATIO	1	1.2	2.9					

* - DETERMINED FROM BUCKET TEST

#2

April 10, 1995

40% DRY SOLIDS INFEED MIX AND DESIGN SLUDGE AND RECYCLE RATIO

WORK DAY BASIS
120 MINUTES FILLING/DAY

	SLUDGE	AMENDMENT	RECYCLE	TO MIX	TO BIO	TO CURE	CURE DISCHARGE	PRODUCT
DENSITY KG M^3	1055.6*	224.3*	416.5*	496.6	496.6	416.5*	384.4*	
WET WEIGHT KG	58015	15516.3	61804.4	135335.7	135335.7	43216.1	38108.8	
DRY WEIGHT KG	10442.8	12800.9	30902.2	54134.3	54134.3	21608.1	20959.9	
VOLUME M^3	54.96	69.18	148.39	272.53	272.53	103.8	99.1	
WATER KG	47573.0	2715.4	30902.2	81201.4	81201.4	21608.1	17148.9	
DRY SOLIDS %	18	82.5	50	40	40	50	55	
VOLUME RATIO	20	25	54					
RATIO	1	1.26	2.7					

* DETERMINED BY BUCKET TEST

#3

38% DRY SOLIDS INFEED MIX WITH DESIGN SLUDGE AND RECYCLE RATIO
WORK DAY BASIS
120 MINUTES FILLING/DAY

	SLUDGE	AMENDMENT	RECYCLE	MIX	TO BIO	TO CURE	CURE DISCHARGE	PRODUCT
DENSITY KG M^3	1055.6*	224.3*	416.5*	526.7	526.78	416.5*	389.4*	
WET WEIGHT KG	58015.8	9424.9	61804.4	129245.1	129245.1	33475.0	29518.9	
DRY WEIGHT KG	10442.8	7775.5	30902.2	49113.1	49113.1	16737.5	16235.4	
VOLUME M^3	54.96	42.02	148.39	245.37	245.37	80.37	75.8	
WATER KG	47573.0	1649.4	30902.2	80132.0	80132	16475.0	13283.5	
DRY SOLIDS %	18	825	50	38	38	50	55	
VOLUME RATIO	22	17	60					
RATIO	1	0.76	2.7					

* DETERMINED BY BUCKET TEST

APPENDIX F

TASK 4 TECHNICAL MEMORANDUMS

City of Guelph Biosolids Management Plan
Task 4 Evaluation of Biosolids Management Alternatives – Part 1 Development and Screening of Long List of Alternatives

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DATE:	December 30, 2003

1. Introduction

Task 4 of the Biosolids Master Plan included developing a long list of biosolids end uses, products, and technologies, and developing screening criteria to determine which alternatives on the long list should be carried forward to a detailed evaluation, which is summarized herein. The detailed evaluation was completed as the second part of Task 4 and is presented in a separate memorandum, *Task 4 Evaluation of Biosolids Management Alternatives - Part 2*.

Task 4 was preceded by Tasks 1, 2, and 3, which collected the background information required for the Biosolids Master Plan, and assessed the feasibility and cost of maintaining the existing biosolids composting system for the long-term.

It was determined that, in general, the solids management processes had or could, with minor upgrades, have sufficient capacity to manage the wastewater treatment plant's (WWTP) solids up to the liquid side expansion plans of 73 ML/d. However, it is unlikely that the composted biosolids product produced at the WWTP will gain regulatory acceptance in Ontario as a stand-alone material for distribution or sale.

The demonstration projects recommended in Task 2 will determine if there is regulatory acceptability and a market for the composted biosolids for topsoil blending, sod farming, and/or land reclamation projects.

The current lack of regulatory acceptance for the WWTP compost, lack of a suitable market, reliability issues associated with the compost facility, and increasing costs of composting and compost disposal resulted in the City’s proactive decision to initiate Task 4 of the Biosolids Master Plan to ensure that both short-term and long-term biosolids issues are resolved.

2. Background

The City of Guelph currently supplies treated water for, and treats wastewater from, a population of approximately 100,000. In 2000, some 30,000 tonnes of biosolids were produced and composted, land applied, or landfilled. The long-term biosolids management plan will consider treatment requirements up to the maximum capacity of the WWTP after the Stage 2 expansion to 73 ML/d and recommend suitable management practices.

This memorandum, documenting the screening of the technologies and management practices available for managing biosolids, represents the first part of Task 4. The detailed evaluation of the selected alternatives is presented in the second memorandum of this series, *Task 4 Evaluation of Biosolids Management Alternatives – Part 2*.

3. Development of Long List of Alternatives

The management of biosolids generated at facilities similar in size to the Guelph WWTP, generally requires that the biosolids product available for utilization has first gone through a number of treatment processes. These treatment processes reduce the odour potential and pathogen content of the final biosolids product and reduce the attractiveness of the biosolids product to vectors, such as flies, mosquitoes, and other potential disease-carrying organisms.

In order to determine which of the many technology alternatives available for biosolids management are feasible for the City of Guelph, the project team first reviewed all the possible end uses for biosolids with respect to the screening criteria. Once feasible end uses had been identified, the products required for these end uses were then identified. Finally, the technologies available to make these products, that met the screening criteria, were determined.

4. Screening Criteria

During the project team meeting on December 16, 2003, the following screening criteria were developed. These represent "must have" criteria that each end use and technology must have to satisfy the City of Guelph's biosolids management alternatives.

TABLE 4.1
SCREENING CRITERIA

Priorities for End Uses	• **Community health and safety (pathogen management; quality of air, water, and land)**: risks associated with end use options should be managed to protect community health and safety • **Reliability**: end uses should meet or exceed Ontario's regulatory requirements and standards; the overall biosolids management strategy must be reliable and enforceable within the City of Guelph's current framework • **Sustainability**: end uses should endure over time in an environmentally safe manner, and the solution implemented must have the capacity to handle all of the biosolids produced at the Guelph WWTP • **Flexibility**: end use options should include a variety of treatment and end use options to be adaptable under different circumstances
Priorities for Treatment Technologies	• **Environmentally safe (quality of air, water, and land)**: technologies must produce biosolids which will endure over time in an environmentally safe manner • **Odour**: technologies should minimize odours • **Reliability**: technologies should be proven to maintain uninterrupted operations, treatment must be proven to demonstrate reliability, at least three years implementation at a similar size facility. Development of emerging technologies being supported by the City of Guelph are not excluded

5. End Uses

The methods for utilization/disposal of biosolids generally considered in a biosolids management plan include:

- Land utilization
- Marketing strategies
- Landfill disposal and landfill cover
- Industrial use

5.1 Land Utilization

5.1.1 Agricultural Land.

Application of biosolids on agricultural land to complement fertilizer requirements is the most widely established method of biosolids utilization in Canada. This practise is used by the City as an alternative to composting. Several of the medium-sized and larger Canadian municipalities that are land-applying biosolids include Calgary, Alberta; Winnipeg, Manitoba; and Toronto, Hamilton-Wenthworth, Ottawa-Carleton, Halton Region, Niagara Region, and Kitchener-Waterloo in Ontario.

As a partial replacement for commercial fertilizers, biosolids are a valuable source of nitrogen and phosphate for grass or cereal crops, and also provide small amounts of potassium, as well as many trace elements required by plants, as illustrated in Table 5.1.

TABLE 5.1
ESSENTIAL NUTRIENTS

	Macronutrients	Symbol	Micronutrients	Symbol
Essential to plants	Nitrogen	N	Chloride	Cl
	Phosphorus	P	Iron	Fe
	Potassium	K	Boron	B
	Sulfur	S	Manganese	Mn
	Calcium	Ca	Zinc	Zn
	Magnesium	Mg	Copper	Cu
			Molybdenum	Mo
			Cobalt[1]	Co
Essential to animals but not plants	None		Selenium	Se
			Iodine	I
			Chromium	Cr

[1] Cobalt is essential for nitrogen fixation in legumes.

Biosolids are also a good soil conditioner for soils with a low organic content, facilitating nutrient uptake, increasing water retention, permitting easier root penetration, and improving soil texture.

Biosolids may contain elements that are not desirable for agricultural crops, such as certain metals and pathogens. The Ontario *"Guidelines for Utilization of Biosolids and Other Wastes on Agricultural Lands"* (MOE/OMAFRA, March 1996) ensures that biosolids applied on agricultural land impact neither human health or the environment.

Based on long-term experience from many years of biosolids application on land, the risk to human and animal health is minimal, when biosolids are processed and applied on land in accordance with existing guidelines and regulations.

Application limits are based on a maximum addition of biosolids to soils of eight tonnes total solids/ha per five-year period. Limits for heavy metals are based on maximum acceptable ratios of nitrogen to metals after anaerobic digestion, and maximum metal concentrations on a dry weight basis after dewatering. Maximum cumulative metal additions to soils may also limit usage of each application site to nine applications and a site life to 45 years, based on typical background soil metal concentrations and maximum allowable biosolids metal concentrations.

Biosolids can generally be applied on agricultural land between April and December, when the weather permits and at the convenience of the farmer. In Ontario, biosolids generally cannot be applied on frozen or snow-covered ground due to risks of runoff during thaw periods. Biosolids cannot be applied during wet weather periods due to risks from runoff and biosolids spreading equipment not being able to access the land.

Generally, municipal programs apply biosolids five days per week (Monday to Friday). The number of spreading days available per year varies from 150 days in a dry year to approximately 100 days in a wet year.

The equipment and facilities needed for handling and applying liquid or dewatered biosolids include application vehicles, portable roadside storage tanks, road tankers or dump trucks, and a biosolids storage facility for storage during the winter months.

Generally, utilization of a liquid or dewatered biosolids on agricultural lands is practised in one of the following ways:

- Biosolids utilization using liquid biosolids spreading vehicles equipped with flotation-type tires
- Biosolids utilization using liquid biosolids spreading vehicles equipped with flotation-type tires and subsurface injection capabilities
- Biosolids utilization using standard hauling vehicles not equipped with either flotation tires or subsurface injecting equipment
- Biosolids utilization employing liquid biosolids spray irrigation
- Dewatered biosolids utilization using spreading vehicles equipped with flotation-type tires. Incorporation is done following spreading using applicable equipment

Trucks are widely used for transporting both liquid and dewatered biosolids and are generally the most flexible means of transportation. Terminal points and haul routes can be readily changed with minimal cost.

As noted above, many spreading configurations are available. The impact of method of incorporation on the ammonia and ammonium-N retained after biosolids application is shown in Table 5.2.

TABLE 5.2
ESTIMATES OF AMMONIA + AMMONIUM-N RETAINED AFTER BIOSOLIDS APPLICATION

Days to Incorporation by Tillage	Surface-Applied					
	Liquid Biosolids pH greater than 7*	Dewatered Biosolids pH greater than 7*	Liquid or Dewatered Biosolids pH less than 7*	Lime-Stabilized Biosolids **	Injected Biosolids	Composted or Drying Bed Biosolids
	------------------- Ammonia + ammonium-N retained, percent of applied ------------					
0 to 2	80	60	90	10	100	100
3 to 6	70	50	90	10	100	100
Over 6***	60	40	90	10	100	100

* pH of biosolids immediately before application.
** For lime-stabilized biosolids analyzed for ammonia + ammonium-N before lime addition.
*** If biosolids will not be incorporated by tillage, use over six days to incorporation.

Biosolids application vehicles are generally used only to apply the biosolids on the agricultural land. Road tanker trucks for liquid biosolids and dump trucks for dewatered biosolids are used to transport the biosolids from the treatment plant or biosolids storage facility to the agricultural utilization site. Portable roadside storage tanks for liquid biosolids or front-end loaders for dewatered biosolids are used to transfer biosolids from the road tankers/dump trucks to the application vehicles.

5.1.1.1 Biosolids Storage and Blending. The selection and design of centralized or decentralized biosolids storage facilities depends on a number of factors, including the availability of land adjacent to the plant site selected, the quantity of land needed, and the location of the utilization sites. The location of decentralized transfer facilities should consider the social impact of the facilities. The transportation route to the decentralized facilities should use major highways and be located away from residential areas to prevent traffic congestion, odour, and noise problems.

Consideration of odour control for both liquid and dewatered biosolids cake storage is very important. The City of Winnipeg and the City of Guelph, for example, have had odour problems storing anaerobically digested dewatered biosolids on open pads. Covered storage facilities equipped with odour control may be required if the facility is located in an urbanized area.

Blending of biosolids from different wastewater treatment facilities in a centralized storage facility is currently acceptable in Ontario, provided the quality of biosolids from each wastewater pollution control plant (WPCP) is acceptable. Halton Region, Durham Region, the Region of Niagara, and the Region of Kitchener-Waterloo are examples in which biosolids from several WPCPs are blended in centralized storage facilities.

Biosolids can also be blended and stored with livestock manures and other organic wastes, provided the biosolids quality is acceptable before blending. Farmers would be responsible for spreading the blended biosolids in accordance with the provincial guidelines.

Biosolids with low ammonia plus nitrate concentrations, resulting in unacceptable nitrogen- and phosphorus-to-metal ratios, can be blended with other biosolids in order to produce acceptable nitrogen-to-metal ratios. Addition of nitrogen sources (i.e. urea) to the biosolids to increase the nitrogen-to-metal ratio has been used in Ontario in the past; however, it is not a generally accepted practice.

The Ontario Ministry of the Environment (MOE) and Ontario Ministry of Agriculture and Food's (OMAF) general philosophy is expected to support blending of biosolids to provide a more consistent uniform quality. Similar to other provincial jurisdictions, blending biosolids that have high metal concentrations, or that are poorly stabilized with good quality biosolids to produce a marginal quality biosolids, are not expected to be acceptable. Centralized storage facilities should also be designed and operated to conserve the nitrogen content of the biosolids and to control odours. Enclosed tanks or covered lagoons may be required in some cases. The acceptability and requirements for centralized storage facilities would be evaluated by the MOE on a case-by-case basis.

5.1.2 Forested Land.

As with agricultural crops, forests can benefit from the application of biosolids. Nitrogen, phosphorus, organic matter, and micronutrients in biosolids are utilized by trees as they are by agricultural crops. The biosolids may also improve the texture of the soil. Extensive brush growth generally takes place after biosolids application. This is generally beneficial for wildlife habitats.

Typical forest soils have high infiltration rates that reduce the risks of runoff and ponding. Odour is generally not a problem when stabilized biosolids are applied and there is sufficient distance from residences.

In a University of Washington study, trees grown on soils conditioned with biosolids were found to grow significantly faster than trees grown on soils that were not conditioned. Tree growth rings increased in diameter by 50 to 400 percent, and the value of the timber on an annual basis increased by greater than 50 percent.

The primary environmental and public health concern when applying stabilized biosolids to forested land is contamination of water supplies. The high infiltration rates and low nutrient uptake rates typical of forest soils can result in groundwater supplies being contaminated by nitrates. Studies conducted in the U.S. indicate that nitrate contamination of the groundwater can be prevented by limiting the biosolids application rates on typical forest soils.

Successive biosolids applications on forested land are controlled by the nutrient requirements of the trees and the frequency with which the trees are harvested.

Unlike agricultural land, forested lands are generally rough in terrain, requiring special application vehicles and the construction of a road system. Application to recently cleared forest sites is easier than for established forest sites because of increased accessibility for application equipment. However, many tree seedlings grown on sites with recent biosolids applications have poor survival rates due to competition with weeds and brush growth. Also, seedlings have lower nutrient uptake rates. Application in established forests often requires the cutting and clearing of 3-metre-wide trails for the application vehicles to access the land.

Forest species in established forests have nitrogen uptake rates ranging from 100 to 400 kg/ha/year, which is in the same range as agricultural crops. Recently cleared areas and seedlings would have lower nitrogen uptake rates.

Forest soils are typically more acidic than agricultural sites. Soil pH values of less than 5.5 are common. Biosolids application on agricultural land with acidic soils with a pH less than 6.0 is prohibited because, as soil pH decreases, metals uptake into plants and metals infiltration into groundwater increases. Forest products are not food chain crops; therefore, the risks to the public are not, generally, as great.

Application on forested land has been used for many years by Seattle Metro and is currently being piloted by the Greater Vancouver Regional District (GVRD). Whistler, British Columbia, is also considering forested land application.

5.1.3 Land Reclamation.

Biosolids application has been successfully used to turn barren land into productive land. Land disturbed by mines, quarries, and sand and gravel pits left unreclaimed are often unsightly and can be harmful to the environment. Environmental problems include acid runoff, high erosion rates, low nutrient levels, and toxic levels of trace metals. Biosolids application can improve these problems. Typically, either dewatered, alkaline, or composted biosolids are used for reclaiming disturbed lands.

High biosolids application rates are necessary to introduce sufficient organic matter and nutrients into the soil to support vegetation and create a self-sustaining productive soil. Application rates in other jurisdictions have ranged from 7 to 450 dry tonnes/ha and are typically about 100 dry tonnes/ha.

Some contamination of ground and surface waters can occur after biosolids application (i.e. nitrate contamination of groundwater); however, with good site management, contamination is minimized and, generally, the contamination is negligible compared to the problems before reclamation. Good site management includes prompt revegetation after biosolids application and site levelling to reduce slopes. Also, dewatered, alkaline and/or composted biosolids application may be preferred to reduce the soluble nitrogen added to the soil and to minimize the nitrogen leached to the groundwater or runoff to surface waters. Alkaline or composted biosolids may be preferred where odours cannot be tolerated.

Land reclamation of barren lands by application of biosolids has been used at many locations in the U.S. GVRD is conducting a pilot study involving application on reclaimed land as part of their present biosolids management program, and Falconbridge, in Sudbury, has pilot-tested the use of biosolids on tailings sites in and around Sudbury.

5.1.4 Public Contact Sites.

Use of biosolids products on public contact sites, such as recreational parks, ball fields, golf courses, and road embankments, has many of the same advantages as application on agricultural land. To protect the public, a higher degree of stabilization and pathogen destruction is required than necessary for application on agricultural land. Stabilization processes, such as composting, thermal drying, auto thermophilic aerobic digestion (ATAD) and advanced alkaline stabilization, are examples of acceptable stabilization processes.

Currently, Smith Falls is the only Ontario municipality that applies biosolids products on public contact sites. Toronto is considering this option when pelletized (dried) biosolids product is produced in the near future. Windsor has applied composted biosolids on recreational parkland in the past; however, this practice stopped when the composting operation was closed down.

5.1.5 Lawns and Home Gardens.

Application of biosolids on home lawns and gardens is not recommended according to the Ontario *Guidelines for Utilization of Biosolids and Other Wastes on Agricultural Lands*

(MOE/OMAFRA, March 1996) because the application rate cannot be controlled as it is in large-scale application programs. Also, to protect public health, biosolids application on vegetables grown for human consumption is not recommended due to the potential risk of transmission of human pathogens that may be present in low levels in the biosolids.

5.2 Marketing

The following are general comments on the marketing of biosolids in Ontario.

5.2.1 Home Gardeners.

The Ontario MOE does not recommend the use of biosolids on home lawns and gardens.

5.2.2 Nurseries.

Use of biosolids products by nurseries has not been widely practised in Ontario. Chapleau, Ontario is conducting a pilot study involving application of biosolids on a tree nursery. For use as a potting soil, a highly stabilized biosolids product would be required. Biosolids would be mixed with topsoil in a ratio of 1:1 or less. The MOE or Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA) currently does not have a policy regarding the acceptability of using biosolids products as potting soils.

5.2.3 Landscapers.

The Ontario MOE does not recommend the use of biosolids on home lawns; therefore, landscapers are not expected to use a large amount of biosolids products.

5.2.4 Fertilizer Companies.

Fertilizer companies can utilize thermally-dried (pelletized) biosolids as an organic base for making fertilizers. A minimum solids content of 92 percent total solids is generally required. Thermally dried biosolids could be sold to fertilizer companies, where it is fortified, bagged, and sold as a fertilizer. Milorganite is the most widely known biosolids-based fertilizer from Milwaukee, Wisconsin. Gatineau, Quebec, as well as Smith Falls, Ontario, are currently marketing their thermally dried biosolids pellets for fertilizer production.

Marketing is important to ensure that there is sufficient demand for the product. In the past, several facilities in the U.S. producing compost and dried biosolids have had to stockpile large quantities of their product or dispose of it in a landfill because of insufficient demand for their product. This may also happen with fertilizer products in the future because of the many large U.S. cities that are currently constructing composting and thermal drying facilities. Several facilities in the U.S. have agreements with fertilizer companies who fortify the biosolids and market the final product.

The quality of the dried biosolids product is very important for maintaining a long-term demand for the product. Fertilizer companies generally want dried biosolids products with less than 10 percent moisture, a low dust content, and a high nitrogen content. The low moisture content is to minimize the volume of the biosolids and allow for practical fertilizer application rates. A low dust content is desirable for aesthetic reasons and also to prevent explosive conditions in the product storage facilities. The nitrogen content generally determines the value of the dried biosolids product for use as a fertilizer. Fertilizer companies currently pay up to $20 per tonne of biosolids per percent nitrogen content.

In Ontario, agricultural co-operatives have worked with N-Viro to market their advanced alkaline stabilized product to farmers for nominal revenue.

5.2.5 Farmers.

Programs that apply biosolids on agricultural land have successfully operated for several years in Ontario, including the Region of Niagara, as well as several others (i.e. Durham Region, Halton Region, Hamilton-Wentworth, Kitchener-Waterloo, Ottawa-Carleton, and Toronto). Farmers have recognized the benefits of using biosolids. In all Ontario programs, the biosolids are transported to and applied on the farm site at no charge to the farmer. In some jurisdictions in the U.S., farmers are charged a fee for the biosolids. For example, Madison, Wisconsin has charged farmers $7.50 (U.S.) per acre of land that receives anaerobically digested biosolids (1987).

Often biosolids application must be done in conjunction with the farmers' planting and harvesting schedules.

5.2.6 Forestry Companies.

Forestry companies with large forested land holdings may be receptive to having biosolids applied on their forested lands. Pilot studies would be required to establish the benefits of biosolids application.

5.2.7 Mining Companies.

Mining companies with abandoned mine tailings areas, pits, and quarries could utilize biosolids or biosolids products for reclamation of the sites. The market potential for land reclamation is very large, considering the high application rates for land reclamation.

5.2.8 Municipal and Provincial Government Agencies.

Municipalities may be able to use biosolids products on recreational parks, golf courses, road embankments, forested areas, cemeteries, and sand and gravel pits.

5.3 Landfill

Stabilized biosolids may not always be suitable for utilization on agricultural or forested land, because of insufficient land, or as a result of poor biosolids quality. One alternative to land utilization is utilization/disposal of the stabilized biosolids at an approved landfill.

Biosolids may be landfilled in one of four ways:

- By combining with municipal solid waste
- By itself (biosolids-only landfill)
- Dedicated land disposal
- Utilization as cover material

Ash, the product of biosolids incineration, may be disposed of in approved landfills. These can be municipal landfills where the ash is combined with municipal solid waste or ash only landfills.

5.3.1 Co-disposal with Municipal Solids Waste.

Co-disposal of biosolids with municipal solid waste (MSW) is the most prevalent landfill disposal method used in Canada.

The biosolids are spread in a layer at the active face and immediately bladed into the MSW. Generally this is done just before closing time so that the biosolids can be immediately topped with the daily cover soil. The cover soil prevents odours and reduces health risks from exposure of the public to the biosolids.

Landfilling biosolids just before applying the daily cover may reduce the daily cover requirements, because the biosolids would tend to fill the void spaces in the garbage. However, biosolids with a high moisture content may increase daily cover requirements. Approximately 225 mm (9 inches) of topsoil is generally added for daily cover, of which approximately half is used to fill the void spaces in the garbage. Therefore, the biosolids could potentially use only a minimal amount of landfill volume.

Biosolids application can affect landfill gas production by stimulating acid souring which could inhibit methane production. Biosolids application should be coordinated with landfill gas handling initiatives.

Public access to the area to which the biosolids are disposed must be controlled to minimize health risks. Often, biosolids cannot be disposed until all public vehicles have departed.

In co-disposal, the refuse absorbs moisture from the biosolids and also reduces and slows leachate migration. The biosolids act as a conditioner, improving the rate of refuse decomposition. The biosolids also promote the revegetation of the site when mixed with soil and used as a daily landfill cover.

A biosolids solids content greater than 20 percent is generally required for co-disposal with MSW to minimize operational problems. Operational problems include equipment being unable to move around to mix and compact the solid waste because the biosolids make the area too slippery. Potential odour problems are also a concern.

Where ash is disposed in a municipal landfill, the ash must meet the requirements of Regulation 347 for non-hazardous wastes. The ash is disposed of in the same manner as municipal solid waste.

5.3.2 Biosolids-Only Landfill.

Biosolids-only landfills are landfills that are operated expressly for the disposal of wastewater biosolids and other wastewater treatment by-products such as screenings, grit, and ash.

The trench fill method involves excavating trenches so that biosolids, dewatered to greater than 15 percent solids concentration, may be buried below the original ground surface. Two types of trenches are used, depending on the solids content of the biosolids.

Narrow trenches, 3 m (10 ft) deep and less than 3 m wide, are used to dispose of biosolids with a solids content between 15 and 30 percent Total Solids (TS). The biosolids must be less than 30 percent solids so the biosolids will spread evenly when placed into the narrow trench.

Wide trenches, 3 m deep and greater than 3 m wide, are used to dispose of biosolids with a solids content greater than 30 percent solids. The wide trenches allow biosolids hauling vehicles to work within the trench. The biosolids must be greater than 30 percent solids so it will stay in piles and not slump, and be able to support excavating vehicles (e.g. bulldozer).

The wide trench fill method requires one-third less land than the narrow trench fill method. Also, disposal of biosolids with greater than 30 percent solids will generate one-third the volume of leachate, compared to biosolids with 20 percent solids.

Normal operating procedure requires daily coverage of the trenches with excavated soil. Stabilized and unstabilized biosolids can be disposed of because the immediate application of cover material reduces associated odours. Stabilized biosolids are, however, recommended for this type of landfilling method. Biosolids stabilization processes reduce the odour and number of pathogens in the biosolids. Unstabilized biosolids should only be disposed of using this method in cases of emergency, such as process upsets or failures.

The area fill method involves mixing the biosolids with topsoil and depositing the mixture on the ground surface. Substantial amounts of imported soil are required, proportional to the moisture content of the biosolids. Therefore, it is desirable to dewater biosolids to greater than 30 percent TS to minimize soil requirements. The biosolids must be stabilized to minimize odour problems, as daily cover is not normally provided.

5.3.3 Biosolids Disposal on Dedicated Land or in Permanent Lagoons.

Biosolids disposal on dedicated land or in permanent lagoons is used by several municipalities in Canada and the U.S. These methods are generally used to dispose of digested biosolids with a solids content of three to five percent. Dedicated land disposal (DLD) and disposal in permanent lagoons is similar to biosolids-only landfill methods, as the nutrients in the biosolids are generally not utilized. The difference is in the solids content of the biosolids disposed.

The land requirements for DLD and disposal in permanent lagoons are similar to the requirements for disposal in landfills, and substantially less than the requirements for utilization on agricultural and forested land. Since the land is usually owned by the municipalities, there is no need to convince farmers and forestry companies to accept the biosolids. Transportation costs are very economical when the land is located adjacent to the treatment plant.

Odour problems often require the land to be a fair distance away from highway and residential areas. Also, high metal concentrations in the soil after successive biosolids applications to the land often limit the future uses of the land.

For DLD, typical biosolids application rates are 200 to 900 dry tonnes of digested biosolids per hectare per year, which is approximately 100 times the application rate on agricultural land. Some type of vegetation is usually grown on the land to remove nutrients, prevent leaching of metals, and improve drainage characteristics of the land. The vegetation grown is not for human consumption. Types of vegetation grown are sod and trees for pulpwood. Leachate and runoff water must be collected and treated. Installation and operation of groundwater monitoring wells are also required.

For disposal in permanent lagoons, biosolids are applied in layers up to 200 mm (8 inches) in depth at one time. Successive applications are made after the supernatant has been drawn off and the previous biosolids application has dried. The lagoons generally have significant odour problems, as they are not covered. Lagoon liners and leachate collection systems may be required to prevent groundwater contamination.

DLD and disposal in permanent lagoons have been popular methods for biosolids disposal in the past, because disposal is simple and economical, especially if the land is adjacent to the treatment plant. However, requirements for collection and treatment of leachate and runoff water increase costs. Also, potential odour problems and risks from groundwater contamination may make these methods unacceptable. Due to the disadvantages of these methods, they are not recommended for biosolids disposal.

5.3.4 Landfill Cover Material.

Landfill disposal has been, and continues to be, a popular biosolids disposal option, but there is ever-increasing competition for available landfill space. Producing a highly stabilized biosolids suitable for landfill cover is becoming more attractive to municipalities to avoid the high costs of landfill tipping fees. It also can be attractive to the landfill operator where the landfill has a shortage of topsoil.

Biosolids that have been highly stabilized are suitable for daily cover. Processes such as composting and advanced alkaline stabilization produce highly stabilized biosolids that may be acceptable for landfill cover.

Biosolids can generally be utilized as landfill cover or disposed in a landfill if the biosolids are not classified as a hazardous waste. Solid waste leachate extraction tests are used to determine if the waste is classified as hazardous or non-hazardous.

Since disposal of biosolids can generate a significant amount of leachate, the landfill must have adequate leachate collection and control systems to prevent groundwater contamination.

The requirements for transportation of the biosolids from the treatment plant to the landfill should consider the traffic impact and the application period. The transportation route should be, as much as possible, on major highways and away from residential areas to prevent traffic congestion, odour, and noise problems.

5.4 Industrial Use

A number of industrial use alternatives exist, such as use of biosolids or ash as an ingredient in brick-making, aggregate, and cement. Fuel can also be derived from biosolids.

Industrial use of biosolids is generally specific to local market opportunities and may require the use of proprietary and/or innovative treatment technologies. There is no local market for industrial use of biosolids or ash in the Guelph area at present, and developing markets in other municipalities has involved considerable cost and effort, as well as time. Specific industrial uses are identified in Section 6.

5.5 Assessment of End Uses Summary

The long list of end uses was evaluated in the December 16, 2003 project team meeting and the evaluation is presented in Table 5.3.

TABLE 5.3
BIOSOLIDS END USES

Biosolids End Uses/Disposal	Description	Advantages	Disadvantages	Assessment
Agricultural Land	Injection/incorporation of biosolids into soil on farm sites used for crop growth or pasture land	• Nutrients in biosolids recycled for crop growth • Indirect benefit to region by reduced fertilizer costs for farmers • Biosolids dewatering not required	• Seasonal application; large storage facilities required • Dependant on willingness of farmers to accept biosolids and farming practices (i.e. crop selection) • Weather dependant	*Meets screening criteria*
Forested Land	Application of biosolids on forested sites to provide fertilizer for tree growth. Typically surface applied on mature stands from	• Nutrients recycled for tree growth • Biosolids dewatering not required • Improves natural habitat	• Consistent application rate difficult due to rough terrain, limited trails for application vehicles • Application to clear-cuts may affect tree survival due to weed and brush	*Not viable – forested land not available*

TABLE 5.3
BIOSOLIDS END USES

Biosolids End Uses/Disposal	Description	Advantages	Disadvantages	Assessment
	logging roads		growth	
Land Reclamation	Application on disturbed lands at high application rates to provide sufficient organic matter for vegetative growth	• Organic matter and nutrients supports vegetative growth • Reduces environmental impacts • High application rates	• Pretreatments to reduce risks of nutrient, pathogen runoff may be required • May be long travel distances to application sites	*Meets screening criteria*
Landfill Disposal (monofill, co-disposal, dedicated land disposal)	Biosolids disposed in a landfill	• Year-round operation (not weather dependant) • Reliable disposal method	• Landfill space consumed • High tipping fees	*Not sustainable, contingency only* (no landfill in Guelph area)
Public Contact (e.g. golf courses)	Application to turf grass, gardens to provide nutrients for vegetative growth. High level of pathogen reduction required since the public may come into contact with the biosolids	• Potential revenue from sale of biosolids	• High degree of processing required • Potential liability due to public perceptions	*Meets screening criteria*
Industrial Reuse	Use of biosolids products for making bricks, aggregate, fuel, and cement-kiln fuel	• Provides for beneficial final use • Potential revenue from sale of biosolids	• High degree of processing may be required • Market would have to be developed	*Not viable – no potential local market*

Viable end uses are:

- Agricultural land application
- Land reclamation
- Public contact
- Landfill as contingency only

6. Biosolids Products

The biosolids products generally considered in a biosolids management plan include:

- Liquid biosolids
- Dewatered biosolids
- Compost
- Ag-lime substitute
- Fertilizer
- Ash
- Innovative and other technology products

The technologies used to create these products are discussed in Section 7.

6.1 Liquid Biosolids

Liquid biosolids are generally considered as those which have a total solids content of about three to seven percent. Over about seven percent total solids, liquid biosolids become difficult to pump. Liquid biosolids are generally the least processed biosolids product, and therefore, the least expensive to produce.

6.2 Dewatered Biosolids

Dewatering reduces the volume of biosolids and concentrates the solids. Dewatered biosolids generally have a solids content of about 15 to 35 percent total solids. The solids content can be increased with additional conditioning processes. The biosolids may be stabilized or unstabilized (raw) prior to dewatering.

6.3 Compost

Dewatered biosolids can be aerobically composted, often with additional organic matter, such as wood chips or sawdust.

Biosolids compost typically consists of 50 to 65 percent total solids content, and if additional organic matter has been incorporated, the biosolids constituents may be "diluted" resulting in, for example, lower metals concentrations in the compost, compared to the biosolids.

6.4 Ag-lime Substitute

Acidic soils can be treated with lime to increase the pH to an acceptable value, depending on the crop requirements. These soils may also require fertilizer. Alkaline stabilized biosolids can combine the benefits of the soil conditioning properties of biosolids with the pH-increasing benefits (to acid soils) of lime or other alkaline product utilized.

6.5 Fertilizer

Biosolids processed to a high degree of stabilization can be federally permitted in Canada as fertilizer rather than biosolids. Where biosolids use is restricted under the Ontario regulations, use of fertilizer is unrestricted, and may therefore have a larger potential market.

6.6 Ash

Ash is the product of the thermal destruction of biosolids. Biosolids are dewatered prior to thermal destruction, to reduce the energy requirements of the process.

Ash is the inorganic portion of the biosolids that remains after the thermal process has destroyed the organic portion. Depending on the process used, ash may be a wet or dry product. Thermal destruction significantly reduces the volume and mass of the biosolids to about five to 15 percent of the dewatered biosolids cake.

Incinerator ash is sanitary, odourless, and free of toxic organic chemicals, therefore, its disposal may be less complicated than that of biosolids, provided the concentration of metals complies with the regulations. However, ash is typically disposed of in a landfill or utilized for industrial uses, neither of which end uses remain after screening.

6.7 Innovative and Other Technology Products

A number of other products can be generated, and may require innovative and/or proprietary processes. Examples include "biobricks" produced by mixing biosolids with clay in the brick-making industry and "oil-from-sludge", or fuel, produced by a proprietary process. A comprehensive list of the industry recognized alternative products is shown in Table 6.1.

TABLE 6.1
BIOSOLIDS PRODUCTS

Biosolids Product	Description	Advantages	Disadvantages	Assessment
Digested Biosolids (liquid)	Liquid product with solids content of three – five percent TS	• Nutrient content conserved • Dewatering not required	• Limited end uses (i.e. agricultural, forested land) • Large storage facilities required	*Meets screening criteria*
Dewatered Biosolids	Digested biosolids de-watered to a solid material	• Volume reduced	• High odour potential	*Meets screening criteria*
Compost	Aerobically stabilized organics	• Low odour potential	• High capital and operating costs	*Not viable – biosolids compost cannot be produced to meet Ontario regulations as a stand-alone product*
Ag-Lime Substitute	Alkaline stabilized biosolids with a high calcium carbonate equivalency (CCE)	• Increases pH of soil • Soil conditioner	• Potential for odour redevelopment	*Meets screening criteria*
Fertilizer	Dried biosolids used as a component in fertilizer production	• Revenue from sale as fertilizer, usually based on nitrogen content	• Potential for odour redevelopment • High costs to produce	*Meets screening criteria*
OCI Waste Conversion System	Anhydrous ammonia and sulfuric acid added to drying process to fortify pellets	• High nutrient content	• High cost of processing	*Does not meet reliability criteria*
Ash	Ash from incineration process	• Application to agricultural land in some cases	• Generally limited to landfill disposal	*Does not meet screening criteria because landfill disposal did not*
Brick Production (BioBrick)	Sludge mixed with clay in brick kilns	• Pathogens destroyed	• Lower strength than regular bricks	*Does not meet reliability criteria*
Aggregate (Minergy)	Dewatered biosolids, ash and clay dried to produce large diameter aggregate	• Light-weight aggregate produced for limited use in masonry and structural concrete applications	• High cost of production	*Does not meet reliability criteria*
Metal recovery	Metals recovered from ash by acidification, extraction, precipitation	• Potential revenue from metals recovered	• High cost of processing • No full-scale experience	*Does not meet reliability criteria*
Fuel	Oil, gas (ethanol, methanol)	• Energy value of fuel produced	• High cost of production	*Does not meet reliability criteria*
Cement-Kiln Fuel	Dewatered or dried sludge burned in cement kiln	• Reduces fuel requirements • Reduces nitrogen oxide emissions from kiln	• Increased ash generation in kiln • Increased contaminants in cement • Limited full-scale operations	*Does not meet reliability criteria*

6.8 Summary and Assessment of Biosolids Products

The long list of products was evaluated in the December 16, 2003 project team meeting and the evaluation is presented and summarized in Table 6.1.

Viable products are:

- Liquid digested/stabilized
- Digested/stabilized dewatered
- Ag-lime substitute
- Fertilizer

7. Technologies

Viable technologies to be screened are required to produce stabilized, liquid, dewatered, ag-lime substitute, fertilizer and ash products from biosolids. These are discussed fully below and summarized in Attachment 1.

7.1 Liquid Product

7.1.1 Introduction.

Application of liquid biosolids product on agricultural land to complement fertilizer requirements is the most widely established method of biosolids utilization in Canada. In Ontario, over 75 percent of municipalities utilize liquid product on agricultural lands.

Biosolids are a valuable source of nitrogen and phosphate for grass or cereal crops and also provide small amounts of potassium, as well as many trace elements required by plants.

Biosolids are also a very good soil conditioner for soils with a low organic content, facilitating nutrient uptake, increasing water retention, permitting easier root penetration, and improving soil texture.

For liquid product to be acceptable for application on land, the biosolids must be stable, odour free, and be processed by a stabilization process approved by the MOE. The stabilization/pathogen reduction alternative processes typically considered to produce a liquid product include:

- Conventional High Rate Mesophilic Anaerobic Digestion
- Low Rate Mesophilic Anaerobic Digestion
- High Rate Thermophilic Anaerobic Digestion
- Conventional Aerobic Digestion
- Autothermal Thermophilic Aerobic Digestion (ATAD)
- Dual Digestion
- Alkaline Stabilization
- Irradiation
- Other Processes
  - Chlorine Disinfection
  - Pasteurization
  - Facultative Sludge Lagoons (FSLs)

A discussion of the high-rate mesophilic digestion process is included below. As the WWTP is presently equipped with the high rate mesophilic digestion process, all discussion within the body of this report, in regard to stabilization, is limited to this process, except in the alternatives which include alkaline stabilization and irradiation. A summary of each process is included in Attachment 1.

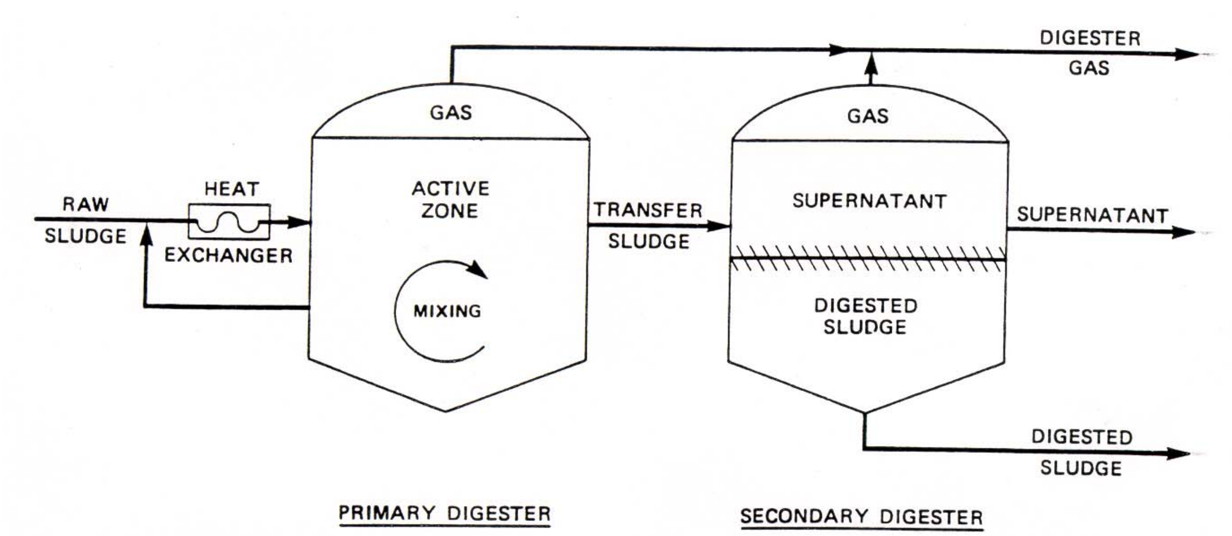
7.1.2 High Rate Mesophilic Digestion.

The high rate mesophilic anaerobic digestion process, as practised in Guelph, is the most commonly used biosolids stabilization process in Canada and the U.S. The process is simple to operate and has proven reliability. In the anaerobic digestion process, biological microorganisms decompose organic matter in the absence of oxygen. The organic matter is converted into methane, carbon dioxide, water, and partly degraded intermediate organics. The digested biosolids are relatively stable compared to raw biosolids.

Temperatures in conventional anaerobic digestion are maintained at 30°C – 38°C (86°F – 100°F) which is the optimum temperature range for mesophilic microorganisms. Methane gas generated in the process is typically burned and the heat is used to maintain the optimum temperature in the digester.

The anaerobic digestion process can be either a single- or two-stage system, depending on the subsequent biosolids processes and the ultimate utilization/disposal method. Figure 7-1 shows a schematic of a two-stage system. In the first stage, biosolids are digested for a minimum of 15 days. Heating and mixing is provided. The purpose of a second stage is to store and concentrate the biosolids. The biosolids are concentrated by gravity thickening of the biosolids and by decanting of the supernatant liquor. The design of the secondary stage is similar to the primary stage, except that it is neither heated or mixed.

FIGURE 7-1
SCHEMATIC OF TWO-STAGE ANAEROBIC DIGESTION



Advantages and disadvantages of the high rate anaerobic digestion process are listed below.

- Advantages of anaerobic digestion include:
  - Production of a valuable end-product, methane, that is combustible and can be used to produce heat for the digestion process and other uses
  - Relatively low operating costs
  - Digested solids may be suitable for disposal in a landfill or application on land as a soil conditioner

  - Mass of solids reduced
  - Commonly used and well understood process

- Disadvantages of anaerobic digestion include:
  - Methane-producing bacteria are slow growing and sensitive to process upset
  - Digesters have high capital cost
  - Relatively complex operation
  - Potential risk from methane gas leak

7.2 Liquid Product Summary

Biosolids stabilization processes can significantly reduce the odour potential of the biosolids and significantly reduce the number of pathogens in the biosolids. The stabilization process chosen can also significantly impact the dewaterability of the stabilized biosolids. Typically, aerobic digestion processes produce a stabilized biosolids with poorer dewatering characteristics than anaerobic digestion processes. A summary of the effectiveness of some of the biosolids stabilization processes is shown in Table 7.2.

TABLE 7.2
EFFECTIVENESS OF BIOSOLIDS STABILIZATION PROCESSES ON END PRODUCT QUALITY

Method	Odour Potential Reduction	Pathogen Destruction	Dewaterability Enhancement
Mesophilic Anaerobic Digestion	Fair	Fair	Good
Thermophilic Anaerobic Digestion	Fair	Good	Good
Conventional Aerobic Digestion	Fair/Poor[1]	Fair/Poor[1]	Poor
ATAD	Fair	Good	Poor
Dual Digestion	Fair	Good	Good

[1] Effectiveness of digestion process decreases rapidly at temperatures less than 15°C.

A high degree of pathogen destruction is a desirable characteristic. Stabilization processes providing the highest degree of pathogen destruction for liquid products include ATAD, dual digestion, and high rate thermophilic digestion.

7.3 Dewatered Product

7.3.1 Introduction.

Biosolids conditioning and dewatering (volume reduction) processes produce a dewatered product. Stabilization processes, such as the processes discussed above, would also be used. The conditioning and dewatering processes generally considered are listed below in Table 7.3.

TABLE 7.3
BIOSOLIDS CONDITIONING AND DEWATERING PROCESS ALTERNATIVES USED TO PRODUCE A DEWATERED PRODUCT

Biosolids Conditioning Alternatives	Biosolids Dewatering Alternatives
• Chemical Conditioning (polymer) • Thermal Conditioning • Other Processes – Elutriation – Freeze-thaw – Bacteria – Electricity – Solvent Extraction – Ultrasonic	• Belt Filter Press • Centrifuge • Recessed Plate Filter Press • Screw Press/Rotary Press • Vacuum Belt Filters • Other Processes – Drying Beds – Tube Filters – Cyclones – Screens – Electro-osmosis

7.3.2 Biosolids Conditioning.

Chemical conditioning with polymers, as practised at Guelph, is the most commonly used conditioning process for conditioning biosolids prior to mechanical dewatering processes.

Chemical conditioning and dewatering can produce a biosolids product dry enough for landfill disposal.

Thermal conditioning combined with dewatering has been used to pretreat the biosolids before thermal oxidation or landfill disposal. Thermal conditioning can produce biosolids with a higher solids content than chemical conditioning, without increasing the bulk of the biosolids. It is also effective on difficult-to-dewater biosolids. However, thermal conditioning is more complex, requiring highly skilled operational personnel, and has a higher capital, operation, and maintenance cost than chemical conditioning for most types of biosolids. High capital costs generally limit thermal conditioning to large wastewater treatment plants. Also, thermal conditioning produces gas and high-strength liquid sidestreams that require further treatment.

Thermal conditioning releases a substantial portion of the organic nitrogen from the biosolids. The nitrogen is removed in the dewatering sidestream. For incineration, this is beneficial as it lowers the nitrogen oxide emissions from the incineration exhaust gases. For landfill disposal, this is also beneficial, as it reduces the leachate generation rate and the risk of nitrate contamination of the ground water. For fertilizer production, release of nitrogen is not beneficial, as it lowers the nitrogen content and value of the biosolids as a fertilizer.

Elutriation has been used in the past at some plants in Ontario. Elutriation involves washing the biosolids with water (i.e. plant effluent) to remove alkalinity and fines from the biosolids. Elutriation is generally used in combination with chemical conditioning to reduce chemical requirements. Elutriation is not commonly used because the elutriate that is recycled back to the wastewater treatment system can degrade the final effluent quality.

Natural freeze-thaw conditioning is used by Yorkton, SK, and many other small facilities in Canada and the northern U.S. This process requires large land areas and is generally limited to populations less than 20,000. Mechanical freeze-thaw systems are at the development stage and have not been proven at a full-scale facility.

Other biosolids conditioning processes, such as bacteria, electricity, solvent extraction, and ultrasonic processes, have not been proven to be viable at a full-scale facility.

7.3.3 Biosolids Dewatering.

There are a variety of biosolids dewatering options that may be considered for reducing the volume of biosolids and concentrating the solids. Biosolids dewatering processes are generally used following stabilization/pathogen reduction processes. Biosolids dewatering may be used to process raw unstabilized biosolids in some specific cases, such as prior to composting, thermal drying, and alkaline stabilization processes.

The selection of the most appropriate dewatering method should be based on a consideration of subsequent handling processes and on the ultimate biosolids utilization/disposal method selected. It is generally desirable to achieve as high a dry solids content as possible in the dewatering stage, in order to reduce the volume and total mass of biosolids material. Most applications require the dewatered biosolids to be between 20 and 35 percent dry solids concentrations. Lower solids concentration could be acceptable for agricultural or forested land applications in some specific cases, however, the lower costs generally do not outweigh the benefits of adaptability to other utilization/disposal alternatives.

7.3.3.1 Belt Filter Press.

Belt filter presses (BFPs) are a commonly used type of equipment for dewatering biosolids. BFPs are used in Port Colborne and also in Guelph, Chatham, and Woodstock. BFPs were also used in Ottawa during the 1991 to 1993 period and at Ashbridges Bay in Toronto from 1980 to 1995.

Figure 7-1 shows a diagram of a typical BFP and Table 7.4 shows typical performance of BFPs with different types of biosolids.

FIGURE 7-1
TYPICAL BELT FILTER PRESS

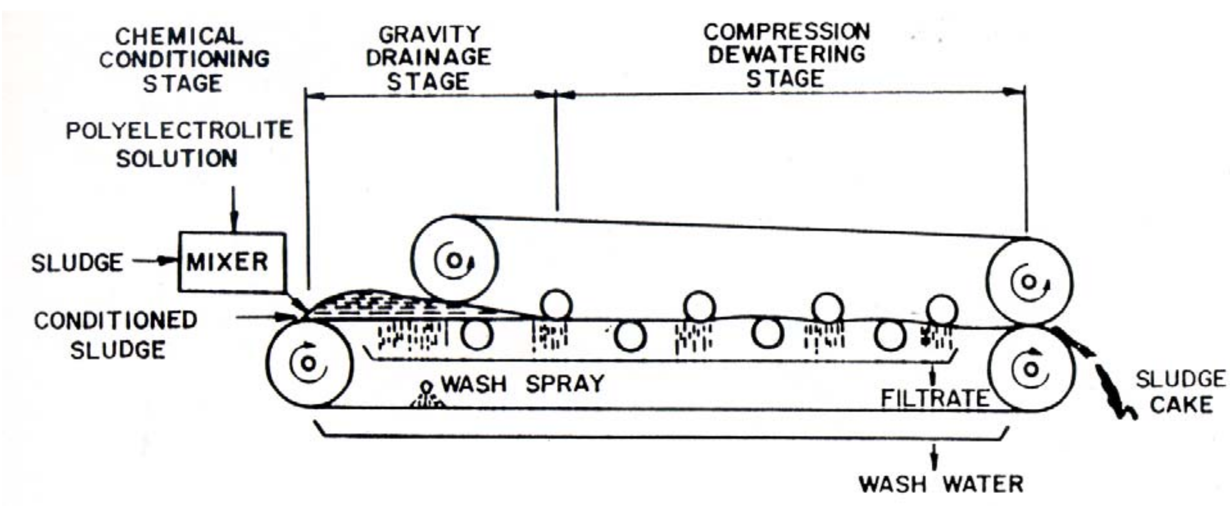


TABLE 7.4
TYPICAL PERFORMANCE DATA FOR A BELT FILTER PRESS

Type of Biosolids	Dry Feed Solids (%)	Loading Per Metre Belt Width		Dry Polymer[a] (g/kg Dry Solids)	Cake Solids (%)	
		L/s[c]	kg/h[d]		Typical	Range
Raw Primary (P)	3 – 7	1.9 – 3.2	360 – 550	1 – 4	28	26 – 32
Waste Activated Sludge (WAS):	1 – 4	0.6 – 2.5	45 – 180	3 – 10	15	12 – 20
P + WAS (50:50)[b]	3 – 6	1.3 – 3.2	180 – 320	2 – 8	23	20 – 28
P + WAS (40:60)[b]	3 – 6	1.3 – 3.2	180 – 320	2 – 10	20	18 – 25
P + Trickling Filter (TF)	3 – 6	1.3 – 3.2	180 – 320	2 – 8	25	23 – 30
*Anaerobically Digested:						
P	3 – 7	1.9 – 3.2	360 – 550	2 – 5	28	24 – 30
WAS	3 – 4	0.6 – 2.5	45 – 135	4 – 10	15	12 – 20
P + WAS	3 – 6	1.3 – 3.2	180 – 320	3 – 8	22	20 – 25
*Aerobically Digested:						
P + WAS, unthickened	1 – 3	0.6 – 3.2	135 – 225	2 – 8	16	12 – 20
P + WAS (50:50), thickened	4 – 8	0.6 – 3.2	135 – 225	2 – 8	18	12 – 25
Oxygen Activated WAS	1 – 3	0.6 – 2.5	90 – 180	4 – 10	18	15 – 23

[a] Polymer needs based on high molecular weight polymer (100% strength, dry basis).
[b] Ratio is based on dry solids for the primary and WAS.
[c] L/s x 15.85 = gpm
[d] kg/h x 2.205 = lb/hr
[e] g/kg x 2.0 = lb/ton
* Biosolids types similar to some of those considered for the WWTP.

Advantages of a belt filter press include:

- Relatively low capital cost
- Relatively low power consumption
- High solids capture with minimum polymer requirements
- Continuous feed
- Moderate cake solids concentration
- Moderate throughout capabilities versus space requirement
- Open design provides good visual control capability for process performance

Disadvantages of a belt filter press include:

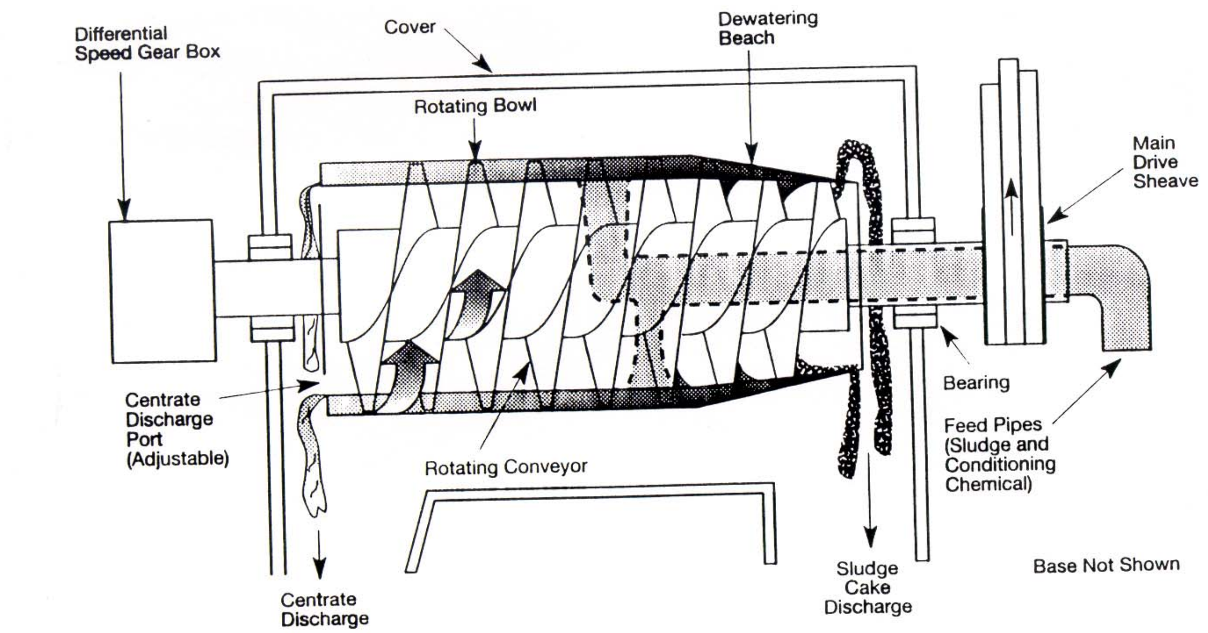
- Housekeeping – open design does not allow containment during process upsets
- Moderate operator attention requirements; larger installations require continuous operator attention
- Odour potential
- Downtime
- Sensitive to incoming feed characteristics

7.3.3.2 Centrifuge. The centrifuge operation involves the application of centrifugal force to a liquid biosolids stream, which accelerates the separation of the liquid and solid fractions. The process involves both clarification of the centrate stream and compaction of the biosolids.

The style of centrifuge equipment typically used to thicken and dewater municipal biosolids is the solid bowl conveyor centrifuge. Figure 7-2 shows a cut-away view of a solid bowl centrifuge. This centrifuge unit operates with a continuous feed and discharge similar to the belt filter press.

The biosolids, which are conditioned with polymer, are fed into the rotating bowl, which has a conical shape at one end and an end plate at the other. The end plate has holes in it for the discharge of the centrate. These holes are equipped with adjustable weir plates to control the operating level of the liquid in the bowl. The bowl is driven by a motor at speeds ranging from 2,000 to 3,000 rpm. This spinning action creates the centrifugal forces required to concentrate the biosolids against the bowl wall. To remove these solids, a spiral conveyor in the bowl rotates at a slightly differing speed than the bowl and conveys the biosolids towards the conical solids discharge. The centrate water is discharged over the weir plates at the opposite end of the centrifuge.

FIGURE 7-2
CUT-AWAY VIEW OF A CENTRIFUGE



Typical biosolids concentrations for conventional centrifuges are similar to those achieved with a belt filter press. Recently, technical advancements have developed what is referred to in the industry as a "high solids" centrifuge. These high solids centrifuge machines can produce biosolids cakes in the 28 to 40 percent dry solids range for most biosolids types by centrifugal force and a squeezing action. Typical performance data for different biosolids types is included in Table 7.5.

Centrifuges are used at several facilities in Canada and the U.S., including Ottawa, Brockville, Cornwall, Kingston, Kingston Township, City of Toronto, St. Thomas, Thunder Bay, and Windsor in Ontario.

TABLE 7.5
TYPICAL PERFORMANCE DATA FOR A CONVENTIONAL SOLIDS BOWL CENTRIFUGE

Biosolids Type	Feed Solids Concentration (% solids)	Average Cake Solids Concentration (% solids)[1]	Dry Polymer Required g/kg Feed Solids (lb/ton)	Recovery Based on Centrate Solids (%)
Raw Primary	5 – 8	25 – 36 28 – 36	0.5 – 2.5 (1 – 5) 0	90 – 95 70 – 90
Anaerobically Digested Primary[2]	2 – 5 9 – 12	28 – 35 30 – 35 25 – 30	3 – 5 (6 – 10) 0 0.5 – 1.5 (1 – 3)	98+ 65 – 80 82 – 92
Anaerobically Digested Primary Irradiated at 400 krad	2 – 5	29 – 35	3 – 5 (6 – 10)	95+
Waste Activated	0.5 – 3.0	8 – 12	5 – 8 (10 – 15)	85 – 90
Anaerobically Digested Waste Activated[2]	1.3	8 – 10	1.5 – 3 (3 – 6)	90 – 95
Thermally Conditioned:				
Primary + Waste Activated	9 – 14 13 – 15	35 – 40 29 – 35	0 0.5 – 2 (1 – 4)	75 – 85 90 – 95
Primary + Trickling Filter	7 – 10	35 – 40 30 – 35	0 1 – 2 (2 – 4)	60 – 70 98+
High Lime	10 – 12	30 – 50	0	90 – 95
Raw Primary + Waste Activated	4 – 5	18 – 25	1.5 – 3.5 (3 – 7)	90 – 95
Anaerobically Digested: (Primary + Waste Activated)[2]	2 – 4 4 – 7	15 – 18 17 – 21	3.5 – 5 (7 – 10) 2 – 4 (4 – 8)	90 – 95 90 – 95
Anaerobically Digested (Primary + Waste Activated + Trickling Filter	1.5 – 2.5	18 – 23 14 – 16	1 – 2.5 (2 – 5) 6 – 8 (12 – 15)	85 – 90 85 – 90
Combined Sewer Overflow Treatment Sludge	highly variable			

[1] Assumes skimming of cake.
[2] Biosolids types similar to some of those seen at facilities in the Eastern Area.

Advantages of a centrifuge include:

- Contained process minimizes housekeeping and odour considerations
- Continuous operation provides flexible control capability for process performance
- Moderate or high cake solids concentration
- Relatively small area requirements
- Moderate to high throughput capabilities versus space requirements
- Low operator attention requirements
- High solids capture

Disadvantages of a centrifuge include:

- Relatively high capital cost
- Relatively high power requirements
- Moderate to high polymer requirements
- High operating speeds
- High noise potential

7.3.3.3 Recessed Plate Filter Press. Recessed plate filter presses operate on the principle of applying pressure to the material to "squeeze-out" the water. There are two types of equipment in use. One utilizes a diaphragm constructed of rubber or other similar materials. The other type uses a filter cloth material. The liquid material is introduced into the cavity of the plates and the diaphragm (filter cloth). Pressure is applied to the material to separate the liquid from the solids. The separated liquid is drained and the solids and remaining liquid are retained in the press. Pressure in a recessed plate filter press is applied by the positive-displacement feed pump. Pressure in a recessed diaphragm is applied by high pressure air. The plates are opened at the end of the pressing cycle and the resulting cake is discharged to a hopper located below the press.

Recessed plate filter presses are used at the Duffin Creek WPCP in Pickering, Ontario and also at several other facilities in Canada and the U.S.

Advantages of a recessed plate filter press include:

- Contained process minimizes housekeeping
- Relatively moderate power consumption
- High solids capture
- High cake solids concentration
- Moderate noise potential

Disadvantages of a recessed plate filter press include:

- Batch operation
- Operator attention required during cake discharge
- Potential for poor cake release may require pre-coat
- Odour potential
- Relatively high capital cost
- Moderate to high polymer requirements

7.3.3.4 Screw Press/Rotary Press. Screw presses have been used at several small facilities in Canada and the U.S., including facilities in Ladysmith and Squamish, British Columbia.

Advantages of a screw press include:

- Flexible control capability for optimizing process performance
- Low operating speeds
- Low capital costs
- Low operator attention requirements
- Low power consumption
- Contained process minimizes housekeeping and odour potential
- Low noise potential

Disadvantages of a screw press include:

- Limited experience and success dewatering sewage biosolids
- Relatively low unit capacity
- Moderate polymer requirements
- Low solids capture
- Low to moderate cake solids concentration

Rotary presses are being used at a treatment plant in Montreal, Quebec and in the Saanich Peninsula, British Columbia. Rotary presses are similar in operation to screw presses and have the same advantages and disadvantages as screw presses.

7.3.3.5 Rotary Vacuum Filters. Rotary vacuum filtration is an old technology that is now used only for special applications such as dewatering thermally conditioned biosolids. Vacuum filters cannot produce biosolids cakes in the 20 to 35 percent total solids range when the biosolids are chemically conditioned.

7.3.3.6 Sand Drying Beds. Sand drying beds are being used in Kingston Township, Ontario; Trail, British Columbia; and several other small facilities in Canada and the U.S. The beds are generally limited to small communities with populations under 20,000 because of the large land requirements and the potential for odour. Climatic conditions such as high precipitation also affect the suitability of the beds.

Advantages of a sand drying bed include:

- Where elaborate lining and leachate control is not necessary and where land is available, capital cost is low for small plants
- Low requirement for operator attention and skill
- Low electric power consumption
- Low sensitivity to biosolids variability
- Low polymer consumption
- Moderate to high dry cake solids contents

Disadvantages of a sand drying bed include:

- Lack of rational design approach for sound economic analysis
- Large land requirement
- Stabilized biosolids requirement
- Impact of climatic effects on design
- High visibility to general public
- Labour-intensive biosolids removal
- Permitting and groundwater contamination concerns
- High fuel and equipment costs for bed cleaning systems
- Real or perceived odour and visual nuisances
- Effectiveness is weather dependent

7.3.3.7 Other Processes. Other biosolids dewatering processes such as tube filters, cyclones, screens, and electro-osmosis are not considered suitable for biosolids dewatering or have not been proven at a large full-scale facility.

7.3.3.8 Dewatering Technology Summary. Biosolids dewatering significantly reduces the biosolids volume prior to utilization/disposal or downstream solids treatment processes. This provides a smaller volume of concentrated material requiring utilization/disposal.

The three common types of dewatering equipment presently used in municipal wastewater biosolids dewatering that are capable of consistently producing dewatered biosolids cakes between 18 and 35 percent dry solids concentration are:

- Belt filter press 18 – 25 percent
- Centrifuge 20 – 35 percent
- Recessed plate filter press 24 – 35 percent

Other types of equipment are available; however, they have limited operating experience on municipal wastewater biosolids, and they have not been able to consistently achieve the generally accepted minimum requirement of 20 percent dry solids concentration, for example:

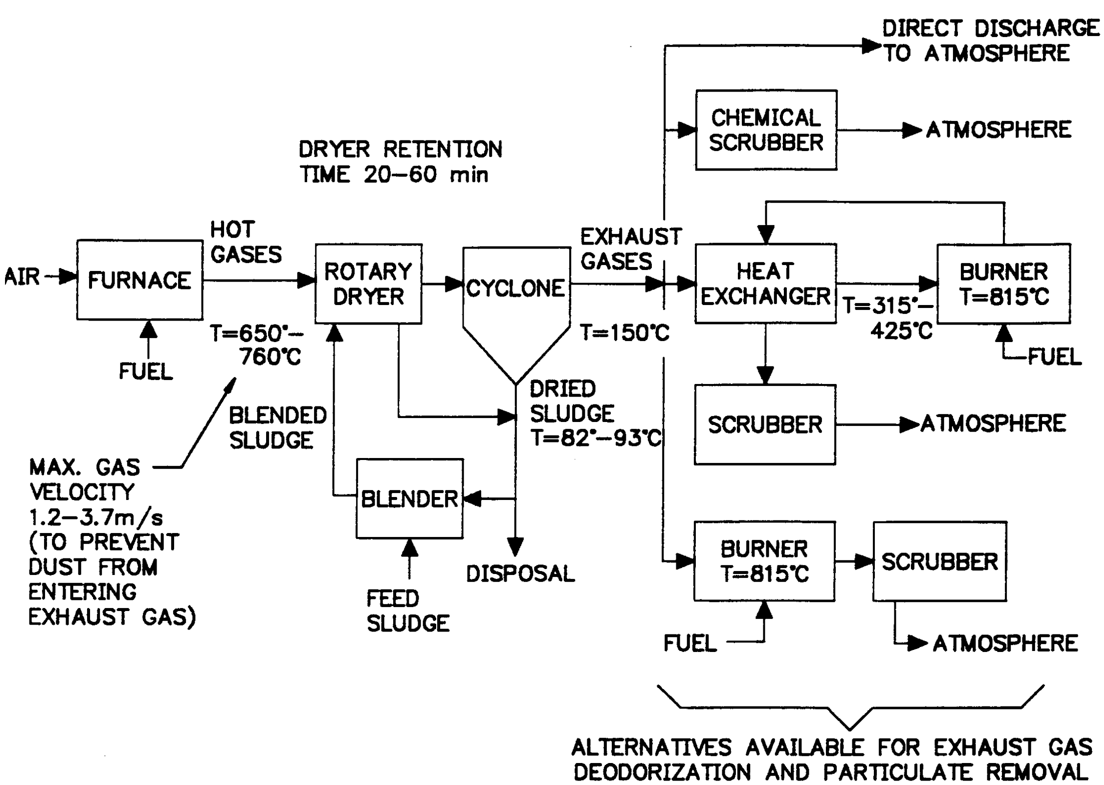
- Horizontal screw press 15 – 24 percent
- Vertical screw press 8 – 16 percent

Natural biosolids dewatering methods, such as sand drying beds, are not considered to be economically or technically viable for the long-term dewatering of biosolids generated at the Guelph WWTP.

7.4 Fertilizer (Heat Dried) Product

Thermal drying processes are generally used to produce a dried fertilizer product. Dewatering processes, such as the processes discussed in Section 7.3, would also be used. Stabilization processes, such as discussed in Section 7.1, may be used, but are not necessary. Figure 7-3 shows a flow schematic of a direct heat drying system.

FIGURE 7-3
FLOW SCHEMATIC OF A DIRECT HEAT DRYING SYSTEM



The thermal drying process alternatives considered to produce a dry product include:

- Direct (convective) Dryers
  - Rotary Dryers
  - Flash Dryers
- Indirect (conductive) Dryers
- Other Processes
  - Radiant
  - Dielectric
  - Microwave
  - Carver Greenfield Process (multi-effect evaporation)
  - Solvent extraction

Methane gas produced by the anaerobic digestion process could be used to replace some or all of the natural gas required in the thermal drying process.

7.4.1 Direct (Convective) Dryers.

Direct, convective-heat dryers include rotary dryers and spray or flash dryers. Rotary dryers are the most common. Rotary dryers are used at several facilities in the U.S. including Cobb County, Georgia; Boston (Deer Island), Massachusetts; New York, New York; Hagerstown, Maryland; and Largo and Tampa, Florida.

Manufacturers of drying systems have developed methods of improving the thermal efficiencies of drying systems. For example, Swiss Combi Inc. continuously recycles the sweep gases used to evaporate the water. The sweep gases are indirectly superheated, passed through the dryer, and then cooled to condense water to allow the gases to be recycled. Swiss Combi Inc. has several facilities operating in Canada: Smiths Falls and Windsor, Ontario; and Gatineau, Montreal, Laval, and Quebec City, Quebec.

Advantages of direct dryers include:

- High heat transfer rates due to direct contact of the drying medium with the biosolids, thereby decreasing the residence time of the biosolids within the dryer
- Flexibility of temperature control achievable by varying the flow and/or temperature of the hot gas over the biosolids

Disadvantages of direct dryers include:

- Potential for combustion and explosions of the biosolids material in the dryer
- Thermal inefficiency due to high sensible heat loss in the stack gases
- Large volume of off-gas requiring treatment for dust entrainment and odours

The disadvantages can be overcome by recycling a portion of the exhaust air, condensing and scrubbing the exhaust air, and then burning the non-condensable off-gases after scrubbing.

Flash dryers are used at two facilities in Houston, Texas. The operation and maintenance of flash drying facilities is relatively complex. Also, dust from the process is extremely abrasive and can create explosive conditions.

7.4.2 Indirect (Conductive) Dryers.

Several different types of indirect dryers are available, including heated agitation equipment, such as the hollow disk, paddle and helical screw dryers, and also drum type dryers with jacketed walls for the heat medium, as well as vertical tray dryers.

Hollow disk dryers have been successfully used in a full-scale biosolids drying demonstration study for Seattle (Metro), Washington. A full-scale facility in Buffalo, New York, thermally dewaters 16 to 18 percent dewatered biosolids from a BFP up to 35 percent prior to incineration to provide an autogenous feed for the incineration process. A full-scale facility was operated at the Hyperion WWTP in Los Angeles, California for several years. YWC Inc.'s thin film and paddle-type indirect dryers have been used for drying biosolids in Europe.

Vertical tray dryers have been used in Baltimore, Maryland and Toronto, Ontario. They are arranged in a vertical insulated vessel with several trays forming separate drying compartments. There is a vertical rotating shaft with arms at each compartment. Hot oil is circulated through each tray, biosolids are fed into the top compartment and the material travels horizontally due to the action of the rotating arms and drops to the compartment below. Dry material discharges from the bottom.

Several advantages of indirect drying include:

- Minimal volumes of off-gas are produced when compared to direct drying; a relatively low flow rate of purge gas (if any) is required to discharge the vapour resulting from the evaporated liquid
- Dust entrainment in the exhaust air is minimized when compared to direct dryers because the heating medium does not contact the biosolids
- The atmosphere inside the dryer is inherently inert, minimizing the potential explosive and fire hazards
- A higher thermal efficiency can be achieved
- A variety of thermal media can be used including gas, oil, and steam

Disadvantages of indirect drying include:

- Higher costs for providing a thermal source such as steam, hot water, or hot oil (if such a source is not readily available)
- Heat transfer surfaces could become fouled if not cleaned regularly
- Indirect drying produces a dusty product with relatively fine particles compared to a direct dried product

7.4.3 Other Drying Processes.

Other drying processes, such as radiant drying, dielectric drying, and microwave drying, have high capital costs and have not been successfully used for municipal sewage biosolids drying.

Solvent extraction was evaluated by the cities of Seattle, Washington and Los Angeles, California where it was determined that the process was not cost-effective. No full-scale facilities using the process have been constructed.

The Carver-Greenfield process has been used primarily in the food and agricultural industries. The process is used to dry biosolids at two facilities in Japan and was used at the Los Angeles, California Hyperion plant for about 15 years. The system at the Hyperion plant was plagued by operating problems and never reached its design capacity, prior to shutdown.

7.5 Ag-lime Product

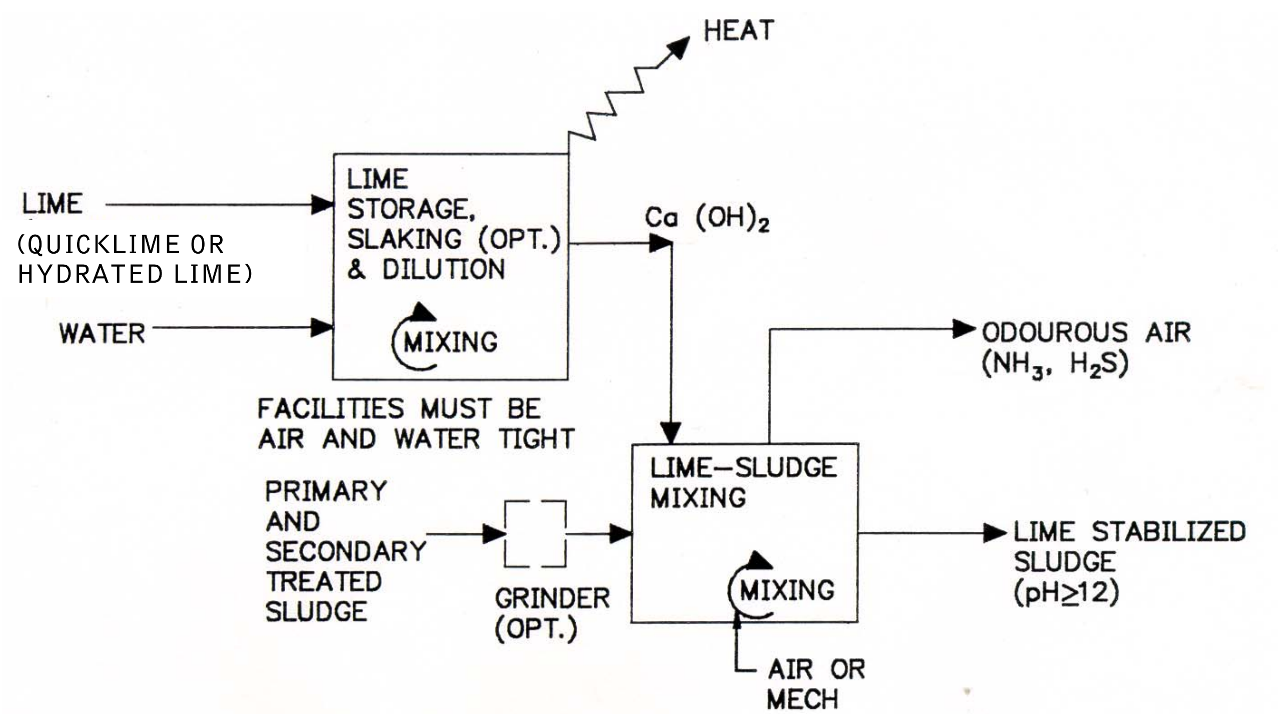
7.5.1 Introduction.

Alkaline stabilization of biosolids has been a practical stabilization method for many years. The basic approach is to elevate the pH of the biosolids by the addition of one of the several materials containing lime, either as calcium oxide (CaO – quicklime) or calcium hydroxide ($Ca[OH]_2$ – hydrated lime).

Essentially, any alkaline material with sufficient alkalinity can be used. Certain methods of using cement kiln dust (CKD) for alkaline stabilization are, however, covered by patents. No known patents apply to the use of other alkaline sources, such as fly ash, quicklime, and hydrated lime.

Alkaline stabilization can be used to stabilize a liquid (pre-dewatering or pre-lime) or dewatered sludge (post-dewatering or post-lime). Figure 7-4 shows a schematic of a post-dewatering alkaline stabilization system. In most cases, the alkaline material is used in a post-dewatering system producing a dewatered product. Lime requirements range from 10 to 50 percent of the sludge dry solids weight, depending on several factors as discussed below. Adding calcium oxide (CaO) or quicklime generates high pH values. It also generates high temperatures exceeding 55°C (131°F), when added to dewatered biosolids, which destroys pathogens. Addition of lime to biosolids and the high temperatures also volatilizes ammonia, amines, and other odourous compounds. Care must be taken in the design of these systems to prevent odours.

FIGURE 7-4
ALKALINE STABILIZATION SCHEMATIC



Advantages of the alkaline stabilization process include:

- Simplicity of operation
- Organic nitrogen content of biosolids is not significantly reduced
- High pH reduces pathogens and the odour potential of the final biosolids product; high temperatures generated when quicklime is used in post-dewatering stabilization also destroys additional pathogens

Disadvantages of the alkaline stabilization process include:

- High operating cost due to chemical consumption
- Difficult to handle chemicals
- Volatile solids are not oxidized, therefore, there is a risk of odours redeveloping
- Ammonia generation during processing requires odour control
- Biosolids products with a high pH may have restricted uses
- The dry mass and volume of the biosolids may be increased considerably

7.5.2 Post Dewatering Lime (Post-Lime) Stabilization.

The selection of a suitable alkaline product dosage to achieve and maintain an elevated pH depends on a variety of factors, including:

- Chemical characteristics of the material used as the alkaline source
- Chemical characteristics of the biosolids, including both organic and inorganic constituents
- Physical characteristics of the biosolids, including moisture content and viscosity
- Adequacy and speed of mixing the biosolids and the alkaline material
- Length of time high pH is to be maintained

The involvement of these variables has led to a stabilization process where no rational method has been developed that predicts the alkaline dose required to meet a given treatment objective.

7.5.3 Process Objectives.

Alkaline stabilization depends on maintaining the pH at a high enough level for a sufficient period of time to inactivate the microorganism population of the biosolids and prevent odours from redeveloping. Experience has shown that stabilization objectives are met by maintaining a pH of 12 or more for at least two hours. To meet these criteria, previous studies have found the pH should be raised to 12.5 and maintained for at least 30 minutes, as the pH typically decreases slowly during and after the stabilization process. Stabilization by this process halts or substantially retards the microbial reactions that can otherwise lead to odour production and vector attraction. The process can also inactivate viruses, bacteria, and other microorganisms that are present.

7.5.4 Process Variations.

Several variations in the design and operation of alkaline stabilization processes are available. Alkaline stabilization can be used to stabilize raw solids or further stabilize digested biosolids. Both proprietary and non-proprietary processes are available. The most common post-dewatering alkaline stabilization process currently in use are summarized below. The advantages and disadvantages of each process are summarized in Table 7-7.

TABLE 7-7
SUMMARY OF POST-DEWATERING ALKALINE STABILIZATION PROCESSES

Process	Advantages	Disadvantages	Comments
Conventional Lime Stabilization	• Low capital cost • Flexible operation	• "Class B" biosolids • Potential pH instability • Product handling concerns	
Modified Lime Stabilization	• Flexible operation • "Class A" biosolids	• High chemical requirements • High operating costs	
Advanced Alkaline Stabilization (N-Viro)	• "Class A" biosolids • Stable pH/high CCE • Good produce handling characteristics • Revenue from sale as liming agent	• High chemical requirements • High operating costs • Large increase in solids mass • Two chemicals added	
En-Vessel Pasteurization (RDP)	• "Class A" biosolids • Low operating costs • Low chemical requirements • Flexible operation	• Potential pH instability • Product handling concerns	
Biofix (Bio Gro)	• Flexible operation • "Class A or B" biosolids	• High chemical requirements • High operating costs	
Bioset Process	• Low area requirements • "Class A" biosolids • Good odour control	• High capital costs • Two chemicals added • Potential pH instability	

7.5.5 Conventional Lime Stabilization (USEPA Class B).

Conventional lime stabilization consists of mixing quicklime or hydrated lime with raw (or partially digested) dewatered solids to achieve a pH of 12 or greater for a minimum of two hours. This conventional process is classified as a PSRP (Class B) process by the United States Environmental Protection Agency (EPA). The system generally includes a lime storage silo(s), a mixer, a sludge storage bin(s), metering screws, and conveyors.

7.5.6 Modified Lime Stabilization (USEPA Class A).

Modified lime stabilization is similar to conventional lime stabilization except additional quicklime is added to raise the temperature of the biosolids to greater than 70°C. An insulated reactor may be provided to maintain a minimum temperature of 70°C for 30 minutes. The process is classified as a PFRP (Class A) process by the EPA.

7.5.7 Advanced Alkaline Stabilization (N-Viro International Corp.).

The Advanced Alkaline Stabilization with Subsequent Accelerated Drying (AASSAD) process is a variation of lime stabilization and drying processes. The process involves mixing CKD and quicklime with raw (or digested) dewatered solids. Sufficient calcium oxide (in the form of CKD or quicklime) is added to raise the temperatures to a range of 52–62°C. The mixture is then air dried in windrows or thermally dried in one-pass rotary dryers. Heat curing, by maintaining temperatures at a minimum of 52°C for 12 hours, is provided after mixing when air drying is used, or after thermal drying when thermal drying is used.

CKD, a by-product of the cement manufacturing industry, may be used as a partial substitute for quicklime. CKD can be relatively inexpensive source of alkaline material as cement manufacturing plants generally dispose of this material in a landfill.

Like other lime stabilization processes, ammonia is generated by the alkaline addition. The use of thermal drying allows easier containment and collection of odours when drying is required. Thermal drying is used at two of N-Viro's facilities (Leamington and Sarnia, Ontario).

N-Viro currently has about 30 installations worldwide. The largest is at Middlesex, New Jersey.

The process, patented by N-Viro International Corporation (Toledo, Ohio), is classified by the EPA as a PFRP (Class A) process.

In Canada, N-Viro has patented a soil improvement product as N-Viro Soil™ for use to suppress plant-parasitic nematodes.

7.5.8 En-Vessel Pasteurization (RDP Technologies Inc.).

En-Vessel Pasteurization is a variation of the modified lime stabilization process. Quicklime is mixed with dewatered solids to raise the pH to greater than 12. Supplemental heat is added to the biosolids in the blender by electrical heating elements, rather than quicklime, to raise the temperature to about 72°C.

The mixture is conveyed to an insulated pasteurization reactor, which maintains the solids at a minimum temperature of 70°C for 30 minutes.

The process, patented by RDP Technologies Inc. (Norristown, Pennsylvania), produces a Class A biosolids by meeting the PFRP pasteurization criteria. In Canada, there is an installation at the Saanich Peninsula WWTP.

7.5.9 Biofix (Bio-Gro Division, Wheelabrator Water Technologies Inc.).

Biofix is similar to the modified lime stabilization process. Quicklime is mixed with dewatered solids in a blender. The quicklime dosage can be varied to produce either a Class A or Class B product.

The Biofix process is marketed by the Bio Gro Division of Wheelabrator Water Technologies Inc.

7.5.10 Bioset Process.

The Bioset process is similar to RDP's En-vessel Pasteurization process. Quicklime is mixed with dewatered solids to raise the pH to greater than 12. Sulfamic acid, quicklime, and sludge are blended together. An acid-base chemical reaction raises the temperature to 65 to 93°C (150 to 200°F). The mixture is conveyed by a modified progressive cavity pump through a long pipe referred to as the "pressure zone". Pressures of 15 to 20 psig are achieved in the pressure zone.

Bioset, Inc. (Bioset) has one full-scale installation in Houston, Texas and a second facility in Kissimee, Florida. The process, patented by Bioset (Houston, Texas), produces a Class A biosolids by meeting the PFRP pasteurization criteria.

7.6 Stabilization by Irradiation

High energy irradiation is a disinfection process that inactivates pathogens to produce an aseptic product. The process does not reduce the volatile solids or moisture content of the biosolids; therefore, the odour potential and volume of the biosolids are not reduced. The objective of the irradiation process, to inactivate pathogens, is similar to the pasteurization process.

Two types of irradiation, electron (beta) irradiation and gamma irradiation, have been used in the past. Electron irradiation is generated using electron accelerators. Gamma irradiation is obtained from exposure to Cobalt-60 (Co-60) or Cesium-137 (Cs-137). Co-60 is produced by "bombarding" cobalt metal with neutrons. Cs-137 is a by-product from the processing of nuclear wastes.

Gamma irradiators, typically installed with an energy source of radioactive Co-60, have been used since the 1960s for the sterilization of medical products and consumer goods. Their use as a stabilization process for biosolids has been limited to the full-scale biosolids irradiation facility at Geiselbullach, Federal Republic of Germany (FRG). This facility, which services a population of 240,000, irradiates liquid anaerobically digested biosolids at four percent solids prior to utilization of the irradiated product on agricultural land.

Irradiation systems can be used to process liquid and dewatered biosolids. Electron irradiation has been considered for processing liquid biosolids only due to the limited penetrating power (maximum penetration depth approximately 0.2 cm). Gamma irradiation has been considered for processing liquid and dewatered biosolids.

Irradiated biosolids are reported to be non-radioactive. Electron irradiation can induce radioactivity; however, the radioactivity is reported to be insignificant. Gamma irradiation is reported to not induce radioactivity.

Electron and gamma irradiation systems have been used to irradiate liquid biosolids in several bench- and pilot-scale facilities. Only one irradiation facility, in Geiselbullach, FRG, is in full-scale operation. Gamma irradiation has been used in a full-scale facility.

Dosages of 300 to 500 KRad have been used to irradiate liquid biosolids. The European Economic Community (EEC) recommends a 500 KRad dosage for disinfection of liquid biosolids.

Irradiation of dewatered biosolids is a promising technology that has not yet been applied in a full-scale operation. Nordion International Inc. is marketing a proprietary process for irradiation of dewatered biosolids. Past experience with irradiation systems indicates that irradiation may be a suitable alternative to pasteurization.

Irradiation dosages of 400 to 1,000 KRad have been proposed for dewatered and dried biosolids. The dosage depends on the pathogen content of the unirradiated biosolids and the degree of disinfection required. The EEC recommends a minimum dosage of 1,000 KRad for dried biosolids. The U.S. EPA also recommends a minimum dosage of 1,000 KRad at 20°C to achieve pathogen reductions equivalent to a PFRP process.

The irradiation stabilization process, typically, as proposed by Nordion, follows the dewatering process in one of two ways:

- Irradiation of dewatered biosolids, followed by an air-drying stage, where the irradiated biosolids are mixed with wood chips, allowed to dry to 55 to 60 percent dry solids, and are screened and bagged or stored for bulk sale
- Mixing, air-drying, and screening of the dewatered biosolids, followed by irradiation to produce a final biosolids product

Nordion expects that a minimum of 12-days air-drying will be required to produce an irradiated biosolids suitable for marketing and distribution.

A typical gamma irradiation facility consists of:

- The product handling mechanism, including tote boxes and control and safety systems
- The irradiation room, including the Cobalt-60 source storage pool
- The cobalt-60 gamma irradiation source
- Mixing and air drying

Biosolids from the dewatering process would be conveyed into aluminum tote boxes. These totes move automatically and continuously into the concrete Irradiator Building. A water-filled pool is installed in the floor of the irradiation room. This pool acts as a storage area for the cobalt-60 source when the irradiator is not in use. During processing, the source is raised from the storage pool to its irradiate position in the middle of the irradiation room. Totes are then conveyed by the product handling mechanism in a predetermined pattern around the source. Nordion's system is designed to provide an irradiation dose of 600 KRad.

The irradiated biosolids are dumped out of the totes and moved to a mixing area where woodchips are added to facilitate air drying. The irradiated biosolids mixture is formed into a pile, which is occasionally turned to prevent heat and odour buildup. Following this air-drying step, the irradiated product is reported to be suitable for utilization.

The cobalt-60 gamma source used in the irradiation process consists of a stainless steel frame which holds a number of stainless steel cobalt-60 sources. The cobalt-60 emits gamma rays that are able to pass through the biosolids. The cobalt-60 source will need to be replenished every one to two years. After about 15 years, Nordion will accept the original cobalt-60, which it supplied (and that is now depleted), for reprocessing, recycling, or disposal.

7.7 Summary and Assessment of Long List of Treatment Technologies

The summary and assessment of the long list of treatment technologies is displayed in Attachment 1.

Viable treatment technologies are:

- Stabilization
- Conditioning and dewatering
- Heat drying
- Alkaline stabilization

8. Screened Alternatives

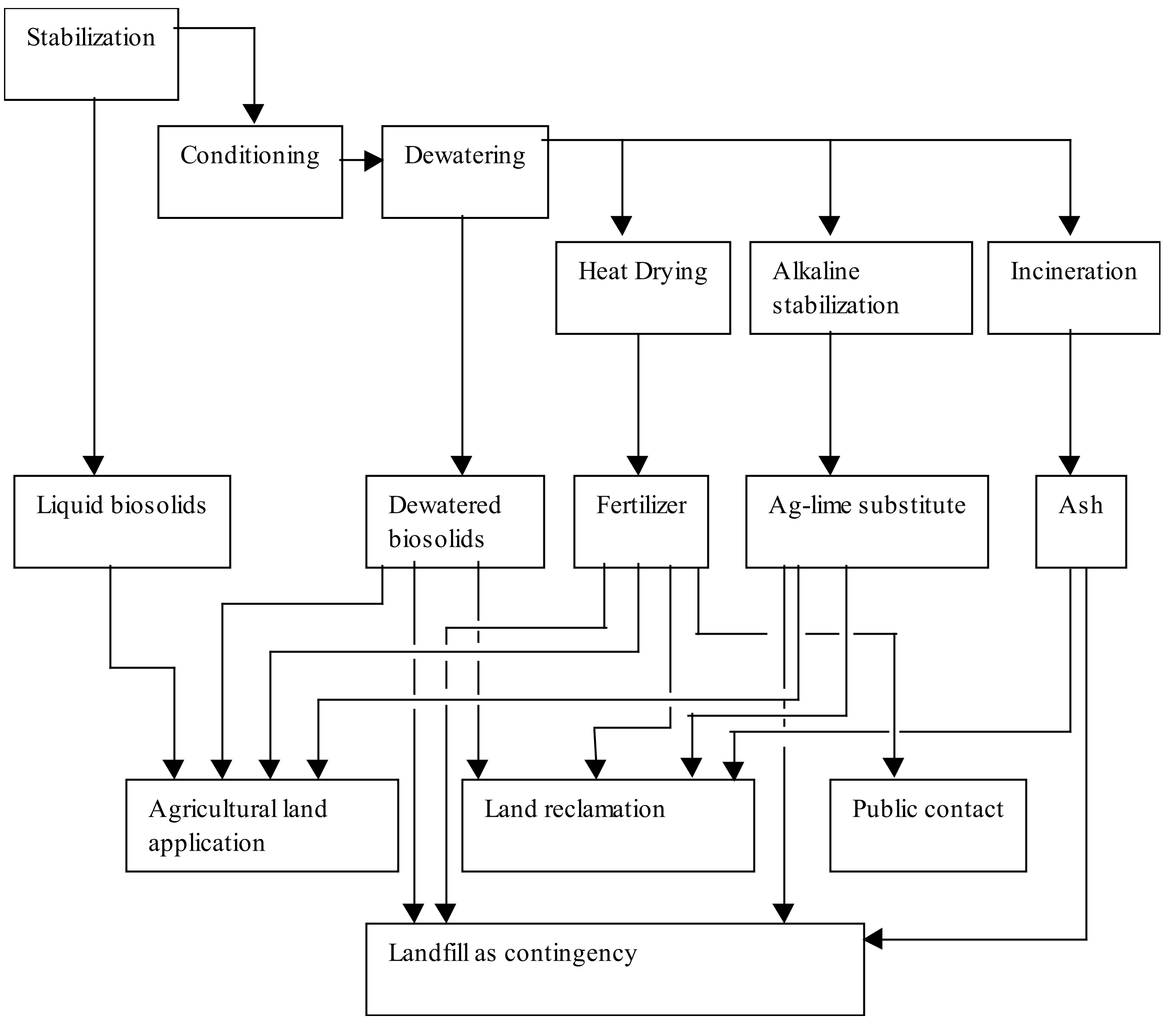
Through investigation of the long list of biosolids management alternatives, and evaluation of these alternatives using the screening criteria, it was determined that:

- Viable end uses are:
  - Agricultural land application
  - Land reclamation
  - Public contact
  - Landfill as contingency only
- Viable products are:
  - Liquid digested/stabilized
  - Digested/stabilized dewatered
  - Ag-lime substitute
  - Fertilizer

- Viable treatment technologies are
  - Stabilization
  - Conditioning and dewatering
  - Heat drying
  - Alkaline stabilization

The interactions between these end uses, products, and treatment technologies are shown in Figure 8-1.

FIGURE 8-1
SUMMARY OF SCREENED ALTERNATIVES



Part 2 of Task 4 will evaluate these technologies, and ensure that the products and end uses meet the minimum detailed evaluation criteria. Through the evaluation process, recommendations for the City of Guelph's Biosolids Master Plan will be developed.

ATTACHMENT 1

SUMMARY OF TECHNOLOGIES

ATTACHMENT II

Comparison of Biosolids Processing Technologies

Process/ Operation	Description	Advantages	Disadvantages	Assessment
Conditioning/Optimization				
Polymer	Biosolids mixed with polymer prior to dewatering to condition solids and promote the separation of water	• Minimal increase in solids contents • Proven process	• Increased potential for odours • High cost of polymer	*Meets screening criteria*
Inorganic chemicals	Inorganic salts, such as ferric chloride and alum used for conditioning	• May aid in odour control	• Solids mass increased	*Not suitable for required products*
Thermal conditioning (Zimpro)	Sludge conditioned at high temperatures and pressures to partially oxidize organics	• High solids content in dewatered cake (~50% TS) • No chemicals required • Sludge quantities (solids and volume) reduced • Reduces NOx emissions in incineration process	• High COD and nutrients in recycle stream from decanting and dewatering requires treatment • High potential for odours from process • Limited to pretreatment before incineration	*Limited to pretreatment before incineration*
Cambi Process	Combines thermal conditioning, anaerobic digestion, and dewatering	• High VS reduction • High biogas production • Class A biosolids • Reduced biosolids quantities	• High potential for odours • High processing costs • Limited full-scale experience • Potential for digestion process upset	*Does not meet reliability criteria*
Thermal Hydrolysis	Variation of thermal conditioning and acidification	• Acidification solubilizes phosphorus for recovery from dewatering recycle stream	• High processing cost • Potential for odours • Lower nutrient content in dewatered cake • Limited full-scale experience	*Does not meet reliability criteria*
Acidification	Sludge acidified with sulfuric acid to solubilize organics	• Reduced sludge production	• Limited full-scale experience	*Does not meet reliability criteria*
Kady Process	Mechanical cavitation device ruptures biological cells	• Reduces sludge production	• Limited full-scale operating experience	*Does not meet reliability criteria*

Process/ Operation	Description	Advantages	Disadvantages	Assessment
Acoustical cavitation	Acoustic device provides agitation to break surface tension between solids and liquid	• Reduces polymer use • Increases solids content	• Not used at full-scale • Limited data from bench scale testing of batch process	*Does not meet reliability criteria*
Carbon dioxide injection – Pre-dewatering	Carbon injection into biosolids prior to dewatering	• Minimizes struvite formation	• Limited full-scale experience	*Consider for pilot testing if future process changes result in scaling in centrifuge centrate lines*
Carbon dioxide injection – Alkaline Stabilization (Wurtz Process)	Carbon injection into dewatered biosolids and alkaline material mixture during alkaline stabilization	• Increases heat generation when used with quicklime	• Limited full-scale experience • May reduce long term stability	*Does not meet reliability criteria*
Electrocoagulation	Variation of inorganic chemicals		• Not proven at full-scale	*Does not meet reliability criteria*
Electroacoustic Dewatering (EAD)	Electric and ultrasonic fields used with BFPs	• Slight increase in cake solids content	• No full-scale experience	*Does not meet reliability criteria*
Electroosmotic Dewatering	Similar to EAD without ultrasonic field	• Slight increase in cake solids	• Not proven at full-scale	*Does not meet reliability criteria*
Electrodewatering	Electric field applied to RPFP	• Increase in cake solids content	• No full-scale experience	*Does not meet reliability criteria*
Enzyme condtioning	Enzymes mixed with biosolids		• Long conditioning time (16 hr) • Not proven at full-scale	*Does not meet reliability criteria*
Freeze-thaw (natural)	Freezing sludge solids in thin layers; used with drying beds	• High solids content achievable (40%+) • Low capital cost	• Weather dependant • Potential for odours • Large land area required	*Not suitable technology for Guelph WWTP*
Freeze-thaw (mechanical)	Refrigeration to freeze sludge solids; followed by thaw and mechanical dewatering	• High solids content achievable (40%+)	• Not proven at full-scale	*Does not meet reliability criteria*
Preheating	Heat to 60°C for 30 min to reduce viscosity	• Decreased polymer use • Increased centrifuge throughput	• High potential for odours • Demonstration stage only	*Does not meet reliability criteria*
Pulse Power	Biosolids passed through high voltage arc chamber to condition before digestion	• Improved VS reduction reported	• Not proven at full-scale	*Does not meet reliability criteria*
Sirex Pulse Power	Variation of pulse power; used with gravity thickeners		• Not proven at full-scale	*Does not meet reliability criteria*

Process/ Operation	Description	Advantages	Disadvantages	Assessment
Oxygen Injection – Incineration	Oxygen injected into MHF incinerators	• Increases capacity	• Limited full-scale experience	*Does not meet reliability criteria*
Thickening – Waste Activated Solids or Digested Biosolids				
Centrifuge	Thickened by centrifugal force for solids/liquid separation	• No chemicals required	• Reduced solids capture under some conditions	*Meets screening criteria*
Gravity belt thickener (GBT)	Conditioned biosolids conveyed over porous belt for solids/liquid separation	• Low capital cost • Good performance	• Potential for odours	*Meets screening criteria*
Rotary Drum Thickener	Similar to GBT except solids conveyed through rotating drum	• Low capital cost • Better containment of odours	• Higher polymer requirements • Limited control over solids content	*Meets screening criteria*
Anoxic Gas Flotation	Digested biosolids thickened in flotation thickener with biogas	• Reduces digester volume	• Not proven at full-scale	*Track progress for future digester upgrades*
Dissolved Air Flotation (DAF)	Dissolved air released into WAS for separation of solids from liquid by flotation	• Reliable proven process	• High energy costs • Odorous air requires treatment • Polymer required	*Meets screening criteria*
Bioflot	Similar to DAF. Nitrogen gas generated by bacteria	• Low energy requirement	• Calcium nitrate addition required • Limited full-scale testing	*Does not meet reliability criteria*
Recuperative Thickening	Similar to anoxic gas flotation. Centrifuge used for biosolids thickening	• Reduces digester volume • Reduces risk of ammonia toxicity	• Limited full-scale experience	*Track progress for future digester expansions/upgrade*
Stabilization Processes – Liquid:				
Conventional Anaerobic Digestion	Digestion in completely mixed tanks under anaero-bic conditions at 29 – 38°C, for a period of greater than15 days. Twostage systems have unheated, unmixed second stage for thickening and further stabilization.	• Valuable end-product, methane, that is combustible and can be used to produce heat for the digestion process and other uses • Relatively low operating costs • Biosolids suitable for application on land as a soil conditioner • Mass of solids reduced • Commonly used and well understood process	• Methane-producing bacteria are slow growing and sensitive to process upset • Digesters have high capital cost • Relatively complex operation • Potential risk from methane gas leak	*Meets screening criteria*

Process/ Operation	Description	Advantages	Disadvantages	Assessment
Thermophilic anaerobic digestion	Similar to conventional, except operating temperatures at 50 – 60°C	• May reduce digestion time • Enhances VS reduction and biogas generation • May produce Class A biosolids	• Poor sidestream quality • Higher digester cost • Requires additional heat input • Process more susceptible to upset • Less biogas for energy recovery • Series operation to prevent short-circuiting	
Temperature-Phased Anaerobic Digestion	Combination of thermophilic and conventional anaerobic digestion	• Good pathogen reduction • May produce Class A biosolids	• Limited full-scale experience	*Review for potential upgrade to produce "Class A" biosolids*
Conventional Aerobic digestion	Digestion in completely mixed tanks under aerobic conditions at ambient temperatures, for a period of 20 – 45 days. Typically, two stage systems with thickening in the second stage.	• Low capital costs • Large land area • Easy operation	• High O&M costs • Poor dewaterability of digested solids • No methane biogas • Poor performance at cold temperatures (<15°C) • Odours and foaming	*Does not meet odour criteria*
ATAD	Similar to conventional aerobic digestion, except temperatures are in range of 50 – 60°C, for a period of 6 – 12 days. Biosolids thickened before digestion. Tanks are covered. Typically, 2 or more tanks in series.	• Reduces pathogens to produce high-grade Class A biosolids • Decreases space requirements	• Odours and foaming • Questionable dewaterability of digested solids • No energy recovery • High O&M costs • Multiple units • Reliability/upsets • Mechanical thickening required	*Does not meet odour criteria*
Vertad Process	Similar to ATAD process in a deep-shaft configuration	• Class A biosolids	• No full-scale experience	*Does not meet reliability criteria*
Dual digestion	Similar to conventional aerobic digestion, except thermophilic, aerobic stage used before anaerobic digestion. Pure oxygen used for aeration. SRT approx. 1 – 2 days.	• Class A biosolids • Potential SRT reduction • Compatible with oxygen activated sludge	• Odour and foaming control required • Oxygen required for thermophilic aerobic digester • Few full-scale facilities • Mechanical thickening required	*Does not meet odour criteria*

Process/ Operation	Description	Advantages	Disadvantages	Assessment
Aerobic Thermophilic Pre-Treatment (ATP)	Thermophilic aerobic digestion using air for aeration. SRT approx. 1 – 2 days. Typically used for pretreatment prior to conventional anaerobic digestion.	• Class A biosolids • Potential SRT reduction	• Odour and foaming control required • Few full-scale facilities • Mechanical thickening required	*Does not meet odour criteria*
Two-Phase Anaerobic Digestion (TPAD)	Similar to conventional anaerobic digestion, except digesters operated in series, with acidification and methanogenisis in separate digesters	• Potential reduction in digester volume and capital costs • Potential for Class A biosolids	• Limited full-scale experience • Higher potential for process upsets	*Track progress for future digestion facility upgrades*
Pre-pasteurization	Biosolids heated to greater than 70 °C in vessels with retention times greater than 30 minutes.	• Class A biosolids • Add to existing facilities • Small footprint	• Full-scale applications • High O&M costs • Potential odour and scaling problems	*Does not meet odour or reliability criteria*
Aerobic/Anoxic Digestion	Variation of conventional aerobic digestion	• Reduced oxygen requirements with denitrification • Temperature control with mechanical thickening	• Limited to aerobic digestion facilities	*Consider only if aerobic digestion is selected*
Biocombustion (Pirt) Process	Four stage mesophilic-thermophilic digestion	• High VS reduction reported	• No full-scale experience	*Does not meet reliability criteria*
Brinecell Process	Brinecell generates chlorine to disinfect biosolids		• No pilot or full-scale experience	*Does not meet reliability criteria*
High Pressure Anaerobic Digestion	Variation of conventional anaerobic digestion. Operates at 2 – 5 atm.	• Gas compressors not required	• Not proven at full-scale	*Does not meet reliability criteria*
Irradiation – electron beam	Irradiation source used to disinfect biosolids.	• Good pathogen reduction	• Biosolids not stabilized • Limited full-scale experience • Public concern with radiation • Pathogen regrowth if not stabilized	*Does not meet reliability criteria*
Lime Stabilization – Liquid	Lime or other alkaline materials blended with sludge for about 1 hour; pH raised to > 12.	• Small area required • Low capital costs • Applicable to small STPs	• High chemical requirements • Biosolids temporarily stabilized • Increase in solids	*Meets screening criteria*
Liquid A (RDP)	Variation of liquid lime stabilization	• Class A biosolids	• Energy for heating biosolids to 65 °C	*Meets screening criteria*

Process/ Operation	Description	Advantages	Disadvantages	Assessment
Active Sludge Pasteurization	Anhydrous ammonia and phosphoric acid added to thickened sludge	• High temperature (65 – 70 °C) and high pH (pH > 11.5) kills pathogens • High nutrient content	• Biosolids not stabilized • Potential for odour redevelopment • No full-scale experience	*Does not meet reliability criteria*
Micronair	Combination of aerobic digestion and DAF	• Reduce aerobic digester volume • Increase VS reduction	• Limited full-scale experience	*Does not meet reliability criteria*
Ozone (Oxyozone, Synox)	Thickened sludge acidified and mixed with ozone for 30 min. Several process variations with dewatering, lime stabilization and drying		• No full-scale experience	*Does not meet reliability criteria*
Bacterial Metal Leaching	Bacterial acidification of sludge to pH of 2	• Solubilization and removal of metals with dewatering • Good pathogen reduction	• No full-scale experience	*Does not meet reliability criteria*
Dewatering Processes:				
Sand Drying Beds	Biosolids applied in thin layers over drying area. Moisture removed by drainage and evaporation. Variations include paved drying beds, engineered-media beds (GFS), and enclosed beds.	• Capital cost is low for small plants (particularly where bed lining and leachate control is not necessary and where land is available) • Low requirement for operator attention and skill • Low electric power consumption • Low sensitivity to biosolids variability • Low polymer consumption • Moderate to high cake solids contents	• Lack of rational design approach for sound economic analysis • Large land requirement • Stabilized biosolids requirement • Impact of climatic effects on design • High visibility to general public • Labour-intensive biosolids removal • Permitting and groundwater contami-nation concerns • High equipment costs for bed cleaning systems • Real or perceived odour and visual nuisances • Effectiveness is weather dependent	*Does not meet reliability criteria*
Vacuum Assisted Dewatering Beds (EDI)	Variation of sand drying beds using engineered-media bed with vacuum to dewater polymer conditioned biosolids	• Low land requirements • Suitable for climates with low evaporation rates • Short retention time (~ 1 day)	• Polymer required for conditioning • Building required to house bed and equipment • low cake solids content (15% - 20% TS)	*Does not meet reliability criteria*

Process/ Operation	Description	Advantages	Disadvantages	Assessment
Mechanically-Assisted Drying Beds (Brown Bear)	Variation of sand drying beds. Paved beds with auger aerator tractors used to increase evaporation rates.	• Reduced drying period and bed area • Suitable for climates with high evaporation rates • High cake solids contents	• Effectiveness is weather dependent • Potential for odours • Higher equipment capital and O&M costs	*Does not meet odour or reliability criteria*
Solar Dryer (Thermo-System by Parkson)	Dries liquid or dewatered biosolids to over 70% using solar rays in a greenhouse-like drying chamber	• Energy and operator costs lower than other thermal drying technologies • Consistent product • Odours are contained and can be treated	• Large land area required • Limited full-scale experience	*Does not meet reliability criteria*
Quick-Dry (Deskin) Process	Variation of conventional drying beds, with proprietary drainage media	• Improved rate of drainage to reduce drying time	• Used with polymer conditioning • Large land area • Applicable to small plants	*Does not meet reliability criteria*
DAB System	Batch gravity dewatering process in large silos. Liquid drains through porous screens	• Low capital and operating cost • Moderate solids content (15 – 20% TS)	• Polymer conditioning required • Applicable for small facilities only • Batch process (~ 12 hrs/cycle) • Limited full-scale experience	*Does not meet reliability criteria*
Sludge Bagger (Draimad)	Batch gravity dewatering. Biosolids polymer conditioned and conveyed to porous plastic bags. Liquid drains through bags.	• Low capital and operating costs • Bags used for storage	• For small facilities only • Poor solids capture in some cases • Potential for odours	*Does not meet odour or reliability criteria*
Rectangular Bin Gravity Dewatering (Simon Moos)	Similar to DAB process, without live-bottom conveyors	• Low capital cost • Mobile unit	• Polymer conditioning required • For small facilities only	*Does not meet reliability criteria*
Screw/Rotary Press	Biosolids pressed between porous screens.	• Flexible control capability for optimizing process performance • Low operating speeds • Low capital costs • Low operator attention requirements • Low power consumption • Contained process minimizes housekeeping and odour potential • Low noise potential	• Limited experience and success dewatering sewage biosolids • Relatively low unit capacity • Moderate polymer requirements • Low solids capture • Low to moderate cake solids concentration	*Does not meet reliability criteria*

Process/ Operation	Description	Advantages	Disadvantages	Assessment
Recessed Plate Filter Press (RPFP)	Batch process. Biosolids pressed in a chamber between two plates or membranes under increasing pressure.	• Contained process minimizes housekeeping • Relatively moderate power consumption • High solids capture • High cake solids concentration • Moderate noise potential	• Batch operation • Operator attention required during cake discharge • Potential for poor cake release may require precoat • Odour potential • Relatively high capital cost • Moderate to high polymer requirement	*Does not meet odour criteria*
Tubular filter press	Variation of RPFP. Biosolids pressed in tubes rather than between plates	• Good cake separation from dewatering may be possible	• No full-scale experience	*Does not meet reliability criteria*
Verti-press	Variation of RPFP. Plates stacked horizontally onto moving belts	• Improved automation of cake removal possible	• No full-scale experience	*Does not meet reliability criteria*
Centrifuge (high torque)	Centrifugal force used to separate moisture from biosolids. Long bowl type.	• Contained process minimizes housekeeping and odour considerations • Continuous operation provides flexible control capability for process performance • Moderate or high cake solids concentration • Relatively small area requirements • Moderate to high throughput capabilities versus space requirements • Low operator attention requirements • High solids capture	• Relatively high capital cost • Relatively high power requirements • Moderate to high polymer requirements • High operating speeds; • High noise potential	*Meets screening criteria*
Belt Filter Press	Biosolids pressed between two porous moving belts.	• Relatively low capital cost • Relatively low power consumption • High solids capture with minimum polymer • Continuous feed • Moderate cake solids concentration • Moderate throughout capabilities versus space requirement • Open design provides good visual control capability for process performance	• Housekeeping – open design does not allow containment during process upsets, odour potentia • Moderate operator attention require-ments • Odour potential • Maintenance downtime • Sensitive to incoming feed characteristics	*Meets screening criteria*

Process/ Operation	Description	Advantages	Disadvantages	Assessment
Stabilization Processes – Post-Dewatering:				
Irradiation – gamma ray	Similar to electron-beam irradiation	• Good pathogen reduction	• Limited full-scale experience	*Does not meet reliability criteria*
Composting-open	Windrow or aerated static pile (ASP) composting. Biosolids mixed with wood chips or other amendments and formed into piles. Piles aerated mechanically or by drawing air through the piles.	• Low capital costs • Class A biosolids possible	• Weather dependent • High O&M costs • Labour intensive • Potential for odours • Potential for pathogen emissions through aerosols • Large land requirements	*Does not meet environmentally safe (for compost as a stand-alone product) or odour criteria*
Composting – Enclosed / In-vessel	Similar to open composting, except compost process occurs in a vessel, channel or building	• Good pathogen reduction because temperatures are maintained at greater than 55°C for longer than 3 consecutive days • Good volatile solids destruction • Easily handled product • Odour free final biosolids product • Lower risk of groundwater and surface water contamination from compost product application • Co-composting with municipal solid wastes can be considered	• High capital and/or operating costs • Biosolids dewatering required • Relatively high land requirements (depending on the compost process used) • Potential for odours during processing; • Existing regulations in Ontario severely restrict potential uses of compost product due to low metal limits	*Does not meet environmentally safe (for compost as a stand-alone product) or odour criteria*
Co-Composing	Similar to biosolids composting, except biosolids is a component in the composting process, with municipal solid waste	• Lower per tonne capital and operating costs • Moisture, nitrogen supply for solid waste composting	• Potential for odours • Metal in biosolids may reduce compost value	*Does not meet environmentally safe (for compost as a stand-alone product), odour or reliability criteria*
Vermi-composting	Dewatered sludge mixed with earthworms. Earthworms consume solids producing stabilized castings	• Low capital cost • Lower potential for odours	• Ammonia toxic to worms • Separation of worms and metal contamination of worms • Limited full-scale experience	*Does not meet environmentally safe (for compost as a stand-alone product), odour or reliability criteria*

Process/ Operation	Description	Advantages	Disadvantages	Assessment
Thermal Drying - Direct Rotary Dryer	Moisture evaporated from biosolids by mixing hot gas with the biosolids in a rotating drum	• High heat transfer rates due to direct contact of the drying medium with the biosolids, thereby decreasing the residence time of the biosolids within the dryer • Flexibility of temperature control achievable by varying the flow and/or temperature of the hot gas over the biosolids	• Potential for combustion and explosions of the biosolids material in the dryer • Thermal inefficiency due to high sensible heat loss in the stack gases • The large volume of off-gas requiring treatment for dust entertainment and odours	*Meets screening criteria*
Thermal Drying – Indirect Connective Drying (Stordt, Sludge Master IRC, Dragon Dryer)	Moisture evaporated from biosolids by contact with a hot surface. Hot gas or fluid passed through hollow screw augers and/or hollow shells to provide the heated surface. A small quantity of sweep gas is drawn through the dryer to remove the moisture.	• Minimal volumes of off-gas are produced when compared to direct drying; a relatively low flow rate of purge gas (if any) is required to discharge the vapour resulting from the evaporated liquid • Dust entertainment in the exhaust air is minimized when compared to direct dryers because the heating medium does not contact the biosolids • The atmosphere inside the dryer is inherently inert, minimizing the potential explosive and fire hazards • A higher thermal efficiency can be achieved • A variety of thermal media can be used including • Gas, oil, and steam	• Higher costs for providing a thermal source such as steam, hot water or hot oil (if such a source is not readily available) • Heat transfer surfaces could become fouled if not cleaned regularly	*Meets screening criteria*
Vertical hearth dryers (thin film)	Solids conveyed vertically down several hearths	• Retrofit for multiple hearth furnace incinerators	• Limited full-scale experience	*Does not meet reliability criteria*
Thermotech	Variation of combined ATP, centrifuge dewatering and thermal drying. Several process variations	• Used without digestion • Slight increase in product stability over raw sludge thermal drying • Class A biosolids	• High capital costs • Potential for odours • Minimum size requires addition of other feedstock such as food waste or garbage • Limited full-scale operating experience	*Does not meet reliability criteria*
Flash Dryer	Spray atomization used to inject biosolids into drying zone	• Class A biosolids	• Potential for explosions • Few full-scale operating facilities	*Does not meet reliability criteria*

Process/ Operation	Description	Advantages	Disadvantages	Assessment
Solar Dryer (Thermo-System by Parkson)	Dries liquid or dewatered biosolids to over 70% using solar rays in a greenhouse-like drying chamber	• Energy and operator costs lower than other drying technologies • Consistent product • Odours are contained and can be treated	• Large land area required • Limited full-scale experience	*Does not meet reliability criteria*
Carver-Greenfield Process	Multiple-effect dehydration using carrier oil	• Class A biosolids may be possible	• Powder product potentially explosive • High capital and operating costs • Limited full-scale facilities	*Does not meet reliability criteria*
Centridry Process (Humboldt)	Combined dewatering and drying in a centrifuge	• Class A biosolids may be possible • No solids recycling	• Limited full-scale experience	*Does not meet reliability criteria*
DryVac / Rollfit	Combines RPFP with thermal drying.	• Class A biosolids may be possible	• Limited full-scale experience	*Does not meet reliability criteria*
Infrared drying	Variation of indirect drying using infrared heating elements	• Similar to indirect drying	• Limited full-scale experience	*Does not meet reliability criteria*
Microwave drying	Heat provided by micro-waves		• No full-scale experience	*Does not meet reliability criteria*
Fluidized bed drying	Evaporation in a fluidized bed of sand.	• Rapid drying of sludge	• Limited to pretreatment for incineration • Limited full-scale operating experience	*Does not meet reliability criteria*
Tray / Belt Dryers	Biosolids conveyed on belts or trays through sev. drying zones		• No full-scale experience	*Does not meet reliability criteria*
Ball Bearing Dryer (DHV)	Heated ball bearings mixed with sludge in screw conveyors	• Low capital cost reported	• No full-scale facilities	*Does not meet reliability criteria*
EcoTechnology	Combination of dewatering, direct and indirect thermal drying		• No full-scale experience	*Does not meet reliability criteria*

Process/ Operation	Description	Advantages	Disadvantages	Assessment
Alkaline Stabilization	Biosolids mixed with alkaline materials, such as quick lime or hydrated lime, to increase the pH to inhibit biological activity. A temperature rise with quicklime addition may also kill pathogens and pasteurize the biosolids.	• Simplicity of operation; • Organic nitrogen content of sludge or biosolids is not significantly reduced; • High pH reduces pathogens and the odour potential • High temperatures generated when quick-lime is used in post-dewatering stabilization also destroy additional pathogens	• High operating cost due to chemical consumption; • Difficult to handle chemicals; • Volatile solids are not oxidized; risk of odours redeveloping; • Ammonia generation during processing requires odour control; • Biosolids products with a high pH may have restricted uses; • The dry mass of the biosolids is increased considerably.	*Meets screening criteria*
AASSAD (N-Viro)	Variation of conventional alkaline stabilization. CKD and LKD used as alternative source of CaO. Windrows used for air drying.	• Class A biosolids • Stable pH / high CCE • Good handling characteristics • Revenue from sale as liming agent	• High chemical req'ts • High operating costs • Increase in solids mass • Two chemicals added	*Meets screening criteria*
Biodry (N-Viro)	Same as AASSAD, except one-pass dryer and scrubber used rather than windrow	• Similar to AASSAD • Improved containment of ammonia and other odour emissions • Only one chemical added	• Similar to AASSAD • High capital and O&M costs	*Meets screening criteria*
Envessel Pasteurization (RDP)	Variation of conventional alkaline stabilization. Heated screws and through in mixer used to supplement heat from chemical reaction	• Class A biosolids • Low operating costs • Lower chemical req'ts • Flexible operation	• Potential pH instability • Product handling concerns • Odour concerns	*Meets screening criteria*
Chemifix	Sludge blended with alkaline materials, Portland cement and sodium silicates	• Product with high compressive strength	• High operating cost • Limited full-scale applications	*Does not meet reliability criteria*
Pori ST Process	Dewatered biosolids further processed by acidification, steam injection, lime addition and second-stage dewatering	• High cake solids content (65 – 70% TS)	• High processing costs • No full-scale facilities	*Does not meet reliability criteria*

Process/ Operation	Description	Advantages	Disadvantages	Assessment
Biofix (Synagro/ Biogro)	Variation of conventional alkaline stabilization. Quicklime blended with biosolids	• Class A or B biosolids • Flexible operation	• High chemical requirements • High operating cost	*Meets screening criteria*
Bioset	Variation of conventional alkaline stabilization. Sulfamic acid and quick-lime blended with biosolids	• Class A biosolids • Lower chemical requirements • Lower area requirements	• High capital costs • Two chemicals added • Potential pH instability • No full-scale fixed facilities	*Does not meet reliability criteria*
High Temperature Combustion /Oxidation Processes:				
Thermal Oxidation (incineration)	High temperatures and pressures used to break and oxidize cellular material, releasing bound water	• Maximum solids reduction • Energy recovery • Pathogens eliminated • Stable, odourless ash • Easily dewaterable ash	• High O& M costs • High capital costs • High maintenance requirements, ash may be hazardous due to metal leachability • Air pollution control • Public perception	*Product does not meet environmental criteria as landfilling is not a reliable alternative*
Fluidized Bed Furnaces – thermal oxidation	Sludge combusted in a fluidized bed	• No additional fuel for dewatered cake greater than about 35 % TS	• Same as thermal oxidation	*Product does not meet environmental criteria as landfilling is not a reliable alternative*
Multiple-hearth furnace – thermal oxidation	Sludge conveyed down over several hearths	• Similar to FBF	• Same as thermal oxidation • Afterburner required for control of emissions	*Product does not meet environmental criteria as landfilling is not a reliable alternative*
RHOX Process	Variation of MHF with lower top-hearth tempera-ture and external after-burner following air pollu-tion control train	• Lower fuel usage • Lower metal and organics emissions • Economical retrofit technology	• Same as thermal oxidation • Limited full-scale experience	*Product does not meet environmental or reliability criteria Landfilling is not a reliable alternative*
Melting Furnace (Kubota; Cormin)	Slagging furnace that forms ash into glassy material	• Metals will not leach from sintered ash product	• High capital and operating costs • Limited full-scale facilities in Japan only	*Product does not meet environmental or reliability criteria Landfilling is not a reliable alternative*

Process/ Operation	Description	Advantages	Disadvantages	Assessment
Glass Aggregate (Minergy)	Heat drying followed by vitrification in a cyclonic slagging furnace with heat recovery	• Metals will not leach from glass aggregate • Production of electrical energy	• High capital and operating costs • Furnaces limited 300 t/d DS or larger • Consumes large quantities of natural gas • Limited full-scale facilities	*Does not meet reliability criteria*
Catalytic Extraction	Similar to melting furnace. Molten metals and chemical reactants added to oxidize solids	• Complete pathogen destruction and stabilization of solids	• No full-scale experience	*Does not meet reliability criteria*
Molten-salt Incineration	Combustion in bed of molten salts		• No full-scale experience	*Does not meet reliability criteria*
Wet Air Oxidation (Kenox)	Similar to Zimpro thermal conditioning; except longer retention time and complete oxidation of organics	• Nearly complete pathogen and organics destruction	• High capital and operating costs • High potential for odours • High maintenance costs • Limited full-scale experience	*Does not meet reliability criteria*
Deep-Shaft Oxidation (Vertox)	Variation of wet air oxidation in a deep shaft configuration	• Same as Wet air oxidation	• No full-scale facilities in operation	*Does not meet reliability criteria*
Super Critical Water Oxidation	Oxidation at high temperatures (375 – 650°C) and pressures (220 – 250 bar)	• Rapid oxidation of organics	• Corrosion concerns • No full-scale experience	*Does not meet reliability criteria*
Oil from sludge (pyrolysis)	Dewatered biosolids pyrolized to produce a viscous oil product. Char (ash) generated as a by-product.	• Reduces solids mass • Produce small quantities of reusable oil product • Small land requirement	• Scaling concerns • Unproven at full-scale • Potential for odours • High capital cost • Drying required • Oil characteristics poor	*Does not meet reliability criteria*
Gasification (pyrolysis).	Variation of Oil-from-Sludge process. (Syngass – Thermanetic, Renugas)	• Methanol or low BTU gas produced • High capital and operating costs	• No full-scale experience	*Does not meet reliability criteria*
Electric-arc gasification	Variation of gasification. Heat from electric air, rather than oxidation		• No full-scale experience	*Does not meet reliability criteria*

Process/ Operation	Description	Advantages	Disadvantages	Assessment
Microwave gasification	Combination of pyrolysis and combustion	• Sludge volume reduced • Energy recovered	• No full-scale experience	*Does not meet reliability criteria*
Co-gasification	Variation of gasification using coal and sludge	• Metals encapsulated at high operating temperatures up to 2,500°C	• High capital and operating costs • No full-scale experience	*Does not meet reliability criteria*
Oil Extraction (Best, McDonald) Process	Solvent mixed with liquid biosolids, with dewatering, drying, and distillation	• Separates oil from contaminated sludges	• No full-scale experience on biosolids	*Does not meet reliability criteria*

City of Guelph Biosolids Management Plan
Task 4 Evaluation of Biosolids Management Alternatives – Part 2 Results of Screening of Long List of Alternatives and Development of Evaluation Process for Short Listed Strategies

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DATE: August 3, 2004

1. Introduction

Task 4 of the Biosolids Master Plan included developing a long list of biosolids end uses, products, and technologies, and developing screening criteria to determine which alternatives on the long list should be carried forward to the development of management strategies for detailed evaluation. The results of this exercise are presented in a separate memorandum, *Task 4 Evaluation of Biosolids Management Alternatives – Part 1*. This memorandum summarizes the screening of the long list of technologies and end use practices available for managing biosolids, and presents the management strategies developed from the short listed options and the proposed methodology for evaluating the strategies. Task 4 was preceded by Tasks 1, 2, and 3, which included collecting the background information required for the Biosolids Master Plan, and assessing the feasibility and cost of maintaining the existing biosolids composting system for the long-term.

It was determined that the WWTP solids management processes (anaerobic digestion combined with composting) have or could, with minor upgrades, have sufficient capacity to manage the anticipated solids volumes that will be generated to the Stage 2 liquid side treatment capacity expansion plans of 73 ML/d. However, based on the investigation of market potential, it was determined that it is unlikely the composted biosolids product produced at the WWTP will gain regulatory acceptance in Ontario as a standalone material for sale.

The current lack of regulatory acceptance for the WWTP compost, lack of a suitable market, reliability issues associated with the compost facility, and increasing costs of composting and compost disposal resulted in the City's proactive decision to initiate Task 4 of the Biosolids Master Plan to address both short-term and long-term biosolids management issues.

2. Background

The City of Guelph currently supplies treated water for, and collects and treats wastewater from, a population of approximately 100,000. In 2000, some 30,000 tonnes of biosolids were produced and composted, land applied, or landfilled. The long-term biosolids management plan will consider treatment requirements up to the maximum capacity of the WWTP after the Stage 2 expansion to 73 ML/d (up to 16.6 dry tonnes per day, under maximum industrial loadings scenario, as discussed in TM1) and recommend suitable management practices.

3. Screening Results

A summary of the screening exercise for end uses is presented in Table 3.1. A summary of the screening exercise for technologies is presented in Table 3.2. A discussion of the screening exercise follows.

TABLE 3.1
SUMMARY OF SCREENING EXERCISE FOR END USES

End Use Option	Must-Have Criteria				Remarks
	Community Health & Safety	Reliability	Sustainability	Flexibility	
Agricultural Land	Pass	Pass	Pass	Pass	
Forested Land	Pass	Pass	Fail	Pass	Sufficient area of forested land is not available
Land Reclamation	Pass	Pass	Pass	Pass	
Landfill Disposal*	Pass	Pass	Fail	Pass	No operating landfill in Guelph area
Public Contact	Pass	Pass	Pass	Pass	
Industrial Reuse	Pass	Pass	Fail	Pass	No market potential

Notes: * Landfilling could be maintained as a back-up end-use, utilizing facilities outside of the Guelph area
The shaded End Use Options pass all must-have criteria

Six end-use alternatives were screened using three "must-have" criteria. Three of the options failed the screening. Biosolids application to forested land does not meet the requirement for sustainability due to the limited area of forested land accessible to Guelph, at the present. As there is no landfill in the Guelph area, this cannot be considered a sustainable option for the long term, but could be utilized as a back-up contingency. There is no identified market potential for industrial reuse of biosolids at this time, in the Guelph area.

While land reclamation passes all the must-have criteria, as there is potential for quarry reclamation close to the WWTP, this market would have to be developed.

Should the markets for end use alternatives change in the future, the technology alternatives selected should allow for flexibility to adapt to these opportunities under the guidance of the subsequent updates of this Biosolids Master Plan.

TABLE 3.2
SUMMARY OF SCREENING EXERCISE FOR TECHNOLOGIES

Technology	Must-Have Criteria			Remarks
	Environmentally Safe	Minimize Odours	Reliability	
Conditioning/Optimization				
Polymer	Pass	Pass	Pass	Integral component of mechanical dewatering
Inorganic chemicals	Fail	Pass	Pass	Not suitable process for required products
Thermal conditioning	Fail	Fail	Pass	Not suitable process for required products; potential for odours
Cambi process	Pass	Fail	Fail	Not proven technology; potential for odours
Thermal hydrolysis	Pass	Fail	Fail	Not proven technology; potential for odours
Acidification	Pass	Pass	Fail	Not proven technology
Kady process	Pass	Pass	Fail	Not proven technology
Acoustical cavitation	Pass	Pass	Fail	Not proven technology
CO_2 injection, pre-dewatering	Pass	Pass	Fail	Not proven technology
Wurtz process	Fail	Pass	Fail	Not proven technology; may reduce long-term product stability
Electrocoagulation	Pass	Pass	Fail	Not proven technology
Electro-osmotic dewatering	Pass	Pass	Fail	Not proven technology
Electrodewatering	Pass	Pass	Fail	Not proven technology
Enzyme conditioning	Pass	Pass	Fail	Not proven technology
Freeze-thaw	Pass	Pass	Fail	Not proven technology
Preheating	Pass	Fail	Fail	Not proven technology; potential for odours
Pulse power	Pass	Pass	Fail	Not proven technology
Sirex pulse power	Pass	Pass	Fail	Not proven technology
O_2 injection	Pass	Pass	Fail	Not proven technology
Thickening				
Centrifuge	Pass	Pass	Pass	
Gravity belt thickener	Pass	Pass	Pass	
Rotary drum thickener	Pass	Pass	Pass	
Anoxic gas floatation	Pass	Pass	Fail	Not proven technology
Dissolved air floatation	Pass	Pass	Pass	
Bioflot	Pass	Pass	Fail	Not proven technology
Recuperative thickening	Pass	Pass	Fail	Not proven technology
Stabilization – Liquid				
Conventional anaerobic digestion	Pass	Pass	Pass	
Thermophilic anaerobic digestion	Pass	Pass	Pass	

TABLE 3.2
SUMMARY OF SCREENING EXERCISE FOR TECHNOLOGIES

Technology	Must-Have Criteria			Remarks
	Environmentally Safe	Minimize Odours	Reliability	
Temperature phased anaerobic digestion (TPAD)	Pass	Pass	Fail	Not proven technology
Conventional aerobic digestion	Pass	Fail	Pass	Potential for odours
ATAD	Pass	Fail	Pass	Potential for odours
Vertad prcocess	Pass	Pass	Fail	Not proven technology
Dual digestion	Pass	Fail	Pass	Potential for odours
ATP	Pass	Fail	Pass	Potential for odours
Two Phase (Acid/Gas)	Pass	Pass	Pass	Proven at full scale
Pre-pasteurization	Pass	Fail	Fail	Not proven technology; potential for odours
Aerobic/anoxic digestion	Pass	Fail	Pass	Potential for odours; may consider further only if aerobic digestion was selected
Pirt process	Pass	Pass	Fail	Not proven technology
Brinecell process	Pass	Pass	Fail	Not proven technology
High pressure anaerobic digestion	Pass	Pass	Fail	Not proven technology
Irradiation	Pass	Pass	Fail	Not proven technology
Lime stabilization (liquid)	Pass	Pass	Pass	
RDP	Pass	Pass	Pass	
Active sludge pasteurization	Pass	Pass	Fail	Not proven technology
Micronair	Pass	Pass	Fail	Not proven technology
Ozone	Pass	Pass	Fail	Not proven technology
Bacterial metal leaching	Pass	Pass	Fail	Not proven technology
Dewatering				
Sand drying beds	Pass	Pass	Fail	Not practical for scale
Vacuum assisted dewatering beds	Pass	Pass	Fail	Not proven technology at this scale
Mechanically-assisted drying beds	Pass	Fail	Fail	Not proven technology; potential for odours
Solar dryer	Pass	Pass	Fail	Not proven technology at this scale
Quick-dry process	Pass	Pass	Fail	Not proven technology
DAB system	Pass	Pass	Fail	Not proven technology
Sludge bagger	Pass	Fail	Fail	Not proven technology; potential for odours
Rectangular bin gravity dewatering	Pass	Pass	Fail	Not proven technology
Screw/rotary press	Pass	Pass	Fail	Not proven effective technology at this scale
Recessed plate filter press	Pass	Fail	Pass	Potential for odours
Tubular filter press	Pass	Pass	Fail	Not proven technology

TABLE 3.2
SUMMARY OF SCREENING EXERCISE FOR TECHNOLOGIES

Technology	Must-Have Criteria			Remarks
	Environmentally Safe	Minimize Odours	Reliability	
Verti-press	Pass	Pass	Fail	Not proven technology
Centrifuge	Pass	Pass	Pass	
Belt filter press	Pass	Pass	Pass	
Stabilization Processes – Post-Dewatering				
Irradiation – gamma ray	Pass	Pass	Fail	Not proven technology
Composting-open	Fail	Fail	Pass	Compost cannot be sold as a standalone product; potential for odours
Composting – enclosed	Fail	Pass	Pass	Compost cannot be sold as a standalone product
Co-composing	Fail	Fail	Fail	Compost cannot be sold as a standalone product; potential for odours; not reliable
Vermi-composting	Fail	Fail	Fail	Compost cannot be sold as a standalone product; potential for odours; not reliable
Thermal drying (Direct rotary, fluid bed, multiple hearth, rotary disc and belt	Pass	Pass	Pass	
Vertical hearth dryers (thin film)	Pass	Pass	Fail	Not proven technology
Thermotech	Pass	Fail	Fail	Not proven technology; potential for odours
Flash dryer	Pass	Pass	Fail	Not proven technology in North America
Solar dryer (Thermo-System by Parkson)	Pass	Pass	Fail	Not proven technology in north America
Carver-Greenfield process	Pass	Pass	Fail	Technology has proven unreliable
Centridry process (Humboldt)	Pass	Pass	Fail	Not proven technology in North America
DryVac/Rollfit	Pass	Pass	Fail	Not proven technology
Infrared drying	Pass	Pass	Fail	Not proven technology
Microwave drying	Pass	Pass	Fail	Not proven technology
Ball bearing dryer (DHV)	Pass	Pass	Fail	Not proven technology
EcoTechnology	Pass	Pass	Fail	Not proven technology
Alkaline stabilization (AASSAD, Biodry, Envessel Pasteurization, Biofix)	Pass	Pass	Pass	
Chemifix	Pass	Pass	Fail	Not proven technology
Pori ST process	Pass	Pass	Fail	Not proven technology
Lystek™	Pass	Pass	Pass	Currently being demonstrated at Guelph WWTP
Bioset	Pass	Pass	Fail	Not proven technology

TABLE 3.2
SUMMARY OF SCREENING EXERCISE FOR TECHNOLOGIES

Technology	Must-Have Criteria			Remarks
	Environmentally Safe	Minimize Odours	Reliability	
High Temperature Combustion/Oxidation Processes				
Thermal Oxidation - Fluidized bed furnaces	Fail	Pass	Pass	As landfilling is not a reliable end-use, fails safe criteria
Thermal Oxidation - Multiple-hearth furnace	Fail	Pass	Pass	As landfilling is not a reliable end-use, fails safe criteria
RHOX process	Fail	Pass	Pass	As landfilling is not a reliable end-use, fails safe criteria
Melting furnace (Kubota; Cormin)	Fail	Pass	Fail	As landfilling is not a reliable end-use, fails safe criteria
Glass aggregate (Minergy)	Pass	Pass	Fail	Not proven technology
Catalytic extraction	Pass	Pass	Fail	Not proven technology
Molten-salt incineration	Pass	Pass	Fail	Not proven technology
Wet Air oxidation (Kenox)	Pass	Pass	Fail	Not proven technology
Deep-shaft oxidation (Vertox)	Pass	Pass	Fail	Not proven technology
Super critical water oxidation	Pass	Pass	Fail	Not proven technology
Oil from sludge (pyrolysis)	Pass	Pass	Fail	Not proven technology
Gasification (pyrolysis).	Pass	Pass	Fail	Not proven technology
Electric-arc gasification	Pass	Pass	Fail	Not proven technology
Microwave gasification	Pass	Pass	Fail	Not proven technology
Co-gasification	Pass	Pass	Fail	Not proven technology
Oil extraction (Best, McDonald) process	Pass	Pass	Fail	Not proven technology

The shaded Technologies Options pass all “must-have” criteria

Only one technology for conditioning/optimization, polymer, passed the screening exercise. The other technologies listed in this group primarily failed, as they are not proven technologies. The majority of WWTPs in North America utilize polymer for conditioning/optimization, and this practice is currently used at the Guelph WWTP.

Four thickening technologies (centrifuge, gravity belt thickener, rotary drum thickener and dissolved air floatation) met the must-have criteria. The Guelph WWTP is currently installing a rotary drum thickener, sized to manage all of the plant's waste actived sludge (WAS), under a long-term demonstration project.

The four liquid stabilization technologies that passed the screening exercise were conventional anaerobic digestion, thermophilic anaerobic digestion, two phase digestion and liquid lime stabilization. All these technologies are used in North America for liquid biosolids stabilization, and the Guelph WWTP currently uses conventional anaerobic digestion.

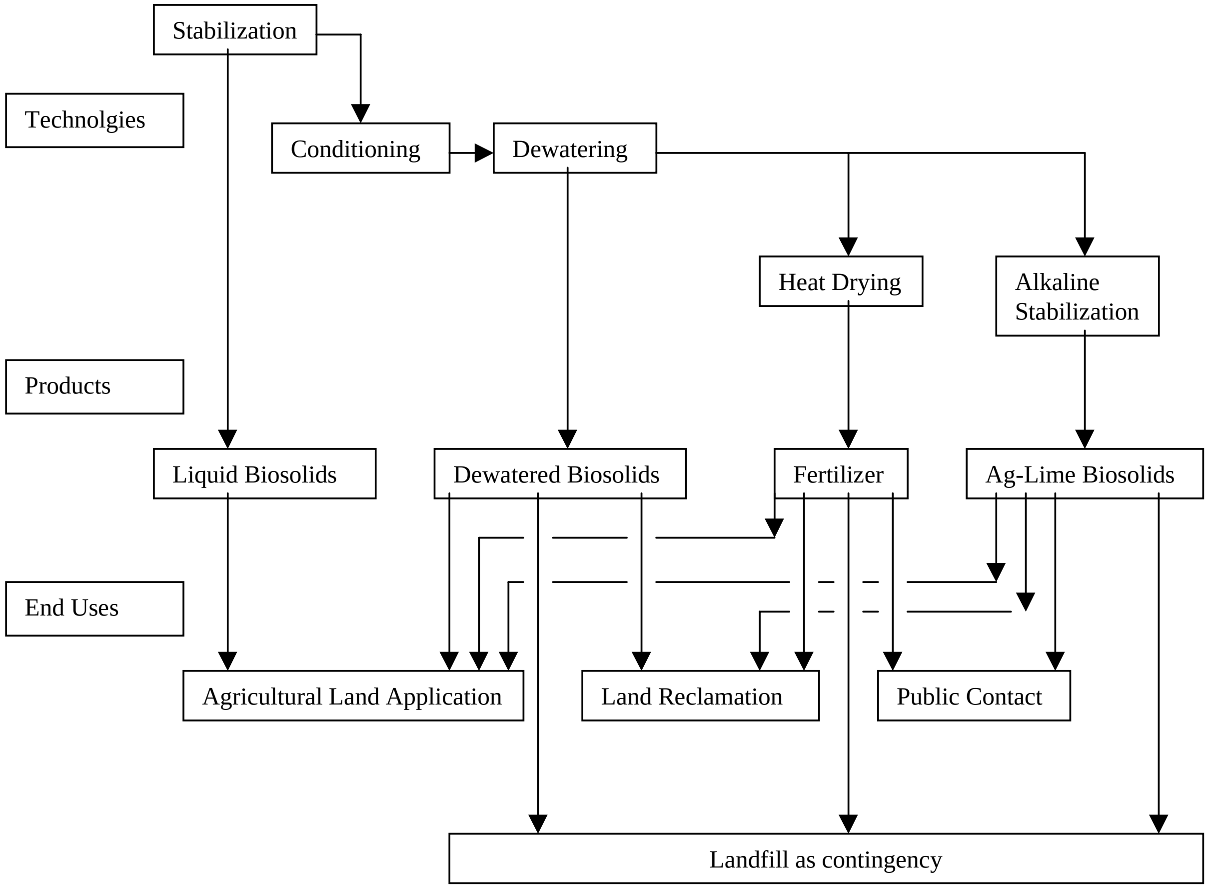
Of the 14 dewatering processes screened, two (centrifuge and belt press) technologies passed the exercise. Belt filter presses are currently utilized at the Guelph WWTP, and the City is currently determining the preferred alternative for dewatering capacity expansion and replacement of the oldest belt filter press. The other technologies listed in this group primarily failed as they are not proven technologies.

Thermal drying, alkaline stabilization and Lystek treatment were the only post-dewatering technologies that passed all the "must-have" criteria. The other technologies listed in this group failed either due to the lack of sustainability related to final product use or as they are not proven technologies. The City has been processing dewatered biosolids through an enclosed composting system since 1995. Although this technology did not pass screening because of utilization issues, technically, it can continue to provide the City with a means of processing solids, especially in winter.

The Lystek process, which treats dewatered cake, produces a material that is approximately 14 to 15 percent solids, but has viscous properties similar to liquid biosolids, and can be manipulated to produce a "Class A" (under USEPA Part 503 definition) biosolids. This process results in a reduction in the biosolids volume, compared to a traditional liquid product. Odour potential is also reduced. This results in reduced storage and transportation requirements. The product can be stored and land applied, similar to a liquid product.

Figure 3-1 presents the results of the screening exercise and shows the process flow from the technologies which passed the screening exercise, through the products determined to be acceptable in the screening exercise, through to the end uses which passed the must-have criteria, and the possible interactions between these components. defining alternative biosolids management strategies.

FIGURE 3-1
SUMMARY OF SCREENED ALTERNATIVES



4. Development of Biosolids Management Strategies for Detailed Evaluation

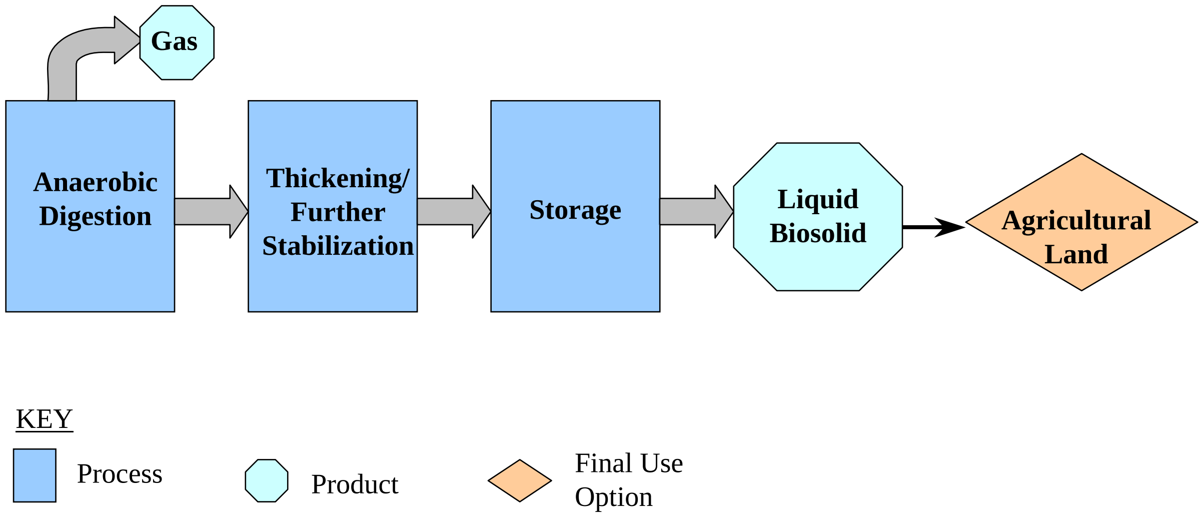
As the City wished to maximize its investment in existing infrastructure, consideration was given to maximizing the value of these resources in the management strategies developed. These facilities are:

- Rotary drum thickening of WAS (under construction 2004/5)
- Anaerobic digestion
- Lystek treatment (unit under construction 2004/5)
- Belt press dewatering (additional unit under construction 2004/5)
- Woodchip blending/composting

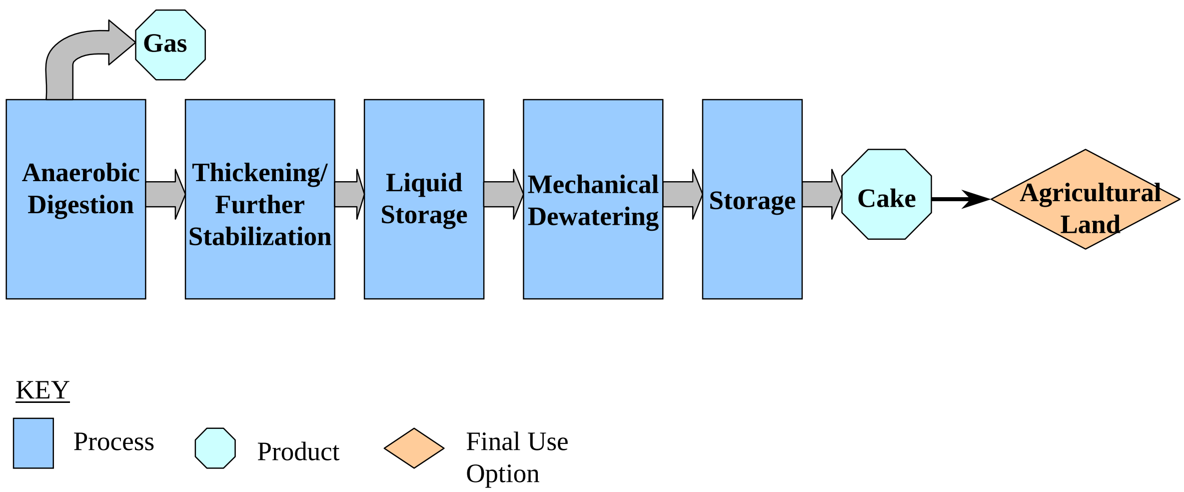
The strategies were developed based on the screening results. Each strategy includes a combination of technologies and products that support the desired end uses. Accordingly, from the list of available technologies and products, four alternative biosolids management strategies were developed for detailed evaluation. They are presented below.

It should be noted that Lystek treatment of a portion of the WWTP's biosolids would be included in each of the strategies. The WWTP staff provided the cost of this treatment and this was incorporated into the analysis of each strategy. This process is not shown on the diagrams below as it is the same for each alternative.

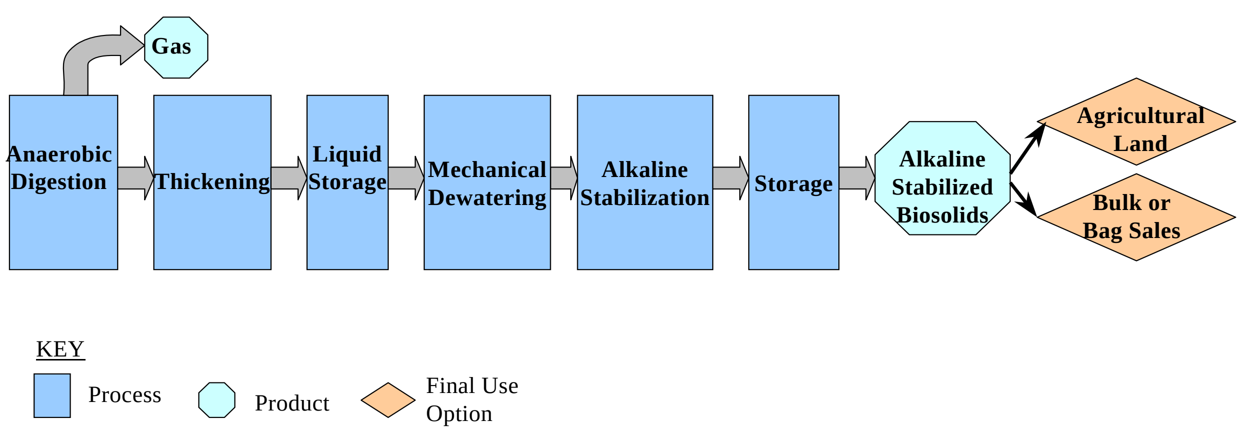
Liquid biosolids to agricultural land.



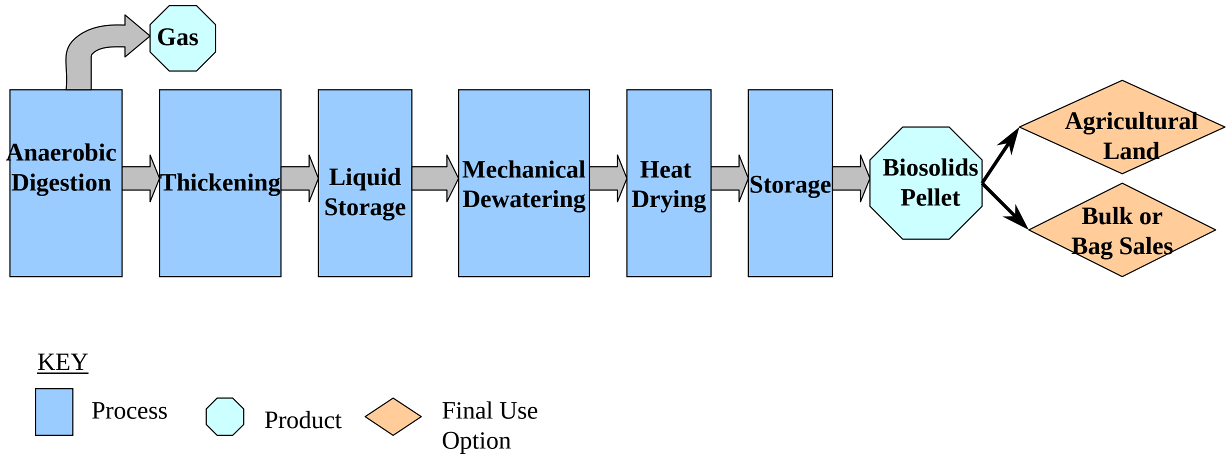
Dewatered biosolids to agricultural land.



Alkaline stabilized biosolids to land application.



Heat dried biosolids to land application.



5. Evaluation of Strategy Options

Evaluation Process

The evaluation process will utilize the CH2M HILL BMP Tool©. This is a model that is based on the multi-attribute utility analysis (MUA) decision process. The model allows evaluation of multiple options and analyses benefits and benefit-cost of each option. The following describes the steps in the evaluation process.

5.1.1 Step 1: Develop the Basis of Design for Each Option. For each strategy option, a basis of design will be prepared, each of which will include the following common assumptions:

- Facility design will be sized for 100 percent capacity of the projected total solids expected to be produced at the WWTP, including a portion treated by Lystek, as determined by the City. Each option will include multiple process trains using the process trains above
- Further processing facilities owned and operated by the City will be located at the WWTP facility
- Storage facilities may be located onsite or offsite
- Landfilling is a back-up contingency for all options
- Product suitability for land reclamation will be considered, although costs will not be developed as market information is currently not available

5.1.2 Step 2: Develop Sizing and Cost Estimate for Each Option. Facility sizing will be developed based on project wastewater flows to the 20-year planning horizon of the Biosolids Master Plan and equipment estimated from vendors.

Operating costs will be developed using energy estimates supplied by vendors and labour requirements will be estimated using in-house information and the City's labour rates.

5.1.3 Step 3: Apply Weighted Evaluation Criteria to Each Option. The evaluation criteria were developed by the City and CH2MHILL, in consultation with the public through the Public Open House events. Each criteria will be weighted between 0 and 100, based on relative importance to the stakeholders, with 100 being the most important. The criteria will be applied to each strategy option and a performance measure will be assigned to each option for each weighted criteria. The measures will be used a input to the BMP Tool.

5.1.4 Step 4: MUA Analysis. The MUA analysis will be carried out in a workshop with the City and CH2M HILL project teams using the BMP Tool model. The model will be preloaded with evaluation criteria and cost data. Draft performance measures and draft weightings will also be preloaded. Workshop participants will review and agree to final evaluation criteria, performance measures and weightings. The participants will then "score" each criteria against each option using performance measures. Scores will loaded into the model and the model will be run, with the results available immediately.

5.1.5 Step 5: Rank Options. The model results will include ranking options by benefit and by benefit-cost. Workshop participants will use these results to rank strategy options in descending order (rank 1 has the highest score).

5.1.6 Step 6: Review Diversity of Program. Once the strategy options are ranked, they will be reviewed to determine what options, option components or existing facilities, if any, could be combined to create greater diversity in the recommended management program for the purpose of reducing the long term risk to the City. The diversity program may consider processing portions of the biosolids through different technologies, such as utilizing liquid land application in the summer and dewatering in the winter only, to reduce the volume of storage required.

5.1.7 Step 7: Recommend Preferred Option(s). The outcome of the evaluation exercise will include the identification of a recommended strategy for the long-term management of biosolids.

5.1.8 Step 8: Develop Implementation Plan. An implementation plan will be prepared for the preferred biosolids management strategy. The purpose of the plan is to set out the scheduling for required facilities, system improvements, and additional approvals that will be required over the planning period.

Evaluation Criteria

The evaluation criteria developed for this project include criterion and measure the consider five categories:

- Technical Environment
- Social/Cultural Considerations
- Natural Environment Considerations
- Economic Considerations

Each criteria category includes several sub-factors. The evaluation process includes comparing each system to the sub-factors, by first describing the system with respect to the sub-factor and determining whether the system rates high, medium or low, where high represents the least impact. Table 5.1 presents the evaluation criteria and the measure of each sub-factor.

TABLE 5.1
EVALUATION CRITERIA

Evaluation Criteria	Description	Measure
Technical Environment		
Technology Performance	The ability of an alternative to satisfactorily perform its intended functions (treatment, utilization method, disposal options)	H – The alternative is very reliable, consistently meets or exceeds performance criteria and product quality M – The alternative is moderately reliable, meets performance criteria and product quality with regular operation and maintenance L – The alternative is not very reliable and requires high levels of operation and maintenance to meet performance and product quality
Energy Requirements	The energy, water, and other utilities requirements for the product produced by the alternative are comparable relative to the existing treatment system and other alternatives.	H – The alternative is very energy efficient; re-use and recycle options are possible M – The alternative is somewhat energy efficient L– The alternative is not very energy efficient; uses significant amounts of energy/utilities
Long-Term Sustainability	The ability of an alternative (treatment, utilization/disposal) to adapt to changing conditions (technologies, regulations, market factors)	H – The alternative can easily be adapted to changing conditions to meet long-term needs M – The alternative is somewhat flexible to meet long-term needs (some constraints) L – The alternative is not very flexible; difficult to meet needs in the long term
Ease of Implementation	The alternative can be easily implemented on a technical, regulatory and practical basis (land availability, operational aspects, administrative requirements, etc.): • Additional operation and maintenance requirements are minimized • Regulatory approvals are not complicated • Can be implemented based on current knowledge or requires pilot demonstrations for further study with Guelph's wastewater and biosolids characteristics	H – The alternative is very easy to implement with respect to approvals and construction M – The alternative is somewhat easy to implement (some constraints) L – The alternative has many difficulties with respect to implementation
Social/Cultural Considerations		
Odour	The potential for alternative to minimize odour events	H – The alternative has little or no potential to produce odour M – The alternative has moderate potential to produce odour, odour control measures may be needed to prevent migration offsite L – The alternative has high potential to produce odour; significant mitigation needed to control migration offsite
Agricultural Practice	The potential for the alternative to be compatible with current (and developing)	H – The alternative is very compatible with current practices and developing

TABLE 5.1
EVALUATION CRITERIA

Evaluation Criteria	Description	Measure
	agricultural practices over the long term	practices M – The alternative is somewhat compatible with current and developing practices L – The alternative is not compatible with existing and developing practices; may require significant modifications to increase compatibility
Visual Character (Viewscape)	The potential for the alternative to maintain the visual character of an area	H – The alternative is discreet and will have no impact on the visual character of an area ; existing visual character will be maintained M – Components of the alternative may have a minor impact on the visual character of an area: visual character may be modified somewhat L – The alternative will have a significant impact on the visual character of an area; existing character will be altered to a great degree
Transportation	The potential for the alternative to avoid increase demands on the transportation systems (patterns,volumes and infrastructure requirements)	H – The alternative will not place additional demands on transportation system M – The alternative may place minor additional demands on the transportation system L – The alternative may place major demands on the transportation system
Noise	The potential for the alternative to minimize the production of noise during normal operations	H – The alternative has little or no potential to produce noise M– The alternative has moderate potential to produce noise, noise control measures may be needed to prevent migration offsite L – The alternative has high potential to produce noise; significant mitigation needed to control migration offsite
Recreational Uses	The impact on an alternative on recreational resources	This may be difficult to measure
Community Health and Safety	Potential risk or liability to community health and safety from exposure to: • Explosions • Traffic accidents • Gaseous emissions • Toxic organics • Heavy metals • Flooding of watercourses (Grand River)	H – The alternative will result in very little potential risk to community health and safety compared to other alternatives M – The alternative will result in a moderate potential risk to community health and safety are compared with other alternatives L – The alternative will result in a high potential risk to community health and safety compared to other alternatives (without substantial mitigation)
Occupational Health and Safety	Potential risk/liability or benefit to occupational health and safety from	H – The alternative will result in very little potential risk to operator health and

TABLE 5.1
EVALUATION CRITERIA

Evaluation Criteria	Description	Measure
	exposure to: • Explosions • Traffic accidents • Gaseous emissions, methane/biogas • Toxic organics • Heavy metals • Flooding of watercourses (Grand River)	safety compared to other alternatives M – The alternative will result in moderate potential risks to operator health and safety are moderate compared with other alternatives L – The alternative will result in high (potential risk to operators health and safety compared to other alternatives without substantial mitigation)
Public Acceptability	The potential of the alternative to receive public support and acceptance based on: • Projects of a similar nature in other Ontario communities • Community history with the WWTP	H – The alternative has the potential to receive a high level of support and endorsement by the public M – The alternative has the potential to receive a moderate level of support and endorsement from the public L – The alternative has the potential to receive a low level of support and endorsement from the publication needed to control impacts
Natural Environment Considerations		
Effluent Quality	The potential of the alternative to meet WWTP effluent quality requirements	H – The alternative will contribute to the WWTP effluent exceeding the criteria requirements on a consistent basis M – The alternative will contribute to the WWTP effluent meetings and sometimes exceeding the criteria requirements L – The alternative will not contribute to the WWTP meeting effluent quality requirements
Water Quality	The potential of the alternative to improve Grand River water quality and aquatic habitats	H – The alternative results in significant improvements to Grand River water quality and aquatic habitats M – The alternative results in moderate improvements to Grand River water quality and aquatic habitats L – The alternative results in little improvement to Grand River water quality beyond regulations; significant mitigation required to control impacts on aquatic habitats
Terrestrial Systems	The potential of the alternative to improve terrestrial habitats/ systems (including mammals, reptiles, birds) and terrestrial features/functions	H – The alternative results in a net improvement in terrestrial systems and habitats M – The alternative results in the maintenance of the existing terrestrial systems and habitats L – The alternative results in a net loss of terrestrial systems and habitats – compensation measures may be required

TABLE 5.1
EVALUATION CRITERIA

Evaluation Criteria	Description	Measure
Groundwater Quality and Flow	The potential of the alternative to protect groundwater resources	H - The alternative provides significant protection to groundwater resources M – The alternative provides moderate protection to groundwater resources L – The alternative provides little if any protection to groundwater resources; significant mitigation needed to provide protection
Air Emissions	The potential for an alternative to meet provincial regulatory requirements for air emissions This criteria does not address odours	H – The alternative exceeds regulatory requirements and results in a significant reduction in overall air emissions from the WWTP M – The alternative meets the regulatory requirements and may result in a moderate reduction in overall air emissions from the WWTP L – The alternative does not consistently meet regulatory requirements and results in no change or an increase in overall emissions from the WWTP; significant mitigation required to control air emissions to meet regulations
Soil Quality	The impact of an alternative on soil productivity	H - The alternative improves the quality and/or productivity of the soil through application M - The alternative does not impact the quality or productivity of the soil L - The alternative reduces or impacts the quality and/or productivity of the soil
Economic Considerations		
Capital Costs	Estimated costs for capital works	Estimated capital cost of alternative relative to other alternatives ($2004)
O/M Costs	Estimated costs for staff resources, energy needs, on-going routine operation and maintenance activities.	Estimated operating cost of alternative in excess of current operating costs ($2004)
Cost Savings Opportunities	The ability of an alternative to generate cost savings	H – The alternative offers significant cost savings opportunities compared to other alternatives M – The alternative offers moderate cost savings opportunities compared to other alternatives L – The alternative offers few if any cost savings opportunities compared to other alternatives

H – High
M- Moderate
L - Low

6. Summary

Following confirmation of the screening exercise, strategy options and evaluation criteria presented above, the basis of design for each strategy will be developed.

Following the evaluation process, a sensitivity analysis will be carried out to analyze the reliability of the evaluation. Parameters to be reviewed in the sensitivity analysis may include changing the interest and discount rates in the economic analysis, changing the cost of biosolids transportation and land application, and increasing diversity. Diversity may be achieved in an agricultural land application strategy for example, by utilizing the existing composting system (with required upgrades) in winter and providing for compost storage, rather than storing liquid or dewatered biosolids. Development of these parameters will occur in consultation with the City.

City of Guelph Biosolids Management Plan Basis of Design for Evaluating Short-Listed Management Options

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DATE: April 28, 2005

1. Option Development Methodology

1.1 Technology Alternatives

A number of alternatives that could potentially be used for managing biosolids produced at the City of Guelph's wastewater treatment plant (WWTP) were selected for detailed evaluation. These short-listed alternatives were developed from the long list complied in Task 4 Part 1 and evaluated in Task 4 Part 2.

The technology alternatives were developed into management options, each designed to process 100 percent of the biosolids at the design capacity of the Stage 2 expansion of the WWTP (73 MLD). The management options included processes existing (or planned) at the WWTP as well as technologies currently not utilized at the WWTP.

The technologies selected and their statuses at the Guelph WWTP are shown in Table 1.

TABLE 1
Summary of Technologies Short-Listed for Evaluation

Technology	Description and Status
WAS Thickening	Currently planned to be constructed in 2005/6, including 3 Rotary Drum Thickener (RDT) units, each rated to process 50 m^3/hr of feed
Anaerobic Digestion	3 Primary Digesters and 1 Secondary Digester Digester capacity expansion pre-design study planned for 2005/06. Additional capacity likely required in future; either as an expansion of the existing system or with additional acid-phase digestion

TABLE 1
Summary of Technologies Short-Listed for Evaluation

Technology	Description and Status
Mechanical Dewatering	Four belt presses currently installed Two belt presses planned to be installed in 2005/6 to replace two oldest presses Remaining two belt presses require future replacement, due to age Additional capacity may also be required in the future
Liquid Biosolids	Liquid biosolids can currently be loaded to transport trucks at the secondary digester outlet piping; no liquid biosolids storage following digestion is currently available
Biosolids Cake	Biosolids cake can currently be loaded into transport trucks from the cake bin; no additional biosolids cake storage is currently available
Biosolids Cake/ Woodchip Mixing	The existing belt filter presses do not produce a cake with a solids content acceptable at the contracted landfill, so biosolids are mixed with woodchips to increase the solids content to about 30% The need for this could be eliminated in the future with improved dewatering or landfilling of a different product
Lystek	Expansion planned in 2005/06 to double the existing capacity to a $6m^3$ unit No Lystek product storage is currently available
Composting	Three vessel composting system currently installed Compost is currently loaded into transport trucks from screw conveyors
Heat Drying	Potential new technology. Storage of product would be a component of the system
Alkaline Stabilization	Potential new technology. Storage of product would be a component of the system

The management options developed from the technologies listed in Table 1 are discussed in Section 2.

1.2 Development of Basis of Design

In order that a fair and equitable comparison and evaluation of the options be made, a basis of design was developed for each alternative.

The basis of design allowed for management of the biosolids over the full design period of the study, with equitable production, contingency and storage capacities. Redundancy requirements were assumed for each alternative, and redundant capacity is explained in each description.

For each management option, product storage is based on 4-months of total storage to meet the maximum period requirement (December to March), when biosolids cannot be land applied.

It is assumed biosolids will be landfilled when conditions are not suitable for land application. Under this 4-month storage scenario, should conditions not permit the beneficial use of biosolids for a longer period of time, alternative disposal (landfilling) will be assumed.

As landfilling will be a part of every management option, it has further been assumed that the two new dewatering units will be centrifuges, to eliminate the need to blend cake with woodchips to obtain a higher solids content than belt presses can achieve.

The purpose of this technical memorandum is to summarize each management option 's basis of design.

During the system selection and facility layout, the existing space and site utilities were considered to ensure that the system could be feasibly installed at the Guelph WWTP, or off-site footprint requirements if they could not.

2. Basis of Design

2.1 Capacity

The estimated mass of raw solids produced at capacity of the Stage 2 expansion of the liquid train at the Guelph WWTP (to a total plant capacity of 73 MLD) is about 26,700 kg/d, based on current per capita equivalent solids contributions to the City's wastewater.

Two major industrial contributors to the municipal wastewater stream, Better Beef and Sleemans, are expected to improve pretreatment of wastewater prior to release to the municipal sewers before the full capacity of the Stage 2 expansion is reached. The expected best-case scenario would be for these industries to meet sewer by-law compliance limits.

Analysis of the data suggests that even if these industries meet sewer by-law compliance limits in the future, with potential future industrial expansions and increasing populations across the serviced area, the raw (undigested) solids production at the WWTP will still approach 26,700 kg/d (9,745 dt/yr) when the full capacity of Stage 2 expansion is completed.

However, implementation of required solids train capacity increases may be delayed, in the short term, by improved industrial sewer discharge quality. This will be further discussed in the implementation plan of the recommended Biosolids Management Plan in the final project report.

2.2 Physical Characteristics

The physical characteristics of the biosolids produced at the Guelph WWTP, shown in Table 2, were developed from historical plant data and anticipated future biosolids quality for planned equipment.

TABLE 2
Basis of Design: Physical Characteristics of Biosolids

	Average	Range
Concentration of Primary Biosolids (percent of total solids)	4%	3.5% - 4.5%
Concentration of WAS[1] (as % of total solids)	0.2%	0.1% - 0.3%
Concentration of Co-thickened Primary and WAS (percent of total solids)	3.3%	3% - 4%
Concentration of Mechanically Thickened WAS (percent of total solids)	6%	5.5% - 6.5%
Volatile Concentration (percent of dry solids)	70%	62% - 75%
Concentration of Digested Biosolids (percent of total solids)	2%	1.5% - 2.5%
VS Destruction in Digestion	53%	50% - 58%
Concentration of Dewatered Biosolids (Belt Filter Press) (percent of total solids)	18%	16% - 20%
Concentration of Dewatered Biosolids (Centrifuge) (percent of total solids)	28%	25% - 30%
Metals (mg/kg dry biosolids)		
Arsenic	0.03	0.002 - 0.1
Beryllium[2]	NM	NM
Cadmium	0.22	0.01 - 0.86
Chromium	3.6	0.1 – 8.3
Copper	13.3	0.1 – 26.5
Lead	0.9	0.1 - 2.3
Mercury	0.23	0.0001 – 3.5
Molybdenum	0.26	0.1 - 0.58
Nickel	0.27	0.1 - 0.78
Selenium	0.02	0.001 - 0.04
Zinc	30	1.15 - 43.7
Nutrients		
Total Kjehldahl Nitrogen (TKN)	1230	620 - 2040
Total Phosphorous	475	150 - 850

[1] Estimated; plant data not available
[2] NM = Not measured

2.3 Design Guidelines

The industry-standard design guidelines for each of the alternative technologies were reviewed, and are summarized in Table 3.

TABLE 3
Summary of Design Guidelines for AlternativeTechnologies Short-Listed for Evaluation

Alternative	Selected Technology	Design Guidelines
WAS Thickening[1]	Rotary Drum Thickener	Typical TWAS concentration: 5.5 - 6.6%
		Typical solids capture: 95 - 98%
		Typical Hydraulic loading range: Not specified as success is highly dependant on biosolids characteristics
		Polymer Dose Rate: 7.5 g/kg [5]
Anaerobic Digestion[1]	High-rate, mesophilic	Working volume: 85 - 95%
		Volatile solids destruction: 40 - 65%
		Solids Residence Time: 10 - 20 days (MOE Guideline: 15 days)
		Peak Volatile solids loading: 1.9 - 2.5 kg VS/m^3.d
		Maximum VS loading: 3.2 kg VS/m^3.d
		Minimum VS loading: 1.3 kg VS/m^3.d
Acid-Phase Digestion[2]	Phase separated digestion	Design HRT: 2 days
		Design Maximum SLR: 32 kg VS/m^3/day
Mechanical Dewatering[1]	Belt Filter Press	Typical: Cake Solids / Loading Primary sludge 24 - 30% / 1.9-3.2 L/m.s WAS 12 - 20% / 0.6-2.5 L/m.s P + WAS 20 - 25% / 1.3-3.2 L/m.s
		Typical solids capture: 80 - 95%
		Typical Polymer Dose Rate:1 to 6 g/kg dry solids[6]
	Centrifuge	Typically available capacity range: 0.6 - 44 L/s
		Cake solids concentration: 28 up to 40% (with high polymer dosage)
		Typical solids capture: 85 - 96%
		Typical Polymer Dose Rate:0 to 4 g/kg dry solids[6]
Biosolids Cake/ Woodchip Mixing[2]		Mixing is performed to meet the requirements of the landfill. Dose depends on the cake solids content to obtain a 30%+ solids blend.
Lystek		No industry standard – new technology
Composting[3]	In-vessel	Design input solids: 15,100 kg/day at 17 - 23% solids
		Design Retention time: 28 days
Heat Drying[1]	Rotary drum	Pellet (product) dryness: 92% (minimum)
		Specific Evaporation rate: 3,250 – 4,200 kJ/kg water evaporated
		Energy consumption is based on quantity of water evaporated, and therefore depends on the feed cake solids content.

TABLE 3
Summary of Design Guidelines for AlternativeTechnologies Short-Listed for Evaluation

Alternative	Selected Technology	Design Guidelines
Alkaline Stabilization[4]	In-vessel	Lime Dose: 20 - 50% of the wet-weight 75 – 200% dry weight of biosolids Retention time: Dryer - sufficient to obtain 62 - 65% solids in the blend Heat Pulse - 12 hour Elevated pH Storage - 3 days

Notes:
[1] *Design of Municipal Wastewater Treatment Plants*; WEF Manual of Practice No. 8 (1992)
[2] CH2M HILL design guidelines
[3] Data typical of existing in-vessel system is provided
[4] Data typical of *N-Viro* system is provided
[5] Determined by bench-testing of Guelph's WAS (2004)
[6] *Sludge Conditioning*, Manual of Practice No. 14 (1988)

2.4 Technology Advantages

Feasible equipment, redundancy and storage alternatives are shown in Table 4, along with their respective primary advantages and disadvantages.

The following section (Section 3) reviews the management options and technology alternatives shown in Table 4 to provide complete and comparable systems.

TABLE 4
Basis of Design: Alternative Sizing

Technology	Alternative Sizing	Primary Advantages	Primary Disadvantages
WAS Thickening (Rotary Drum Thickener)	Alternative 1: 2 operating and 1 standby unit, each rated to process 50 m3/hr of feed	Provides one standby unit that could also be operated in peak periods if required	Requires continuous (24 hour/7day) operation TWAS storage required if dewatering/downstream treatment is not operated continuously and digestion is not utilized
	Alternative 2: 5 operating and 1 standby unit, each rated to process 50 m3/hr of feed	Provides one standby unit that could also be operated in peak periods if required Allows for facility to be operated 8 hrs/ day, matching dewatering/ downstream operations	Additional footprint required
Anaerobic Digestion	Alternative 1: Maintain existing capacity with Acid-Phase Digestion as an upstream process to the existing anaerobic digesters	Eliminates the requirement for additional anaerobic digestion capacity No changes to existing system required	New process for WWTP, requiring learning curve to optimize operation
	Alternative 2: Increase capacity to meet future requirements	Treatment of all biosolids to produce a consistent product Redundancy could be built-in	Additional footprint required is greater than in digestion alternative #1

TABLE 4
Basis of Design: Alternative Sizing

Technology	Alternative Sizing	Primary Advantages	Primary Disadvantages
Mechanical Dewatering	Replace 2 old BFPs with higher solids mechanical dewatering (centrifuges) and maintain 2 new BFPS installed 2005/6	Reduces space requirement in existing facility Opportunity to install units which produce higher cake solids content Allows for two types of cake to be produced (lower and higher solids content) for alternative post-dewatering use	Potential side stream impacts to liquid treatment train New process for WWTP, requiring learning curve to optimize operation
Liquid Biosolids Storage & Loading	Maintain existing system, and install dedicated piping for truck loading and storage as required for each management option	Provides potential for contingency storage outside of application season or during equipment maintenance periods May reduce contractor costs and increase farmer satisfaction as full site applications can be completed at one time	Footprint required to locate and construct facility, if required for management option Potential for odour issues Potential side stream impacts to liquid treatment train if supernating is practiced
Biosolids Cake Storage & Loading	Maintain existing system	Long term storage of cake is not recommended due to odour concerns	Lack of storage resulting in increased contractor costs and land owner inconvenience as a full application site cannot be completed in a short timeframe (when land applying)
Lystek	Maintain existing system and install storage as required for each management option	Provides a diversified product for land application Reduce reliance on upstream stabilization process	Footprint required for storage
Composting	Alternative 1: Maintain existing system, along with other management options, and install storage as required for each management option	Ability to tailor production to reasonable reliable capacity Ability to produce beneficial product and store over winter for additional stabilization and ultimate use	Other management facilities required as existing system too small to manage predicted biosolids quantity Additional footprint required
	Alternative 2: Decommission	May reduce overall maintenance requirements at WWTP	Decommissioning useable equipment may result in loss of investment
Heat Drying	Install facility to treat portion of biosolids and install storage as required for each management option	Provides a diversified "Class A" product for land application	Development of market required for product
Alkaline Stabilization	Install facility to treat portion of biosolids and install storage as required for each management option	Provides a diversified "Class A" product for land application Reduce reliance on upstream stabilization process	Development of market required for product Footprint required for storage Odour control required for storage

3. Description of Options

The following seven management options were developed from the technology alternatives to form complete and comparable systems, each with diversified products and four months for product storage.

3.1 Option 1 - Expand Existing System

3.1.1 Description of System

The option expands the existing system to meet future flows and includes Lystek and WAS thickening. No new technologies are included. Storage is provided for composted biosolids, Lystek biosolids and liquid biosolids.

Figure 1
Option 1 Solids Management Schematic

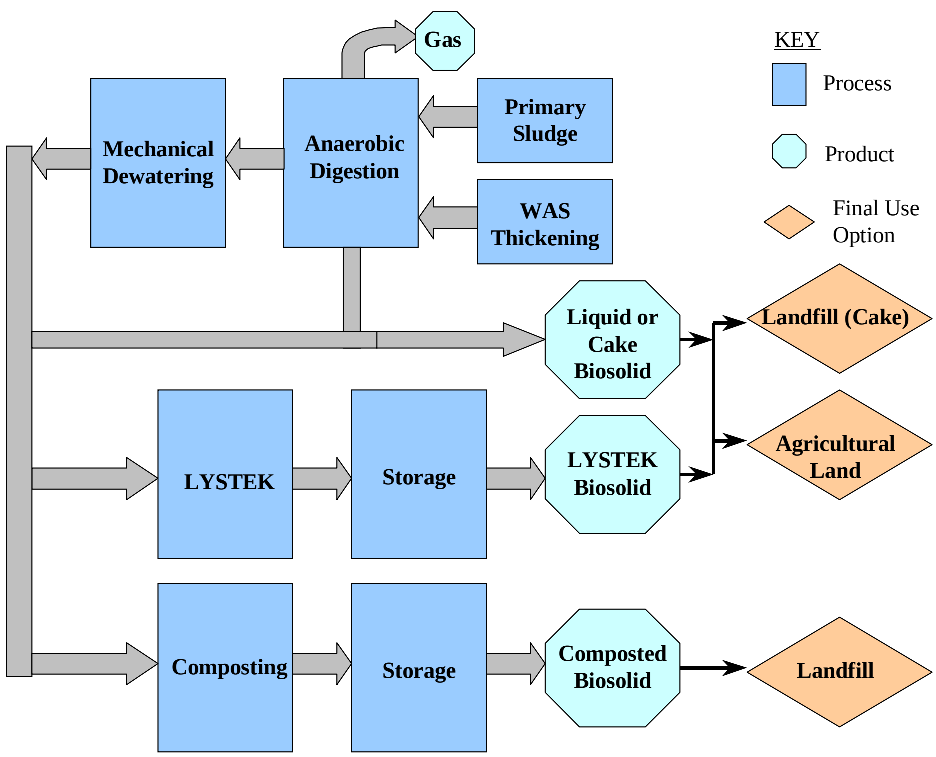


TABLE 4
Summary of Management Option 1Technologies

System	Technology	Size	Operating Hours	New Impact	New Construction
Primary Sludge	Thicken in primaries to 4%	NA	24 hours/7 days	-	-
WAS	Mechanically thickened	Alternative #1 - 3 units	24 hours/7 days	-	-
		Alternative #2 - 6 units	8 hours/7 days	Reduced operating hours	3 additional units
Digestion	1 or 2 additional digesters; similar to existing	2,440 m^3 each	24 hours/7 days	Improved stabilization; redundant capacity (in interim)	1- 2 additional units
Liquid Biosolids	Existing system with improved loading & storage	35,306 m^3 storage	24 hours/7 days Average 110 m^3/day managed	Storage provides contingency	36,711 m^3 storage
Dewatering	2 new centrifuges	Peak capacity 220 m^3/d each	16 hours/5 days	-	Replacement of 2 old BFPs
Lystek Processing with Storage	Process 3-6 dt/d, with storage: 4-months capacity	6 m^3 unit	24 hours/7 days; 10 months/year	Permanent facility provided Ensures process can be utilized at maximum potential year-round	4,800 m^3 capacity storage facility
Composting	Existing system with storage: 4-months capacity	NA	24 hours/7 days; 8 months/year	Permanent facility provided Ensures process can be utilized at maximum potential in winter	2,053 m^3 capacity storage facility

3.1.2 Description of Technologies

Raw Sludge

Waste activated sludge (WAS) will not be returned to the primaries for co-thickening with primary sludge. Instead, WAS will be thickened and pumped directly to the digesters. It is assumed that the raw primary will self-thicken by gravity to 4 percent (average) and will be pumped to digesters.

A waste sludge thickening facility will be required to manage the WAS. Three units of similar size to the demonstration Baycor RDT unit will be required (2 operating, 1 standby) for a continuous operation, or six units (5 operating, 1 standby) for 8-hour/day, 7-day/week operation.

Digestion

Additional digestion capacity will be required to process the increase in flow of primary sludge and TWAS and the increased volatile solids loading. This will likely require the addition of one or two digesters of similar capacity to the existing primary digesters (2,440 m^3 each).

Digested sludge is pumped to the dewatering facility or to liquid transport and storage.

Dewatering

Additional dewatering capacity is required to manage the increase in flow. The two oldest BFPs will be replaced with at least centrifuges, with one (minimum) operating and one on standby.

Further Processing

For this option, it is assumed that there will be three routes for the dewatered cake: trucking directly to agricultural land, conveying to Lystek and conveying to composting.

Direct Utilization/Disposal

Liquid storage is provided so that a total of four months storage is provided amongst all the technologies. Liquid biosolids may be directly land applied, or dewatered.

The dewatered cake will be conveyed to trucks as is done currently. Additional conveying and loadout may be required. The dewatered cake can either be delivered to land application sites or to landfill.

LYSTEK

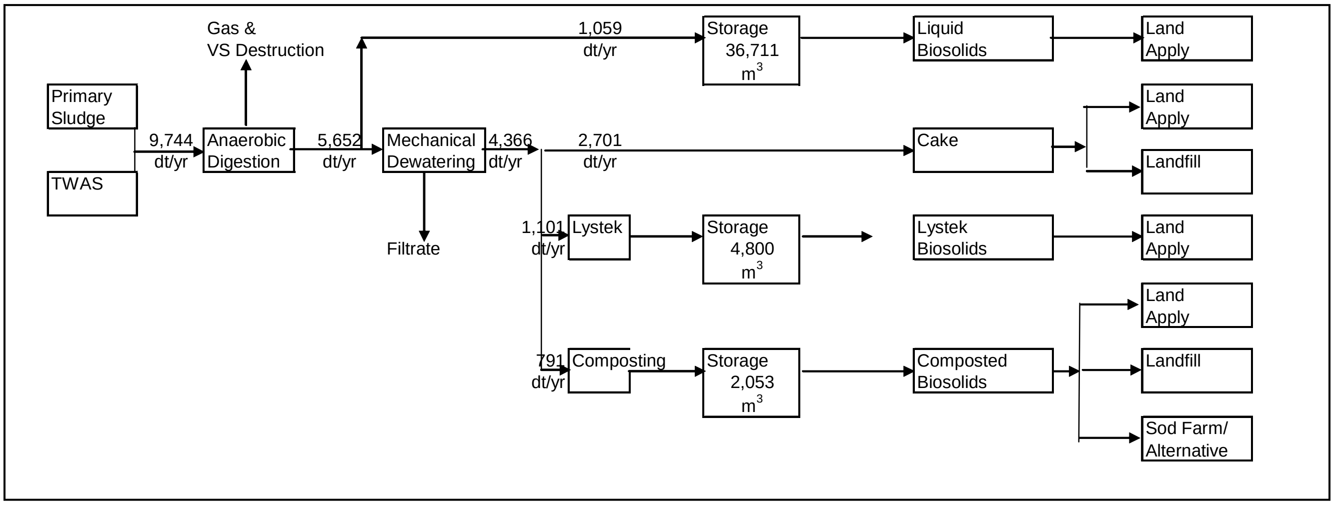
It is assumed that a 6m^3 Lystek unit with a production capacity of about 150 m^3 to 300 m^3 per week or 3 dry t/d to 6 dry t/d (continuous equivalent). The resulting Lystek biosolid will be stored in new on-site storage, providing four months Lystek product capacity.

Composting

It is assumed that the composting facility will be kept in operation at reduced throughput until it is retired from service. The optimum period to operate the composting would be during the winter, with the resulting product shipped to soil blenders in the spring. Thus, landfilling would be reduced.

3.1.3 Option 1 - Solids Management Sizing

The following figure shows the quantities of biosolids managed by each process stream and stored. Biosolids shown in the liquid stream may be dewatered, increasing the actual quantity dewatered and biosolids requiring use/disposal as cake.



3.2 Option 2 - Expand Existing System with Phased Digestion

3.2.1 Description of System

The option expands the existing system to meet future flows utilizing acid phase digestion, and includes Lystek and WAS thickening.

Figure 2
Option 2 Solids Management Schematic

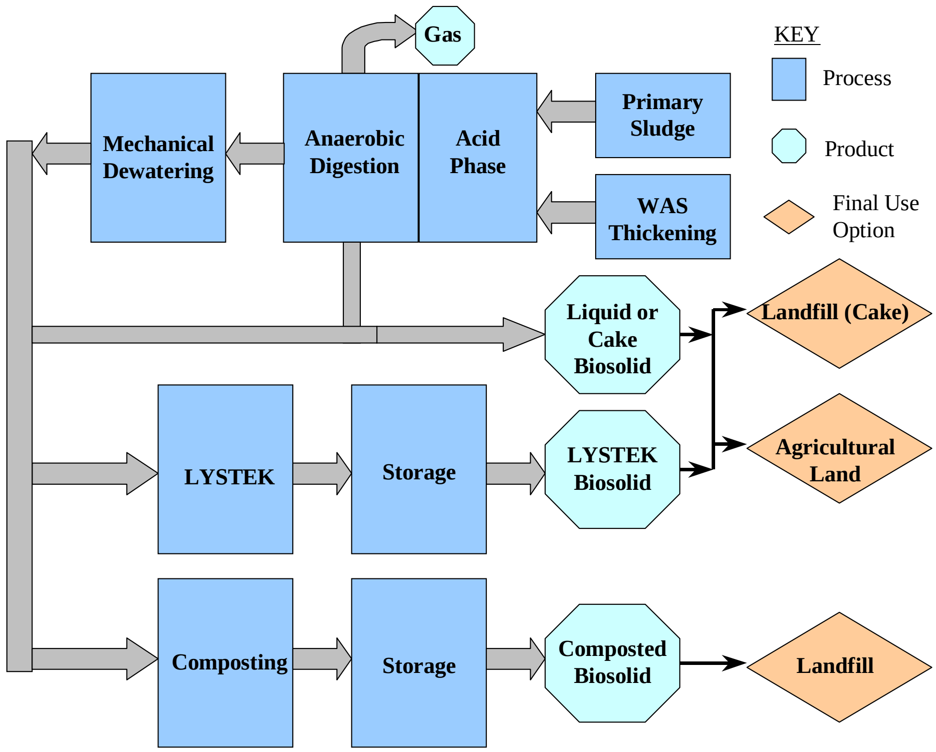


TABLE 5
Summary of Management Option 2 Technologies

System	Technology	Size	New Impact	New Construction
All Systems except digestion	See Option 1	See Option 1	See Option 1	See Option 1
Digestion	1 acid-phase digester; prior to existing primary digesters	1,135 m^3 working volume	Improved stabilization; redundant capacity (in interim)	1 acid-phase unit

3.2.2 Description of Technologies

Raw Sludge

Waste activated sludge (WAS) will not be returned to the primaries for co-thickening with primary sludge. Instead, WAS will be thickened and pumped directly to the digesters. It is assumed that the raw primary will self-thicken by gravity to 4 percent (average) and will be pumped to the digesters.

A waste sludge thickening facility will be required to manage the WAS. Three units of similar size to the demonstration Baycor RDT unit will be required (2 operating, 1 standby) for a continuous operation, or six units (5 operating, 1 standby) for 8-hour/day, 7-day/week operation.

Digestion

Additional digestion capacity will be required to handle the increase in flow of primary sludge and TWAS and the increased volatile solids loading. This will be provided by modifying the digestion process to a phased digestion process. An acid phase digester will be installed upstream of the primary digesters. The acid phase digester will provide 2 days HRT. The existing primary digesters will operate as gas phase digesters.

Digested sludge is pumped to the dewatering facility or to liquid transport and storage.

Dewatering

Additional dewatering capacity is required to manage the increase in flow. The two oldest BFPs will be replaced with at least centrifuges, with one (minimum) operating and one on standby.

Further Processing

For this option, it is assumed that there will be three routes for the dewatered cake: trucking directly to agricultural land when available; conveying to Lystek and conveying to composting.

Direct Utilization/Disposal

Liquid storage is provided so that a total of four months storage is provided amongst all the technologies. Liquid biosolids may be directly land applied, or dewatered.

The dewatered cake will be conveyed to trucks as is done currently. Additional conveying and loadout may be required. The dewatered cake can either be delivered to land application sites or to landfill.

LYSTEK

It is assumed that a 6m^3 Lystek unit with a production capacity of about 150 m^3 to 300 m^3 per week or 3 dry t/d to 6 dry t/d (continuous equivalent). The resulting Lystek biosolid will be stored on new on-site storage, providing four months Lystek product capacity.

Composting

It is assumed that the composting facility will be kept in operation at reduced throughput until it is retired from service. The optimum period to operate the composting would be during the winter, with the resulting product shipped to soil blenders in the spring. Thus, landfilling would be reduced.

3.3 Option 3 - Expand Existing System with Heat Drying

3.3.1 Description of System

The option expands the existing system to meet future flows and includes Lystek, heat drying and WAS thickening. The composting system would be decommissioned and the new technology (heat drying) installed.

Figure 3
Option 3 Solids Management Schematic

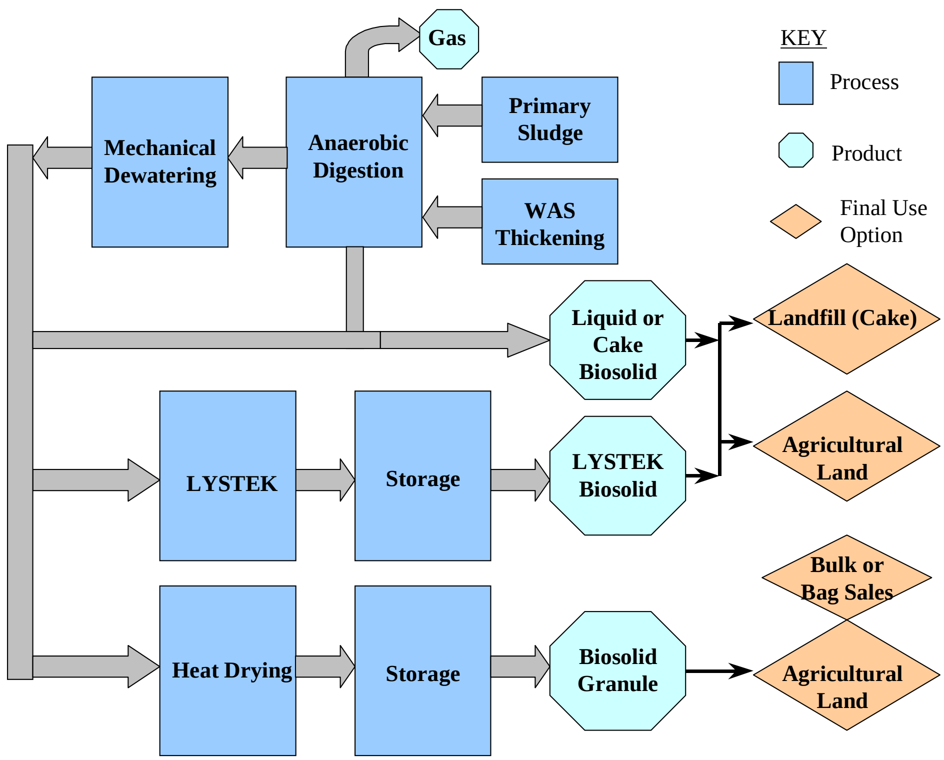


TABLE 6
Summary of Management Option 3 Technologies

System	Technology	Size	Operating Hours	New Impact	New Construction
Primary Sludge	Thicken in primaries to 4%	NA	24 hours/7 days	-	-
WAS	Mechanically thickened	Alternative #1 - 3 units	24 hours/7 days	-	-
		Alternative #2 - 6 units	8 hours/7 days	Reduced operational hours	3 additional units
Digestion	1 or 2 additional digesters; similar to existing	2,440 m^3 each	24 hours/7 days	Improved stabilization; redundant capacity (in interim)	1- 2 additional units

TABLE 6
Summary of Management Option 3 Technologies

System	Technology	Size	Operating Hours	New Impact	New Construction
Liquid Biosolids	Existing system	NA	24 hours/7 days	-	-
Dewatering	2 new centrifuges	Peak capacity 220 m^3/d each	16 hours/5 days	-	Replacement of 2 old BFPs
Lystek Processing with Storage	Process 3-6 dt/d, with storage: 4-months capacity	6 m^3 unit	24 hours/7 days; 10 months/year	Permanent facility provided Ensures process can be utilized at maximum potential year-round	4,800 m^3 capacity storage facility
Heat Drying	Process 5,103 dt/yr; with 4-months storage	13,112 tonnes of water evaporated per year (based on 28% TS feed cake)	24 hours/6 days	Permanent facility provided Ensures process can be utilized at maximum potential year-round	Heat drying train with 1,824 tonne product (pellet) storage
Composting	Decommission	NA	NA	-	-

3.3.2 Description of Technologies

Raw Sludge

Waste activated sludge (WAS) will not be returned to the primaries for co-thickening with primary sludge. Instead, WAS will be thickened and pumped directly to the digesters. It is assumed that the raw primary will self-thicken by gravity to 4 percent (average) and will be pumped to the digesters.

A waste sludge thickening facility will be required to manage the WAS. WAS flow will be about 80 m^3/d. Therefore, 3 units of similar size to the demonstration Baycor RDT unit will be required (2 operating, 1 standby) for a continuous operation.

Digestion

Additional digestion capacity will be required to handle the increase in flow of primary sludge and TWAS and the increased volatile solids loading. This will likely require the addition of one or two digesters of similar capacity to the existing primary digesters (2,440 m^3 each).

Digested sludge is pumped to dewatering. The facility for loading directly into liquid tankers for land application is provided.

Dewatering

Additional dewatering capacity is required to manage the increase in flow. The two oldest BFPs will be replaced with at least centrifuges, with one (minimum) operating and one on standby.

Further Processing

For this option, it is assumed that there will be three routes for the dewatered cake: trucking directly to agricultural land when available; conveying to Lystek and conveying to heat drying.

Direct Utilization/Disposal

The dewatered cake will be conveyed to trucks as is done currently. Additional conveying and loadout may be required. The dewatered cake can either be delivered to land application sites or to landfill.

Liquid storage will not be provided.

LYSTEK

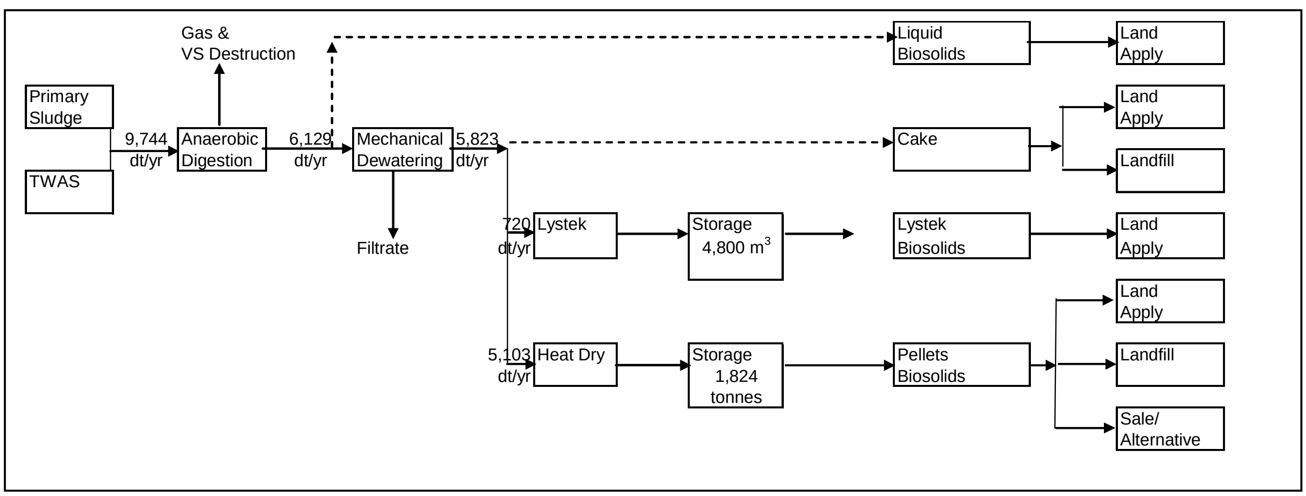
It is assumed that a 6m^3 Lystek unit with a production capacity of about 150 m^3 to 300 m^3 per week or 3 dry t/d to 6 dry t/d (continuous equivalent). The resulting Lystek biosolid will be stored in new on-site storage, providing four months storage.

Heat Drying

A heat drying facility utilizing a direct fired rotary drier will produce biosolid granules. It is assumed that some digester gas will be available for firing the dryer. Product storage silos will be provided.

3.4 Option 3 - Solids Management Sizing

The following figure shows the quantities of biosolids managed by each process stream and stored. Liquid biosolids and cake utilization or disposal may be use as contingency management alternatives.



3.5 Option 4 - Expand Existing System with Heat Drying and Phased Digestion

3.5.1 Description of System

The option expands the existing system to meet future flows utilizing phased digestion, and includes Lystek, heat drying and WAS thickening. The compost system would be decommissioned.

Figure 4
Option 4 Solids Management Schematic

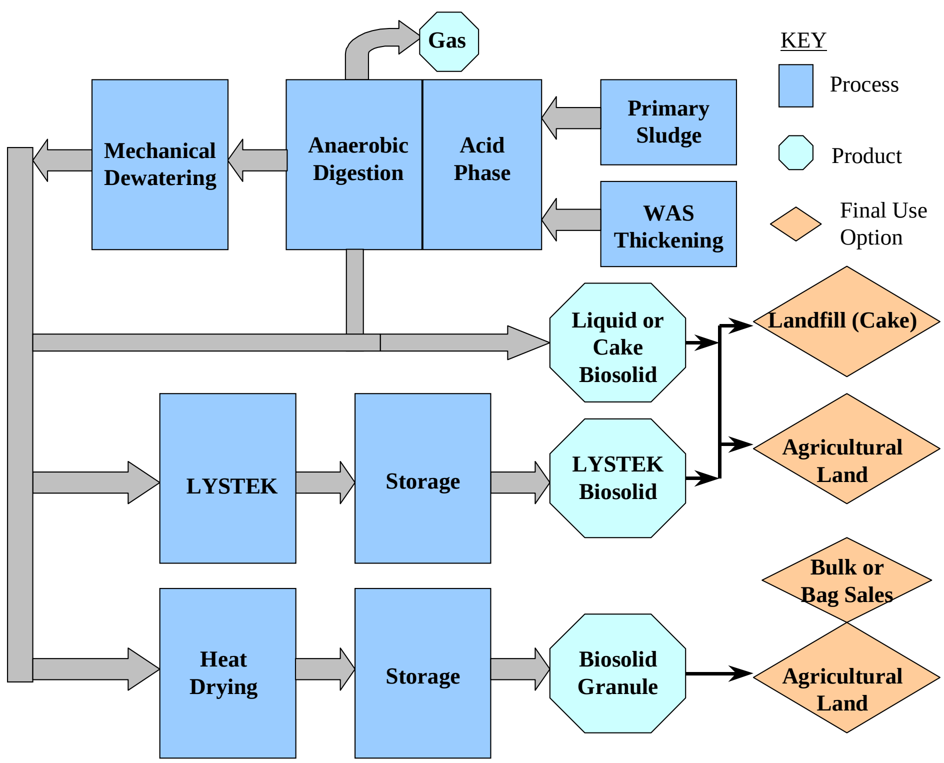


TABLE 7
Summary of Management Option 4 Technologies

System	Technology	Size	Operating Hours	New Impact	New Construction
All Systems except digestion	See Option 3	See Option 3	See Option 3	See Option 3	See Option 3
Digestion	1 acid-phase digester; prior to existing primary digesters	1,135 m^3 working volume	24 hours/ 7 days	Improved stabilization; redundant capacity (in interim)	1 acid-phase unit

3.5.2 Description of Technologies

Raw Sludge

Waste activated sludge (WAS) will not be returned to the primaries for co-thickening with primary sludge. Instead, WAS will be thickened and pumped directly to the digesters. It is assumed that the raw primary will self-thicken by gravity to 4 percent (average) and will be pumped to digesters.

A waste sludge thickening facility will be required to manage the WAS. Three units of similar size to the demonstration Baycor RDT unit will be required (2 operating, 1 standby) for a continuous operation.

Digestion

Additional digestion capacity will be required to handle the increase in flow of primary sludge and TWAS and the increased volatile solids loading. This will be provided by modifying the digestion process to a phased digestion process. An acid phase digester will be installed upstream of the primary digesters. The acid phase digester will provide 2 days HRT. The existing primary digesters will operate as gas phase digesters.

Digested sludge is pumped to dewatering. The facility for loading directly into liquid tankers for land application is provided.

Dewatering

Additional dewatering capacity is required to manage the increase in flow. The two oldest BFPs will be replaced with at least centrifuges, with one (minimum) operating and one on standby.

Further Processing

For this option, it is assumed that there will be three routes for the dewatered cake: trucking directly to agricultural land when available; conveying to Lystek and conveying to heat drying.

Direct Utilization/Disposal

The dewatered cake will be conveyed to trucks as is done currently. Additional conveying and loadout may be required. The dewatered cake can either be delivered to land application sites or to landfill.

Liquid storage is not provided.

LYSTEK

It is assumed that a 6m^3 Lystek unit with a production capacity of about 150 m^3 to 300 m^3 per week or 3 dry t/d to 6 dry t/d (continuous equivalent). The resulting Lystek biosolid will be stored in new on-site storage.

Heat Drying

A heat drying facility utilizing a direct fired rotary drier will produce biosolid granules. It is assumed that some digester gas will be available for firing the dryer. Product storage silos will be provided.

3.6 Option 5 - Expand Existing System with Primary Solids Only Digestion and Heat Drying

3.6.1 Description of System

The option expands the existing system to meet future flows and includes Lystek, heat drying and WAS thickening. Thickened WAS is not digested. The composting facility would be decommissioned. Biosolids cake could not be land applied, as the WAS would not be stabilized prior to dewatering.

Figure 5
Option 5 Solids Management Schematic

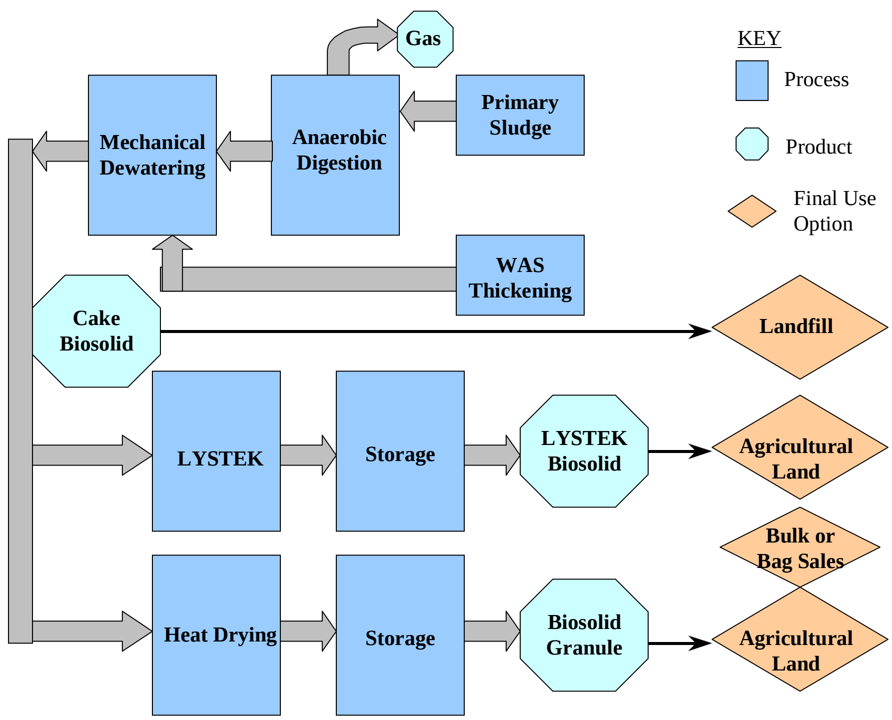


TABLE 8
Summary of Management Option 5 Technologies

System	Technology	Size	New Impact	New Construction
Primary Sludge	Thicken in primaries to 4%	NA	-	-
WAS	Mechanically thickened	Alternative #1 - 3 units	-	-
		Alternative #2 - 6 units	Reduced operational hours	3 additional units
Digestion	Existing system, bypassing TWAS digestion	NA	-	-

TABLE 8
Summary of Management Option 5 Technologies

System	Technology	Size	New Impact	New Construction
Dewatering	2 new centrifuges	Total dewatering capacity 567 m^3/d at 3.8% TS	-	Replacement of 2 old BFPs; Larger size centrifuges
Lystek Processing with Storage	Process 3-6 dt/d, with storage: 4-months capacity	6 m^3 unit	Permanent facility provided Ensures process can be utilized at maximum potential year-round	4,800 m^3 capacity storage facility
Heat Drying	Process 6,702 dt/yr; with 4-months storage	17,234 tonnes of water evaporated per year, assuming cake at 28% TS	Permanent facility provided Ensures process can be utilized at maximum potential year-round	Heat drying train with 2,395 tonne storage
Composting	Decommission	NA	-	-

3.6.2 Description of Technologies

Raw Sludge

Waste activated sludge (WAS) will not be returned to the primaries for co-thickening with primary sludge. Instead, WAS will be thickened and pumped directly to dewatering. It is assumed that the raw primary will self-thicken by gravity to 4 percent (average) and will be pumped to digesters.

A waste sludge thickening facility will be required to manage the WAS. Three units of similar size to the demonstration Baycor RDT unit will be required (2 operating, 1 standby) for a continuous operation.

Digestion

Additional digestion capacity will be not required as TWAS bypasses digestion.

Digested sludge is pumped to dewatering.

Dewatering

Additional dewatering capacity is required to handle the increase in loading. Note, the flow rate will be the same by not digesting the TWAS, but the solids loading will increase.

The two oldest BFPs will be replaced with at least centrifuges, with one (minimum) operating and one on standby.

Further Processing

For this option, it is assumed that there will be two routes for the dewatered cake: conveying to Lystek and conveying to heat drying.

LYSTEK

It is assumed that a 6m³ Lystek unit with a production capacity of about 150 m³ to 300 m³ per week or 3 dry t/d to 6 dry t/d (continuous equivalent). The resulting Lystek biosolid will be stored on new on-site storage.

Heat Drying

A heat drying facility utilizing a direct fired rotary drier will produce biosolid granules. It is assumed that some digester gas will be available for firing the dryer. A slightly larger dryer will be required to process similar to the other heat drying options. Product storage silos will be provided.

3.7 Option 6 - Expand Existing System with Alkaline Stabilization

3.7.1 Description of System

The option expands the existing system to meet future flows and includes Lystek, alkaline stabilization and WAS thickening. The composting facility would be decommissioned.

Figure 6
Option 6 Solids Management Schematic

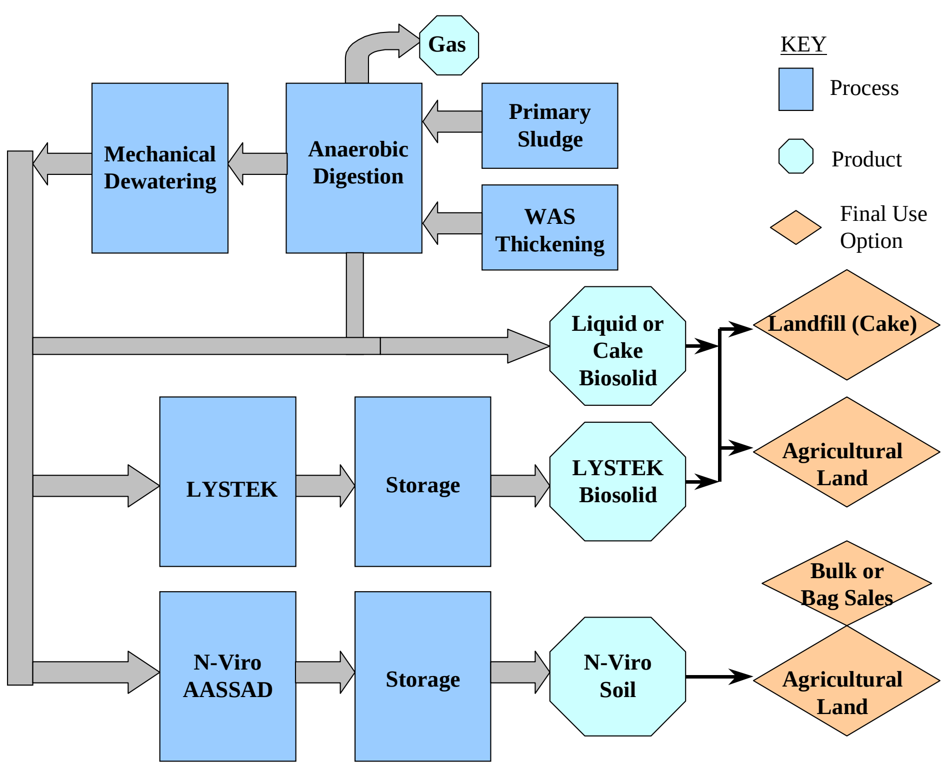


TABLE 6
Summary of Management Option 6 Technologies

System	Technology	Size	New Impact	New Construction
Primary Sludge	Thicken in primaries to 4%	NA	-	-
WAS	Mechanically thickened	Alternative #1 - 3 units	-	-
		Alternative #2 - 6 units	Reduced operational hours	3 additional units
Digestion	1 or 2 additional digesters; similar to existing	2,440 m^3 each	Improved stabilization; redundant capacity	1- 2 additional units
Liquid Biosolids	Existing system	NA	-	-
Dewatering	2 new centrifuges	Peak capacity 220 m^3/d each	-	Replacement of 2 old BFPs
Lystek Processing with Storage	Process 3 dt/d, with storage: 4-months capacity (300 m^3/d; 5 day/week, 120 days)	6 m^3 unit	Permanent facility provided Ensures process can be utilized at maximum potential year-round	4,800 m^3 capacity storage facility
Alkaline Stabilization	Process 5,103 dt/yr; with 4-months storage		Permanent facility provided Ensures process can be utilized at maximum potential year-round	New facility
Composting	Decommission	NA	-	-

3.7.2 Description of Technologies

Raw Sludge

Waste activated sludge (WAS) will not be returned to the primaries for co-thickening with primary sludge. Instead, WAS will be thickened and pumped directly to the digesters. It is assumed that the raw primary will self-thicken by gravity to 4 percent (average) and will be pumped to digesters.

A waste sludge thickening facility will be required to manage the WAS. Three units of similar size to the demonstration Baycor RDT unit will be required (2 operating, 1 standby) for a continuous operation, or six units (5 operating, 1 standby) for 8-hour/day, 7-day/week operation.

Digestion

Additional digestion capacity will be required to handle the increase in flow of primary sludge and TWAS and the increased volatile solids loading. This will likely require the addition of one or two digesters of similar capacity to the existing primary digesters (2,440 m^3 each).

Digested sludge is pumped to dewatering. The facility for loading directly into liquid tankers for land application is provided. No liquid biosolids storage is provided.

Dewatering

Additional dewatering capacity is required to handle the increase in flow. The two oldest BFPs will be replaced with at least centrifuges, with one (minimum) operating and one on standby.

Further Processing

For this option, it is assumed that there will be three routes for the dewatered cake: trucking directly to agricultural land when available; conveying to Lystek and conveying to alkaline stabilization.

Direct Cake Utilization/Disposal

The dewatered cake will be conveyed to trucks as is done currently. Additional conveying and loadout may be required. The dewatered cake can either be delivered to land application sites or to landfill.

LYSTEK

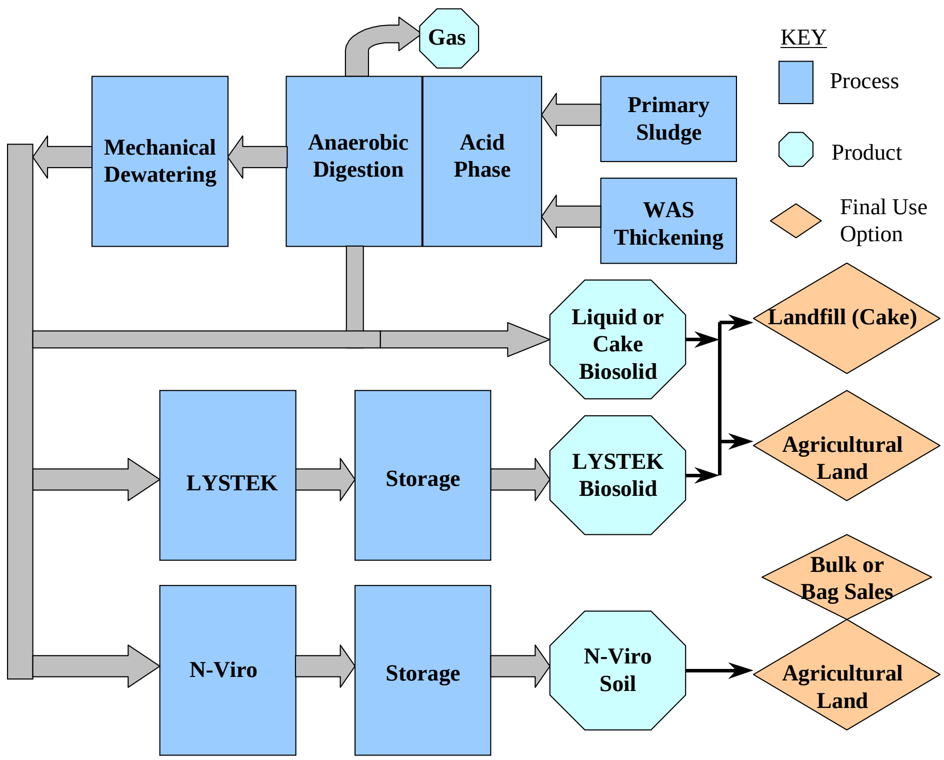
It is assumed that a 6m^3 Lystek unit with a production capacity of about 150 m^3 to 300 m^3 per week or 3 dry t/d to 6 dry t/d (continuous equivalent). The resulting Lystek biosolid will be stored on new on-site storage.

Alkaline Stabilization

An alkaline stabilization facility utilizing the N-Viro AASSAD process consisting of alkaline admixture mixing with dewatered cake, followed drying in a direct fired rotary drier and a temperature hold at specified pH for 24 hours will produce an N-Viro soil. It is assumed that some digester gas will be available for firing the dryer. Product storage silos will be provided.

3.8 Option 7 - Expand Existing System with Alkaline Stabilization and Phased Digestion

Figure 7
Option 7 Solids Management Schematic



3.8.1 Description of System

The option expands the existing system to meet future flows utilizing phased digestion and includes Lystek, heat drying and WAS thickening.

TABLE 7
Summary of Option 7 Technology

System	Technology	Size	New Impact	New Construction
All Systems except digestion	See Option 6	See Option 6	See Option 6	See Option 6
Digestion	1 acid-phase digester; prior to existing primary digesters	1,135 m^3 working volume	Improved stabilization; redundant capacity (in interim)	1 acid-phase unit

Raw Sludge

Waste activated sludge (WAS) will not be returned to the primaries for co-thickening with primary sludge. Instead, WAS will be thickened and pumped directly to the digesters. It is assumed that the raw primary will self-thicken by gravity to 4 percent to 4.5 percent and will be pumped to digesters.

A waste sludge thickening facility will be required to manage the WAS. Three units of similar size to the demonstration Baycor RDT unit will be required (2 operating, 1 standby) for a continuous operation, or six units (5 operating, 1 standby) for 8-hour/day, 7-day/week operation.

Digestion

Additional digestion capacity will be required to handle the increase in flow of primary sludge and TWAS and the increased volatile solids loading. This will be provided by modifying the digestion process to a phased digestion process. An acid phase digester will be installed upstream of the primary digesters. The acid phase digester will provide 2 days HRT. The existing primary digesters will operate as gas phase digesters.

Digested sludge is pumped to dewatering. The facility for loading directly into liquid tankers for land application is provided.

Dewatering

Additional dewatering capacity is required to handle the increase in flow. The two oldest BFPs will be replaced with at least centrifuges, with one (minimum) operating and one on standby.

Further Processing

For this option, it is assumed that there will be three routes for the dewatered cake: trucking directly to agricultural land when available; conveying to Lystek and conveying to heat drying.

Direct Cake Utilization/Disposal

The dewatered cake will be conveyed to trucks as is done currently. Additional conveying and loadout may be required. The dewatered cake can either be delivered to land application sites or to landfill.

LYSTEK

It is assumed that a 6m^3 Lystek unit with a production capacity of about 150 m^3 to 300 m^3 per week or 3 dry t/d to 6 dry t/d (continuous equivalent). The resulting Lystek biosolid will be stored on new on-site storage.

Alkaline Stabilization

An alkaline stabilization facility utilizing the N-Viro AASSAD process consisting of alkaline admixture mixing with dewatered cake, followed drying in a direct fired rotary drier and a temperature hold at specified pH for 24 hours will produce an N-Viro soil. It is assumed that some digester gas will be available for firing the dryer. Product storage silos will be provided.

4. Summary of Options

TABLE 8
Summary of Options

	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Description	Expand Existing System	Expand Existing System with Phased Digestion	Expand Existing System with Heat Drying	Expand Existing System with Heat Drying and Phased Digestion	Expand Existing System with Primary Solids Only Digestion and Heat Drying	Expand Existing System with Alkaline Stabilization	Expand Existing System with Alkaline Stabilization and Phased Digestion
Primary Sludge	No change; Same for all options						
TWAS	No change; Same for all options Storage may be required if operating period is less than 24 hours/7 days						
Anaerobic Digestion	Additional digestion	Additional acid-phase digestion	Additional digestion	Additional acid-phase digestion	No change	Additional digestion	Additional acid-phase digestion
Liquid Biosolids	36,711 m^3 storage		No change				
Mechanical Dewatering	Additional dewatering (centrifuges) Same technology for all options; Sizing for each option may vary						
Cake Biosolids	No change; Same for all options						
Lystek	4,800 m^3 storage; Same for all options						
Composting	2,053 m^3 storage		Decommission				
Heat Drying	NA		5,103 dt/yr capacity with 1,824 tonne capacity storage		6,702 dt/yr capacity with 2,395 tonne capacity storage	NA	
Alkaline Stabilization	NA					5,103 dt/yr capacity	

City of Guelph Biosolids Management Plan Evaluation of Short-Listed Management Options

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DATE: November 2005

1. Introduction

A number of alternatives that could potentially be used for managing biosolids produced at the City of Guelph's wastewater treatment plant (WWTP) were selected for detailed evaluation. These short-listed alternatives were developed from the long list compiled in Task 4 Part I and evaluated in Task 4 Part II. Task 4 Part IIIA developed and documented the basis of design for each of the selected alternatives. This memorandum describes equipment for each selected alternative and evaluates each option.

All costs were developed using a similar methodology and an equal product storage period of four months for each Option, and are therefore comparable between each Option examined. Costs were estimated at a planning level.

2. Option1 – Existing System

Option 1 expands the existing system to meet future solids processing requirements and includes Lystek and WAS thickening. No new technologies are included. Storage is provided for composted biosolids, Lystek biosolids and liquid biosolids. TM 4-IIIA provides further details.

This option allows two- and four-month scheduled maintenance periods for Lystek and composting facilities, respectively. The typical operating schedule would consist of the following:

- Composting at peak capacity (two operating reactor vessels, with additional curing in the third vessel and/or on the storage pad) for two months per year in the winter (January and February)
- Composting at firm capacity (one operating reactor vessels, with additional curing a second vessel and/or on the storage pad, and one vessel out-of-service) for six months per year in the spring and fall (March, April, September, October, November, and December)
- Compost facility scheduled maintenance (all vessels out-of-service) for four months in the summer
- Lystek treatment at peak capacity (6 m^3/day) for two months in the spring (May and June)

- Lystek treatment at firm capacity (3 m^3/day) for eight months of the year (March and April, and July through December)
- Lystek facility scheduled maintenance (all equipment out-of-service) for two months in the winter (January and February)
- Liquid biosolids storage in the winter and subsequent land application of approximately 20% of the total annual biosolids produced
- Dewatering and land application of the remainder of the biosolids

Table 2.1 illustrates an example of this schedule and the quantities processed per day by product type.

TABLE 2.1
EXAMPLE ANNUAL OPERATING SCHEDULE

Month	Unit	Total Quantity	Compost		Lystek		Liquid Quantity	Cake Quantity
			Period	Quantity	Period	Quantity		
Jan	dt/d	15.5	Peak	5.3	Maintenance	0.0	10.2	0.0
Feb	dt/d	15.5	Peak	5.3	Maintenance	0.0	10.2	0.0
Mar	dt/d	15.5	Firm	2.6	Firm	3.0	9.9	0.0
Apr	dt/d	15.5	Firm	2.6	Firm	3.0	0.0	9.9
May	dt/d	15.5	Maintenance	0.0	Peak	6.0	0.0	9.5
Jun	dt/d	15.5	Maintenance	0.0	Peak	6.0	0.0	9.5
Jul	dt/d	15.5	Maintenance	0.0	Firm	3.0	0.0	12.5
Aug	dt/d	15.5	Maintenance	0.0	Firm	3.0	0.0	12.5
Sep	dt/d	15.5	Firm	2.6	Firm	3.0	0.0	9.9
Oct	dt/d	15.5	Firm	2.6	Firm	3.0	0.0	9.9
Nov	dt/d	15.5	Firm	2.6	Firm	3.0	0.0	9.9
Dec	dt/d	15.5	Firm	2.6	Firm	3.0	9.9	0.0
Total	**dt/yr**	**5,574**		**788**		**1,080**	**1,208**	**2,508**

As discussed in Task 4 Part IIIA, it should be noted that all Options considered an equal operating scenario; namely, 100 percent beneficial utilization of biosolids. As such, Option 1 requires the storage of liquid biosolids. The actual storage recommendations will be reviewed following selection of the preferred option.

2.1 Equipment Selection, Sizing, and Operations Requirements

Table 2.2 is a short-form equipment summary for Option 1, also showing anticipated operations requirements.

TABLE 2.2
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 1

A) RAW SLUDGE	Unit	Primary Sludge	TWAS	Total Sludge	Total kW	Service Factor	Operating Hours/Yr	Total kWh/yr
Required Capacity	m^3/d	367	200	567	NA	NA	NA	
	L/s	4.2	2.3	6.6	NA	NA	NA	
Existing Units								
Primary pump capacity – Max	L/s	NA	NA	40	22.50	0.75	1,460	24,638
Primary pump capacity – Avg	L/s	NA	NA	20	NA	NA	NA	
WAS pump capacity – Max	L/s	NA	NA	NA	NA	NA	NA	
WAS pump capacity – Avg	L/s	NA	NA	NA	NA	NA	NA	
New Units								
New primary pump capacity	L/s	10	NA	NA	5.50	0.75	1,460	6,023
New WAS pump capacity	L/s	NA	10	NA	5.50	0.75	1,460	6,023
TWAS thickening RDTs	L/s	NA		NA	20.00	0.75	8,760	131,400
TWAS pump capacity	L/s	NA		NA	20.00	0.75	8,760	131,400
Polymer								
Dose rate	g/kg	NA	7.5					
B) PRIMARY DIGESTION	**Unit**	**Primary**	**Secondary**	**Total**	**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
Total installed volume – Primary	m^3	7320	2350	9670	NA	NA	NA	
Total working volume – Primary	m^3	6588	2115	8703	NA	NA	NA	
New Units								
New digester diameter	m	19.88	0	NA	NA	NA	NA	
New digester depth	m	7.92	0	NA	NA	NA	NA	
New digester volume	m^3	2,440	0	NA	NA	NA	NA	
No. new duty units	#	2	0	NA	NA	NA	NA	
Total operational units	#	2	0	NA	NA	NA	NA	
Total standby units	#	0	0	NA	NA	NA	NA	
No. new standby units	#	0	0	NA	NA	NA	NA	
Total no. new units	#	2	0	NA	NA	NA	NA	
Digester working capacity	% of tot. cap.	90%	90%	NA	NA	NA	NA	
Total new digester working volume	m^3	4,392	0	4,392	NA	NA	NA	
Recirculation Pumps								
Number of existing units	#	3	1	4	11.25	0.75	8,760	73,913
Number of new units	#	2	0	2	5.63	0.75	8,760	36,956
Heat Exchangers								
Number of existing units	#	2	1	3	NA	NA	NA	
Capacity – Each	MBTU/hr	1.5	1	2.5	NA	NA	NA	
Number of new units	#	1	0	1	NA	NA	NA	
Capacity – Each	MBTU/hr	1.5	0	1.5	NA	NA	NA	

TABLE 2.2
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 1

Transfer Pumps								
Number of existing units	#	1	1	2	3.75	0.75	1,460	4,106
Capacity – Each	L/s	18.9	15.8	34.7	NA	NA	NA	
Number of new units	#	1	0	1	1.88	0.75	1,460	2,053
Capacity – Each	L/s	18.9	0.0	18.9	NA	NA	NA	
Mixers								
Number of existing units	#	12	0		67.20	0.75	8,760	441,504
Rating, each mixer	kW	7.5						
Number of new units	#	8	0		44.80	0.75	8,760	294,336
Rating, each mixer	kW	7.5						
Performance								
Digestion VS reduction	% of VS	60%	0%	NA	NA	NA	NA	
Digester gas production	m^3/kg VSR	0.75	0.75	NA	NA	NA	NA	
Digester gas calorific value	kJ/m^3	22355	22355	NA	NA	NA	NA	
Boiler efficiency (average)	%	80%	80%	NA	NA	NA	NA	
C) LIQUID BIOSOLIDS	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
New Units								
Storage tanks	m^3	29,112			NA	NA	NA	
Mixers	#	10			56.00	1.00	8,760	490,560
Pumps	#	2			3.75	0.75	1,460	4,106
D) DEWATERING	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
New BFP 1 operating capacity	L/s	6.3			4.50	1.00	2,920	13,140
New BFP 2 operating capacity	L/s	6.3			4.50	1.00	2,920	13,140
BFP 3 capacity	L/s	6.3			4.18	0.25	2,920	3,048
BFP 4 capacity	L/s	6.3			4.18	0.25	2,920	3,048
Pumps – Polymer, filtrate feed, and sump	#	14			50.00	1.00	2,920	146,000
Polymer pump capacity – Each	L/s	0.57						
Polymer mixing tank	#	2						
Polymer tank capacity – Each	L	8800						
Polymer mixers	#	2			1.50	0.50	8,760	6,570
Supply and exhaust air fans	#	10			5.05	1.00	4,380	22,119
Misc. – Air compressor, heater, valves, etc.					38.60	0.25	8,760	84,534
New Units								
Centrifuge 1 capacity	L/s	6.5			12.36	1.00	2,920	36,093
Centrifuge 2 capacity	L/s	6.5			12.36	0.25	2,920	9,023
Polymer pumps	#	2			1.50	1.00	2,920	4,380
Polymer mixing tank	#	1			0.75	1.00	8,760	6,570

TABLE 2.2
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 1

Feed Pumps						
Number of existing units	#	4	18.50	0.75	2,920	40,515
Capacity – Each	L/s	9.5				
Number of new units	#	2	9.25	0.75	4,380	30,386
Capacity – Each	L/s	9.5				
Polymer						
Dose rate	g/kg	6.0				
E) DEWATERED CAKE TO LAND	**Unit**	**Total**	**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units						
Cross screw conveyor	#	1	2.20	1.00	4,380	9,636
Lift screw conveyor	#	1	2.20	1.00	4,380	9,636
Horizontal screw conveyor	#	2	5.00	1.00	4,380	21,900
F) LYSTEK	**Unit**		**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
6 m^3/d system			54.81	0.50	5,143	140,934
G) COMPOSTING	**Unit**		**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing System			1400	0.05	5,760	403,200
New Units						
Covered storage pad and loading area			15.00	1.00	730	10,950
Heavy equipment			2.50	1.00	730	1,825
PRODUCTION FACTOR						
Initial Year Biosolids Production Rate	7,420	dt/yr				
Ultimate Year Raw Biosolids Production Rate	9,744	dt/yr				

2.2 Estimated Costs

Attachment A includes detailed capital and operations costs for each option and Table 2.3 provides a summary for Option 1.

TABLE 2.3
SUMMARY OF ESTIMATED COSTS FOR OPTION 1

Time	Capital Cost Schedule	Revenue and Cash Savings Schedule	Combined Operations and Maintenance, and Other Costs Schedule	Discount Rate	NPV
Year 0	$25,090,000			1.0000	$25,090,000
Year 1	0	-$608,000	$2,440,000	0.9750	$1,786,000
Year 2	0	-$633,000	$2,524,000	0.9506	$1,798,000
Year 3	0	-$659,000	$2,610,000	0.9269	$1,808,000
Year 4	0	-$685,000	$2,699,000	0.9037	$1,820,000
Year 5	0	-$713,000	$2,791,000	0.8811	$1,831,000
Year 6	0	-$741,000	$2,885,000	0.8591	$1,842,000

TABLE 2.3
SUMMARY OF ESTIMATED COSTS FOR OPTION 1

Time	Capital Cost Schedule	Revenue and Cash Savings Schedule	Combined Operations and Maintenance, and Other Costs Schedule	Discount Rate	NPV
Year 7	0	-$771,000	$2,983,000	0.8376	$1,853,000
Year 8	0	-$801,000	$3,084,000	0.8167	$1,864,000
Year 9	0	-$833,000	$3,188,000	0.7962	$1,875,000
Year 10	0	-$865,000	$3,295,000	0.7763	$1,886,000
Year 11	0	-$899,000	$3,406,000	0.7569	$1,898,000
Year 12	0	-$934,000	$3,520,000	0.7380	$1,908,000
Year 13	0	-$970,000	$3,637,000	0.7195	$1,919,000
Year 14	0	-$1,007,000	$3,758,000	0.7016	$1,930,000
Year 15	0	-$1,046,000	$3,883,000	0.6840	$1,941,000
Year 16	0	-$1,086,000	$4,012,000	0.6669	$1,951,000
Year 17	0	-$1,127,000	$4,145,000	0.6502	$1,962,000
Year 18	0	-$1,169,000	$4,282,000	0.6340	$1,974,000
Year 19	0	-$1,213,000	$4,424,000	0.6181	$1,985,000
Year 20	0	-$1,257,000	$4,565,000	0.6027	$1,994,000
Total					**$62,915,000**

The capital cost per dry tonne of raw biosolids processed over the 20-year period is estimated to be $139. The net present value per dry tonne of raw biosolids processed is estimated to be $349.

3. Option 2 – Expand Existing System with Phased Digestion

Option 2 expands the existing system to meet future solids processing requirements and includes Lystek and WAS thickening. Digestion would be provided with a two-phased system, requiring a new acid-phase digestion facility. Storage is provided for composted biosolids, Lystek biosolids and liquid biosolids, and the same operating schedule and maintenance periods were allowed for as in Option 1.

3.1 Equipment Selection, Sizing, and Operations Requirements

Table 3.1 is a short-form equipment summary for Option 2, also showing anticipated operations requirements.

TABLE 3.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 2

A) RAW SLUDGE	Unit	Primary Sludge	TWAS	Total Sludge	Total kW	Service Factor	Operating Hours/Yr	Total kWh/yr
Required Capacity	m^3/d	367	200	567	NA	NA	NA	
	L/s	4.2	2.3	6.6	NA	NA	NA	
Existing Units								
Primary pump capacity – Max	L/s	NA	NA	40	22.50	0.75	1,460	24,638
Primary pump capacity – Avg	L/s	NA	NA	20	NA	NA	NA	
WAS pump capacity – Max	L/s	NA	NA	NA	NA	NA	NA	
WAS pump capacity – Avg	L/s	NA	NA	NA	NA	NA	NA	

TABLE 3.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 2

New Units								
New primary pump capacity	L/s	10	NA	NA	5.50	0.75	1,460	6,023
New WAS pump capacity	L/s	NA	10	NA	5.50	0.75	1,460	6,023
TWAS thickening RDTs	L/s	NA		NA	20.00	0.75	8,760	131,400
TWAS pump capacity	L/s	NA		NA	20.00	0.75	8,760	131,400
Polymer								
Dose rate	g/kg	NA	7.5					
B) PRIMARY DIGESTION	**Unit**	**Primary**	**Secon-dary**	**Total**	**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
Total installed volume – Primary	m^3	7320	2350	9670	NA	NA	NA	
Total working volume – Primary	m^3	6588	2115	8703	NA	NA	NA	
New Units								
New digester diameter	m	10.37	0	NA	NA	NA	NA	
New digester depth	m	4	0	NA	NA	NA	NA	
New digester volume	m^3	1,350	0	NA	NA	NA	NA	
No. new duty units	#	1	0	NA	NA	NA	NA	
Total operational units	#	1	0	NA	NA	NA	NA	
Total standby units	#	0	0	NA	NA	NA	NA	
No. new standby units	#	0	0	NA	NA	NA	NA	
Total no. new units	#	1	0	NA	NA	NA	NA	
Digester working capacity	% of tot. cap.	90%	90%	NA	NA	NA	NA	
Total new digester working volume	m^3	1,215	0	1,215	NA	NA	NA	
Recirculation Pumps								
Number of existing units	#	3	1	4	11.25	0.75	8,760	73,913
Number of new units	#	1	0	1	2.81	0.75	8,760	18,478
Heat Exchangers								
Number of existing units	#	2	1	3	NA	NA	NA	
Capacity – Each	MBTU/ hr	1.5	1	2.5	NA	NA	NA	
Number of new units	#	1	0	1	NA	NA	NA	
Capacity – Each	MBTU/ hr	1.5	0	1.5	NA	NA	NA	
Transfer Pumps								
Number of existing units	#	1	1	2	3.75	0.75	1,460	4,106
Capacity – Each	L/s	18.9	15.8	34.7	NA	NA	NA	
Number of new units	#	1	0	1	1.88	0.75	1,460	2,053
Capacity – Each	L/s	18.9	0.0	18.9	NA	NA	NA	
Mixers								
Number of existing units	#	12	0		67.20	0.75	8,760	441,504
Rating, each mixer	kW	7.5						
Number of new units	#	2	0		11.20	0.75	8,760	73,584
Rating, each mixer	kW	7.5						

TABLE 3.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 2

Performance								
Digestion VS reduction	% of VS	60%	0%	NA	NA	NA	NA	
Digester gas production	m^3/kg VSR	0.75	0.75	NA	NA	NA	NA	
Digester gas calorific value	kJ/m^3	22355	22355	NA	NA	NA	NA	
Boiler efficiency (average)	%	80%	80%	NA	NA	NA	NA	
C) LIQUID BIOSOLIDS	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
New Units								
Storage tanks	m^3	27,207			NA	NA	NA	
Mixers	#	10			56.00	1.00	8,760	490,560
Pumps	#	2			3.75	0.75	1,460	4,106
D) DEWATERING	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
New BFP 1 operating capacity	L/s	6.3			4.50	1.00	4,380	19,710
New BFP 2 operating capacity	L/s	6.3			4.50	1.00	4,380	19,710
BFP 3 capacity	L/s	6.3			4.18	1.00	4,380	18,287
BFP 4 capacity	L/s	6.3			4.18	1.00	4,380	18,287
Pumps – Polymer, filtrate feed, and sump	#	14			50.00	0.50	8,760	219,000
Polymer pump capacity – Each	L/s	0.57						
Polymer mixing tank	#	2						
Polymer tank capacity – Each	L	8800						
Polymer Mixers	#	2			1.50	0.50	8,760	6,570
Supply and exhaust air fans	#	10			5.05	1.00	4,380	22,119
Misc. – Air compressor, heater, valves, etc.					38.60	0.50	8,760	169,068
New Units								
Centrifuge 1 capacity	L/s	6.7			12.79	1.00	4,380	56,011
Centrifuge 2 capacity	L/s	6.7			12.79	1.00	4,380	56,011
Polymer pumps	#	2			1.50	0.50	8,760	6,570
Polymer mixing tank	#	1			0.75	0.50	8,760	3,285
Feed Pumps								
Number of existing units	#	4			18.50	1.00	4,380	81,030
Capacity – Each	L/s	9.5						
Number of new units	#	2			9.25	1.00	4,380	40,515
Capacity – Each	L/s	9.5						
Polymer								
Dose rate	g/kg	6.0						

TABLE 3.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 2

E) DEWATERED CAKE TO LAND	Unit	Total	Total kW	Service Factor	Operating Hours	Total kWh/yr
Existing Units						
Cross screw conveyor	#	1	2.20	1.00	4,380	9,636
Lift screw conveyor	#	1	2.20	1.00	4,380	9,636
Horizontal screw conveyor	#	2	5.00	1.00	4,380	21,900
F) LYSTEK	**Unit**		**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
6 m^3/d system			54.81	0.50	6,240	170,999
G) COMPOSTING	**Unit**		**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing System			1400	0.10	2,920	408,800
New Units						
Covered storage pad and loading area			15.00	1.00	730	10,950
Heavy equipment			2.50	1.00	730	1,825
PRODUCTION FACTOR						
Initial Year Biosolids Production Rate	7,420	dt/yr				
Ultimate Year Raw Biosolids Production Rate	9,744	dt/yr				

3.2 Estimated Costs

Table 3.2 provides a summary of estimated capital and operations costs for Option 2. Attachment A includes a detailed cost estimated breakdown.

TABLE 3.2
SUMMARY OF ESTIMATED COSTS FOR OPTION 2

Time	Capital Cost Schedule	Revenue and Cash Savings Schedule	Combined Operations and Maintenance, and Other Costs Schedule	Discount Rate	NPV
Year 0	$22,180,000			1.0000	$22,180,000
Year 1	0	-$687,000	$2,364,000	0.9750	$1,635,000
Year 2	0	-$715,000	$2,445,000	0.9506	$1,645,000
Year 3	0	-$744,000	$2,528,000	0.9269	$1,654,000
Year 4	0	-$774,000	$2,614,000	0.9037	$1,663,000
Year 5	0	-$805,000	$2,702,000	0.8811	$1,671,000
Year 6	0	-$837,000	$2,794,000	0.8591	$1,681,000
Year 7	0	-$870,000	$2,888,000	0.8376	$1,690,000
Year 8	0	-$905,000	$2,985,000	0.8167	$1,699,000
Year 9	0	-$940,000	$3,085,000	0.7962	$1,708,000
Year 10	0	-$977,000	$3,189,000	0.7763	$1,717,000
Year 11	0	-$1,015,000	$3,296,000	0.7569	$1,727,000
Year 12	0	-$1,055,000	$3,406,000	0.7380	$1,735,000

TABLE 3.2
SUMMARY OF ESTIMATED COSTS FOR OPTION 2

Time	Capital Cost Schedule	Revenue and Cash Savings Schedule	Combined Operations and Maintenance, and Other Costs Schedule	Discount Rate	NPV
Year 13	0	-$1,095,000	$3,519,000	0.7195	$1,744,000
Year 14	0	-$1,137,000	$3,636,000	0.7016	$1,753,000
Year 15	0	-$1,181,000	$3,757,000	0.6840	$1,762,000
Year 16	0	-$1,226,000	$3,881,000	0.6669	$1,771,000
Year 17	0	-$1,272,000	$4,009,000	0.6502	$1,780,000
Year 18	0	-$1,320,000	$4,142,000	0.6340	$1,789,000
Year 19	0	-$1,370,000	$4,278,000	0.6181	$1,798,000
Year 20	0	-$1,419,000	$4,414,000	0.6027	$1,805,000
Total					**$56,607,000**

The capital cost per dry tonne of raw biosolids processed over the 20-year period is estimated to be $123. The net present value per dry tonne of raw biosolids processed is estimated to be $314.

4. Option 3 – Expand Existing System with Heat Drying

Option 3 expands the existing system to meet future solids processing requirements and includes Lystek and WAS thickening. Option 3 also includes demolition of the composting system and installation of a new heat drying facility in the compost building. Storage is provided for heat dried biosolids pellets in silos and Lystek biosolids.

The capital cost estimate was based on a vendor quotation by US Filter for a Dragon Dryer® system. Attachment B displays vendor quotations. It was assumed that Lystek would operate at peak capacity for two months per year, firm capacity at eight months per year, and have a scheduled maintenance period of two months per year, as in all other Options. It was further assumed that the heat drying system would operate year-round, with a two-week scheduled maintenance period. The dryer would operate 24-hours per day, typically five to six days per week, depending on the requirements, as per the quantity of biosolids processed.

4.1 Equipment Selection, Sizing, and Operations Requirements

Table 4.1 is a short-form equipment summary for Option 3, also showing anticipated operations requirements.

TABLE 4.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 3

A) RAW SLUDGE	Unit	Primary Sludge	TWAS	Total Sludge	Total kW	Service Factor	Operating Hours/Yr	Total kWh/yr
Required Capacity	m^3/d	367	200	567	NA	NA	NA	
	L/s	4.2	2.3	6.6	NA	NA	NA	
Existing Units								
Primary pump capacity – Max	L/s	NA	NA	40	22.50	0.75	1,460	24,638
Primary pump capacity – Avg	L/s	NA	NA	20	NA	NA	NA	
WAS pump capacity – Max	L/s	NA	NA	NA	NA	NA	NA	
WAS pump capacity – Avg	L/s	NA	NA	NA	NA	NA	NA	
New Units								
New primary pump capacity	L/s	10	NA	NA	5.50	0.75	1,460	6,023
New WAS pump capacity	L/s	NA	10	NA	5.50	0.75	1,460	6,023
TWAS thickening RDTs	L/s	NA		NA	20.00	0.75	8,760	131,400
TWAS pump capacity	L/s	NA		NA	20.00	0.75	8,760	131,400
Polymer								
Dose rate	g/kg	NA	7.5					
B) PRIMARY DIGESTION	**Unit**	**Primary**	**Secondary**	**Total**	**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
Total installed volume – Primary	m^3	7320	2350	9670	NA	NA	NA	
Total working volume – Primary	m^3	6588	2115	8703	NA	NA	NA	
New Units								
New digester diameter	m	19.88	0	NA	NA	NA	NA	
New digester depth	m	7.92	0	NA	NA	NA	NA	
New digester volume	m^3	2,440	0	NA	NA	NA	NA	
No. new duty units	#	2	0	NA	NA	NA	NA	
Total operational units	#	2	0	NA	NA	NA	NA	
Total standby units	#	0	0	NA	NA	NA	NA	
No. new standby units	#	0	0	NA	NA	NA	NA	
Total no. new units	#	2	0	NA	NA	NA	NA	
Digester working capacity	% of tot. cap.	90%	90%	NA	NA	NA	NA	
Total new digester working volume	m^3	4,392	0	4,392	NA	NA	NA	
Recirculation Pumps								
Number of existing units	#	3	1	4	11.25	0.75	8,760	73,913
Number of new units	#	2	0	2	5.63	0.75	8,760	36,956
Heat Exchangers								
Number of existing units	#	2	1	3	NA	NA	NA	
Capacity – Each	MBTU /hr	1.5	1	2.5	NA	NA	NA	
Number of new units	#	1	0	1	NA	NA	NA	
Capacity – Each	MBTU /hr	1.5	0	1.5	NA	NA	NA	

TABLE 4.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 3

Transfer Pumps								
Number of existing units	#	1	1	2	3.75	0.75	1,460	4,106
Capacity – Each	L/s	18.9	15.8	34.7	NA	NA	NA	
Number of new units	#	1	0	1	1.88	0.75	1,460	2,053
Capacity – Each	L/s	18.9	0.0	18.9	NA	NA	NA	
Mixers								
Number of existing units	#	12	0		67.20	0.75	8,760	441,504
Rating, each mixer	kW	7.5						
Number of new units	#	8	0		44.80	0.75	8,760	294,336
Rating, each mixer	kW	7.5						
Performance								
Digestion VS reduction	% of VS	60%	0%	NA	NA	NA	NA	
Digester gas production	m^3/kg VSR	0.75	0.75	NA	NA	NA	NA	
Digester gas calorific value	kJ/m^3	22355	22355	NA	NA	NA	NA	
Boiler efficiency (average)	%	80%	80%	NA	NA	NA	NA	
C) LIQUID BIOSOLIDS	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
New Units	NA							
D) DEWATERING	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
New BFP 1 operating capacity	L/s	6.3			4.50	1.00	4,380	19,710
New BFP 2 operating capacity	L/s	6.3			4.50	1.00	4,380	19,710
BFP 3 capacity	L/s	6.3			4.18	1.00	4,380	18,287
BFP 4 capacity	L/s	6.3			4.18	1.00	4,380	18,287
Pumps – Polymer, filtrate feed, and sump	#	14			50.00	0.50	8,760	219,000
Polymer pump capacity – Each	L/s	0.57						
Polymer mixing tank	#	2						
Polymer tank capacity – Each	L	8800						
Polymer mixers	#	2			1.50	0.50	8,760	6,570
Supply and exhaust air fans	#	10			5.05	1.00	4,380	22,119
Misc. – Air compressor, heater, valves, etc.					38.60	0.50	8,760	169,068
New Units								
Centrifuge 1 capacity	L/s	6.3			46.00	1.00	4,380	201,480
Centrifuge 2 capacity	L/s	6.3			46.00	1.00	4,380	201,480
Polymer pumps	#	2			1.50	0.50	8,760	6,570
Polymer mixing tank	#	1			0.75	0.50	8,760	3,285

TABLE 4.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 3

Feed Pumps						
Number of existing units	#	4	18.50	1.00	4,380	81,030
Capacity – Each	L/s	9.5				
Number of new units	#	2	9.25	1.00	4,380	40,515
Capacity – Each	L/s	9.5				
Polymer						
Dose rate	g/kg	6.0				
E) DEWATERED CAKE	**Unit**	**Total**	**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units						
Cross screw conveyor	#	1	2.20	1.00	4,380	9,636
Lift screw conveyor	#	1	2.20	1.00	4,380	9,636
Horizontal screw conveyor	#	2	5.00	1.00	4,380	21,900
New Units						
Cross screw conveyor	#	0	2.20	0.00	4,380	0
Lift screw conveyor	#	0	2.20	0.00	4,380	0
Horizontal screw conveyor	#	0	5.00	0.00	4,380	0
F) LYSTEK	**Unit**		**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
6 m^3/d system			54.81	0.50	6,240	170,999
G) HEAT DRYING	**Unit**		**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
New Units						
Heat Drying Process Train	#	1	69.00	1.00	7,512	518,328
PRODUCTION FACTOR						
Initial Year Biosolids Production Rate	7,420	dt/yr				
Ultimate Year Raw Biosolids Production Rate	9,744	dt/yr				

4.2 Estimated Costs

Table 4.2 provides a summary of estimated capital and operations costs for Option 3. Attachment A includes a detailed cost estimated breakdown.

TABLE 4.2
SUMMARY OF ESTIMATED COSTS FOR OPTION 3

Time	Capital Cost Schedule	Revenue and Cash Savings Schedule	Combined Operations and Maintenance, and Other Costs Schedule	Discount Rate	NPV
Year 0	$35,820,000			1.0000	$35,820,000
Year 1	0	-$608,000	$2,163,000	0.9750	$1,516,000
Year 2	0	-$633,000	$2,237,000	0.9506	$1,525,000
Year 3	0	-$659,000	$2,314,000	0.9269	$1,534,000
Year 4	0	-$685,000	$2,393,000	0.9037	$1,543,000
Year 5	0	-$713,000	$2,474,000	0.8811	$1,552,000
Year 6	0	-$741,000	$2,558,000	0.8591	$1,561,000
Year 7	0	-$771,000	$2,645,000	0.8376	$1,570,000
Year 8	0	-$801,000	$2,735,000	0.8167	$1,579,000
Year 9	0	-$833,000	$2,827,000	0.7962	$1,588,000
Year 10	0	-$865,000	$2,922,000	0.7763	$1,597,000
Year 11	0	-$899,000	$3,020,000	0.7569	$1,605,000
Year 12	0	-$934,000	$3,122,000	0.7380	$1,615,000
Year 13	0	-$970,000	$3,226,000	0.7195	$1,623,000
Year 14	0	-$1,007,000	$3,334,000	0.7016	$1,633,000
Year 15	0	-$1,046,000	$3,445,000	0.6840	$1,641,000
Year 16	0	-$1,086,000	$3,559,000	0.6669	$1,649,000
Year 17	0	-$1,127,000	$3,678,000	0.6502	$1,659,000
Year 18	0	-$1,169,000	$3,799,000	0.6340	$1,667,000
Year 19	0	-$1,213,000	$3,925,000	0.6181	$1,676,000
Year 20	0	-$1,257,000	$4,051,000	0.6027	$1,684,000
Total					**$67,837,000**

The capital cost per dry tonne of raw biosolids processed over the 20-year period is estimated to be $199. The net present value per dry tonne of raw biosolids processed is estimated to be $376.

5. Option 4 – Expand Existing System with Heat Drying and Phased Digestion

Option 4 expands the existing system to meet future solids processing requirements and includes Lystek and WAS thickening. The additional digestion capacity required is provided with a new acid-phase digester. Option 4 also includes demolition of the composting system and installation of a new heat drying facility. Storage is provided for heat dried biosolids pellets and Lystek biosolids, and process operating scenarios are the same as Option 3.

5.1 Equipment Selection, Sizing, and Operations Requirements

Table 5.1 is a short-form equipment summary for Option 4, also showing anticipated operations requirements.

TABLE 5.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 4

A) RAW SLUDGE	Unit	Primary Sludge	TWAS	Total Sludge	Total kW	Service Factor	Operating Hours/Yr	Total kWh/yr
Required Capacity	m^3/d	367	200	567	NA	NA	NA	
	L/s	4.2	2.3	6.6	NA	NA	NA	
Existing Units								
Primary pump capacity – Max	L/s	NA	NA	40	22.50	0.75	1,460	24,638
Primary pump capacity – Avg	L/s	NA	NA	20	NA	NA	NA	
WAS pump capacity – Max	L/s	NA	NA	NA	NA	NA	NA	
WAS pump capacity – Avg	L/s	NA	NA	NA	NA	NA	NA	
New Units								
New primary pump capacity	L/s	10	NA	NA	5.50	0.75	1,460	6,023
New WAS pump capacity	L/s	NA	10	NA	5.50	0.75	1,460	6,023
TWAS thickening RDTs	L/s	NA		NA	20.00	0.75	8,760	131,400
TWAS pump capacity	L/s	NA		NA	20.00	0.75	8,760	131,400
Polymer								
Dose rate	g/kg	NA	7.5					

B) PRIMARY DIGESTION	Unit	Primary	Secondary	Total	Total kW	Service Factor	Operating Hours	Total kWh/yr
Existing Units								
Total installed volume – Primary	m^3	7320	2350	9670	NA	NA	NA	
Total working volume – Primary	m^3	6588	2115	8703	NA	NA	NA	
New Units								
New digester diameter	m	10.37	0	NA	NA	NA	NA	
New digester depth	m	4	0	NA	NA	NA	NA	
New digester volume	m^3	1,350	0	NA	NA	NA	NA	
No. new duty units	#	1	0	NA	NA	NA	NA	
Total operational units	#	1	0	NA	NA	NA	NA	
Total standby units	#	0	0	NA	NA	NA	NA	
No. new standby units	#	0	0	NA	NA	NA	NA	
Total no. new units	#	1	0	NA	NA	NA	NA	
Digester working capacity	% of tot. cap.	90%	90%	NA	NA	NA	NA	
Total new digester working volume	m^3	1,215	0	1,215	NA	NA	NA	
Recirculation Pumps								
Number of existing units	#	3	1	4	11.25	0.75	8,760	73,913
Number of new units	#	1	0	1	2.81	0.75	8,760	18,478
Heat Exchangers								
Number of existing units	#	2	1	3	NA	NA	NA	
Capacity – Each	MBTU /hr	1.5	1	2.5	NA	NA	NA	
Number of new units	#	1	0	1	NA	NA	NA	
Capacity – Each	MBTU /hr	1.5	0	1.5	NA	NA	NA	

TABLE 5.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 4

Transfer Pumps								
Number of existing units	#	1	1	2	3.75	0.75	1,460	4,106
Capacity – Each	L/s	18.9	15.8	34.7	NA	NA	NA	
Number of new units	#	1	0	1	1.88	0.75	1,460	2,053
Capacity – Each	L/s	18.9	0.0	18.9	NA	NA	NA	
Mixers								
Number of existing units	#	12	0		67.20	0.75	8,760	441,504
Rating, each mixer	kW	7.5						
Number of new units	#	2	0		11.20	0.75	8,760	73,584
Rating, each mixer	kW	7.5						
Performance								
Digestion VS reduction	% of VS	60%	0%	NA	NA	NA	NA	
Digester gas production	m^3/kg VSR	0.75	0.75	NA	NA	NA	NA	
Digester gas calorific value	kJ/m^3	22355	22355	NA	NA	NA	NA	
Boiler efficiency (average)	%	80%	80%	NA	NA	NA	NA	
C) LIQUID BIOSOLIDS	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
New Units								
D) DEWATERING	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
New BFP 1 operating capacity	L/s	6.3			4.50	1.00	4,380	19,710
New BFP 2 operating capacity	L/s	6.3			4.50	1.00	4,380	19,710
BFP 3 capacity	L/s	6.3			4.18	1.00	4,380	18,287
BFP 4 capacity	L/s	6.3			4.18	1.00	4,380	18,287
Pumps – Polymer, filtrate feed, and sump	#	14			50.00	0.50	8,760	219,000
Polymer pump capacity – Each	L/s	0.57						
Polymer mixing tank	#	2						
Polymer tank capacity – Each	L	8800						
Polymer mixers	#	2			1.50	0.50	8,760	6,570
Supply and exhaust air fans	#	10			5.05	1.00	4,380	22,119
Misc. – Air compressor, heater, valves, etc.					38.60	0.50	8,760	169,068
New Units								
Centrifuge 1 capacity	L/s	9.9			18.89	1.00	4,380	82,752
Centrifuge 2 capacity	L/s	9.9			18.89	1.00	4,380	82,752
Polymer pumps	#	2			1.50	0.50	8,760	6,570
Polymer mixing tank	#	1			0.75	0.50	8,760	3,285
Feed Pumps								
Number of existing units	#	4			18.50	1.00	4,380	81,030
Capacity – Each	L/s	9.5						
Number of new units	#	2			9.25	1.00	4,380	40,515
Capacity – Each	L/s	9.5						

TABLE 5.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 4

Polymer						
Dose rate	g/kg	6.0				
E) DEWATERED CAKE TO LAND	**Unit**	**Total**	**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units						
Cross screw conveyor	#	1	2.20	1.00	4,380	9,636
Lift screw conveyor	#	1	2.20	1.00	4,380	9,636
Horizontal screw conveyor	#	2	5.00	1.00	4,380	21,900
New Units						
Cross screw conveyor	#	0	2.20	0.00	4,380	0
Lift screw conveyor	#	0	2.20	0.00	4,380	0
Horizontal screw conveyor	#	0	5.00	0.00	4,380	0
F) LYSTEK	**Unit**		**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
6 m^3/d system			54.81	0.50	6,240	170,999
G) HEAT DRYING	**Unit**		**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
New Units						
Heat drying process train	#	1	69.00	1.00	7,512	518,328
PRODUCTION FACTOR						
Initial Year Biosolids Production Rate	7,420	dt/yr				
Ultimate Year Raw Biosolids Production Rate	9,744	dt/yr				

5.2 Estimated Costs

Attachment A includes detailed capital and operations costs for each Option and Table 5.2 provides a summary for Option 4.

TABLE 5.2
SUMMARY OF ESTIMATED COSTS FOR OPTION 4

Time	Capital Cost Schedule	Revenue and Cash Savings Schedule	Combined Operations and Maintenance, and Other Costs Schedule	Discount Rate	NPV
Year 0	$33,570,000			1.0000	$33,570,000
Year 1	0	-$685,000	$1,990,000	0.9750	$1,272,000
Year 2	0	-$713,000	$2,057,000	0.9506	$1,278,000
Year 3	0	-$742,000	$2,126,000	0.9269	$1,283,000
Year 4	0	-$772,000	$2,197,000	0.9037	$1,288,000
Year 5	0	-$803,000	$2,271,000	0.8811	$1,293,000
Year 6	0	-$835,000	$2,347,000	0.8591	$1,299,000
Year 7	0	-$868,000	$2,426,000	0.8376	$1,305,000
Year 8	0	-$903,000	$2,506,000	0.8167	$1,309,000

TABLE 5.2
SUMMARY OF ESTIMATED COSTS FOR OPTION 4

Time	Capital Cost Schedule	Revenue and Cash Savings Schedule	Combined Operations and Maintenance, and Other Costs Schedule	Discount Rate	NPV
Year 9	0	-$938,000	$2,590,000	0.7962	$1,315,000
Year 10	0	-$975,000	$2,676,000	0.7763	$1,321,000
Year 11	0	-$1,013,000	$2,764,000	0.7569	$1,325,000
Year 12	0	-$1,052,000	$2,856,000	0.7380	$1,331,000
Year 13	0	-$1,093,000	$2,950,000	0.7195	$1,336,000
Year 14	0	-$1,135,000	$3,047,000	0.7016	$1,341,000
Year 15	0	-$1,178,000	$3,147,000	0.6840	$1,347,000
Year 16	0	-$1,223,000	$3,251,000	0.6669	$1,353,000
Year 17	0	-$1,269,000	$3,357,000	0.6502	$1,358,000
Year 18	0	-$1,317,000	$3,467,000	0.6340	$1,363,000
Year 19	0	-$1,367,000	$3,580,000	0.6181	$1,368,000
Year 20	0	-$1,416,000	$3,693,000	0.6027	$1,372,000
Total					**$60,027,000**

The capital cost per dry tonne of raw biosolids processed over the 20-year period is estimated to be $186. The net present value per dry tonne of raw biosolids processed is estimated to be $333.

6. Option 5 – Expand Existing System with Primary Solids Only Digestion and Heat Drying

Option 5 expands the existing system to meet future solids processing requirements and includes Lystek and WAS thickening. Only primary sludge would be digested; it would then blended with the TWAS prior to heat drying. Additional digester capacity would not be required. Option 4 also includes demolition of the composting system and installation of a new heat drying facility. Storage is provided for heat dried biosolids pellets and Lystek biosolids, and process operating scenarios are the same as Options 3 and 4.

6.1 Equipment Selection, Sizing, and Operations Requirements

Table 6.1 is a short-form equipment summary for Option 5, also showing anticipated operations requirements.

TABLE 6.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 5

A) RAW SLUDGE	Unit	Primary Sludge	TWAS	Total Sludge	Total kW	Service Factor	Operating Hours/Yr	Total kWh/yr
Required Capacity	m^3/d	367	0	367	NA	NA	NA	
	L/s	4.2	0.0	4.2	NA	NA	NA	
Existing Units								
Primary pump capacity – Max	L/s	NA	NA	40	22.50	0.75	1,460	24,638
Primary pump capacity – Avg	L/s	NA	NA	20	NA	NA	NA	

TABLE 6.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 5

WAS pump capacity – Max	L/s	NA	NA	NA	NA	NA	NA	
WAS pump capacity – Avg	L/s	NA	NA	NA	NA	NA	NA	
New Units								
New primary pump capacity	L/s	10	NA	NA	5.50	0.75	1,460	6,023
New WAS pump capacity	L/s	NA	10	NA	5.50	0.75	1,460	6,023
TWAS thickening RDTs	L/s	NA		NA	20.00	0.75	8,760	131,400
TWAS pump capacity	L/s	NA		NA	20.00	0.75	8,760	131,400
Polymer								
Dose rate	g/kg	NA	7.5					
B) PRIMARY DIGESTION	**Unit**	**Primary**	**Secondary**	**Total**	**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
Total installed volume – Primary	m^3	7320	2350	9670	NA	NA	NA	
Total working volume – Primary	m^3	6588	2115	8703	NA	NA	NA	
New Units								
New digester diameter	m	0	0	NA	NA	NA	NA	
New digester depth	m	0	0	NA	NA	NA	NA	
New digester volume	m^3	0	0	NA	NA	NA	NA	
No. new duty units	#	0	0	NA	NA	NA	NA	
Total operational units	#	0	0	NA	NA	NA	NA	
Total standby units	#	0	0	NA	NA	NA	NA	
No. new standby units	#	0	0	NA	NA	NA	NA	
Total no. new units	#	0	0	NA	NA	NA	NA	
Digester working capacity	% of tot. cap.	90%	90%	NA	NA	NA	NA	
Total new digester working volume	m^3	0	0	0	NA	NA	NA	
Recirculation Pumps								
Number of existing units	#	3	1	4	11.25	0.75	8,760	73,913
Number of new units	#	0	0	0	NA	NA	NA	
Heat Exchangers								
Number of existing units	#	2	1	3	NA	NA	NA	
Capacity – Each	MBTU /hr	1.5	1	2.5	NA	NA	NA	
Number of new units	#	0	0	0	NA	NA	NA	
Capacity – Each	MBTU /hr	1.5	0	1.5	NA	NA	NA	
Transfer Pumps								
Number of existing units	#	1	1	2	3.75	0.75	1,460	4,106
Capacity – Each	L/s	18.9	15.8	34.7	NA	NA	NA	
Number of new units	#	0	0	0	NA	NA	NA	
Capacity – Each	L/s	18.9	0.0	18.9	NA	NA	NA	

TABLE 6.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 5

Mixers								
Number of existing units	#	12	0		67.20	0.75	8,760	441,504
Rating, each mixer	kW	7.5						
Number of new units	#	0	0		NA	NA	NA	
Rating, each mixer	kW	7.5						
Performance								
Digestion VS reduction	% of VS	60%	0%	NA	NA	NA	NA	
Digester gas production	m^3/kg VSR	0.75	0.75	NA	NA	NA	NA	
Digester gas calorific value	kJ/m^3	22355	22355	NA	NA	NA	NA	
Boiler efficiency (average)	%	80%	80%	NA	NA	NA	NA	
C) LIQUID BIOSOLIDS	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
New Units								
D) DEWATERING	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
New BFP 1 operating capacity	L/s	6.3			4.50	1.00	4,380	19,710
New BFP 2 operating capacity	L/s	6.3			4.50	1.00	4,380	19,710
BFP 3 capacity	L/s	6.3			4.18	1.00	4,380	18,287
BFP 4 capacity	L/s	6.3			4.18	1.00	4,380	18,287
Pumps – Polymer, filtrate feed, and sump	#	14			50.00	0.50	8,760	219,000
Polymer pump capacity – Each	L/s	0.57						
Polymer mixing tank	#	2						
Ploymer tank capacity – Each	L	8800						
Ploymer mixers	#	2			1.50	0.50	8,760	6,570
Supply and exhaust air fans	#	10			5.05	1.00	4,380	22,119
Misc. – Air compressor, heater, valves, etc.					38.60	0.50	8,760	169,068
New Units								
Centrifuge 1 capacity	L/s	6.3			46.00	1.00	4,380	201,480
Centrifuge 2 capacity	L/s	6.3			46.00	1.00	4,380	201,480
Polymer pumps	#	2			1.50	0.50	8,760	6,570
Polymer mixing tank	#	1			0.75	0.50	8,760	3,285
Feed Pumps								
Number of existing units	#	4			18.50	1.00	4,380	81,030
Capacity – Each	L/s	9.5						
Number of new units	#	2			9.25	1.00	4,380	40,515
Capacity – Each	L/s	9.5						
Polymer								
Dose rate	g/kg	6.0						

TABLE 6.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 5

E) DEWATERED CAKE	Unit	Total	Total kW	Service Factor	Operating Hours	Total kWh/yr
Existing Units						
Cross screw conveyor	#	1	2.20	1.00	4,380	9,636
Lift screw conveyor	#	1	2.20	1.00	4,380	9,636
horizontal screw conveyor	#	2	5.00	1.00	4,380	21,900
New Units						
Cross screw conveyor	#	0	2.20	0.00	4,380	0
Lift screw conveyor	#	0	2.20	0.00	4,380	0
Horizontal screw conveyor	#	0	5.00	0.00	4,380	0
F) LYSTEK	**Unit**		**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
6 m^3/d system			54.81	0.50	6,240	170,999
G) HEAT DRYING	**Unit**		**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
New Units						
Heat drying process train	#	1	69.00	1.00	7,512	518,328
PRODUCTION FACTOR						
Initial Year Biosolids Production Rate	7,420	dt/yr				
Ultimate Year Raw Biosolids Production Rate	9,744	dt/yr				

6.2 Estimated Costs

Detailed capital and operations costs for each Option are included in Attachment A and a summary for Option 5 is provided in Table 6.2.

TABLE 6.2
SUMMARY OF ESTIMATED COSTS FOR OPTION 5

Time	Capital Cost Schedule	Revenue and Cash Savings Schedule	Combined Operations and Maintenance, and Other Costs Schedule	Discount Rate	NPV
Year 0	$33,640,000			1.0000	$33,640,000
Year 1	0	-$339,000	$2,604,000	0.9750	$2,208,000
Year 2	0	-$353,000	$2,696,000	0.9506	$2,227,000
Year 3	0	-$368,000	$2,791,000	0.9269	$2,246,000
Year 4	0	-$382,000	$2,890,000	0.9037	$2,266,000
Year 5	0	-$398,000	$2,991,000	0.8811	$2,285,000
Year 6	0	-$414,000	$3,096,000	0.8591	$2,304,000
Year 7	0	-$430,000	$3,204,000	0.8376	$2,323,000
Year 8	0	-$447,000	$3,316,000	0.8167	$2,343,000
Year 9	0	-$465,000	$3,431,000	0.7962	$2,362,000
Year 10	0	-$483,000	$3,550,000	0.7763	$2,381,000

TABLE 6.2
SUMMARY OF ESTIMATED COSTS FOR OPTION 5

Time	Capital Cost Schedule	Revenue and Cash Savings Schedule	Combined Operations and Maintenance, and Other Costs Schedule	Discount Rate	NPV
Year 11	0	-$502,000	$3,672,000	0.7569	$2,399,000
Year 12	0	-$521,000	$3,799,000	0.7380	$2,419,000
Year 13	0	-$541,000	$3,929,000	0.7195	$2,438,000
Year 14	0	-$562,000	$4,064,000	0.7016	$2,457,000
Year 15	0	-$584,000	$4,203,000	0.6840	$2,475,000
Year 16	0	-$606,000	$4,346,000	0.6669	$2,494,000
Year 17	0	-$629,000	$4,494,000	0.6502	$2,513,000
Year 18	0	-$653,000	$4,647,000	0.6340	$2,532,000
Year 19	0	-$677,000	$4,805,000	0.6181	$2,552,000
Year 20	0	-$701,000	$4,962,000	0.6027	$2,568,000
Total					**$81,432,000**

The capital cost per dry tonne of raw biosolids processed over the 20-year period is estimated to be $187. The net present value per dry tonne of raw biosolids processed is estimated to be $451.

7. Option 6 – Expand Existing System with Alkaline Stabilization

Option 6 expands the existing system to meet future solids processing requirements and includes Lystek and WAS thickening. Option 6 also includes demolition of the composting system and installation of a new alkaline stabilization facility. Storage is provided for alkaline biosolids material and Lystek biosolids. The operating scenario is similar to Option 3, with alkaline stabilization operating year-round, with a two-week scheduled maintenance period; however, an approximately eight-hour per day schedule would be required, unless process demand increased.

7.1 Equipment Selection, Sizing, and Operations Requirements

Table 7.1 is a short-form equipment summary for Option 6, also showing anticipated operations requirements.

TABLE 7.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 6

A) RAW SLUDGE	Unit	Primary Sludge	TWAS	Total Sludge	Total kW	Service Factor	Operating Hours/Yr	Total kWh/yr
Required Capacity	m^3/d	367	200	567	NA	NA	NA	
	L/s	4.2	2.3	6.6	NA	NA	NA	
Existing Units								
Primary pump capacity – Max	L/s	NA	NA	40	22.50	0.75	1,460	24,638
Primary pump capacity – Avg	L/s	NA	NA	20	NA	NA	NA	
WAS pump capacity – Max	L/s	NA	NA	NA	NA	NA	NA	
WAS pump capacity – Avg	L/s	NA	NA	NA	NA	NA	NA	

TABLE 7.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 6

New Units								
New primary pump capacity	L/s	10	NA	NA	5.50	0.75	1,460	6,023
New WAS pump capacity	L/s	NA	10	NA	5.50	0.75	1,460	6,023
TWAS thickening RDTs	L/s	NA		NA	20.00	0.75	8,760	131,400
TWAS pump capacity	L/s	NA		NA	20.00	0.75	8,760	131,400
Polymer								
Dose rate	g/kg	NA	7.5					
B) PRIMARY DIGESTION	**Unit**	**Primary**	**Secondary**	**Total**	**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
Total installed volume – Primary	m^3	7320	2350	9670	NA	NA	NA	
Total working volume – Primary	m^3	6588	2115	8703	NA	NA	NA	
New Units								
New digester diameter	m	19.88	0	NA	NA	NA	NA	
New digester depth	m	7.92	0	NA	NA	NA	NA	
New digester volume	m^3	2,440	0	NA	NA	NA	NA	
No. new duty units	#	2	0	NA	NA	NA	NA	
Total operational units	#	2	0	NA	NA	NA	NA	
Total standby units	#	0	0	NA	NA	NA	NA	
No. new standby units	#	0	0	NA	NA	NA	NA	
Total no. new units	#	2	0	NA	NA	NA	NA	
Digester working capacity	% of tot. cap.	90%	90%	NA	NA	NA	NA	
Total new digester working volume	m^3	4,392	0	4,392	NA	NA	NA	
Recirculation Pumps								
Number of existing units	#	3	1	4	11.25	0.75	8,760	73,913
Number of new units	#	2	0	2	5.63	0.75	8,760	36,956
Heat Exchangers								
Number of existing units	#	2	1	3	NA	NA	NA	
Capacity – Each	MBTU/hr	1.5	1	2.5	NA	NA	NA	
Number of new units	#	1	0	1	NA	NA	NA	
Capacity – Each	MBTU/hr	1.5	0	1.5	NA	NA	NA	
Transfer Pumps								
Number of existing units	#	1	1	2	3.75	0.75	1,460	4,106
Capacity – Each	L/s	18.9	15.8	34.7	NA	NA	NA	
Number of new units	#	1	0	1	1.88	0.75	1,460	2,053
Capacity – Each	L/s	18.9	0.0	18.9	NA	NA	NA	

TABLE 7.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 6

Mixers								
Number of existing units	#	12	0		67.20	0.75	8,760	441,504
Rating, each mixer	kW	7.5						
Number of new units	#	8	0		44.80	0.75	8,760	294,336
Rating, each mixer	kW	7.5						
Performance								
Digestion VS reduction	% of VS	60%	0%	NA	NA	NA	NA	
Digester gas production	m^3/kg VSR	0.75	0.75	NA	NA	NA	NA	
Digester gas calorific value	kJ/m^3	22355	22355	NA	NA	NA	NA	
Boiler efficiency (average)	%	80%	80%	NA	NA	NA	NA	
C) LIQUID BIOSOLIDS	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
New Units	NA							
D) DEWATERING	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
New BFP 1 operating capacity	L/s	6.3			4.50	1.00	4,380	19,710
New BFP 2 operating capacity	L/s	6.3			4.50	1.00	4,380	19,710
BFP 3 capacity	L/s	6.3			4.18	1.00	4,380	18,287
BFP 4 capacity	L/s	6.3			4.18	1.00	4,380	18,287
Pumps – Polymer, filtrate feed, and sump	#	14			50.00	0.50	8,760	219,000
Polymer pump capacity – Each	L/s	0.57						
Polymer mixing tank	#	2						
Ploymer tank capacity – Each	L	8800						
Ploymer mixers	#	2			1.50	0.50	8,760	6,570
Supply and exhaust air fans	#	10			5.05	1.00	4,380	22,119
Misc. – Air compressor, heater, valves, etc.					38.60	0.50	8,760	169,068
New Units								
Centrifuge 1 capacity	L/s	6.3			46.00	1.00	4,380	201,480
Centrifuge 2 capacity	L/s	6.3			46.00	1.00	4,380	201,480
Polymer pumps	#	2			1.50	0.50	8,760	6,570
Polymer mixing tank	#	1			0.75	0.50	8,760	3,285
Feed Pumps								
Number of existing units	#	4			18.50	1.00	4,380	81,030
Capacity – Each	L/s	9.5						
Number of new units	#	2			9.25	1.00	4,380	40,515
Capacity – Each	L/s	9.5						
Polymer								
Dose rate	g/kg	6.0						

TABLE 7.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 6

E) DEWATERED CAKE	Unit	Total	Total kW	Service Factor	Operating Hours	Total kWh/yr
Existing Units						
Cross screw conveyor	#	1	2.20	1.00	4,380	9,636
Lift screw conveyor	#	1	2.20	1.00	4,380	9,636
Horizontal screw conveyor	#	2	5.00	1.00	4,380	21,900
New Units						
Cross screw conveyor	#	0	2.20	0.00	3,753	0
Lift screw conveyor	#	1	2.20	1.00	3,753	8,256
Horizontal screw conveyor	#	0	5.00	0.00	3,753	0
F) LYSTEK	**Unit**		**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
6 m^3/d system			54.81	0.50	6,240	170,999
G) Alkaline Stabilization	**Unit**		**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
New Units						
Heat drying process train	#	1	120	1.00	3,753	450,351
PRODUCTION FACTOR						
Initial Year Biosolids Production Rate	7,420	dt/yr				
Ultimate Year Raw Biosolids Production Rate	9,744	dt/yr				

7.2 Estimated Costs

Attachment A includes detailed capital and operations costs for each Option and Table 7.2 provides a summary for Option 6.

TABLE 7.2
SUMMARY OF ESTIMATED COSTS FOR OPTION 6

Time	Capital Cost Schedule	Revenue and Cash Savings Schedule	Combined Operations and Maintenance, and Other Costs Schedule	Discount Rate	NPV
Year 0	$31,380,000			1.0000	$31,380,000
Year 1	0	-$608,000	$3,441,000	0.9750	$2,762,000
Year 2	0	-$633,000	$3,568,000	0.9506	$2,790,000
Year 3	0	-$659,000	$3,700,000	0.9269	$2,819,000
Year 4	0	-$685,000	$3,835,000	0.9037	$2,847,000
Year 5	0	-$713,000	$3,976,000	0.8811	$2,875,000
Year 6	0	-$741,000	$4,121,000	0.8591	$2,904,000
Year 7	0	-$771,000	$4,270,000	0.8376	$2,931,000
Year 8	0	-$801,000	$4,425,000	0.8167	$2,960,000
Year 9	0	-$833,000	$4,585,000	0.7962	$2,987,000
Year 10	0	-$865,000	$4,749,000	0.7763	$3,015,000
Year 11	0	-$899,000	$4,920,000	0.7569	$3,044,000

TABLE 7.2
SUMMARY OF ESTIMATED COSTS FOR OPTION 6

Time	Capital Cost Schedule	Revenue and Cash Savings Schedule	Combined Operations and Maintenance, and Other Costs Schedule	Discount Rate	NPV
Year 12	0	-$934,000	$5,096,000	0.7380	$3,072,000
Year 13	0	-$970,000	$5,277,000	0.7195	$3,099,000
Year 14	0	-$1,007,000	$5,464,000	0.7016	$3,127,000
Year 15	0	-$1,046,000	$5,658,000	0.6840	$3,155,000
Year 16	0	-$1,086,000	$5,858,000	0.6669	$3,183,000
Year 17	0	-$1,127,000	$6,064,000	0.6502	$3,210,000
Year 18	0	-$1,169,000	$6,277,000	0.6340	$3,238,000
Year 19	0	-$1,213,000	$6,496,000	0.6181	$3,266,000
Year 20	0	-$1,257,000	$6,715,000	0.6027	$3,289,000
Total					**$91,953,000**

The capital cost per dry tonne of raw biosolids processed over the 20-year period is estimated to be $174. The net present value per dry tonne of raw biosolids processed is estimated to be $510.

8. Option 7 – Expand Existing System with Alkaline Stabilization and Phased Digestion

Option 7 expands the existing system to meet future solids processing requirements and includes Lystek and WAS thickening. A new acid-phase digester would provide the required additional digester capacity. Option 7 also includes the demolition of the composting system and the installation of a new alkaline stabilization facility. Storage is provided for alkaline biosolids material and Lystek biosolids.

8.1 Equipment Selection, Sizing, and Operations Requirements

Table 8.1 is a short-form equipment summary for Option 7, also showing anticipated operations requirements.

TABLE 8.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 7

A) RAW SLUDGE	Unit	Primary Sludge	TWAS	Total Sludge	Total kW	Service Factor	Operating Hours/Yr	Total kWh/yr
Required Capacity	m^3/d	367	200	567	NA	NA	NA	
	L/s	4.2	2.3	6.6	NA	NA	NA	
Existing Units								
Primary pump capacity – Max	L/s	NA	NA	40	22.50	0.75	1,460	24,638
Primary pump capacity – Avg	L/s	NA	NA	20	NA	NA	NA	
WAS pump capacity – Max	L/s	NA	NA	NA	NA	NA	NA	
WAS pump capacity – Avg	L/s	NA	NA	NA	NA	NA	NA	
New Units								
New primary pump capacity	L/s	10	NA	NA	5.50	0.75	1,460	6,023

TABLE 8.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 7

New WAS pump capacity	L/s	NA	10	NA	5.50	0.75	1,460	6,023
TWAS thickening RDTs	L/s	NA		NA	20.00	0.75	8,760	131,400
TWAS pump capacity	L/s	NA		NA	20.00	0.75	8,760	131,400
Polymer								
Dose rate	g/kg	NA	7.5					
B) PRIMARY DIGESTION	**Unit**	**Primary**	**Secondary**	**Total**	**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
Total installed volume – Primary	m^3	7320	2350	9670	NA	NA	NA	
Total working volume – Primary	m^3	6588	2115	8703	NA	NA	NA	
New Units								
New digester diameter	m	10.37	0	NA	NA	NA	NA	
New digester depth	m	4	0	NA	NA	NA	NA	
New digester volume	m^3	1,350	0	NA	NA	NA	NA	
No. new duty units	#	1	0	NA	NA	NA	NA	
Total operational units	#	1	0	NA	NA	NA	NA	
Total standby units	#	0	0	NA	NA	NA	NA	
No. new standby units	#	0	0	NA	NA	NA	NA	
Total no. new units	#	1	0	NA	NA	NA	NA	
Digester working capacity	% of tot. cap.	90%	90%	NA	NA	NA	NA	
Total new digester working volume	m^3	1,215	0	1,215	NA	NA	NA	
Recirculation Pumps								
Number of existing units	#	3	1	4	11.25	0.75	8,760	73,913
Number of new units	#	1	0	1	2.81	0.75	8,760	18,478
Heat Exchangers								
Number of existing units	#	2	1	3	NA	NA	NA	
Capacity – Each	MBTU /hr	1.5	1	2.5	NA	NA	NA	
Number of new units	#	1	0	1	NA	NA	NA	
Capacity – Each	MBTU /hr	1.5	0	1.5	NA	NA	NA	
Transfer Pumps								
Number of existing units	#	1	1	2	3.75	0.75	1,460	4,106
Capacity – Each	L/s	18.9	15.8	34.7	NA	NA	NA	
Number of new units	#	0	0	0	1.88	0.75	1,460	2,053
Capacity – Each	L/s	18.9	0.0	18.9	NA	NA	NA	
Mixers								
Number of existing units	#	12	0		67.20	0.75	8,760	441,504
Rating, each mixer	kW	7.5						
Number of new units	#	2	0		11.20	0.75	8,760	73,584
Rating, each mixer	kW	7.5						

TABLE 8.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 7

Performance								
Digestion VS reduction	% of VS	60%	0%	NA	NA	NA	NA	
Digester gas production	m3/kg VSR	0.75	0.75	NA	NA	NA	NA	
Digester gas calorific value	kJ/m3	22355	22355	NA	NA	NA	NA	
Boiler efficiency (average)	%	80%	80%	NA	NA	NA	NA	
C) LIQUID BIOSOLIDS	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
New Units	NA							
D) DEWATERING	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
New BFP 1 operating capacity	L/s	6.3			4.50	1.00	4,380	19,710
New BFP 2 operating capacity	L/s	6.3			4.50	1.00	4,380	19,710
BFP 3 capacity	L/s	6.3			4.18	1.00	4,380	18,287
BFP 4 capacity	L/s	6.3			4.18	1.00	4,380	18,287
Pumps – Polymer, filtrate feed, and sump	#	14			50.00	0.50	8,760	219,000
Polymer pump capacity – Each	L/s	0.57						
Polymer mixing tank	#	2						
Ploymer tank capacity – Each	L	8800						
Ploymer mixers	#	2			1.50	0.50	8,760	6,570
Supply and exhaust air fans	#	10			5.05	1.00	4,380	22,119
Misc. – Air compressor, heater, valves, etc.					38.60	0.50	8,760	169,068
New Units								
Centrifuge 1 capacity	L/s	9.9			18.89	1.00	4,380	82,752
Centrifuge 2 capacity	L/s	9.9			18.89	1.00	4,380	82,752
Polymer pumps	#	2			1.50	0.50	8,760	6,570
Polymer mixing tank	#	1			0.75	0.50	8,760	3,285
Feed Pumps								
Number of existing units	#	4			18.50	1.00	4,380	81,030
Capacity – Each	L/s	9.5						
Number of new units	#	2			9.25	1.00	4,380	40,515
Capacity – Each	L/s	9.5						
Polymer								
Dose rate	g/kg	6.0						
E) DEWATERED CAKE TO LAND	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
Cross screw conveyor	#	1			2.20	1.00	4,380	9,636
Lift screw conveyor	#	1			2.20	1.00	4,380	9,636
Horizontal screw conveyor	#	2			5.00	1.00	4,380	21,900

TABLE 8.1
EQUIPMENT AND OPERATIONAL REQUIREMENTS SUMMARY FOR OPTION 7

New Units							
Cross screw conveyor	#	0		2.20	0.00	4,380	0
Lift screw conveyor	#	1		2.20	0.00	3,111	0
Horizontal screw conveyor	#	0		5.00	0.00	4,380	0
F) LYSTEK	**Unit**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
6 m^3/d system				54.81	0.50	6,240	170,999
G) ALKALINE STABILIZATION	**Unit**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
New Units							
Alkaline stabilization process train	#	1		120.00	1.00	3,111	373,279
PRODUCTION FACTOR							
Initial Year Biosolids Production Rate	7,420	dt/yr					
Ultimate Year Raw Biosolids Production Rate	9,744	dt/yr					

8.2 Estimated Costs

Attachment A includes detailed capital and operations costs for each Option and Table 8.2 provides a summary for Option 7.

TABLE 8.2
SUMMARY OF ESTIMATED COSTS FOR OPTION 7

Time	Capital Cost Schedule	Revenue and Cash Savings Schedule	Combined Operations and Maintenance, and Other Costs Schedule	Discount Rate	NPV
Year 0	$27,850,000			1.0000	$27,850,000
Year 1	0	-$685,000	$3,064,000	0.9750	$2,320,000
Year 2	0	-$713,000	$3,176,000	0.9506	$2,341,000
Year 3	0	-$742,000	$3,292,000	0.9269	$2,363,000
Year 4	0	-$772,000	$3,411,000	0.9037	$2,385,000
Year 5	0	-$803,000	$3,535,000	0.8811	$2,407,000
Year 6	0	-$835,000	$3,662,000	0.8591	$2,429,000
Year 7	0	-$868,000	$3,794,000	0.8376	$2,451,000
Year 8	0	-$903,000	$3,930,000	0.8167	$2,472,000
Year 9	0	-$938,000	$4,070,000	0.7962	$2,494,000
Year 10	0	-$975,000	$4,215,000	0.7763	$2,515,000
Year 11	0	-$1,013,000	$4,365,000	0.7569	$2,537,000
Year 12	0	-$1,052,000	$4,519,000	0.7380	$2,559,000
Year 13	0	-$1,093,000	$4,679,000	0.7195	$2,580,000
Year 14	0	-$1,135,000	$4,843,000	0.7016	$2,601,000
Year 15	0	-$1,178,000	$5,013,000	0.6840	$2,623,000
Year 16	0	-$1,223,000	$5,189,000	0.6669	$2,645,000

TABLE 8.2
SUMMARY OF ESTIMATED COSTS FOR OPTION 7

Time	Capital Cost Schedule	Revenue and Cash Savings Schedule	Combined Operations and Maintenance, and Other Costs Schedule	Discount Rate	NPV
Year 17	0	-$1,269,000	$5,370,000	0.6502	$2,667,000
Year 18	0	-$1,317,000	$5,557,000	0.6340	$2,688,000
Year 19	0	-$1,367,000	$5,750,000	0.6181	$2,709,000
Year 20	0	-$1,416,000	$5,942,000	0.6027	$2,728,000
Total					**$78,364,000**

The capital cost per dry tonne of raw biosolids processed over the 20-year period is estimated to be $154. The net present value per dry tonne of raw biosolids processed is estimated to be $434.

9. Evaluation

9.1 Evaluation Process

Each possible technology was initially screened according to "must-have" criteria, as TM 4 – Part I discussed. TM 4 – Part II developed technologies that passed the screening exercise.

In TM 4 – Part IIIA the design parameters were determined so that each option could be evaluated on an equally comparable basis. The previous sections of this TM (TM 4 – Part IIIB) described the specific elements of each option.

CH2M HILL and the City initially developed evaluation criteria for the options. The criteria consisted of four groups of objectives and estimated capital and operations and maintenance costs. Each option was subsequently compared to the evaluation criteria in a workshop on May 2, 2005. The scores determined in the workshop were entered into an evaluation matrix; a sensitivity analysis of weightings was also performed. The results of the evaluation are described below.

9.2 Evaluation Criteria

The four groups of objectives were: technical, social/cultural, natural and, economic environment. Within each group, a number of evaluation criteria were identified and a scoring methodology defined, as Table 9.1 describes. Estimated capital and operations and maintenance costs were also considered in the evaluation, and are also discussed below.

TABLE 9.1
EVALUATION OBJECTIVES AND CRITERIA

Objective	Evaluation Criteria	Relative Score (0–10) Versus Measure
Technical Environment	**Technical Performance** – The ability of an alternative to satisfactorily perform its intended functions (treatment, utilization method, disposal options)	The alternative is very reliable, consistently meets or exceeds performance criteria and product quality – 10 The alternative is moderately reliable, meets performance criteria and product quality with regular operation and maintenance – 5 The alternative is not very reliable and requires high levels of operation and maintenance to meet performance and product quality – 0
	Energy Requirements – The energy, water, and other utilities requirements for the product produced by the alternative are comparable relative to the existing treatment system and other alternatives.	The alternative is very energy-efficient; re-use and recycle options are possible – 10 The alternative is somewhat energy-efficient – 5 The alternative is not very energy-efficient; uses significant amounts of energy/utilities – 0
	Long-term Sustainability – The ability of an alternative (treatment, utilization/disposal) to adapt to changing conditions (technologies, regulations, market factors)	The alternative can easily be adapted to changing conditions to meet long-term needs – 10 The alternative is somewhat flexible to meet long-term needs (some constraints) – 5 The alternative is not very flexible; difficult to meet needs in the long term – 0
	Ease of Implementation – The alternative can be easily implemented on a technical, regulatory, and practical basis (land availability, operational aspects, administrative requirements, etc.)	The alternative is very easy to implement with respect to approvals and construction – 10 The alternative is somewhat easy to implement (some constraints) – 5 The alternative has many difficulties with respect to implementation – 0
	Compatibility – The alternative is compatible with current processing units and can be installed and integrated into the current plant operations with minimal impact to current operations	The alternative is very compatible and compliments current processing units and can be integrated into current plant operations with minimal impact – 10 The alternative is somewhat compatible and complimentary to current processing units and can be integrated with minimal impact – 5 The alternative is not compatible or complimentary to current processing units and integration may be difficult – 0
	Complexity – The alternative does not add complexity to current operations and can be operated and maintained by current level of licensed operators with appropriate training	The alternative is not complicated and can be operated and maintained by current staff competencies – 10 The alternative is somewhat complicated and can be operated and maintained with minimal staff training – 5 The alternative is complicated and significant staff training and development is necessary for operation and maintenance – 0
	Regulatory Acceptance/ Approvals – Regulatory approvals are not complicated, both processing and product utilization/disposal are approvable	The alternative is an accepted regulatory practice and approvals are not expected to be difficult – 10 The alternative is unique and expected to receive regulatory acceptance and approval with some effort – 5 The alternative is very unique and regulatory acceptance and approval may take significant effort – 0

TABLE 9.1
EVALUATION OBJECTIVES AND CRITERIA

Objective	Evaluation Criteria	Relative Score (0–10) Versus Measure
Social/Cultural Considerations	**Odour** – The potential for alternative to minimize odour events	The alternative has little or no potential to produce odour – 10 The alternative has moderate potential to produce odour, odour control measures may be needed to prevent migration offsite – 5 The alternative has high potential to produce odour; significant mitigation needed to control migration offsite – 0
	Agricultural Practices – The potential for the alternative to be compatible with current (and developing) agricultural practices over the long term	The alternative is very compatible with current practices and developing practices – 10 The alternative is somewhat compatible with current and developing practices – 5 The alternative is not compatible with existing and developing practices; may require significant modifications to increase compatibility – 0
	Visual Character – The potential for the alternative to maintain the visual character of an area	The alternative is discreet and will have no impact on the visual character of an area ; existing visual character will be maintained – 10 Components of the alternative may have a minor impact on the visual character of an area: visual character may be modified somewhat – 5 The alternative will have a significant impact on the visual character of an area; existing character will be altered to a great degree – 0
	Transportation – The potential for the alternative to avoid increased demands on the transportation systems (patterns, volumes and infrastructure requirements)	The alternative will not place additional demands on transportation system – 10 The alternative may place minor additional demands on the transportation system – 5 The alternative may place major demands on the transportation system – 0
	Noise – The potential for the alternative to minimize the production of noise during normal operations	The alternative has little or no potential to produce noise – 10 The alternative has moderate potential to produce noise, noise control measures may be needed to prevent migration offsite – 5 The alternative has high potential to produce noise; significant mitigation needed to control migration offsite – 1
	Occupational Health & Safety (In-Plant) – Potential risk or liability to staff health and safety from exposure to: • Explosions • Processing chemicals • Gaseous emissions • Toxic organics	The alternative will result in very little potential risk to staff health and safety compared to other alternatives – 10 The alternative will result in a moderate potential risk to staff health and safety are compared with other alternatives – 5 The alternative will result in a high potential risk to staff health and safety compared to other alternatives (without substantial mitigation) – 0

TABLE 9.1
EVALUATION OBJECTIVES AND CRITERIA

Objective	Evaluation Criteria	Relative Score (0–10) Versus Measure
	Occupational Health & Safety (Offsite) – Potential risk or liability to community health and safety from exposure to: • Explosions • Traffic accidents • Gaseous emissions • Toxic organics • Heavy metals • Flooding of watercourses (Speed/Grand River)	The alternative will result in very little potential risk to community health and safety compared to other alternatives – 10 The alternative will result in a moderate potential risk to community health and safety are compared with other alternatives – 5 The alternative will result in a high potential risk to community health and safety compared to other alternatives (without substantial mitigation) – 0
	Public Acceptability – The potential of the alternative to receive public support and acceptance based on: • Projects of a similar nature in other Ontario communities • Community history with the WWTP	The alternative has the potential to receive a high level of support and endorsement by the public – 10 The alternative has the potential to receive a moderate level of support and endorsement from the public – 5 The alternative has the potential to receive a low level of support and endorsement from the publication needed to control impacts – 0
Natural Environment	**Effluent Quality** – The potential of the alternative to meet WWTP effluent quality requirements	The alternative will contribute to the WWTP effluent by bettering the effluent criteria requirements on a consistent basis – 10 The alternative will contribute to the WWTP effluent meeting and sometimes bettering the effluent criteria requirements – 7 The alternative has no impact on WWTP effluent quality – 5 the alternative will not contribute to the WWTP meeting effluent quality requirements – 0
	Water Quality – The potential of the alternative to improve Grand River water quality and aquatic habitats	The alternative results in significant improvements to Grand River water quality and aquatic habitats – 10 The alternative results in moderate improvements to Grand River water quality and aquatic habitats – 7 The alternative has no impact on Grand River water quality and aquatic habitats – 5 The alternative results in little improvement to Grand River water quality beyond regulations; significant mitigation required to control impacts on aquatic habitats – 0
	Terrestrial Systems – The potential of the alternative to improve terrestrial habitats/ systems (including mammals, reptiles, birds) and terrestrial features/functions	The alternative results in a net improvement in terrestrial systems and habitats – 10 The alternative results in the maintenance of the existing terrestrial systems and habitats – 5 The alternative results in a net loss of terrestrial systems and habitats – compensation measures may be required – 0
	Soil – The potential impact of an alternative on soil quality and productivity	The alternative has the potential to improve the quality and/or productivity of the soil through application – 10 The alternative does not have the potential to improve the quality or productivity of the soil (no positive or negative impact) – 5 The alternative has the potential to reduce the quality and/or productivity of the soil – 0

TABLE 9.1
EVALUATION OBJECTIVES AND CRITERIA

Objective	Evaluation Criteria	Relative Score (0–10) Versus Measure
	Groundwater Quality and Flow – The potential of the alternative to protect groundwater resources	The alternative provides significant protection to groundwater resources – 10 The alternative provides moderate protection to groundwater resources – 7 The alternative has no impact on groundwater resources – 5 The alternative provides little if, any, protection to groundwater resources; significant mitigation needed to provide protection – 1
	Air Emissions – The potential for an alternative to meet provincial regulatory requirements for air emissions This criteria does not address odours	The alternative exceeds regulatory requirements and results in a significant reduction in overall air emissions from the WWTP – 10 The alternative meets the regulatory requirements and may result in a moderate reduction in overall air emissions from the WWTP – 7 The alternative has no impact on air emissions from the WWTP – 5 The alternative does not consistently meet regulatory requirements and results in no change or an increase in overall emissions from the WWTP; significant mitigation required to control air emissions to meet regulations – 0
Economic Environment	**Sales Demand** – The potential for the alternative to create a product that meets market demands	The product will have a high market demand – All of product sold – 10 The product will have a moderate market demand – 50% of product sold – 7 The product will have a low market demand – Product given away free – 5 The product will have no market demand and may require incentives, i.e. pay to land apply the product – 0
	Contracts – What is the number and complexity of the service contracts required?	No contracts – 10 Multiple simple contracts – 6 Single complex contract – 3 Numerous complex contracts – 0

9.3 Evaluation Results

9.3.1 Objective Evaluation

The evaluation of objectives was performed in the workshop. Table 9.2 provides the results of the workshop.

TABLE 9.2
EVALUATION OF OPTIONS WITH RESPECT THE TO OBJECTIVE AND CRITERIA

Objective	Evaluation Criteria	Option 1		Option 2		Option 3		Option 4		Option 5		Option 6		Option 7	
		Description	Score	Description	Score	Description	Score	Description	Score	Description	Score	Description	Score	Description	Score
		Expand Existing System		***Expand Existing System with Phased Digestion***		***Heat Drying with Expanded Digestion***		***Heat Drying with Phased Digestion***		***Heat Drying with Primary Only Digestion***		***Alkaline Stabilization with Expanded Digestion***		***Alkaline Stabilization with Phased Digestion***	
Technical Environment	**Technical Performance** – The ability of an alternative to satisfactorily perform its intended functions (treatment, utilization method, disposal options)	The alternative is very reliable, consistently meets or exceeds performance criteria and product quality *The technology is understood and relatively simple*	10	The alternative is very reliable, consistently meets or exceeds performance criteria and product quality *The technology is understood and relatively simple*	10	The alternative is moderately reliable, meets performance criteria and product quality with regular operation and maintenance	5	The alternative is moderately reliable, meets performance criteria and product quality with regular operation and maintenance	5	The alternative is moderately reliable, meets performance criteria and product quality with regular operation and maintenance	5	The alternative is moderately reliable, meets performance criteria and product quality with regular operation and maintenance	5	The alternative is moderately reliable, meets performance criteria and product quality with regular operation and maintenance	5
Technical Environment	**Energy Requirements** – The energy, water, and other utilities requirements for the product produced by the alternative are comparable relative to the existing treatment system and other alternatives.	The alternative is very energy-efficient	10	The alternative is very energy-efficient	10	The alternative is not very energy-efficient; uses significant amounts of energy/utilities	0	The alternative is not very energy-efficient; uses significant amounts of energy/utilities	0	The alternative is not very energy-efficient; uses significant amounts of energy/utilities	0	The alternative is somewhat energy-efficient	5	The alternative is somewhat energy-efficient	5
Technical Environment	**Long-term Sustainability** – The ability of an alternative (treatment, utilization/ disposal) to adapt to changing conditions (technologies, regulations, market factors)	The alternative is somewhat flexible to meet long term needs (*relies on land application and older equipment*)	5	The alternative is somewhat flexible to meet long-term needs (*relies on land application and older equipment*)	5	The alternative can easily be adapted to changing conditions to meet long-term needs	10	The alternative can easily be adapted to changing conditions to meet long-term needs	10	The alternative can easily be adapted to changing conditions to meet long-term needs	10	The alternative is somewhat flexible to meet long-term needs (*relies on land application*)	5	The alternative is somewhat flexible to meet long term needs (*relies on land application*)	5
Technical Environment	**Ease of Implementation** – The alternative can be easily implemented on a technical, regulatory and practical basis (land availability, operational aspects, administrative requirements, etc.)	The alternative is very easy to implement with respect to approvals and construction	10	The alternative is very easy to implement with respect to approvals and construction	10	The alternative is somewhat easy to implement (*some constraints – thermal processing*)	5	The alternative is somewhat easy to implement (*some constraints – thermal processing*)	5	The alternative is somewhat easy to implement (*some constraints – thermal processing*)	5	The alternative is somewhat easy to implement (*some constraints – alkaline stabilization*)	5	The alternative is somewhat easy to implement (*some constraints – alkaline stabilization*)	5
Technical Environment	**Compatibility** – The alternative is compatible with current processing units and can be installed and integrated into the current plant operations with minimal impact to current operations	The alternative is very compatible and compliments current processing units, and can be integrated into current plant operations with minimal impact	10	The alternative is very compatible and compliments current processing units, and can be integrated into current plant operations with minimal impact	10	The alternative is somewhat compatible and complimentary to current processing units and can be integrated with minimal impact (*some constraints – thermal processing*)	5	The alternative is somewhat compatible and complimentary to current processing units and can be integrated with minimal impact (*some constraints – thermal processing*)	5	The alternative is not complimentary to current processing units and integration may be difficult (*no digestion*)	0	The alternative is very compatible and compliments current processing units, and can be integrated into current plant operations with minimal impact	10	The alternative is very compatible and compliments current processing units, and can be integrated into current plant operations with minimal impact	10
Technical Environment	**Complexity** – The alternative does not add complexity to current operations and can be operated and maintained by current level of licensed operators with appropriate training	The alternative is not complicated and can be operated and maintained by current staff competencies	10	The alternative is not complicated and can be operated and maintained by current staff competencies	10	The alternative is complicated and significant staff training and development is necessary for operation and maintenance	0	The alternative is complicated and significant staff training and development is necessary for operation and maintenance	0	The alternative is complicated and significant staff training and development is necessary for operation and maintenance	0	The alternative is complicated and significant staff training and development is necessary for operation and maintenance	0	The alternative is complicated and significant staff training and development is necessary for operation and maintenance	0
Technical Environment	**Regulatory Acceptance/approvals** – Regulatory approvals are not complicated, both processing and product utilization/disposal are approvable	The alternative is an accepted regulatory practice and approvals are not expected to be difficult	10	The alternative is an accepted regulatory practice and approvals are not expected to be difficult	10	The alternative is an accepted regulatory practice and approvals are not expected to be difficult	10	The alternative is an accepted regulatory practice and approvals are not expected to be difficult	10	The alternative is an accepted regulatory practice and approvals are not expected to be difficult	10	The alternative is an accepted regulatory practice and approvals are not expected to be difficult	10	The alternative is an accepted regulatory practice and approvals are not expected to be difficult	10

TABLE 9.2
EVALUATION OF OPTIONS WITH RESPECT THE TO OBJECTIVE AND CRITERIA

Objective	Evaluation Criteria	Option 1		Option 2		Option 3		Option 4		Option 5		Option 6		Option 7	
		Description	Score	Description	Score	Description	Score	Description	Score	Description	Score	Description	Score	Description	Score
		Expand Existing System		***Expand Existing System with Phased Digestion***		***Heat Drying with Expanded Digestion***		***Heat Drying with Phased Digestion***		***Heat Drying with Primary Only Digestion***		***Alkaline Stabilization with Expanded Digestion***		***Alkaline Stabilization with Phased Digestion***	
Social/Cultural Considerations	**Odour** – The potential for alternative to minimize odour events	The alternative has moderate potential to produce odour, odour control measures may be needed to prevent migration off-site	5	The alternative has moderate potential to produce odour, odour control measures may be needed to prevent migration off-site	5	The alternative has little or no potential to produce odour	10	The alternative has little or no potential to produce odour	10	The alternative has little or no potential to produce odour	10	The alternative has moderate potential to produce odour, odour control measures may be needed to prevent migration off-site	5	The alternative has moderate potential to produce odour, odour control measures may be needed to prevent migration off-site	5
Social/Cultural Considerations	**Agricultural Practices** – The potential for the alternative to be compatible with current (and developing) agricultural practices over the long term	The alternative is very compatible with current practices and developing practices	10	The alternative is very compatible with current practices and developing practices	10	The alternative is somewhat compatible with current and developing practices *(a market has not been developed)*	5	The alternative is somewhat compatible with current and developing practices *(a market has not been developed)*	5	The alternative is somewhat compatible with current and developing practices *(a market has not been developed)*	5	The alternative is very compatible with current practices and developing practices	10	The alternative is very compatible with current practices and developing practices	10
Social/Cultural Considerations	**Visual Character** – The potential for the alternative to maintain the visual character of an area	Components of the alternative may have a minor impact on the visual character of an area	5	Components of the alternative may have a minor impact on the visual character of an area	5	Components of the alternative may have a minor impact on the visual character of an area	5	Components of the alternative may have a minor impact on the visual character of an area	5	Components of the alternative may have a minor impact on the visual character of an area	5	Components of the alternative may have a minor impact on the visual character of an area	5	Components of the alternative may have a minor impact on the visual character of an area	5
Social/Cultural Considerations	**Transportation** – The potential for the alternative to avoid increased demands on the transportation systems (patterns, volumes and infrastructure requirements)	The alternative may place major demands on the transportation system	0	The alternative may place major demands on the transportation system	0	The alternative will not place additional demands on transportation system	10	The alternative will not place additional demands on transportation system	10	The alternative will not place additional demands on transportation system	10	The alternative may place minor additional demands on the transportation system	5	The alternative may place minor additional demands on the transportation system	5
Social/Cultural Considerations	**Noise** – The potential for the alternative to minimize the production of noise during normal operations	The alternative has high potential to produce noise (*transport*)	0	The alternative has high potential to produce noise (*transport*)	0	The alternative has moderate potential to produce noise	5	The alternative has moderate potential to produce noise	5	The alternative has moderate potential to produce noise	5	The alternative has moderate potential to produce noise	5	The alternative has moderate potential to produce noise	5
Social/ Cultural Considerations	**Occupational Health & Safety (In-Plant)** – Potential risk or liability to staff health and safety.	The alternative will result in very little potential risk to staff health and safety	10	The alternative will result in very little potential risk to staff health and safety	10	The alternative will result in a high potential risk to staff health and safety (without substantial mitigation)	0	The alternative will result in a high potential risk to staff health and safety (without substantial mitigation)	0	The alternative will result in a high potential risk to staff health and safety (without substantial mitigation)	0	The alternative will result in a moderate potential risk to staff health and safety compared with other alternatives	5	The alternative will result in a moderate potential risk to staff health and safety compared with other alternatives	5
Social/Cultural Considerations	**Occupational Health & Safety (Off-Site)** – Potential risk or liability to community health and safety	The alternative will result in very little potential risk to community health	10	The alternative will result in very little potential risk to community health and safety	10	The alternative will result in very little potential risk to community health and safety	10	The alternative will result in very little potential risk to community health and safety	10	The alternative will result in very little potential risk to community health and safety	10	The alternative will result in very little potential risk to community health and safety	10	The alternative will result in very little potential risk to community health and safety	10
Social/Cultural Considerations	**Public Acceptability** – The potential of the alternative to receive public support and acceptance	The alternative has the potential to receive a moderate level of support and endorsement from the public	5	The alternative has the potential to receive a moderate level of support and endorsement from the public	5	The alternative has the potential to receive a low level of support and endorsement from the public (*heat drying issues in Toronto & Windsor*)	0	The alternative has the potential to receive a low level of support and endorsement from the public (*heat drying issues in Toronto & Windsor*)	0	The alternative has the potential to receive a low level of support and endorsement from the public (*heat drying issues in Toronto & Windsor*)	0	The alternative has the potential to receive a moderate level of support and endorsement from the public	5	The alternative has the potential to receive a moderate level of support and endorsement from the public	5

TABLE 9.2
EVALUATION OF OPTIONS WITH RESPECT THE TO OBJECTIVE AND CRITERIA

Objective	Evaluation Criteria	Option 1		Option 2		Option 3		Option 4		Option 5		Option 6		Option 7	
		Description	Score	Description	Score	Description	Score	Description	Score	Description	Score	Description	Score	Description	Score
		Expand Existing System		***Expand Existing System with Phased Digestion***		***Heat Drying with Expanded Digestion***		***Heat Drying with Phased Digestion***		***Heat Drying with Primary Only Digestion***		***Alkaline Stabilization with Expanded Digestion***		***Alkaline Stabilization with Phased Digestion***	
Natural Environment	**Effluent Quality** – The potential of the alternative to meet WWTP effluent quality requirements	The alternative has no impact on WWTP effluent quality	5	The alternative has no impact on WWTP effluent quality	5	The alternative has no impact on WWTP effluent quality	5	The alternative has no impact on WWTP effluent quality	5	The alternative has no impact on WWTP effluent quality	5	The alternative has no impact on WWTP effluent quality	5	The alternative has no impact on WWTP effluent quality	5
Natural Environment	**Water Quality** – The potential of the alternative to improve Grand River water quality and aquatic habitats	The alternative has no impact on river water quality and aquatic habitats	5	The alternative has no impact on river water quality and aquatic habitats	5	The alternative has no impact on river water quality and aquatic habitats	5	The alternative has no impact on river water quality and aquatic habitats	5	The alternative has no impact on river water quality and aquatic habitats	5	The alternative has no impact on river water quality and aquatic habitats	5	The alternative has no impact on river water quality and aquatic habitats	5
Natural Environment	**Terrestrial Systems** – The potential of the alternative to improve terrestrial habitats/ systems (including mammals, reptiles, birds) and terrestrial features/functions	The alternative results in the maintenance of the existing terrestrial systems and habitats	5	The alternative results in the maintenance of the existing terrestrial systems and habitats	5	The alternative results in the maintenance of the existing terrestrial systems and habitats	5	The alternative results in the maintenance of the existing terrestrial systems and habitats	5	The alternative results in the maintenance of the existing terrestrial systems and habitats	5	The alternative results in the maintenance of the existing terrestrial systems and habitats	5	The alternative results in the maintenance of the existing terrestrial systems and habitats	5
Natural Environment	**Soil** – The potential impact of an alternative on soil quality and productivity	The alternative has the potential to improve the quality and/or productivity of the soil through application	10	The alternative has the potential to improve the quality and/or productivity of the soil through application	10	The alternative has the potential to improve the quality and/or productivity of the soil through application	10	The alternative has the potential to improve the quality and/or productivity of the soil through application	10	The alternative has the potential to improve the quality and/or productivity of the soil through application	10	The alternative has the potential to improve the quality and/or productivity of the soil through application	10	The alternative has the potential to improve the quality and/or productivity of the soil through application	10
Natural Environment	**Ground Water Quality and Flow** – The potential of the alternative to protect groundwater resources	The alternative has no impact on groundwater resources	5	The alternative has no impact on groundwater resources	5	The alternative has no impact on groundwater resources	5	The alternative has no impact on groundwater resources	5	The alternative has no impact on groundwater resources	5	The alternative has no impact on groundwater resources	5	The alternative has no impact on groundwater resources	5
Natural Environment	**Air Emissions** – The potential for an alternative to meet provincial regulatory requirements for air emissions This criteria does not address odours	The alternative has no impact on air emissions from the WWTP	5	The alternative has no impact on air emissions from the WWTP	5	The alternative has no impact on air emissions from the WWTP	5	The alternative has no impact on air emissions from the WWTP	5	The alternative has no impact on air emissions from the WWTP	5	The alternative has no impact on air emissions from the WWTP	5	The alternative has no impact on air emissions from the WWTP	5
Economic Environment	**Sales Demand** – The potential for the alternative to create a product that meets market demands	The product will have no market demand and may require incentives, i.e. City pay to land apply the product	0	The product will have no market demand and may require incentives, i.e. City pay to land apply the product	0	The product will have no market demand and may require incentives, i.e. City pay to land apply the product	0	The product will have no market demand and may require incentives, i.e. City pay to land apply the product	0	The product will have no market demand and may require incentives, i.e. City pay to land apply the product	0	The product will have no market demand and may require incentives, i.e. City pay to land apply the product	0	The product will have no market demand and may require incentives, i.e. City pay to land apply the product	0
Economic Environment	**Contracts** – What is the number and complexity of the service contracts required?	Multiple simple or single complex contract	5	Multiple simple or single complex contract	5	Multiple simple or single complex contract	5	Multiple simple or single complex contract	5	Multiple simple or single complex contract	5	Multiple simple or single complex contract	5	Multiple simple or single complex contract	5

The scores determined in the workshop were entered into the evaluation matrix and weights were assigned to each objective. Table 9.3 summarizes the resultant weighted scores.

TABLE 9.3
EVALUATION OF CRITERIA FOR BIOSOLIDS MANAGEMENT OPTIONS

Evaluation Criteria	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Weight
	Expand Existing System	Expand Existing System with Phased Digestion	Heat Drying with Expanded Digestion	Heat Drying with Phased Digestion	Heat Drying with Primary Only Digestion	Alkaline Stabilization with Expanded Digestion	Alkaline Stabilization with Phased Digestion	
	Score	Score	Score	Score	Score	Score	Score	
Technical Performance	10	10	5	5	5	5	5	50
Energy Requirements	10	10	0	0	0	5	5	50
Long-term Sustainability	5	5	10	10	10	5	5	50
Ease of Implementation	10	10	5	5	5	5	5	50
Compatibility	10	10	5	5	0	10	10	90
Complexity	10	10	0	0	0	0	0	90
Regulatory Acceptance/ Approvals	10	10	10	10	10	10	10	90
Odour	5	5	10	10	10	5	5	40
Agricultural Practices	10	10	5	5	5	10	10	40
Visual Character	5	5	5	5	5	5	5	40
Transportation	0	0	10	10	10	5	5	40
Noise	0	0	5	5	5	5	5	40
Occupational Health & Safety	10	10	0	0	0	5	5	60
Community Health & Safety	10	10	10	10	10	10	10	60
Public Acceptability	5	5	0	0	0	5	5	40
Effluent Quality	5	5	5	5	5	5	5	60
Water Quality	5	5	5	5	5	5	5	40
Terrestrial Systems	5	5	5	5	5	5	5	25
Soil	10	10	10	10	10	10	10	25
Ground Water Quality and Flow	5	5	5	5	5	5	5	40
Air Emissions	5	5	5	5	5	5	5	25
Sales Demand	0	0	0	0	0	0	0	20
Contracts	5	5	5	5	5	5	5	20
Total Normalized Score	**80.10**	**80.10**	**50.40**	**50.40**	**46.89**	**61.44**	**61.44**	

As Table 9.3 demonstrates, Options 1 and 2 received the highest total normalized score, and therefore were evaluated to be highest ranked options, with regard to the criteria.

9.3.2 Evaluation Criteria Sensitivity Analysis

Alternative weightings of the objectives were also examined to determine the sensitivity of the analysis.

9.3.3 Equally Weighted

Initially, each objective was weighted equally. Options 1 and 2 continued to receive the highest total normalized score; however, there was slightly less difference between the Options. Table 9.4 shows the results.

TABLE 9.4
SENSITIVITY ANALYSIS FOR EVALUATION OF CRITERIA FOR BIOSOLIDS MANAGEMENT OPTIONS – EQUALLY WEIGHTED OBJECTIVES

Evaluation Objective	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Weight
	Expand Existing System	Expand Existing System with Phased Digestion	Heat Drying with Expanded Digestion	Heat Drying with Phased Digestion	Heat Drying with Primary Only Digestion	Alkaline Stabilization with Expanded Digestion	Alkaline Stabilization with Phased Digestion	
	Score	Score	Score	Score	Score	Score	Score	
Technical Performance	10	10	5	5	5	5	5	40
Energy Requirements	10	10	0	0	0	5	5	40
Long-term Sustainability	5	5	10	10	10	5	5	40
Ease of Implementation	10	10	5	5	5	5	5	40
Compatibility	10	10	5	5	0	10	10	40
Complexity	10	10	0	0	0	0	0	40
Regulatory Acceptance/ Approvals	10	10	10	10	10	10	10	40
Odour	5	5	10	10	10	5	5	40
Agricultural Practices	10	10	5	5	5	10	10	40
Visual Character	5	5	5	5	5	5	5	40
Transportation	0	0	10	10	10	5	5	40
Noise	0	0	5	5	5	5	5	40
Occupational Health & Safety	10	10	0	0	0	5	5	40
Community Health & Safety	10	10	10	10	10	10	10	40
Public Acceptability	5	5	0	0	0	5	5	40
Effluent Quality	5	5	5	5	5	5	5	40
Water Quality	5	5	5	5	5	5	5	40
Terrestrial Systems	5	5	5	5	5	5	5	40
Soil	10	10	10	10	10	10	10	40
Ground Water Quality and Flow	5	5	5	5	5	5	5	40
Air Emissions	5	5	5	5	5	5	5	40
Sales Demand	0	0	0	0	0	0	0	40
Contracts	5	5	5	5	5	5	5	40
Total Normalized Score	**73.37**	**73.37**	**53.36**	**53.36**	**50.03**	**60.03**	**60.03**	

9.3.4 Technically Weighted

Table 9.5 shows the results of the analysis where additional weight was assigned to the technical criteria.

TABLE 9.5
SENSITIVITY ANALYSIS FOR EVALUATION OF CRITERIA FOR BIOSOLIDS MANAGEMENT OPTIONS – TECHNICALLY WEIGHTED OBJECTIVES

Evaluation Objectives	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Weight
	Expand Existing System	Expand Existing System with Phased Digestion	Heat Drying with Expanded Digestion	Heat Drying with Phased Digestion	Heat Drying with Primary Only Digestion	Alkaline Stabilization with Expanded Digestion	Alkaline Stabilization with Phased Digestion	
	Score	Score	Score	Score	Score	Score	Score	
Technical Performance	10	10	5	5	5	5	5	90
Energy Requirements	10	10	0	0	0	5	5	90
Long-term Sustainability	5	5	10	10	10	5	5	90
Ease of Implementation	10	10	5	5	5	5	5	90
Compatibility	10	10	5	5	0	10	10	90
Complexity	10	10	0	0	0	0	0	90
Regulatory Acceptance/ Approvals	10	10	10	10	10	10	10	90
Odour	5	5	10	10	10	5	5	40
Agricultural Practices	10	10	5	5	5	10	10	40
Visual Character	5	5	5	5	5	5	5	40
Transportation	0	0	10	10	10	5	5	40
Noise	0	0	5	5	5	5	5	40
Occupational Health & Safety	10	10	0	0	0	5	5	60
Community Health & Safety	10	10	10	10	10	10	10	60
Public Acceptability	5	5	0	0	0	5	5	40
Effluent Quality	5	5	5	5	5	5	5	60
Water Quality	5	5	5	5	5	5	5	40
Terrestrial Systems	5	5	5	5	5	5	5	25
Soil	10	10	10	10	10	10	10	25
Ground Water Quality and Flow	5	5	5	5	5	5	5	40
Air Emissions	5	5	5	5	5	5	5	25
Sales Demand	0	0	0	0	0	0	0	20
Contracts	5	5	5	5	5	5	5	20
Total Normalized Score	**81.31**	**81.31**	**52.02**	**52.02**	**47.47**	**59.59**	**59.59**	

Options 1 and 2 continued to receive the highest total normalized score. Increased relative difference between the Options is also evident in Table 9.5.

9.3.5 Social/Environmentally Weighted

When additional weight was applied to the Social/Environmental objectives, a similar result was obtained, as Table 9.6 shows. Options 1 and 2 received the highest total normalized score, but there was less of a difference between the Options.

TABLE 9.6
SENSITIVITY ANALYSIS FOR EVALUATION OF CRITERIA FOR BIOSOLIDS MANAGEMENT OPTIONS – SOCIALLY/ENVIRONMENTALLY WEIGHTED OBJECTIVES

Evaluation Objectives	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Weight
	Expand Existing System	Expand Existing System with Phased Digestion	Heat Drying with Expanded Digestion	Heat Drying with Phased Digestion	Heat Drying with Primary Only Digestion	Alkaline Stabilization with Expanded Digestion	Alkaline Stabilization with Phased Digestion	
	Score	Score	Score	Score	Score	Score	Score	
Technical Performance	10	10	5	5	5	5	5	40
Energy Requirements	10	10	0	0	0	5	5	40
Long-term Sustainability	5	5	10	10	10	5	5	40
Ease of Implementation	10	10	5	5	5	5	5	40
Compatibility	10	10	5	5	0	10	10	40
Complexity	10	10	0	0	0	0	0	40
Regulatory Acceptance/ Approvals	10	10	10	10	10	10	10	40
Odour	5	5	10	10	10	5	5	80
Agricultural Practices	10	10	5	5	5	10	10	80
Visual Character	5	5	5	5	5	5	5	80
Transportation	0	0	10	10	10	5	5	80
Noise	0	0	5	5	5	5	5	80
Occupational Health & Safety	10	10	0	0	0	5	5	80
Community Health & Safety	10	10	10	10	10	10	10	80
Public Acceptability	5	5	0	0	0	5	5	80
Effluent Quality	5	5	5	5	5	5	5	80
Water Quality	5	5	5	5	5	5	5	80
Terrestrial Systems	5	5	5	5	5	5	5	80
Soil	10	10	10	10	10	10	10	80
Ground Water Quality and Flow	5	5	5	5	5	5	5	80
Air Emissions	5	5	5	5	5	5	5	80
Sales Demand	0	0	0	0	0	0	0	20
Contracts	5	5	5	5	5	5	5	20
Total Normalized Score	**67.43**	**67.43**	**54.38**	**54.38**	**52.20**	**60.90**	**60.90**	

Table 9.7 summarizes the results of the sensitivity analysis. It shows that Options 1 and 2 ranked first in all objective weighting scenarios, followed by Options 6 and 7, then Options 3 and 4, and finally Option 5.

TABLE 9.7
SUMMARY OF SENSITIVITY ANALYSIS RESULTS FOR EVALUATION OF CRITERIA FOR BIOSOLIDS MANAGEMENT OPTIONS

Evaluation Criteria	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
	Expand Existing System	Expand Existing System with Phased Digestion	Heat Drying with Expanded Digestion	Heat Drying with Phased Digestion	Heat Drying with Primary Only Digestion	Alkaline Stabilization with Expanded Digestion	Alkaline Stabilization with Phased Digestion
	Rank	Rank	Rank	Rank	Rank	Rank	Rank
Base Case	1	1	5	5	7	3	3
Equally Weighted	1	1	5	5	7	3	3
Technically Weighted	1	1	5	5	7	3	3
Socially/Environmentally Weighted	1	1	5	5	7	3	3
Overall Rank	**1**	**1**	**5**	**5**	**7**	**3**	**3**

It was therefore determined that Options 1 and 2 are the preferred management alternatives with respect to the evaluation objectives.

9.3.6 Economic Evaluation

Attachment A shows the detailed cost analyses, described above and summarized in Table 9.8.

TABLE 9.8
SUMMARY OF ESTIMATED COSTS FOR BIOSOLIDS MANAGEMENT OPTIONS

Cost Criteria	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
	Expand Existing System	Expand Existing System with Phased Digestion	Heat Drying with Expanded Digestion	Heat Drying with Phased Digestion	Heat Drying with Primary Only Digestion	Alkaline Stabilization with Expanded Digestion	Alkaline Stabilization with Phased Digestion
Capital Cost	$25,090,000	$22,180,000	$35,820,000	$33,570,000	$33,640,000	$31,380,000	$27,850,000
O&M Annual Cost	$2,786,000	$2,694,000	$2,472,000	$2,254,000	$3,028,000	$4,098,000	$3,626,000
O&M Annual Credit	$767,000	$866,000	$767,000	$864,000	$428,000	$767,000	$864,000
Net O&M Annual Cost	$2,019,000	$1,828,000	$1,705,000	$1,390,000	$2,600,000	$3,331,000	$2,762,000
NPV	$62,915,000	$56,607,000	$67,837,000	$60,027,000	$81,432,000	$91,953,000	$78,364,000
Capital Cost /DT	$139	$123	$199	$186	$187	$174	$154
O&M Annual Cost /DT	$286	$276	$254	$231	$311	$421	$372
O&M Annual Credit /DT	$79	$89	$79	$89	$44	$79	$89
Net O&M Annual Cost /DT	$207	$188	$175	$143	$267	$342	$283
NPV/DT	$349	$314	$376	$333	$451	$510	$434

Notes:
Costs are shown for ultimate year biosolids production rate
Dry Tonnes Raw Solids Processed (20-year project total) = 180,731
Dry Tonnes Raw Solids Processed (Ultimate Year) = 9,744
Costs per Dry Tonne (DT) are for Raw Solids processed

9.3.7 Capital Costs

Table 9.8 illustrates that the Options with phased digestion (or unexpanded digestion) had lower estimated capital costs than those with expanded digestion. Overall, expanding the existing system options had lower estimated capital costs, followed by the alkaline stabilization options. The highest estimated capital costs were associated with heat drying. This followed a similar ranking to the evaluation of objectives discussed previously.

9.3.7.1 Operations and Maintenance Costs

The heat drying options had the lowest operations and maintenance costs. Heat drying following primary only digestion was more costly than heat drying following full digestion. Expanding the existing system options had the second lowest operations and maintenance costs. Alkaline stabilization options had the highest operations and maintenance costs.

Operations and maintenance credits were greater for the options with phased digestion and least for the option with primary only digestion.

The net operations and maintenance costs were lowest for heat drying options and highest for the alkaline stabilization options. These results are also displayed in Table 9-8.

9.3.7.2 Net Present Value

The total net present value was estimated to be least for the expanding the existing system options, followed by the heat drying options and highest for the alkaline stabilization options.

9.3.8 Benefit/Cost Evaluation Summary

The evaluation matrix was also utilized to determine the overall cost (economic) and benefit (objective) of each option. The best benefit to cost ratio was given a score of 1.41 and the other options were scored relative to the maximum score. Table 9.9 summarizes them and Attachment C shows them in detail.

TABLE 9.9
SUMMARY OF COST/BENEFIT EVALUATION

Cost/Benefit	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
	Expand Existing System	Expand Existing System with Phased Digestion	Heat Drying with Expanded Digestion	Heat Drying with Phased Digestion	Heat Drying with Primary Only Digestion	Alkaline Stabilization with Expanded Digestion	Alkaline Stabilization with Phased Digestion
Overall Score	1.27	1.41	0.77	0.89	0.57	0.67	0.78
Overall Rank	2	1	5	3	7	6	4

10. Conclusions and Recommendations

10.1 Highest Ranked Option

The cost/benefit analysis has shown that the highest ranked option is to expand the existing system. The economic evaluation suggests that phased digestion, compared to expanding the existing conventional anaerobic digestion facility, may be economically beneficial. It is recommended that this is considered and further evaluated in the planning and design stages of digester capacity expansion.

However, the existing compost facility at the WWTP was installed over 10 years ago. It is therefore likely that it will reach the end of its service life before the 20-year planning period addressed in this study, even with the recommended capital investment to enable reliable service. Since biosolids compost has a limited commercial market, and the operations and maintenance costs are high, it is recommended that an alternative biosolids management treatment process should be considered when composting is no longer reliable. This analysis suggests that heat drying would likely be the preferred process if being considered at this time; however, technology, regulatory, and market changes should be re-addressed to determine the appropriate decision.

10.2 Recommend Strategy

The recommended strategy is to maximize the City's existing investment in the WWTP by utilizing the existing system to the end of its useful life. This will require some unit process upgrades and expansions to provide reliable service for the projected biosolids quantities over the study period. It is also recommended to replace the compost system with an alternative processing technology, when the compost equipment reaches the end of its service life.

Options 1 and 2, discussed in this TM, provide for liquid biosolids storage, Lystek-treated biosolids storage and composted biosolids storage, to give four months' product storage, to provide an equal strategy for all the Options.

Because it is recommended to replace composting with an alternative process in approximately 10 years, and it is anticipated that that process will be able to accommodate storage, investment in liquid storage is not recommended at this time. Therefore, a modified Option 1 has been developed for implementation, which includes Lystek and compost storage, but no liquid storage. This is essentially the same as Option 2, but as the decision to implement phased digestion would occur during the planning and design stages of digester capacity expansion, the more economically conservative Option 1 was utilized for analysis. Finally, for forecasting purposes, it was assumed that heat drying, the preferred replacement technology in this analysis, will be installed in the future.

The final Task 4 Technical Memorandum (TM4-IV) provides an implementation plan for the preferred path forward. The implementation plan discusses the steps required to determine the preferred path for replacement of the composting system.

ATTACHMENT A

Option 1

Expand Existing System

OPTION 1 - EXPAND EXISTING

				Peak	Average
Sludge Loadings					
TWAS	Flow		m^3/d	200	200
	Solids		% ds	6.0%	6.0%
	Mass		kg/d	12,014	12,014
	Volatile solids		% VS	73.0%	73.0%
			kg/d	8,770	8,770
Primary Sludge	Flow		m^3/d	367	367
	Solids		% ds	4.0%	4.0%
	Mass		kg/d	14,683	14,683
	Volatile solids		% VS	68.0%	68.0%
			kg/d	9,985	9,985
Total Raw Sludge	Flow		m^3/d	567	567
	Solids		% ds	4.7%	4.7%
	Mass		kg/d	26,697	26,697
	Volatile solids		% VS	70.0%	70.0%
			kg/d	18,688	18,688
Anaerobic Digesters					
Number	Primary			5	5
	Secondary			1	1
Volume	Primary	Each	m^3	2,440	2,440
		Total	m^3	12,200	12,200
	Secondary	Each	m^3	2,350	2,350
		Total	m^3	2,350	2,350
Primary Digester	HRT		days	22	22
	Loading		kg $VSS/m^3.d$	1.5	1.5
Total Digester	HRT		days	26	26
	Loading		kg $VSS/m^3.d$	1.3	1.3
VSS destruction			%	60.0%	60.0%
			kg VS des/d	11,213	11,213
Biogas production			m^3/d	10,091	10,091
	CH_4 content		%	60%	60%
Digested Sludge			m^3/d	567	567
			kg/d	15,484	15,484
			% ds	2.7%	2.7%
			% VS	48.3%	48.3%
Total Heat Required for Sludge Feed					
	Sludge Flow Rate		wet kg/hr	23,617	23,617
	Specific Heat of Water		kJ/kg ^oC	4.1868	4.1868
	Av. Temp. of Raw Sludge		^oC	15	15
	Digester Temp.		^oC	35	35
	Heat Required		kJ/hr	1,977,619	1,977,619
	Natural Gas Equivalent		m^3/yr	461,972	461,972
Total Heat Required for Heat Losses			kJ/hr per m^3 (	27	27
	Heat Losses Occuring		% of time per	50.0%	50.0%
	Natural Gas Equivalent		m^3/yr	45,885	45,885

OPTION 1 - EXPAND EXISTING

Liquid to Storage/Land				Average
	Mass	dt/yr		1,209
	Mass	dt/d		3.31
	Flow	m^3/d		121
	Mass	kg/d		3,314
	Dry Solids	% ds		2.7%
Storage	Days	d		240
Dewatering - Total				Average
Feed Sludge	Mass	dt/yr		4,442
		dt/d		12.17
	Flow	m^3/d	567	446
	Solids	% ds	2.7%	2.7%
	Mass	kg/d	15,484	12,171
	Volatile solids	% VS	48.3%	48.3%
		kg/d	7,475	5,875
Dewatering - BFPs			Peak	Average (Firm)
Press Capacity		L/s	24	12
7 hrs/d; 5 d/wk operating		m^3/d	432	216
Feed Sludge	Flow	m^3/d	103	216
	Solids	% ds	2.7%	2.7%
	Mass	kg/d	2,814	5,901
	Volatile solids	% VS	48.3%	48.3%
		kg/d	1,358	2,849
BFP Cake	Flow	m^3/d	13	28
	Solids	% ds	18.0%	18.0%
	Mass	kg/d	2,392	5,016
	Volatile solids	% VS	48.3%	48.3%
		kg/d	1,155	2,421
	Capture	%	85.0%	85.0%
BFP Sidestream	Flow	m^3/d	90	188
	Solids	mg/L	4,705	4,705
	Mass	kg/d	422	885
	Volatile solids	% VS	48%	48%
		kg/d	204	427
Dewatering - Centrifuges				
Feed Sludge	Flow	m^3/d	135	230
7 hrs/d; 5 d/wk operating		L/s	3.8	6.5
	Solids	% ds	2.7%	2.7%
	Mass	kg/d	3,683	6,270
	Volatile solids	% VS	48.3%	48.3%
		kg/d	1,778	3,027
Centrifuge Cake	Flow	m^3/d	13	22
	Solids	% ds	28.0%	28.0%
	Mass	kg/d	3,572	6,082
	Volatile solids	% VS	48.3%	48.3%
		kg/d	1,725	2,936
	Capture	%	97.0%	97.0%
Centrifuge Sidestream	Flow	m^3/d	122	208
	Solids	mg/L	905	905
	Mass	kg/d	110	188
	Volatile solids	% VS	48%	48%
		kg/d	53	91

OPTION 1 - EXPAND EXISTING

Lystek

Feed Cake	Flow	m^3/d	33	17
	Solids	% ds	18.0%	18.0%
	Mass	kg/d	6000	3000
Lystek Material	Solids	% ds	14%	14%
Operating Capacity	7 day/week	dt/d	6	3
Production		m^3/wk	300	150
Annual capacity		dt/yr	360	720
Storage capacity		m^3	4,800	NA
Remaining Cake	Mass	kg/d	-36	8,097
	Solids	% ds	-977%	26%

Composting

Compost Mass Balance - Peak — 28 days HRT

		Biosolids	Amendment	Recycle	Mixed Feed	Product	Exhaust
solids	t/d	5.254	3.5	10.1	18.8	6.5	2.2
water	t/d	15.8	2.3	12.3	30.4	7.9	10.1
total	t/d	21.0	5.8	22.4	49.2	14.4	
Volume	m^3/d	21.9	24.1	35.0	81.0	22.5	
dry solids		25%	60%	45%	38%	45%	
BD	kg/m^3	960	240	640	608	640	
Ratio	Volume	1.0	1.1	1.6			
Volatile Solids		48%	99%				
	t/d	2.5	3.4				
Volatile Destruction		15%	54%			37%	
Biosolids Volatiles Destroyed							0.38
Amendment Volatiles Destroyed							1.85

Compost Mass Balance - Firm — 28 days HRT

		Biosolids	Amendment	Recycle	Mixed Feed	Product	Exhaust
solids	t/d	2.627	1.7	5.0	9.4	3.2	1.1
water	t/d	7.9	1.2	6.2	15.2	4.0	5.1
total	t/d	10.5	2.9	11.2	24.6	7.2	
Volume	m^3/d	10.9	12.0	17.5	40.50	11.3	
dry solids		25%	60%	45%	38%	45%	
BD	kg/m^3	960	240	640	608	640	
Ratio	Volume	1.0	1.1	1.6			
Volatile Solids		48%	99%				
	t/d	1.3	1.7				
Volatile Destruction		15%	54%			37%	
Biosolids Volatiles Destroyed				t/d			0.19
Amendment Volatiles Destroyed				t/d			0.93

		Peak	Firm	Maintenance	Total
Production - Compost	m3/d	22.5	11.3	0	NA
Quantity	m3/yr	1,352	2,027	0	3,379
Max. Storage Require	m^3	NA	NA	NA	2,703

OPTION 1 - EXPAND EXISTING

Boiler System			
Boiler Efficiency	%	80%	80%
Cogeneration System			
Electrical Conversion Efficiency	%	33%	33%
Thermal Recovery Efficiency	%	40%	40%
Electricity Produced			
Natural Gas Unit Energy	kJ/m^3	37,500	37,500
Biogas Unit Energy	kJ/m^3	22,500	22,500
Electricity Energy Per Unit Biogas	kJ/m^3	7,425	7,425
Biogas used for Cogen	m^3/d	10,091	10,091
Biogas used for Cogen	m^3/s	1.17E-01	1.17E-01
Cogen Electrical Energy Produced	kJ/s	867	867
Cogen Electrical Energy Produced	kW	867	867
Cogen Electrical Energy Produced	kWh/h	867	867
Cogen Electrical Energy Produced	kWh/y	7,596,982	7,596,982

OPTION 1 - EXPAND EXISTING

A) RAW SLUDGE	Unit	Primary Sludge	TWAS	Total Sludge	Total kW	Service Factor	Operating Hours/Yr	Total kWh/yr
Required Capacity	m^3/d	367	200	567	NA	NA	NA	
	L/s	4.2	2.3	6.6	NA	NA	NA	
Existing Units								
Primary Pump Capacity - Max	L/s	NA	NA	40	22.50	0.75	1,460	24,638
Primary Pump Capacity - Ave	L/s	NA	NA	20	NA	NA	NA	
WAS Pump Capacity - Max	L/s	NA	NA	NA	NA	NA	NA	
WAS Pump Capacity - Ave	L/s	NA	NA	NA	NA	NA	NA	
New Units								
New Primary Pump Capacity	L/s	10	NA	NA	5.50	0.75	1,460	6,023
New WAS Pump Capacity	L/s	NA	10	NA	5.50	0.75	1,460	6,023
TWAS Thickening RDTs	L/s	NA		NA	20.00	0.75	8,760	131,400
TWAS Pump Capacity	L/s	NA		NA	20.00	0.75	8,760	131,400
Polymer								
Dose Rate	g/kg	NA	7.5					
B) PRIMARY DIGESTION	**Unit**	**Primary**	**Secondary**	**Total**	**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
Total installed volume - primary	m^3	7320	2350	9670	NA	NA	NA	
Total working volume - primary	m^3	6588	2115	8703	NA	NA	NA	
New Units								
New digester diameter	m	19.88	0	NA	NA	NA	NA	
New digester depth	m	7.92	0	NA	NA	NA	NA	
New digester volume	m^3	2,440	0	NA	NA	NA	NA	
No. New Duty units	#	2	0	NA	NA	NA	NA	
Total Operational Units	#	2	0	NA	NA	NA	NA	
Total Standby Units	#	0	0	NA	NA	NA	NA	
No. new Standby units	#	0	0	NA	NA	NA	NA	
Total no. new units	#	2	0	NA	NA	NA	NA	
Digester working capacity	% of tot. cap.	90%	90%	NA	NA	NA	NA	
Total new digester working volume	m^3	4,392	0	4,392	NA	NA	NA	
Recirculation Pumps								
Number of Existing Units	#	3	1	4	11.25	0.75	8,760	73,913
Number of New Units	#	2	0	2	5.63	0.75	8,760	36,956
Heat Exchangers								
Number of Existing Units	#	2	1	3	NA	NA	NA	
Capacity - Each	MBTU/hr	1.5	1	2.5	NA	NA	NA	
Number of New Units	#	1	0	1	NA	NA	NA	
Capacity - Each	MBTU/hr	1.5	0	1.5	NA	NA	NA	
Transfer Pumps								
Number of Existing Units	#	1	1	2	3.75	0.75	1,460	4,106
Capacity - Each	L/s	18.9	15.8	34.7	NA	NA	NA	
Number of New Units	#	1	0	1	1.88	0.75	1,460	2,053
Capacity - Each	L/s	18.9	0.0	18.9	NA	NA	NA	
Mixers								
Number of Existing Units	#	12	0		67.20	0.75	8,760	441,504
Rating, each mixer	kW	7.5						
Number of New Units	#	8	0		44.80	0.75	8,760	294,336
Rating, each mixer	kW	7.5						
Performance								
Digestion VS reduction	% of VS	60%	0%	NA	NA	NA	NA	
Digester gas production	m^3/kg VSR	0.75	0.75	NA	NA	NA	NA	
Digester gas calorific value	kJ/m^3	22355	22355	NA	NA	NA	NA	
Boiler efficiency (average)	%	80%	80%	NA	NA	NA	NA	
C) LIQUID BIOSOLIDS	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
New Units								
Storage Tanks	m^3	29,112			NA	NA	NA	
Mixers	#	10			56.00	1.00	8,760	490,560
Pumps	#	2			3.75	0.75	1,460	4,106

OPTION 1 - EXPAND EXISTING

D) DEWATERING	Unit	Total			Total kW	Service Factor	Operating Hours	Total kWh/yr
Existing Units								
New BFP 1 Operating Capacity	L/s	6.3			4.50	1.00	2,920	13,140
New BFP 2 Operating Capacity	L/s	6.3			4.50	1.00	2,920	13,140
BFP 3 Capacity	L/s	6.3			4.18	0.25	2,920	3,048
BFP 4 Capacity	L/s	6.3			4.18	0.25	2,920	3,048
Pumps - Polymer, Filtrate Feed & Sump	#	14			50.00	1.00	2,920	146,000
Polymer Pump Capacity - each	L/s	0.57						
Polymer Mixing Tank	#	2						
Ploymer Tank Capacity - Each	L	8800						
Ploymer Mixers	#	2			1.50	0.50	8,760	6,570
Supply and Exhaust Air Fans	#	10			5.05	1.00	4,380	22,119
Misc. - Air Compressor, Heater, Valves, etc					38.60	0.25	8,760	84,534
New Units								
Centrifuge 1 Capacity	L/s	6.5			12.36	1.00	2,920	36,093
Centrifuge 2 Capacity	L/s	6.5			12.36	0.25	2,920	9,023
Polymer Pumps	#	2			1.50	1.00	2,920	4,380
Polymer Mixing Tank	#	1			0.75	1.00	8,760	6,570
Feed Pumps								
Number of Existing Units	#	4			18.50	0.75	2,920	40,515
Capacity - Each	L/s	9.5						
Number of New Units	#	2			9.25	0.75	4,380	30,386
Capacity - Each	L/s	9.5						
Polymer								
Dose Rate	g/kg	6.0						
E) DEWATERED CAKE TO LAND	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
Cross Screw Conveyor	#	1			2.20	1.00	4,380	9,636
Lift Screw Conveyor	#	1			2.20	1.00	4,380	9,636
Horizontal Screw Conveyor	#	2			5.00	1.00	4,380	21,900
F) LYSTEK	**Unit**				**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
6 m^3/d system					54.81	0.50	5,143	140,934
G) COMPOSTING	**Unit**				**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing System					1400	0.05	5,760	403,200
New Units								
Covered Storage Pad & Loading Area					15.00	1.00	730	10,950
Heavy Equipment					2.50	1.00	730	1,825
PRODUCTION FACTOR								
Initial Year Biosolids Production Rate	7,420	dt/yr						
Ultimate Year Raw Biosolids Production Rate	9,744	dt/yr						

CH2M HILL

CAPITAL COST ESTIMATE

PROJECT: Guelph WWTP Biosolids Management Plan
PROJ. NO.: 120703 DATE: October-05
AUTHOR: Baldwin REV. NO.:
SUBJECT: OPTION 1 - EXPAND EXISTING
FILENAME: 1-ExpandExistingSystem-CostAnalysis.xls

REF SPEC SECT No	DESCRIPTION OF ITEM	Q'TY	UNIT	MATERIAL UNIT COST ($)	MATERIAL TOTAL COST ($)	% OF MAT'L (%)	INSTALLATION or UNIT COST ($)	INSTALLATION TOTAL COST ($)	TOTAL INSTALL & MAT'L ($)	SUB TOTAL COST ($)	COST DEVELOPMENT
DIVISION 1 - GENERAL REQUIREMENTS											
	mobilization/demobilization	1	L.S.	200,000	200,000			0	200,000		Historical/Est. Judgement
	general conditions/bonds/insurance	1	L.S.	500,000	500,000			0	500,000		Historical/Est. Judgement
					0			0	0		
					0			0	0		
								Division 1 Total:	700,000	$700,000	
DIVISION 2 - SITEWORK											
					0			0	0		
	Site grading for digesters:, 2 @ 20 m dia	395	m^3	30	11,856			0	11,856		
	Site grading for compost pad	1,360	m^3	30	40,800			0	40,800		
	Site grading for Lystek storage	600	m^3	30	18,000			0	18,000		
	Site grading for liquid storage	2,910	m^3	30	87,300			0	87,300		
	Dewatering	180	days	1,000	180,000			0	180,000		
	Relocate & Expand Fence	1,000	m	30	30,000			0	30,000		
	Site services	1	L.S.	500,000	500,000			0	500,000		
								Division 2 Total:	867,956	$868,000	
DIVISION 3 - CONCRETE											
					0			0	0		
	Compost Storage Pad	680	m^3	500	340,000			0	340,000		
	Liquid Storage - base	1,455	m^3	500	727,500			0	727,500		
	Liquid Storage - walls	650	m^3	1,100	715,000			0	715,000		
	Liquid Storage - roof	580	m^3	1,000	580,000			0	580,000		
	Lystek Storage	300	m^3	500	150,000			0	150,000		
	Lystek Storage - walls	240	m^3	1,100	264,000			0	264,000		
	Lystek Storage - roof	120	m^3	1,000	120,000			0	120,000		
	Digesters - base	310	m^3	550	170,500			0	170,500		
	Digesters - walls	300	m^3	1,200	360,000			0	360,000		
	Digesters - roof	120	m^3	1,100	132,000			0	132,000		
	Miscellaneous Concrete (water stops, joints, etc)	1	L.S.	200,000	200,000			0	200,000		
								Division 3 Total:	3,759,000	$3,759,000	
DIVISION 4 - MASONRY											
					0			0	0		
	Digesters - walls	1,000	m^2	150	150,000			0	150,000		
					0			0	0		
								Division 4 Total:	150,000	$150,000	
DIVISION 5 - METALS											
					0			0	0		
	Compost pad - roof	1,360	m^2	150	204,000			0	204,000		
	Compost pad - roof supports, 8 m spacing, 8 m high average	110	m	200	22,000			0	22,000		
					0			0	0		
	Rock Anchors - liquid storage 3 m deep, 2 m spacing	120	m	650	78,000			0	78,000		
	Rock Anchors - Lystek storage, 3 m deep, 2 m spacing	110	m	650	71,500			0	71,500		
	Rock Anchors - Digesters 3 m deep, 2 m spacing	470	m	650	305,500			0	305,500		
								Division 5 Total:	681,000	$681,000	
DIVISION 6 - WOOD AND PLASTICS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 6 Total:	0	$0	
DIVISION 7 - THERMAL AND MOISTURE PROTECTION											
					0			0	0		
	Liquid Storage - base & walls & roof	8,000	m^2	60	480,000			0	480,000		
	Lystek storage - base & walls & roof	2,000	m^2	60	120,000			0	120,000		
	Digesters - base & walls & roof	3,125	m^2	60	187,496			0	187,496		
					0			0	0		
								Division 7 Total:	787,496	$787,500	
DIVISION 8 - DOORS AND WINDOWS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 8 Total:	0	$0	
DIVISION 9 - FINISHES											
	Architectural Allowance (Paint, finishes, etc)	1	L.S.	500,000	500,000			0	500,000		
					0			0	0		
					0			0	0		
								Division 9 Total:	500,000	$500,000	
DIVISION 10 - MANUFACTURED SPECIALTIES											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 10 Total:	0	$0	
DIVISION 11 - EQUIPMENT											
FIXED EQUIPMENT					0			0	0		
	Truck weigh scale facility	1	L.S.	50,000	50,000		15,000	15,000	65,000		
	Primary Pumps	2	L.S.	20,000	40,000		6,000	12,000	52,000		
	WAS Pumps	4	L.S.	20,000	80,000		6,000	24,000	104,000		
	WAS Thickening RDT	3	L.S.	125,000	375,000		37,500	112,500	487,500		
	TWAS Pumps	1	L.S.	60,000	60,000		18,000	18,000	78,000		
	Digester Recirculation Pumps	1	L.S.	25,000	25,000		7,500	7,500	32,500		
	Heat Exchangers	1	L.S.	150,000	150,000		45,000	45,000	195,000		
	Transfer Pumps	1	L.S.	25,000	25,000		7,500	7,500	32,500		
	Digester Mixers	8	ea.	70,000	560,000		21,000	168,000	728,000		Vendor quotation
	Liquid Biosolids Storage Tank Mixers	10	ea.	40,000	400,000		12,000	120,000	520,000		
	Liquid Biosolids Storage Tank Pumps	2	L.S.	40,000	80,000		12,000	24,000	104,000		
	Dewatering Centrifuges	2	L.S.	275,000	550,000			0	550,000		Vendor - install included
	Polymer System (Tank, Pump)	1	L.S.	40,000	40,000		12,000	12,000	52,000		
	Dewatering Feed Pumps	1	L.S.	40,000	40,000		12,000	12,000	52,000		
	Compost System Upgrades	1	L.S.	450,000	450,000		135,000	135,000	585,000		
	Process Piping	1	L.S.	1,000,000	1,000,000		300,000	300,000	1,300,000		
PORTABLE EQUIPMENT					0			0	0		
	Front End Loader	1	L.S.	150,000	150,000			0	150,000		
					0			0	0		
								Division 11 Total:	5,087,500	$5,087,500	

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CAPITAL COST ESTIMATE

PROJECT: Guelph WWTP Biosolids Management Plan
PROJ. NO.: 120703
AUTHOR: Baldwin
SUBJECT: OPTION 1 - EXPAND EXISTING
FILENAME: 1-ExpandExistingSystem-CostAnalysis.xls
DATE: October-05
REV. NO.:

REF SPEC SECT No	DESCRIPTION OF ITEM	Q'TY	UNIT	MATERIAL UNIT COST ($)	MATERIAL TOTAL COST ($)	% OF MAT'L (%)	INSTALLATION or UNIT COST ($)	INSTALLATION TOTAL COST ($)	TOTAL INSTALL & MAT'L ($)	SUB TOTAL COST ($)	COST DEVELOPMENT
DIVISION 12 - FURNISHINGS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 12 Total:	0	$0	
DIVISION 13 - SPECIAL CONSTRUCTION											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 13 Total:	0	$0	
DIVISION 14 - CONVEYING SYSTEMS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 14 Total:	0	$0	
DIVISION 15 - MECHANICAL											
					0			0	0		
	Mechanical Allowance - 15% of fixed equipment Cost	15%	L.S.	4,937,500	740,625			0	740,625		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
								Division 15 Total:	740,625	$740,700	
DIVISION 16 - ELECTRICAL											
					0			0	0		
	Electrical Allowance - 15% of fixed equipment cost	15%	L.S	4,937,500	740,625			0	740,625		
	I&C Allowance - 5% of fixed equipment cost	5%	L.S.	4,937,500	246,875			0	246,875		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
								Division 16 Total:	987,500	$987,500	
									SUB-TOTAL:	$14,261,200	
ALLOWANCES											
Contractor's overhead and profit		10	%						1,426,120		
			%						0		
			%						0		
			%						0		
			%						0		
								Allowances Total:	1,426,120	$1,426,200	
									SUB-TOTAL:	$15,687,400	
ENGINEERING AND CONTINGENCY											
Engineering (design and construction services)		15	%						2,353,110		
Construction lump sum contingency allowance		25	%						3,921,850		
								Engineering and Contingency Total:	6,274,960	$6,275,000	
									SUB-TOTAL:	$21,962,400	
TAXES											
sales tax - federal		7	%						1,372,650		
sales tax - provincial		8	%						1,756,992		
Other taxes, patent fees, import duties and foreign exch.			%						0		
								Taxes Total:	3,129,642	$3,129,700	
LAND PURCHASE											
								Land Total:			
									GRAND TOTAL:	$25,090,000	

No	REVISION	DATE	NOTES
0			
1			
2			
3			
4			
5			

OPTION 1 - EXPAND EXISTING
ULTIMATE YEAR O&M COSTS

Labour		Hourly Rate	Benefit Rate	Total Cost/Hour	Total Hours/Year	Total Annual Cost (rounded to nearest $1,000)	Production Factor?
0.25	Manager	50	1.35	$67.50	520	$35,000	
1	Supervisor	30	1.35	$40.50	2,080	$84,000	
6	Operator	22	1.35	$29.70	12,480	$371,000	
1.5	Maintenance	25	1.35	$33.75	3,120	$105,000	
						$595,000	**FIXED**
Operations			Unit Cost		Total Units/Year		
	Polymer - Thickening		4.50 $/kg		32,887	$148,000	
	Polymer - Dewatering		4.50 $/kg		33,911	$153,000	
	Electricity		0.08 $/kWh		2,663,663	$213,000	
	Fuel Oil/Diesel - heavy equipment		1.00 $/L		20,000	$20,000	
	Natural Gas - Digestion		0.25 $/m^3		634,821	$159,000	
	Other						
	Operating Materials Allowance		20%		$693,000	$139,000	
						$832,000	**PRODUCTION**
Maintenance - Materials		% of Capital Cost/Year	Equipment Capital Cost				
	New Equipment	2%	$5,087,500			$102,000	
	Existing Equipment		1 L.S.		$100,000	$100,000	
	Compost Facility		1 L.S.		$200,000	$200,000	
						$402,000	**FIXED**
Product Disposal			Unit Cost		Total Units/Year		
	Transport & Land Apply Liquid		10.00 $/m^3		44,274	$443,000	
	Transport & Land Apply Lystek		10.00 $/m^3		7,714	$77,000	
	Transport & Land Apply Cake		30.00 $/wt		10,091	$303,000	
	Transport & Land Apply Compost		30.00 $/wt		2,162	$65,000	
	Transport & Landfill		60.00 $/wt		0	$0	
						$888,000	**PRODUCTION**
Other			Cost per Unit	Total Units/Year			
	Woodchips		80	867 tonnes		$69,000	
						$69,000	**PRODUCTION**
Sub-total Annual O&M Costs						**$2,786,000**	**COMBINED**
Credits		Credit per Unit		Total Units/ Year			
	Heat offset (from biogas)	0.15 $/m^3		1,841,693		$159,000	
	Electricity (from cogen)	0.08 $/kWh		7,596,982		$608,000	
Sub-total Annual O&M Credits						**$767,000**	**PRODUCTION**
Total Annual O&M Costs (Credits)						**$2,019,000**	
Present Worth O&M Costs						**$25,161,000**	

OPTION 1 - EXPAND EXISTING

Actual DT Raw Solids Processed	Production Factor	Escalation Rate	Year	Time	Capital Cost Schedule	Revenue & Cash Savings Schedule	Combined Operations & Maintenance & Other Costs Schedule	Discount Rate	NPV
7,420	76%	1.0000	2005	Year 0	$25,090,000			1.0000	$25,090,000
7,537	77%	1.0250	2006	Year 1	0	-$608,000	$2,440,000	0.9750	$1,786,000
7,654	79%	1.0506	2007	Year 2	0	-$633,000	$2,524,000	0.9506	$1,798,000
7,771	80%	1.0769	2008	Year 3	0	-$659,000	$2,610,000	0.9269	$1,808,000
7,888	81%	1.1038	2009	Year 4	0	-$685,000	$2,699,000	0.9037	$1,820,000
8,005	82%	1.1314	2010	Year 5	0	-$713,000	$2,791,000	0.8811	$1,831,000
8,122	83%	1.1597	2011	Year 6	0	-$741,000	$2,885,000	0.8591	$1,842,000
8,239	85%	1.1887	2012	Year 7	0	-$771,000	$2,983,000	0.8376	$1,853,000
8,356	86%	1.2184	2013	Year 8	0	-$801,000	$3,084,000	0.8167	$1,864,000
8,473	87%	1.2489	2014	Year 9	0	-$833,000	$3,188,000	0.7962	$1,875,000
8,590	88%	1.2801	2015	Year 10	0	-$865,000	$3,295,000	0.7763	$1,886,000
8,707	89%	1.3121	2016	Year 11	0	-$899,000	$3,406,000	0.7569	$1,898,000
8,824	91%	1.3449	2017	Year 12	0	-$934,000	$3,520,000	0.7380	$1,908,000
8,941	92%	1.3785	2018	Year 13	0	-$970,000	$3,637,000	0.7195	$1,919,000
9,058	93%	1.4130	2019	Year 14	0	-$1,007,000	$3,758,000	0.7016	$1,930,000
9,174	94%	1.4483	2020	Year 15	0	-$1,046,000	$3,883,000	0.6840	$1,941,000
9,291	95%	1.4845	2021	Year 16	0	-$1,086,000	$4,012,000	0.6669	$1,951,000
9,408	97%	1.5216	2022	Year 17	0	-$1,127,000	$4,145,000	0.6502	$1,962,000
9,525	98%	1.5597	2023	Year 18	0	-$1,169,000	$4,282,000	0.6340	$1,974,000
9,642	99%	1.5987	2024	Year 19	0	-$1,213,000	$4,424,000	0.6181	$1,985,000
9,744	100%	1.6386	2025	Year 20	0	-$1,257,000	$4,565,000	0.6027	$1,994,000
									$62,915,000
Escalation Rate		2.5%						2.5%	

OPTION 1 - EXPAND EXISTING

Capital Cost	$25,090,000
O&M Annual Cost (Ultimate Year Production)	$2,786,000
O&M Annual Credit (Ultimate Year Production)	$767,000
Net O&M Annual Cost (ultimate Year Production)	$2,019,000
NPV	$62,915,000
Dry Tonnes Raw Solids Processed (20 year total)	180,371
Dry Tonnes Raw Solids Processed (Ultimate Year)	9,744
Capital Cost per Dry Tonne Raw Solids Processed	$139
O&M Annual Cost per Dry Tonne Raw Solids Processed (Ultimate Year)	$286
O&M Annual Credit per Dry Tonne Raw Solids Processed (Ultimate Year)	$79
Net O&M Annual Cost per Dry Tonne Raw Solids Processed (Ultimate Year)	$207
NPV per Dry Tonne Raw Solids Processed	$349

Option 2

Expand Existing System with Phased Digestion

OPTION 2 - EXPAND EXISTING WITH PHASED DIGESTION

				Peak	Average
Sludge Loadings					
TWAS	Flow		m^3/d	200	200
	Solids		% ds	6.0%	6.0%
	Mass		kg/d	12,014	12,014
	Volatile solids		% VS	73.0%	73.0%
			kg/d	8,770	8,770
Primary Sludge	Flow		m^3/d	367	367
	Solids		% ds	4.0%	4.0%
	Mass		kg/d	14,683	14,683
	Volatile solids		% VS	68.0%	68.0%
			kg/d	9,985	9,985
Total Raw Sludge	Flow		m^3/d	567	567
	Solids		% ds	4.7%	4.7%
	Mass		kg/d	26,697	26,697
	Volatile solids		% VS	70.0%	70.0%
			kg/d	18,688	18,688
Anaerobic Digesters					
Acid Phase				1	1
		Each	m^3	1,350	1,350
		HRT	days	2	2
Number	Primary			3	3
	Secondary			1	1
Volume	Primary	Each	m^3	2,440	2,440
		Total	m^3	8,670	8,670
	Secondary	Each	m^3	2,350	2,350
		Total	m^3	2,350	2,350
Primary Digester	HRT		days	13	13
	Loading		kg VSS/m^3.(	2.2	2.2
Total Digester	HRT		days	15	15
	Loading		kg VSS/m^3.(	1.7	1.3
VSS destruction			%	70.0%	70.0%
			kgVS des/d	13,082	13,082
Biogas production			m^3/d	11,773	11,773
	CH_4 content		%	60%	60%
Digested Sludge			m^3/d	567	567
			kg/d	13,615	13,615
			% ds	2.4%	2.4%
			% VS	41.2%	41%
Total Heat Required for Sludge Feed					
	Sludge Flow Rate		wet kg/hr	23,617	23,617
	Specific Heat of Water		kJ/kg °C	4.1868	4.1868
	Av. Temp. of Raw Sludge		°C	15	15
	Digester Temp.		°C	35	35
	Heat Required		kJ/hr	1,977,619	1,977,619
	Natural Gas Equivalent		m^3/yr	461,972	461,972
Total Heat Required for Heat Losses			kJ/hr per m^3	27	27
	Heat Losses Occuring		% of time pe	50.0%	50.0%
	Natural Gas Equivalent		m^3/yr	39,010	39,010

OPTION 2 - EXPAND EXISTING WITH PHASED DIGESTION

Liquid to Storage/Land				
	Mass	dt/yr		994
	Mass	dt/d		2.72
	Flow	m^3/d		113.36
	Mass	kg/d		2,723
	Dry Solids	% ds		2.4%
Storage	Days	d		240
Dewatering - Total				Average
Feed Sludge	Mass	dt/yr		3,976
		dt/d		10.89
	Flow	m^3 /d	567	453
	Solids	% ds	2.4%	2.4%
	Mass	kg/d	13,615	10,892
	Volatile solids	% VS	41.2%	41.2%
		kg/d	5,606	4,485
Dewatering - BFPs			Peak	Average (Firm)
Press Capacity		L/s	24	12
7 hrs/d; 5 d/wk operating		m^3/d	432	216
Feed Sludge	Flow	m^3/d	432	216
	Solids	% ds	2.4%	2.4%
	Mass	kg/d	10,377	5,189
	Volatile solids	% VS	41.2%	41.2%
		kg/d	4,273	2,136
BFP Cake	Flow	m^3/d	49	25
	Solids	% ds	18.0%	18.0%
	Mass	kg/d	8,821	4,410
	Volatile solids	% VS	41.2%	41.2%
		kg/d	3,632	1,816
	Capture	%	85.0%	85.0%
BFP Sidestream	Flow	m^3/d	383	191
	Solids	mg/L	4,064	4,064
	Mass	kg/d	1,557	778
	Volatile solids	% VS	41%	41%
		kg/d	641	320
Dewatering - Centrifuges				
Feed Sludge	Flow	m^3/d	135	237
7 hrs/d; 5 d/wk operating		L/s	3.8	6.7
	Solids	% ds	2.4%	2.4%
	Mass	kg/d	3,238	5,704
	Volatile solids	% VS	41.2%	41.2%
		kg/d	1,333	2,349
Centrifuge Cake	Flow	m^3/d	11	20
	Solids	% ds	28.0%	28.0%
	Mass	kg/d	3,206	5,647
	Volatile solids	% VS	41.2%	41.2%
		kg/d	1,320	2,325
	Capture	%	99.0%	99.0%
Centrifuge Sidestream	Flow	m^3/d	123	217
	Solids	mg/L	263	263
	Mass	kg/d	32	57
	Volatile solids	% VS	41%	41%
		kg/d	13	23

OPTION 2 - EXPAND EXISTING WITH PHASED DIGESTION

Lystek (utilizing BFP cake)

Feed Cake	Flow	m^3/d	33	17
	Solids	% ds	18.0%	18.0%
	Mass	kg/d	6000	3000
Lystek Material	Solids	% ds	14%	14%
Operating Capacity	7 day/week	dt/d	6	3
Production		m^3/wk	300	150
Annual capacity		dt/yr	360	720
Storage capacity		m^3	4,800	NA
Remaining Cake	Mass	kg/d	6,027	7,057
	Solids	% ds	23%	26%

Composting

Compost Mass Balance - Peak 28 days HRT

		Biosolids	\mendmen	Recycle	Mixed Feed	Product	
solids	t/d	5.254	3.5	10.1	18.8	6.5	**Exhaust**
water	t/d	15.8	2.3	12.3	30.4	8.0	2.2
total	t/d	21.0	5.8	22.4	49.2	14.5	10.1
Volume	m^3/d	21.9	24.1	35.0	81.0	22.7	
dry solids		25%	60%	45%	38%	45%	
BD	kg/m^3	960	240	640	608	640	
Ratio	Volume	1.0	1.1	1.6			
Volatile Solids		41%	99%				
	t/d	2.2	3.4				
Volatile Destruction		15%	54%			39%	
Biosolids Volatiles Destroyed			t/d				0.32
Amendment Volatiles Destroyed			t/d				1.85

Compost Mass Balance - Firm 28 days HRT

		Biosolids	\mendmen	Recycle	Mixed Feed	Product	
solids	t/d	2.627	1.7	5.0	9.4	3.3	**Exhaust**
water	t/d	7.9	1.2	6.2	15.2	4.0	1.1
total	t/d	10.5	2.9	11.2	24.6	7.3	5.0
Volume	m^3/d	10.9	12.0	17.5	40.50	11.4	
dry solids		25%	60%	45%	38%	45%	
BD	kg/m^3	960	240	640	608	640	
Ratio	Volume	1.0	1.1	1.6			
Volatile Solids		41%	99%				
	t/d	1.1	1.7				
Volatile Destruction		15%	54%			39%	
Biosolids Volatiles Destroyed				t/d			
Amendment Volatiles Destroyed				t/d			0.16
			Peak	Firm	Maintenance	Total	0.93
Production - Compost	m3/d		22.7	11.4	0	NA	
Quantity	m3/yr		4,090	682	0	4,771	
Max. Storage Required	m^3		NA	NA	NA	2,726	

OPTION 2 - EXPAND EXISTING WITH PHASED DIGESTION

Boiler System			
Boiler Efficiency	%	80%	80%
Cogeneration System			
Electrical Conversion Efficiency	%	33%	33%
Thermal Recovery Efficiency	%	40%	40%
Electricity Produced			
Natural Gas Unit Energy	kJ/m^3	37,500	37,500
Biogas Unit Energy	kJ/m^3	22,500	22,500
Electricity Energy Per Unit Biogas	kJ/m^3	7,425	7,425
Biogas used for Cogen	m^3/d	11,773	11,773
Biogas used for Cogen	m^3/s	1.36E-01	1.36E-01
Cogen Electrical Energy Produced	kJ/s	1,012	1,012
Cogen Electrical Energy Produced	kW	1,012	1,012
Cogen Electrical Energy Produced	kWh/h	1,012	1,012
Cogen Electrical Energy Produced	kWh/y	8,863,145	8,863,145

OPTION 2 - EXPAND EXISTING WITH PHASED DIGESTION

A) RAW SLUDGE	Unit	Primary Sludge	TWAS	Total Sludge	Total kW	Service Factor	Operating Hours/Yr	Total kWh/yr
Required Capacity	m^3/d	367	200	567	NA	NA	NA	
	L/s	4.2	2.3	6.6	NA	NA	NA	
Existing Units								
Primary Pump Capacity - Max	L/s	NA	NA	40	22.50	0.75	1,460	24,638
Primary Pump Capacity - Ave	L/s	NA	NA	20	NA	NA	NA	
WAS Pump Capacity - Max	L/s	NA	NA	NA	NA	NA	NA	
WAS Pump Capacity - Ave	L/s	NA	NA	NA	NA	NA	NA	
New Units								
New Primary Pump Capacity	L/s	10	NA	NA	5.50	0.75	1,460	6,023
New WAS Pump Capacity	L/s	NA	10	NA	5.50	0.75	1,460	6,023
TWAS Thickening RDTs	L/s	NA		NA	20.00	0.75	8,760	131,400
TWAS Pump Capacity	L/s	NA		NA	20.00	0.75	8,760	131,400
Polymer								
Dose Rate	g/kg	NA	7.5					

B) PRIMARY DIGESTION	Unit	Primary	Secondary	Total	Total kW	Service Factor	Operating Hours	Total kWh/yr
Existing Units								
Total installed volume - primary	m^3	7320	2350	9670	NA	NA	NA	
Total working volume - primary	m^3	6588	2115	8703	NA	NA	NA	
New Units								
New digester diameter	m	10.37	0	NA	NA	NA	NA	
New digester depth	m	4	0	NA	NA	NA	NA	
New digester volume	m^3	1,350	0	NA	NA	NA	NA	
No. New Duty units	#	1	0	NA	NA	NA	NA	
Total Operational Units	#	1	0	NA	NA	NA	NA	
Total Standby Units	#	0	0	NA	NA	NA	NA	
No. new Standby units	#	0	0	NA	NA	NA	NA	
Total no. new units	#	1	0	NA	NA	NA	NA	
Digester working capacity	% of tot. cap.	90%	90%	NA	NA	NA	NA	
Total new digester working volume	m^3	1,215	0	1,215	NA	NA	NA	
Recirculation Pumps								
Number of Existing Units	#	3	1	4	11.25	0.75	8,760	73,913
Number of New Units	#	1	0	1	2.81	0.75	8,760	18,478
Heat Exchangers								
Number of Existing Units	#	2	1	3	NA	NA	NA	
Capacity - Each	MBTU/hr	1.5	1	2.5	NA	NA	NA	
Number of New Units	#	1	0	1	NA	NA	NA	
Capacity - Each	MBTU/hr	1.5	0	1.5	NA	NA	NA	
Transfer Pumps								
Number of Existing Units	#	1	1	2	3.75	0.75	1,460	4,106
Capacity - Each	L/s	18.9	15.8	34.7	NA	NA	NA	
Number of New Units	#	1	0	1	1.88	0.75	1,460	2,053
Capacity - Each	L/s	18.9	0.0	18.9	NA	NA	NA	
Mixers								
Number of Existing Units	#	12	0		67.20	0.75	8,760	441,504
Rating, each mixer	kW	7.5						
Number of New Units	#	2	0		11.20	0.75	8,760	73,584
Rating, each mixer	kW	7.5						
Performance								
Digestion VS reduction	% of VS	60%	0%	NA	NA	NA	NA	
Digester gas production	m^3/kg VSR	0.75	0.75	NA	NA	NA	NA	
Digester gas calorific value	kJ/m^3	22355	22355	NA	NA	NA	NA	
Boiler efficiency (average)	%	80%	80%	NA	NA	NA	NA	

C) LIQUID BIOSOLIDS	Unit	Total			Total kW	Service Factor	Operating Hours	Total kWh/yr
New Units								
Storage Tanks	m^3	27,207			NA	NA	NA	
Mixers	#	10			56.00	1.00	8,760	490,560
Pumps	#	2			3.75	0.75	1,460	4,106

OPTION 2 - EXPAND EXISTING WITH PHASED DIGESTION

D) DEWATERING	Unit	Total			Total kW	Service Factor	Operating Hours	Total kWh/yr
Existing Units								
New BFP 1 Operating Capacity	L/s	6.3			4.50	1.00	4,380	19,710
New BFP 2 Operating Capacity	L/s	6.3			4.50	1.00	4,380	19,710
BFP 3 Capacity	L/s	6.3			4.18	1.00	4,380	18,287
BFP 4 Capacity	L/s	6.3			4.18	1.00	4,380	18,287
Pumps - Polymer, Filtrate Feed & Sump	#	14			50.00	0.50	8,760	219,000
Polymer Pump Capacity - each	L/s	0.57						
Polymer Mixing Tank	#	2						
Ploymer Tank Capacity - Each	L	8800						
Ploymer Mixers	#	2			1.50	0.50	8,760	6,570
Supply and Exhaust Air Fans	#	10			5.05	1.00	4,380	22,119
Misc. - Air Compressor, Heater, Valves, etc					38.60	0.50	8,760	169,068
New Units								
Centrifuge 1 Capacity	L/s	6.7			12.79	1.00	4,380	56,011
Centrifuge 2 Capacity	L/s	6.7			12.79	1.00	4,380	56,011
Polymer Pumps	#	2			1.50	0.50	8,760	6,570
Polymer Mixing Tank	#	1			0.75	0.50	8,760	3,285
Feed Pumps								
Number of Existing Units	#	4			18.50	1.00	4,380	81,030
Capacity - Each	L/s	9.5						
Number of New Units	#	2			9.25	1.00	4,380	40,515
Capacity - Each	L/s	9.5						
Polymer								
Dose Rate	g/kg	6.0						
E) DEWATERED CAKE TO LAND	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
Cross Screw Conveyor	#	1			2.20	1.00	4,380	9,636
Lift Screw Conveyor	#	1			2.20	1.00	4,380	9,636
Horizontal Screw COnveyor	#	2			5.00	1.00	4,380	21,900
F) LYSTEK	**Unit**				**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
6 m^3/d system					54.81	0.50	6,240	170,999
G) COMPOSTING	**Unit**				**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing System					1400	0.10	2,920	408,800
New Units								
Covered Storage Pad & Loading Area					15.00	1.00	730	10,950
Heavy Equipment					2.50	1.00	730	1,825
PRODUCTION FACTOR								
Initial Year Biosolids Production Rate	7,420	dt/yr						
Ultimate Year Raw Biosolids Production Rate	9,744	dt/yr						

CH2M HILL

CAPITAL COST ESTIMATE

PROJECT: Guelph WWTP Biosolids Management Plan
PROJ. NO.: 120703 DATE: October-05
AUTHOR: Baldwin REV. NO.:
SUBJECT: OPTION 2 - EXPAND EXISTING WITH PHASED DIGESTION
FILENAME: 2-ExpandExistingSystem-PhasedDig-CostAnalysis.xls

REF SPEC SECT No	DESCRIPTION OF ITEM	Q'TY	UNIT	MATERIAL UNIT COST ($)	MATERIAL TOTAL COST ($)	MATERIAL % OF MAT'L (%)	INSTALLATION or UNIT COST ($)	INSTALLATION TOTAL COST ($)	TOTAL INSTALL & MAT'L ($)	SUB TOTAL COST ($)	COST DEVELOPMENT
DIVISION 1 - GENERAL REQUIREMENTS											
	mobilization/demobilization	1	L.S.	200,000	200,000			0	200,000		Historical/Est. Judgement
	general conditions/bonds/insurance	1	L.S.	500,000	500,000			0	500,000		Historical/Est. Judgement
					0			0	0		
					0			0	0		
								Division 1 Total:	700,000	$700,000	
DIVISION 2 - SITEWORK											
					0			0	0		
	Site grading for acid digester:, 1 @ 10.4 m dia	54	m^3	30	1,613			0	1,613		
	Site grading for compost pad	1,370	m^3	30	41,100			0	41,100		
	Site grading for Lystek storage	600	m^3	30	18,000			0	18,000		
	Site grading for liquid storage	2,720	m^3	30	81,600			0	81,600		
	Dewatering	150	days	1,000	150,000			0	150,000		
	Relocate & Expand Fence	1,000	m	30	30,000			0	30,000		
	Site services	1	L.S.	500,000	500,000			0	500,000		
								Division 2 Total:	822,313	$822,400	
DIVISION 3 - CONCRETE											
					0			0	0		
	Compost Storage Pad	680	m^3	500	340,000			0	340,000		
	Liquid Storage - base	1,360	m^3	500	680,000			0	680,000		
	Liquid Storage - walls	630	m^3	1,100	693,000			0	693,000		
	Liquid Storage - roof	540	m^3	1,000	540,000			0	540,000		
	Lystek Storage - base	300	m^3	500	150,000			0	150,000		
	Lystek Storage - walls	240	m^3	1,100	264,000			0	264,000		
	Lystek Storage - roof	120	m^3	1,000	120,000			0	120,000		
	Digesters - base	310	m^3	550	170,500			0	170,500		
	Digesters - walls	300	m^3	1,200	360,000			0	360,000		
	Digesters - roof	130	m^3	1,100	143,000			0	143,000		
	Miscellaneous Concrete (water stops, joints, etc)	1	L.S.	200,000	200,000			0	200,000		
								Division 3 Total:	3,660,500	$3,660,500	
DIVISION 4 - MASONRY											
					0			0	0		
	Digesters - walls	130	m^2	150	19,500			0	19,500		
					0			0	0		
								Division 4 Total:	19,500	$19,500	
DIVISION 5 - METALS											
					0			0	0		
	Compost pad - roof	1,370	m^2	150	205,500			0	205,500		
	Compost pad - roof supports, 8 m spacing, 8 m high average	110	m	200	22,000			0	22,000		
					0			0	0		
	Rock Anchors - liquid storage 3 m deep, 2 m spacing	110	m	650	71,500			0	71,500		
	Rock Anchors - Lystek storage, 3 m deep, 2 m spacing	110	m	650	71,500			0	71,500		
	Rock Anchors - Digesters 3 m deep, 2 m spacing	130	m	650	84,500			0	84,500		
								Division 5 Total:	455,000	$455,000	
DIVISION 6 - WOOD AND PLASTICS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 6 Total:	0	$0	
DIVISION 7 - THERMAL AND MOISTURE PROTECTION											
					0			0	0		
	Liquid Storage - base & walls & roof	7,500	m^2	60	450,000			0	450,000		
	Lystek storage - base & walls & roof	2,000	m^2	60	120,000			0	120,000		
	Digesters - base & walls & roof	430	m^2	60	25,800			0	25,800		
					0			0	0		
								Division 7 Total:	595,800	$595,800	
DIVISION 8 - DOORS AND WINDOWS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 8 Total:	0	$0	
DIVISION 9 - FINISHES											
					0			0	0		
	Architectural Allowance (Paint, finishes, etc)	1	L.S.	500,000	500,000			0	500,000		
					0			0	0		
								Division 9 Total:	500,000	$500,000	
DIVISION 10 - MANUFACTURED SPECIALTIES											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 10 Total:	0	$0	
DIVISION 11 - EQUIPMENT											
FIXED EQUIPMENT					0			0	0		
	Truck weigh scale facility	1	L.S.	50,000	50,000		15,000	15,000	65,000		
	Primary Pumps	2	L.S.	20,000	40,000		6,000	12,000	52,000		
	WAS Pumps	4	L.S.	20,000	80,000		6,000	24,000	104,000		
	WAS Thickening RDT	3	L.S.	125,000	375,000		37,500	112,500	487,500		
	TWAS Pumps	1	L.S.	60,000	60,000		18,000	18,000	78,000		
	Digester Recirculation Pumps	1	L.S.	10,000	10,000		3,000	3,000	13,000		
	Heat Exchangers	1	L.S.	50,000	50,000		15,000	15,000	65,000		
	Transfer Pumps	1	L.S.	10,000	10,000		3,000	3,000	13,000		
	Digester Mixers	2	ea.	70,000	140,000		21,000	42,000	182,000		
	Liquid Biosolids Storage Tank Mixers	10	ea.	40,000	400,000		12,000	120,000	520,000		
	Liquid Biosolids Storage Tank Pumps	2	L.S.	40,000	80,000		12,000	24,000	104,000		
	Dewatering Centrifuges	2	L.S.	275,000	550,000			0	550,000		Vendor - install included
	Polymer System (Tank, Pump)	1	L.S.	40,000	40,000		12,000	12,000	52,000		
	Dewatering Feed Pumps	1	L.S.	40,000	40,000		12,000	12,000	52,000		
	Compost System Upgrades	1	L.S.	450,000	450,000		135,000	135,000	585,000		
	Process Piping	1	L.S.	1,000,000	1,000,000		300,000	300,000	1,300,000		
PORTABLE EQUIPMENT					0			0	0		
	Front End Loader	1	L.S.	150,000	150,000			0	150,000		
					0			0	0		
								Division 11 Total:	4,372,500	$4,372,500	

CH2M HILL

CAPITAL COST ESTIMATE

PROJECT: Guelph WWTP Biosolids Management Plan
PROJ. NO.: 120703 DATE: October-05
AUTHOR: Baldwin REV. NO.:
SUBJECT: OPTION 2 - EXPAND EXISTING WITH PHASED DIGESTION
FILENAME: 2-ExpandExistingSystem-PhasedDig-CostAnalysis.xls

REF SPEC SECT No	DESCRIPTION OF ITEM	Q'TY	UNIT	MATERIAL UNIT COST ($)	MATERIAL TOTAL COST ($)	% OF MAT'L (%)	INSTALLATION or UNIT COST ($)	INSTALLATION TOTAL COST ($)	TOTAL INSTALL & MAT'L ($)	SUB TOTAL COST ($)	COST DEVELOPMENT
DIVISION 12 - FURNISHINGS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 12 Total:	0	$0	
DIVISION 13 - SPECIAL CONSTRUCTION											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 13 Total:	0	$0	
DIVISION 14 - CONVEYING SYSTEMS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 14 Total:	0	$0	
DIVISION 15 - MECHANICAL											
					0			0	0		
	Mechanical Allowance - 15% of fixed equipment Cost	15%	L.S.	4,222,500	633,375			0	633,375		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
								Division 15 Total:	633,375	$633,400	
DIVISION 16 - ELECTRICAL											
					0			0	0		
	Electrical Allowance - 15% of fixed equipment cost	15%	L.S.	4,222,500	633,375			0	633,375		
	I&C Allowance - 5% of fixed equipment cost	5%	L.S.	4,222,500	211,125			0	211,125		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
								Division 16 Total:	844,500	$844,500	
									SUB-TOTAL:	$12,603,600	
ALLOWANCES											
Contractor's overhead and profit		10	%						1,260,360		
			%						0		
			%						0		
			%						0		
			%						0		
								Allowances Total:	1,260,360	$1,260,400	
									SUB-TOTAL:	$13,864,000	
ENGINEERING AND CONTINGENCY											
Engineering (design and construction services)		15	%						2,079,600		
Construction lump sum contingency allowance		25	%						3,466,000		
								Engineering and Contingency Total:	5,545,600	$5,545,600	
									SUB-TOTAL:	$19,409,600	--
TAXES											
sales tax - federal		7	%						1,213,100		
sales tax - provincial		8	%						1,552,768		
Other taxes, patent fees, import duties and foreign exch.			%						0		
								Taxes Total:	2,765,868	$2,765,900	
LAND PURCHASE											
								Land Total:			
									GRAND TOTAL:	$22,180,000	

No	REVISION	DATE	NOTES
0			
1			
2			
3			
4			
5			

OPTION 2 - EXPAND EXISTING WITH PHASED DIGESTION

ULTIMATE YEAR O&M COSTS

Labour		Hourly Rate	Benefit Rate	Total Cost/Hour	Total Hours/Year	Total Annual Cost (rounded to nearest $1,000)	Production Factor?
0.25	Manager	50	1.35	$67.50	520	$35,000	
1	Supervisor	30	1.35	$40.50	2,080	$84,000	
6	Operator	22	1.35	$29.70	12,480	$371,000	
1.5	Maintenance	25	1.35	$33.75	3,120	$105,000	
						$595,000	**FIXED**
Operations		Unit Cost	Unit	Total Units/Year			
	Polymer - Thickening		4.50 $/kg		32,887	$148,000	
	Polymer - Dewatering		4.50 $/kg		29,818	$134,000	
	Electricity		0.08 $/kWh		2,777,706	$222,000	
	Fuel Oil/Diesel - heavy equipment		1.00 $/L		20,000	$20,000	
	Natural Gas - Digestion		0.25 $/m^3		626,227	$157,000	
	Other						
	Operating Materials Allowance		20%		$681,000	$136,000	
						$817,000	**PRODUCTION**
Maintenance - Materials		% of Capital Cost/Year	Equipment Capital Cost				
	New Equipment	2%	$4,372,500			$87,000	
	Existing Equipment		1 L.S.		$100,000	$100,000	
	Compost Facility		1 L.S.		$200,000	$200,000	
						$387,000	**FIXED**
Product Disposal			Cost per Unit (m^3)		Total Units/Year		
	Transport & Land Apply Liquid		10.00 $/m^3		41,378	$414,000	
	Transport & Land Apply Lystek		10.00 $/m^3		7,714	$77,000	
	Transport & Land Apply Cake		30.00 $/wt		8,106	$243,000	
	Transport & Land Apply Compost		30.00 $/wt		3,054	$92,000	
	Transport & Landfill		60.00 $/wt		0	$0	
						$826,000	**PRODUCTION**
Other			Cost per Unit	Total Units/Year			
	Woodchips		80	867 tonnes		$69,000	
						$69,000	**PRODUCTION**
Sub-total Annual O&M Costs						**$2,694,000**	**COMBINED**
Credits		Credit per Unit		Total Units/ Year			
	Heat offset (from biogas)	0.15 $/m^3		2,148,641		$157,000	
	Electricity (from cogen)	0.08 $/kWh		8,863,145		$709,000	
Sub-total Annual O&M Credits						**$866,000**	**PRODUCTION**
Total Annual O&M Costs (Credits)						$1,828,000	
Present Worth O&M Costs						**$22,781,000**	

OPTION 2 - EXPAND EXISTING WITH PHASED DIGESTION

Actual DT Raw Solids Processed	Production Factor	Escalation Rate	Year	Time	Capital Cost Schedule	Revenue & Cash Savings Schedule	Combined Operations & Maintenance & Other Costs Schedule	Discount Rate	NPV
7,420	76%	1.0000	2005	Year 0	$22,180,000			1.0000	$22,180,000
7,537	77%	1.0250	2006	Year 1	0	-$687,000	$2,364,000	0.9750	$1,635,000
7,654	79%	1.0506	2007	Year 2	0	-$715,000	$2,445,000	0.9506	$1,645,000
7,771	80%	1.0769	2008	Year 3	0	-$744,000	$2,528,000	0.9269	$1,654,000
7,888	81%	1.1038	2009	Year 4	0	-$774,000	$2,614,000	0.9037	$1,663,000
8,005	82%	1.1314	2010	Year 5	0	-$805,000	$2,702,000	0.8811	$1,671,000
8,122	83%	1.1597	2011	Year 6	0	-$837,000	$2,794,000	0.8591	$1,681,000
8,239	85%	1.1887	2012	Year 7	0	-$870,000	$2,888,000	0.8376	$1,690,000
8,356	86%	1.2184	2013	Year 8	0	-$905,000	$2,985,000	0.8167	$1,699,000
8,473	87%	1.2489	2014	Year 9	0	-$940,000	$3,085,000	0.7962	$1,708,000
8,590	88%	1.2801	2015	Year 10	0	-$977,000	$3,189,000	0.7763	$1,717,000
8,707	89%	1.3121	2016	Year 11	0	-$1,015,000	$3,296,000	0.7569	$1,727,000
8,824	91%	1.3449	2017	Year 12	0	-$1,055,000	$3,406,000	0.7380	$1,735,000
8,941	92%	1.3785	2018	Year 13	0	-$1,095,000	$3,519,000	0.7195	$1,744,000
9,058	93%	1.4130	2019	Year 14	0	-$1,137,000	$3,636,000	0.7016	$1,753,000
9,174	94%	1.4483	2020	Year 15	0	-$1,181,000	$3,757,000	0.6840	$1,762,000
9,291	95%	1.4845	2021	Year 16	0	-$1,226,000	$3,881,000	0.6669	$1,771,000
9,408	97%	1.5216	2022	Year 17	0	-$1,272,000	$4,009,000	0.6502	$1,780,000
9,525	98%	1.5597	2023	Year 18	0	-$1,320,000	$4,142,000	0.6340	$1,789,000
9,642	99%	1.5987	2024	Year 19	0	-$1,370,000	$4,278,000	0.6181	$1,798,000
9,744	100%	1.6386	2025	Year 20	0	-$1,419,000	$4,414,000	0.6027	$1,805,000
									$56,607,000

Escalation Rate	2.5%	2.5%

OPTION 2 - EXPAND EXISTING WITH PHASED DIGESTION

Capital Cost	$22,180,000
O&M Annual Cost (Ultimate Year Production)	$2,694,000
O&M Annual Credit (Ultimate Year Production)	$866,000
Net O&M Annual Cost (ultimate Year Production)	$1,828,000
NPV	$56,607,000
Dry Tonnes Raw Solids Processed (20 year total)	180,371
Dry Tonnes Raw Solids Processed (Ultimate Year)	9,744
Capital Cost per Dry Tonne Raw Solids Processed	$123
O&M Annual Cost per Dry Tonne Raw Solids Processed (Ultimate Year)	$276
O&M Annual Credit per Dry Tonne Raw Solids Processed (Ultimate Year)	$89
Net O&M Annual Cost per Dry Tonne Raw Solids Processed (Ultimate Year)	$188
NPV per Dry Tonne Raw Solids Processed	$314

Option 3

Heat Drying

OPTION 3 - HEAT DRYING

				Peak	Average
Sludge Loadings					
TWAS	Flow		m^3/d	200	200
	Solids		% ds	6.0%	6.0%
	Mass		kg/d	12,014	12,014
	Volatile solids		% VS	73.0%	73.0%
			kg/d	8,770	8,770
Primary Sludge	Flow		m^3/d	367	367
	Solids		% ds	4.0%	4.0%
	Mass		kg/d	14,683	14,683
	Volatile solids		% VS	68.0%	68.0%
			kg/d	9,985	9,985
Total Raw Sludge	Flow		m^3/d	567	567
	Solids		% ds	4.7%	4.7%
	Mass		kg/d	26,697	26,697
	Volatile solids		% VS	70.0%	70.0%
			kg/d	18,688	18,688
Anaerobic Digesters					
Number	Primary			5	5
	Secondary			1	1
Volume	Primary	Each	m^3	2,440	2,440
		Total	m^3	12,200	12,200
	Secondary	Each	m^3	2,350	2,350
		Total	m^3	2,350	2,350
Primary Digester	HRT		days	22	22
	Loading		kg VSS/m³	1.5	2
Total Digester	HRT		days	26	26
	Loading		kg VSS/m³	1.3	1
VSS destruction			%	60.0%	1
			kgVS des/(	11,213	11,213
Biogas production			m^3/d	10,091	10,091
	CH_4 content		%	60.0%	60.0%
Digested Sludge			m^3/d	567	567
			kg/d	15,484	15,484
			% ds	2.7%	2.7%
			% VS	48.3%	48.3%
Total Heat Required for Sludge Feed					
	Sludge Flow Rate		wet kg/hr	23,617	23,617
	Specific Heat of Water		kJ/kg °C	4.1868	4.1868
	Av. Temp. of Raw Sludge		°C	15	15
	Digester Temp.		°C	35	35
	Heat Required		kJ/hr	1,977,619	1,977,619
	Natural Gas Equivalent		m^3/yr	461,972	461,972
Total Heat Required for Heat Losses			kJ/hr per n	27	27
	Heat Losses Occuring		% of time (	50.0%	50.0%
	Natural Gas Equivalent		m^3/yr	45,885	45,885

OPTION 3 - HEAT DRYING

Liquid to Storage/Land				
		dt/yr		0
		dt/d		0.00
		m^3/d	0.00	0.00
		kg/d	0	0
		% ds	2.7%	2.7%
Storage	Days	d	250	240
Dewatering - Total				
Feed Sludge	Mass	dt/yr		5,652
		dt/d		15
	Flow	m^3/d	567	567
	Solids	% ds	2.7%	2.7%
	Mass	kg/d	15,484	15,484
	Volatile solids	% VS	48.3%	48.3%
		kg/d	7,475	7,475
Dewatering - BFPs				
Press Capacity		L/s	24	12
7 hrs/d; 5 d/wk operating		m^3/d	432	216
Feed Sludge	Flow	m^3/d	432	216
	Solids	% ds	2.7%	2.7%
	Mass	kg/d	11,801	5,901
	Volatile solids	% VS	48.3%	48.3%
		kg/d	5,697	2,849
BFP Cake	Flow	m^3/d	56	28
	Solids	% ds	18.0%	18.0%
	Mass	kg/d	10,031	5,016
	Volatile solids	% VS	48.3%	48.3%
		kg/d	4,843	2,421
	Capture	%	85.0%	85.0%
BFP Sidestream	Flow	m^3/d	376	188
	Solids	mg/L	4,705	4,705
	Mass	kg/d	1,770	885
	Volatile solids	% VS	48%	48%
		kg/d	855	427
Dewatering - Centrifuges				
Feed Sludge	Flow	m^3/d	135	351
7 hrs/d; 5 d/wk operating		L/s	3.8	9.9
	Solids	% ds	2.7%	2.7%
	Mass	kg/d	3,683	9,584
	Volatile solids	% VS	48.3%	48.3%
		kg/d	1,778	4,627
Centrifuge Cake	Flow	m^3/d	13	34
	Solids	% ds	28.0%	28.0%
	Mass	kg/d	3,646	9,488
	Volatile solids	% VS	48.3%	48.3%
		kg/d	1,760	4,580
	Capture	%	99.0%	99.0%
Centrifuge Sidestream	Flow	m^3/d	122	317
	Solids	mg/l	302	302
	Mass	kg/d	37	96
	Volatile solids	% VS	48%	48%
		kg/d	18	46

OPTION 3 - HEAT DRYING

Lystek				
Feed Cake	Flow	m^3/d	33	17
	Solids	% ds	18.0%	18.0%
	Mass	kg/d	6000	3000
Lystek Material	Solids	% ds	14%	14%
Operating Capacity	7 day/week	dt/d	6	3
Production		m^3/wk	300	150
Annual capacity		dt/yr	360	720
Storage capacity		m^3	4,800	NA
Remaining Cake	Mass	kg/d	7,677	11,503
	Solids	% ds	23%	26%
Heat Drying				
Processing Capacity	dt/yr			4,572
	dt/d			12.7
	wt/yr			17,418
	tonnes/yr water in			12,846
Product	dt/yr processed			4,572
	% solids			92%
	wt/yr			4,969
	tonnes/yr water out			398
Storage	tonnes			1,656
Heat Required	kWh/ tonne water			1,804
	water t/yr			12,448
	kWh/yr			22,456,831
	MJ			80,844,593
	kJ			8.08E+10
	m^3 natural gas			2,155,856
Boiler System				
Boiler Efficiency		%	80%	80%
Cogeneration System				
Electrical Conversion Efficiency		%	33%	33%
Thermal Recovery Efficiency		%	40%	40%
Electricity Produced				
Natural Gas Unit Energy		kJ/m^3	37,500	37,500
Biogas Unit Energy		kJ/m^3	22,500	22,500
Electricity Energy Per Unit Biogas		kJ/m^3	7,425	7,425
Biogas used for Cogen		m^3/d	10,091	10,091
Biogas used for Cogen		m^3/s	1.17E-01	1.17E-01
Cogen Electrical Energy Produced		kJ/s	867	867
Cogen Electrical Energy Produced		kW	867	867
Cogen Electrical Energy Produced		kWh/h	867	867
Cogen Electrical Energy Produced		kWh/y	7,596,982	7,596,982

OPTION 3 - HEAT DRYING

A) RAW SLUDGE	Unit	Primary Sludge	TWAS	Total Sludge	Total kW	Service Factor	Operating Hours/Yr	Total kWh/yr
Required Capacity	m³/d	367	200	567	NA	NA	NA	
	L/s	4.2	2.3	6.6	NA	NA	NA	
Existing Units								
Primary Pump Capacity - Max	L/s	NA	NA	40	22.50	0.75	1,460	24,638
Primary Pump Capacity - Ave	L/s	NA	NA	20	NA	NA	NA	
WAS Pump Capacity - Max	L/s	NA	NA	NA	NA	NA	NA	
WAS Pump Capacity - Ave	L/s	NA	NA	NA	NA	NA	NA	
New Units								
New Primary Pump Capacity	L/s	10	NA	NA	5.50	0.75	1,460	6,023
New WAS Pump Capacity	L/s	NA	10	NA	5.50	0.75	1,460	6,023
TWAS Thickening RDTs	L/s	NA		NA	20.00	0.75	8,760	131,400
TWAS Pump Capacity	L/s	NA		NA	20.00	0.75	8,760	131,400
Polymer								
Dose Rate	g/kg	NA	7.5					
B) PRIMARY DIGESTION	**Unit**	**Primary**	**Secondary**	**Total**	**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
Total installed volume - primary	m³	7320	2350	9670	NA	NA	NA	
Total working volume - primary	m³	6588	2115	8703	NA	NA	NA	
New Units								
New digester diameter	m	19.88	0	NA	NA	NA	NA	
New digester depth	m	7.92	0	NA	NA	NA	NA	
New digester volume	m³	2,440	0	NA	NA	NA	NA	
No. New Duty units	#	2	0	NA	NA	NA	NA	
Total Operational Units	#	2	0	NA	NA	NA	NA	
Total Standby Units	#	0	0	NA	NA	NA	NA	
No. new Standby units	#	0	0	NA	NA	NA	NA	
Total no. new units	#	2	0	NA	NA	NA	NA	
Digester working capacity	% of tot. cap.	90%	90%	NA	NA	NA	NA	
Total new digester working volume	m³	4,392	0	4,392	NA	NA	NA	
Recirculation Pumps								
Number of Existing Units	#	3	1	4	11.25	0.75	8,760	73,913
Number of New Units	#	2	0	2	5.63	0.75	8,760	36,956
Heat Exchangers								
Number of Existing Units	#	2	1	3	NA	NA	NA	
Capacity - Each	MBTU/hr	1.5	1	2.5	NA	NA	NA	
Number of New Units	#	1	0	1	NA	NA	NA	
Capacity - Each	MBTU/hr	1.5	0	1.5	NA	NA	NA	
Transfer Pumps								
Number of Existing Units	#	1	1	2	3.75	0.75	1,460	4,106
Capacity - Each	L/s	18.9	15.8	34.7	NA	NA	NA	
Number of New Units	#	1	0	1	1.88	0.75	1,460	2,053
Capacity - Each	L/s	18.9	0.0	18.9	NA	NA	NA	
Mixers								
Number of Existing Units	#	12	0		67.20	0.75	8,760	441,504
Rating, each mixer	kW	7.5						
Number of New Units	#	8	0		44.80	0.75	8,760	294,336
Rating, each mixer	kW	7.5						
Performance								
Digestion VS reduction	% of VS	60%	0%	NA	NA	NA	NA	
Digester gas production	m³/kg VSR	0.75	0.75	NA	NA	NA	NA	
Digester gas calorific value	kJ/m³	22355	22355	NA	NA	NA	NA	
Boiler efficiency (average)	%	80%	80%	NA	NA	NA	NA	
C) LIQUID BIOSOLIDS	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
New Units								

OPTION 3 - HEAT DRYING

D) DEWATERING	Unit	Total			Total kW	Service Factor	Operating Hours	Total kWh/yr
Existing Units								
New BFP 1 Operating Capacity	L/s	6.3			4.50	1.00	4,380	19,710
New BFP 2 Operating Capacity	L/s	6.3			4.50	1.00	4,380	19,710
BFP 3 Capacity	L/s	6.3			4.18	1.00	4,380	18,287
BFP 4 Capacity	L/s	6.3			4.18	1.00	4,380	18,287
Pumps - Polymer, Filtrate Feed & Sump	#	14			50.00	0.50	8,760	219,000
Polymer Pump Capacity - each	L/s	0.57						
Polymer Mixing Tank	#	2						
Ploymer Tank Capacity - Each	L	8800						
Ploymer Mixers	#	2			1.50	0.50	8,760	6,570
Supply and Exhaust Air Fans	#	10			5.05	1.00	4,380	22,119
Misc. - Air Compressor, Heater, Valves, etc					38.60	0.50	8,760	169,068
New Units								
Centrifuge 1 Capacity	L/s	6.3			46.00	1.00	4,380	201,480
Centrifuge 2 Capacity	L/s	6.3			46.00	1.00	4,380	201,480
Polymer Pumps	#	2			1.50	0.50	8,760	6,570
Polymer Mixing Tank	#	1			0.75	0.50	8,760	3,285
Feed Pumps								
Number of Existing Units	#	4			18.50	1.00	4,380	81,030
Capacity - Each	L/s	9.5						
Number of New Units	#	2			9.25	1.00	4,380	40,515
Capacity - Each	L/s	9.5						
Polymer								
Dose Rate	g/kg	6.0						
E) DEWATERED CAKE	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
Cross Screw Conveyor	#	1			2.20	1.00	4,380	9,636
Lift Screw Conveyor	#	1			2.20	1.00	4,380	9,636
Horizontal Screw COnveyor	#	2			5.00	1.00	4,380	21,900
New Units								
Cross Screw Conveyor	#	0			2.20	0.00	4,380	0
Lift Screw Conveyor	#	0			2.20	0.00	4,380	0
Horizontal Screw COnveyor	#	0			5.00	0.00	4,380	0
F) LYSTEK	**Unit**				**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
6 m^3/d system					54.81	0.50	6,240	170,999
								0
G) HEAT DRYING	**Unit**				**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
New Units								
Heat Drying Process Train	#	1			69.00	1.00	7,512	518,328
PRODUCTION FACTOR								
Initial Year Biosolids Production Rate	7,420	dt/yr						
Ultimate Year Raw Biosolids Production Rate	9,744	dt/yr						

CH2M HILL

CAPITAL COST ESTIMATE

PROJECT: Guelph WWTP Biosolids Management Plan
PROJ. NO.: 120703
AUTHOR: Baldwin
SUBJECT: OPTION 3 - HEAT DRYING
FILENAME: 3-HeatDrying-CostAnalysis.xls
DATE: October-05
REV. NO.:

REF SPEC SECT No	DESCRIPTION OF ITEM	Q'TY	UNIT	MATERIAL UNIT COST ($)	MATERIAL TOTAL COST ($)	% OF MAT'L (%)	INSTALLATION or UNIT COST ($)	INSTALLATION TOTAL COST ($)	TOTAL INSTALL & MAT'L ($)	SUB TOTAL COST ($)	COST DEVELOPMENT
DIVISION 1 - GENERAL REQUIREMENTS											
	mobilization/demobilization	1	L.S.	200,000	200,000			0	200,000		Historical/Est. Judgement
	general conditions/bonds/insurance	1	L.S.	500,000	500,000			0	500,000		Historical/Est. Judgement
					0			0	0		
					0			0	0		
								Division 1 Total:	700,000	$700,000	
DIVISION 2 - SITEWORK											
					0			0	0		
	Site grading for digesters, 2 @ 20 m dia	395	m^2	30	11,856			0	11,856		
	Compost Building Renovations	1	L.S.	2,000,000	2,000,000			0	2,000,000		
	Site grading for Lystek storage	600	m^3	30	18,000			0	18,000		
	Site services	1	L.S.	500,000	500,000			0	500,000		
	Dewatering	120	days	1,000	120,000			0	120,000		
	Relocate & Expand Fence	1,000	m	30	30,000			0	30,000		
	Compost System Decommissioning & Disposal	1	L.S.	2,000,000	2,000,000			0	2,000,000		
								Division 2 Total:	4,679,856	$4,679,900	
DIVISION 3 - CONCRETE											
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
	Lystek Storage - base	300	m^3	500	150,000			0	150,000		
	Lystek Storage - walls	290	m^3	1,100	319,000			0	319,000		
	Lystek Storage - roof	120	m^3	1,000	120,000			0	120,000		
	Digesters - base	310	m^3	550	170,500			0	170,500		
	Digesters - walls	300	m^3	1,200	360,000			0	360,000		
	Digesters - roof	120	m^3	1,100	132,000			0	132,000		
	Miscellaneous Concrete (water stops, joints, etc)	1	L.S.	100,000	100,000			0	100,000		
								Division 3 Total:	1,351,500	$1,351,500	
DIVISION 4 - MASONRY											
					0			0	0		
	Digesters - walls	1,000	m^2	150	150,000			0	150,000		
					0			0	0		
								Division 4 Total:	150,000	$150,000	
DIVISION 5 - METALS											
					0			0	0		
					0			0	0		
					0			0	0		
	Rock Anchors - Lystek storage, 3 m deep, 2 m spacing	110	m	650	71,500			0	71,500		
	Rock Anchors - Digesters 3 m deep, 2 m spacing	470	m	650	305,500			0	305,500		
					0			0	0		
					0			0	0		
								Division 5 Total:	377,000	$377,000	
DIVISION 6 - WOOD AND PLASTICS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 6 Total:	0	$0	
DIVISION 7 - THERMAL AND MOISTURE PROTECTION											
					0			0	0		
					0			0	0		
	Lystek storage - base & walls & roof	2,000	m^2	60	120,000			0	120,000		
	Digesters - base & walls & roof	1,610	m^2	60	96,600			0	96,600		
					0			0	0		
								Division 7 Total:	216,600	$216,600	
DIVISION 8 - DOORS AND WINDOWS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 8 Total:	0	$0	
DIVISION 9 - FINISHES											
					0			0	0		
	Architectural Allowance (Paint, finishes, etc)	1	L.S.	500,000	500,000			0	500,000		
					0			0	0		
								Division 9 Total:	500,000	$500,000	
DIVISION 10 - MANUFACTURED SPECIALTIES											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 10 Total:	0	$0	
DIVISION 11 - EQUIPMENT											
FIXED EQUIPMENT					0			0	0		
	Truck weigh scale facility	1	L.S.	50,000	50,000		15,000	15,000	65,000		
	Primary Pumps	2	L.S.	20,000	40,000		6,000	12,000	52,000		
	WAS Pumps	4	L.S.	20,000	80,000		6,000	24,000	104,000		
	WAS Thickening RDT	3	L.S.	125,000	375,000		37,500	112,500	487,500		
	TWAS Pumps	1	L.S.	60,000	60,000		18,000	18,000	78,000		
	Digester Recirculation Pumps	1	L.S.	25,000	25,000		7,500	7,500	32,500		
	Heat Exchangers	1	L.S.	150,000	150,000		45,000	45,000	195,000		
	Transfer Pumps	1	L.S.	25,000	25,000		7,500	7,500	32,500		
	Digester Mixers	8	L.S.	70,000	560,000		21,000	168,000	728,000		
	Dewatering Centrifuges	2	L.S.	275,000	550,000			0	550,000		Vendor - install included
	Polymer System (Tank, Pump)	1	L.S.	40,000	40,000		12,000	12,000	52,000		
	Dewatering Feed Pumps	1	L.S.	40,000	40,000		12,000	12,000	52,000		
	Process Piping	1	L.S.	1,000,000	1,000,000		300,000	300,000	1,300,000		
	Heat Drying System - Dragon	1	L.S.	3,006,450	3,006,450		751,613	751,613	3,758,063		
	Silo Storage (Pellets)	1	L.S.	1,500,000	1,500,000			0	1,500,000		Vendor - install included
					0			0	0		
					0			0	0		
					0			0	0		
								Division 11 Total:	8,986,563	$8,986,600	

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CAPITAL COST ESTIMATE

PROJECT: Guelph WWTP Biosolids Management Plan
PROJ. NO.: 120703
DATE: October-05
AUTHOR: Baldwin
REV. NO.:
SUBJECT: OPTION 3 - HEAT DRYING
FILENAME: 3-HeatDrying-CostAnalysis.xls

REF SPEC SECT No	DESCRIPTION OF ITEM	Q'TY	UNIT	MATERIAL UNIT COST ($)	MATERIAL TOTAL COST ($)	MATERIAL % OF MAT'L (%)	INSTALLATION or UNIT COST ($)	INSTALLATION TOTAL COST ($)	TOTAL INSTALL & MAT'L ($)	SUB TOTAL COST ($)	COST DEVELOPMENT
DIVISION 12 - FURNISHINGS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 12 Total.	0	$0	
DIVISION 13 - SPECIAL CONSTRUCTION											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 13 Total.	0	$0	
DIVISION 14 - CONVEYING SYSTEMS											
					0			0	0		
	Conveyors (reconfigure & rebuild)	1	L.S.	250,000	250,000			0	250,000		
					0			0	0		
								Division 14 Total:	250,000	$250,000	
DIVISION 15 - MECHANICAL											
					0			0	0		
	Mechanical Allowance - 15% of fixed equipment Cost	15%	LS	8,986,563	1,347,984			0	1,347,984		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
								Division 15 Total:	1,347,984	$1,348,000	
DIVISION 16 - ELECTRICAL											
					0			0	0		
	Electrical Allowance - 15% of fixed equipment cost	15%	LS	8,986,563	1,347,984			0	1,347,984		
	I&C Allowance - 5% if fixed equipment cost	5%	LS	8,986,563	449,328			0	449,328		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
								Division 16 Total.	1,797,313	$1,797,400	
									SUB-TOTAL:	$20,357,000	
ALLOWANCES											
Contractor's overhead and profit		10	%						2,035,700		
			%						0		
			%						0		
			%						0		
			%						0		
								Allowances Total.	2,035,700	$2,035,700	
									SUB-TOTAL:	$22,392,700	
ENGINEERING AND CONTINGENCY											
'Engineering (design and construction services)		15	%						3,358,905		
'Construction lump sum contingency allowance		25	%						5,598,175		
								Engineering and Contingency Total:	8,957,080	$8,957,100	
									SUB-TOTAL:	$31,349,800	
TAXES											
sales tax - federal		7	%						1,959,363		
sales tax - provincial		8	%						2,507,984		
Other taxes, patent fees, import duties and foreign exch.			%						0		
								Taxes Total:	4,467,347	$4,467,400	
LAND PURCHASE											
								Land Total:			
									GRAND TOTAL:	$35,820,000	

No	REVISION	DATE	NOTES
0			
1			
2			
3			
4			
5			

OPTION 3 - HEAT DRYING

ULTIMATE YEAR O&M COSTS

Labour		Hourly Rate	Benefit Rate	Total Cost/Hour	Total Hours/Year	Total Annual Cost (rounded to nearest $1,000)	Production Factor?
0.25	Manager	50	1.35	$67.50	520	$35,000	
1	Supervisor	30	1.35	$40.50	2,080	$84,000	
6	Operator	22	1.35	$29.70	12,480	$371,000	
1.5	Maintenance	25	1.35	$33.75	3,120	$105,000	
						$595,000	**FIXED**
Operations			**Unit Cost**	**Total Units/Year**	**Total Units/Year**		
	Polymer - Thickening		4.50 $/kg		32,887	$148,000	
	Polymer - Dewatering		4.50 $/kg		33,911	$153,000	
	Electricity		0.08 $/kWh		2,909,960	$233,000	
	Natural Gas - Digestion		0.25 $/m^3		634,821	$159,000	
	Natural Gas - Drying		0.25 $/m^3		2,155,856	$539,000	
	Operating Materials Allowance		20%		$693,000	$139,000	
						$1,371,000	**PRODUCTION**
Maintenance - Materials		**% of Capital Cost/Year**	**Equipment Capital Cost**				
	New Equipment	2%	$8,986,600			$180,000	
	Existing Equipment		1 L.S.		$100,000	$100,000	
						$280,000	**FIXED**
Product Disposal		**Cost per Unit (m^3)**	**Total Units/Year**				
	Transport & Land Apply Liquid		10.00 $/m^3		0	$0	
	Transport & Land Apply Lystek		10.00 $/m^3		7,714	$77,000	
	Transport & Land Apply Cake		30.00 $/wt		0	$0	
	Transport & Land Apply Pellets		30.00 $/wt		4,969	$149,000	
	Transport & Landfill Cake		60.00 $/wt		0	$0	
						$226,000	**PRODUCTION**
Other			**Cost per Unit**	**Total Units/Year**			
						$0	
						$0	**PRODUCTION**
Sub-total Annual O&M Costs						**$2,472,000**	**COMBINED**
Credits		**Credit per Unit**		**Total Units/ Year**			
	Heat offset (from biogas)	0.15 $/m^3		1,841,693		$159,000	
	Electricity (from cogen)	0.08 $/kWh		7,596,982		$608,000	
Sub-total Annual O&M Credits						**$767,000**	**PRODUCTION**
Total Annual O&M Costs (Credits)						$1,705,000	
Present Worth O&M Costs						**$21,248,000**	

OPTION 3 - HEAT DRYING

Actual DT Raw Solids Processed	Production Factor	Escalation Rate	Year	Time	Capital Cost Schedule	Revenue & Cash Savings Schedule	Combined Operations & Maintenance & Other Costs Schedule	Discount Rate	NPV
7,420	76%	1.0000	2005	Year 0	$35,820,000			1.0000	$35,820,000
7,537	77%	1.0250	2006	Year 1	0	-$608,000	$2,163,000	0.9750	$1,516,000
7,654	79%	1.0506	2007	Year 2	0	-$633,000	$2,237,000	0.9506	$1,525,000
7,771	80%	1.0769	2008	Year 3	0	-$659,000	$2,314,000	0.9269	$1,534,000
7,888	81%	1.1038	2009	Year 4	0	-$685,000	$2,393,000	0.9037	$1,543,000
8,005	82%	1.1314	2010	Year 5	0	-$713,000	$2,474,000	0.8811	$1,552,000
8,122	83%	1.1597	2011	Year 6	0	-$741,000	$2,558,000	0.8591	$1,561,000
8,239	85%	1.1887	2012	Year 7	0	-$771,000	$2,645,000	0.8376	$1,570,000
8,356	86%	1.2184	2013	Year 8	0	-$801,000	$2,735,000	0.8167	$1,579,000
8,473	87%	1.2489	2014	Year 9	0	-$833,000	$2,827,000	0.7962	$1,588,000
8,590	88%	1.2801	2015	Year 10	0	-$865,000	$2,922,000	0.7763	$1,597,000
8,707	89%	1.3121	2016	Year 11	0	-$899,000	$3,020,000	0.7569	$1,605,000
8,824	91%	1.3449	2017	Year 12	0	-$934,000	$3,122,000	0.7380	$1,615,000
8,941	92%	1.3785	2018	Year 13	0	-$970,000	$3,226,000	0.7195	$1,623,000
9,058	93%	1.4130	2019	Year 14	0	-$1,007,000	$3,334,000	0.7016	$1,633,000
9,174	94%	1.4483	2020	Year 15	0	-$1,046,000	$3,445,000	0.6840	$1,641,000
9,291	95%	1.4845	2021	Year 16	0	-$1,086,000	$3,559,000	0.6669	$1,649,000
9,408	97%	1.5216	2022	Year 17	0	-$1,127,000	$3,678,000	0.6502	$1,659,000
9,525	98%	1.5597	2023	Year 18	0	-$1,169,000	$3,799,000	0.6340	$1,667,000
9,642	99%	1.5987	2024	Year 19	0	-$1,213,000	$3,925,000	0.6181	$1,676,000
9,744	100%	1.6386	2025	Year 20	0	-$1,257,000	$4,051,000	0.6027	$1,684,000
									$67,837,000
Escalation Rate		2.5%						2.5%	

OPTION 3 - HEAT DRYING

Capital Cost	$35,820,000
O&M Annual Cost (Ultimate Year Production)	$2,472,000
O&M Annual Credit (Ultimate Year Production)	$767,000
Net O&M Annual Cost (ultimate Year Production)	$1,705,000
NPV	$67,837,000
Dry Tonnes Raw Solids Processed (20 year total)	180,371
Dry Tonnes Raw Solids Processed (Ultimate Year)	9,744
Capital Cost per Dry Tonne Raw Solids Processed	$199
O&M Annual Cost per Dry Tonne Raw Solids Processed (Ultimate Year)	$254
O&M Annual Credit per Dry Tonne Raw Solids Processed (Ultimate Year)	$79
Net O&M Annual Cost per Dry Tonne Raw Solids Processed (Ultimate Year)	$175
NPV per Dry Tonne Raw Solids Processed	$376

Option 4

Heat Drying with Phased Digestion

OPTION 4 - HEAT DRYING WITH PHASED DIGESTION

				Peak	Average
Sludge Loadings					
TWAS	Flow		m^3/d	200	200
	Solids		% ds	6.0%	6.0%
	Mass		kg/d	12,014	12,014
	Volatile solids		% VS	73.0%	73.0%
			kg/d	8,770	8,770
Primary Sludge	Flow		m^3/d	367	367
	Solids		% ds	4.0%	4.0%
	Mass		kg/d	14,683	14,683
	Volatile solids		% VS	68.0%	68.0%
			kg/d	9,985	9,985
Total Raw Sludge	Flow		m^3/d	567	567
	Solids		% ds	4.7%	4.7%
	Mass		kg/d	26,697	26,697
	Volatile solids		% VS	70.0%	70.0%
			kg/d	18,688	18,688
Anaerobic Digesters					
Acid Phase				1	1
		Each	m^3	1,350	1,350
		HRT	days	2	2
Number	Primary			3	3
	Secondary			1	1
Volume	Primary	Each	m^3	2,440	2,440
		Total	m^3	7,320	7,320
	Secondary	Each	m^3	2,350	2,350
		Total	m^3	2,350	2,350
Primary Digester	HRT		days	13	13
	Loading		kg VSS/m^3.(	2.2	2.2
Total Digester	HRT		days	15	15
	Loading		kg VSS/m^3.(	1.7	1.3
VSS destruction			%	70.0%	70.0%
			kgVS des/d	13,082	13,082
Biogas production			m^3/d	11,773	11,773
	CH_4 content		%	60%	60%
Digested Sludge			m^3/d	567	567
			kg/d	13,615	13,615
			% ds	2.4%	2.4%
			% VS	41.2%	41%
Total Heat Required for Sludge Feed					
	Sludge Flow Rate		wet kg/hr	23,617	23,617
	Specific Heat of Water		kJ/kg °C	4.1868	4.1868
	Av. Temp. of Raw Sludge		°C	15	15
	Digester Temp.		°C	35	35
	Heat Required		kJ/hr	1,977,619	1,977,619
	Natural Gas Equivalent		m^3/yr	461,972	461,972
Total Heat Required for Heat Losses			kJ/hr per m^3	27	27
	Heat Losses Occuring		% of time pe	50.0%	50.0%

OPTION 4 - HEAT DRYING WITH PHASED DIGESTION

	Natural Gas Equivalent	m^3/yr	34,753	34,753
Liquid to Storage/Land				
	Mass	dt/yr		0
	Mass	dt/d		0.00
	Flow	m^3/d		0.00
	Mass	kg/d		0
	Dry Solids	% ds		2.4%
Storage	Days	d		240
Dewatering - Total				Average
Feed Sludge	Mass	dt/yr		4,970
		dt/d		13.62
	Flow	m^3 /d	567	567
	Solids	% ds	2.4%	2.4%
	Mass	kg/d	13,615	13,615
	Volatile solids	% VS	41.2%	41.2%
		kg/d	5,606	5,606
Dewatering - BFPs			Peak	Average (Firm)
Press Capacity		L/s	24	12
7 hrs/d; 5 d/wk operating		m^3/d	432	216
Feed Sludge	Flow	m^3/d	432	216
	Solids	% ds	2.4%	2.4%
	Mass	kg/d	10,377	5,189
	Volatile solids	% VS	41.2%	41.2%
		kg/d	4,273	2,136
BFP Cake	Flow	m^3/d	49	25
	Solids	% ds	18.0%	18.0%
	Mass	kg/d	8,821	4,410
	Volatile solids	% VS	41.2%	41.2%
		kg/d	3,632	1,816
	Capture	%	85.0%	85.0%
BFP Sidestream	Flow	m^3/d	383	191
	Solids	mg/L	4,064	4,064
	Mass	kg/d	1,557	778
	Volatile solids	% VS	41%	41%
		kg/d	641	320
Dewatering - Centrifuges				
Feed Sludge	Flow	m^3/d	135	351
7 hrs/d; 5 d/wk operating		L/s	3.8	9.9
	Solids	% ds	2.4%	2.4%
	Mass	kg/d	3,238	8,427
	Volatile solids	% VS	41.2%	41.2%
		kg/d	1,333	3,470
Centrifuge Cake	Flow	m^3/d	11	30
	Solids	% ds	28.0%	28.0%
	Mass	kg/d	3,206	8,343
	Volatile solids	% VS	41.2%	41.2%
		kg/d	1,320	3,435
	Capture	%	99.0%	99.0%
Centrifuge Sidestream	Flow	m^3/d	123	321
	Solids	mg/L	263	263

OPTION 4 - HEAT DRYING WITH PHASED DIGESTION

	Mass	kg/d	32	84
	Volatile solids	% VS	41%	41%
		kg/d	13	35
Lystek (utilizing BFP cake)				
Feed Cake	Flow	m^3/d	33	17
	Solids	% ds	18.0%	18.0%
	Mass	kg/d	6000	3000
Lystek Material	Solids	% ds	14%	14%
Operating Capacity	7 day/week	dt/d	6	3
Production		m^3/wk	300	150
Annual capacity		dt/yr	360	720
Storage capacity		m^3	4,800 NA	
Remaining Cake	Mass	kg/d	6,027	9,753
	Solids	% ds	23%	27%
Heat Drying				
Processing Capacity	dt/yr			3,890
	dt/d			10.8
	wt/yr			13,892
	tonnes/yr water			10,002
Product	dt/yr processed			3,944
	% solids			92%
	wt/yr			4,287
	tonnes/yr water out			343
Storage	tonnes			1,409
Heat Required	kWh/ tonne water			1,804.000
	water t/yr			9,659
	kWh/yr			17,424,873
	MJ			62,729,543
	kJ			6.27E+10
	m^3 natural gas			1,672,788
Boiler System				
Boiler Efficiency		%	80%	80%
Cogeneration System				
Electrical Conversion Efficiency		%	33%	33%
Thermal Recovery Efficiency		%	40%	40%
Electricity Produced				
Natural Gas Unit Energy		kJ/m^3	37,500	37,500
Biogas Unit Energy		kJ/m^3	22,500	22,500
Electricity Energy Per Unit Biogas		kJ/m^3	7,425	7,425
Biogas used for Cogen		m^3/d	11,773	11,773
Biogas used for Cogen		m^3/s	1.36E-01	1.36E-01
Cogen Electrical Energy Produced		kJ/s	1,012	1,012
Cogen Electrical Energy Produced		kW	1,012	1,012
Cogen Electrical Energy Produced		kWh/h	1,012	1,012
Cogen Electrical Energy Produced		kWh/y	8,863,145	8,863,145

OPTION 4 - HEAT DRYING WITH PHASED DIGESTION

A) RAW SLUDGE	Unit	Primary Sludge	TWAS	Total Sludge	Total kW	Service Factor	Operating Hours/Yr	Total kWh/yr
Required Capacity	m^3/d	367	200	567	NA	NA	NA	
	L/s	4.2	2.3	6.6	NA	NA	NA	
Existing Units								
Primary Pump Capacity - Max	L/s	NA	NA	40	22.50	0.75	1,460	24,638
Primary Pump Capacity - Ave	L/s	NA	NA	20	NA	NA	NA	
WAS Pump Capacity - Max	L/s	NA	NA	NA	NA	NA	NA	
WAS Pump Capacity - Ave	L/s	NA	NA	NA	NA	NA	NA	
New Units								
New Primary Pump Capacity	L/s	10	NA	NA	5.50	0.75	1,460	6,023
New WAS Pump Capacity	L/s	NA	10	NA	5.50	0.75	1,460	6,023
TWAS Thickening RDTs	L/s	NA		NA	20.00	0.75	8,760	131,400
TWAS Pump Capacity	L/s	NA		NA	20.00	0.75	8,760	131,400
Polymer								
Dose Rate	g/kg	NA	7.5					
B) PRIMARY DIGESTION	**Unit**	**Primary**	**Secondary**	**Total**	**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
Total installed volume - primary	m^3	7320	2350	9670	NA	NA	NA	
Total working volume - primary	m^3	6588	2115	8703	NA	NA	NA	
New Units								
New digester diameter	m	10.37	0	NA	NA	NA	NA	
New digester depth	m	4	0	NA	NA	NA	NA	
New digester volume	m^3	1,350	0	NA	NA	NA	NA	
No. New Duty units	#	1	0	NA	NA	NA	NA	
Total Operational Units	#	1	0	NA	NA	NA	NA	
Total Standby Units	#	0	0	NA	NA	NA	NA	
No. new Standby units	#	0	0	NA	NA	NA	NA	
Total no. new units	#	1	0	NA	NA	NA	NA	
Digester working capacity	% of tot. cap.	90%	90%	NA	NA	NA	NA	
Total new digester working volume	m^3	1,215	0	1,215	NA	NA	NA	
Recirculation Pumps								
Number of Existing Units	#	3	1	4	11.25	0.75	8,760	73,913
Number of New Units	#	1	0	1	2.81	0.75	8,760	18,478
Heat Exchangers								
Number of Existing Units	#	2	1	3	NA	NA	NA	
Capacity - Each	MBTU/hr	1.5	1	2.5	NA	NA	NA	
Number of New Units	#	1	0	1	NA	NA	NA	
Capacity - Each	MBTU/hr	1.5	0	1.5	NA	NA	NA	
Transfer Pumps								
Number of Existing Units	#	1	1	2	3.75	0.75	1,460	4,106
Capacity - Each	L/s	18.9	15.8	34.7	NA	NA	NA	
Number of New Units	#	1	0	1	1.88	0.75	1,460	2,053
Capacity - Each	L/s	18.9	0.0	18.9	NA	NA	NA	
Mixers								
Number of Existing Units	#	12	0		67.20	0.75	8,760	441,504
Rating, each mixer	kW	7.5						
Number of New Units	#	2	0		11.20	0.75	8,760	73,584
Rating, each mixer	kW	7.5						
Performance								
Digestion VS reduction	% of VS	60%	0%	NA	NA	NA	NA	
Digester gas production	m^3/kg VSR	0.75	0.75	NA	NA	NA	NA	
Digester gas calorific value	kJ/m^3	22355	22355	NA	NA	NA	NA	
Boiler efficiency (average)	%	80%	80%	NA	NA	NA	NA	
C) LIQUID BIOSOLIDS	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
New Units								

OPTION 4 - HEAT DRYING WITH PHASED DIGESTION

D) DEWATERING	Unit	Total			Total kW	Service Factor	Operating Hours	Total kWh/yr
Existing Units								
New BFP 1 Operating Capacity	L/s	6.3			4.50	1.00	4,380	19,710
New BFP 2 Operating Capacity	L/s	6.3			4.50	1.00	4,380	19,710
BFP 3 Capacity	L/s	6.3			4.18	1.00	4,380	18,287
BFP 4 Capacity	L/s	6.3			4.18	1.00	4,380	18,287
Pumps - Polymer, Filtrate Feed & Sump	#	14			50.00	0.50	8,760	219,000
Polymer Pump Capacity - each	L/s	0.57						
Polymer Mixing Tank	#	2						
Ploymer Tank Capacity - Each	L	8800						
Ploymer Mixers	#	2			1.50	0.50	8,760	6,570
Supply and Exhaust Air Fans	#	10			5.05	1.00	4,380	22,119
Misc. - Air Compressor, Heater, Valves, etc					38.60	0.50	8,760	169,068
New Units								
Centrifuge 1 Capacity	L/s	9.9			18.89	1.00	4,380	82,752
Centrifuge 2 Capacity	L/s	9.9			18.89	1.00	4,380	82,752
Polymer Pumps	#	2			1.50	0.50	8,760	6,570
Polymer Mixing Tank	#	1			0.75	0.50	8,760	3,285
Feed Pumps								
Number of Existing Units	#	4			18.50	1.00	4,380	81,030
Capacity - Each	L/s	9.5						
Number of New Units	#	2			9.25	1.00	4,380	40,515
Capacity - Each	L/s	9.5						
Polymer								
Dose Rate	g/kg	6.0						
E) DEWATERED CAKE TO LAND	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
Cross Screw Conveyor	#	1			2.20	1.00	4,380	9,636
Lift Screw Conveyor	#	1			2.20	1.00	4,380	9,636
Horizontal Screw Conveyor	#	2			5.00	1.00	4,380	21,900
New Units								
Cross Screw Conveyor	#	0			2.20	0.00	4,380	0
Lift Screw Conveyor	#	0			2.20	0.00	4,380	0
Horizontal Screw COnveyor	#	0			5.00	0.00	4,380	0
F) LYSTEK	**Unit**				**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
6 m^3/d system					54.81	0.50	6,240	170,999
G) HEAT DRYING	**Unit**				**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
New Units								
Heat Drying Process Train	#	1			69.00	1.00	7,512	518,328
PRODUCTION FACTOR								
Initial Year Biosolids Production Rate	7,420	dt/yr						
Ultimate Year Raw Biosolids Production Rate	9,744	dt/yr						

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CAPITAL COST ESTIMATE

PROJECT: Guelph WWTP Biosolids Management Plan
PROJ. NO.: 120703 DATE: October-05
AUTHOR: Baldwin REV. NO.:
SUBJECT: OPTION 4 - HEAT DRYING WITH PHASED DIGESTION
FILENAME: 4-HeatDrying-PhasedDig-CostAnalysis.xls

REF SPEC SECT No	DESCRIPTION OF ITEM	Q'TY	UNIT	MATERIAL UNIT COST ($)	MATERIAL TOTAL COST ($)	MATERIAL % OF MAT'L (%)	INSTALLATION or UNIT COST ($)	INSTALLATION TOTAL COST ($)	TOTAL INSTALL & MAT'L ($)	SUB TOTAL COST ($)	COST DEVELOPMENT
DIVISION 1 - GENERAL REQUIREMENTS											
	mobilization/demobilization	1	L.S.	200,000	200,000			0	200,000		Historical/Est. Judgement
	general conditions/bonds/insurance	1	L.S.	500,000	500,000			0	500,000		Historical/Est. Judgement
					0			0	0		
					0			0	0		
								Division 1 Total:	700,000	$700,000	
DIVISION 2 - SITEWORK											
					0			0	0		
	Site grading for acid digester:, 1 @ 10.4 m dia	54	m^3	30	1,613			0	1,613		
	Compost Building Renovations	1	L.S.	2,000,000	2,000,000			0	2,000,000		
	Site grading for Lystek storage	600	m^3	30	18,000			0	18,000		
	Site services	1	L.S.	500,000	500,000			0	500,000		
	Dewatering	120	days	1,000	120,000			0	120,000		
	Relocate & Expand Fence	1,000	m	30	30,000			0	30,000		
	Compost System Decommissioning & Disposal	1	L.S.	2,000,000	2,000,000			0	2,000,000		
								Division 2 Total:	4,669,613	$4,669,700	
DIVISION 3 - CONCRETE											
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
	Lystek Storage - base	300	m^3	500	150,000			0	150,000		
	Lystek Storage - walls	290	m^3	1,100	319,000			0	319,000		
	Lystek Storage - roof	120	m^3	1,000	120,000			0	120,000		
	Digesters - base	40	m^3	550	22,000			0	22,000		
	Digesters - walls	80	m^3	1,200	96,000			0	96,000		
	Digesters - roof	20	m^3	1,100	22,000			0	22,000		
	Miscellaneous Concrete (water stops, joints, etc)	1	L.S.	200,000	200,000			0	200,000		
								Division 3 Total:	929,000	$929,000	
DIVISION 4 - MASONRY											
					0			0	0		
	Digesters - walls	130	m^2	150	19,500			0	19,500		
					0			0	0		
								Division 4 Total:	19,500	$19,500	
DIVISION 5 - METALS											
					0			0	0		
					0			0	0		
					0			0	0		
	Rock Anchors - Lystek storage, 3 m deep, 2 m spacing	110	m	650	71,500			0	71,500		
	Rock Anchors - Digesters 3 m deep, 2 m spacing	130	m	650	84,500			0	84,500		
					0			0	0		
					0			0	0		
								Division 5 Total:	156,000	$156,000	
DIVISION 6 - WOOD AND PLASTICS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 6 Total:	0	$0	
DIVISION 7 - THERMAL AND MOISTURE PROTECTION											
					0			0	0		
					0			0	0		
	Lystek storage - base & walls & roof	2,000	m^2	60	120,000			0	120,000		
	Digesters - base & walls & roof	430	m^2	60	25,800			0	25,800		
					0			0	0		
								Division 7 Total:	145,800	$145,800	
DIVISION 8 - DOORS AND WINDOWS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 8 Total:	0	$0	
DIVISION 9 - FINISHES											
					0			0	0		
	Architectural Allowance (Paint, finishes, etc)	1	L.S	500,000	500,000			0	500,000		
					0			0	0		
								Division 9 Total:	500,000	$500,000	
DIVISION 10 - MANUFACTURED SPECIALTIES											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 10 Total:	0	$0	
DIVISION 11 - EQUIPMENT											
FIXED EQUIPMENT					0			0	0		
	Truck weigh scale facility	1	L.S.	50,000	50,000		15,000	15,000	65,000		
	Primary Pumps	2	L.S.	20,000	40,000		6,000	12,000	52,000		
	WAS Pumps	4	L.S.	20,000	80,000		6,000	24,000	104,000		
	WAS Thickening RDT	3	L.S.	125,000	375,000		37,500	112,500	487,500		
	TWAS Pumps	1	L.S.	60,000	60,000		18,000	18,000	78,000		
	Digester Recirculation Pumps	1	L.S.	10,000	10,000		3,000	3,000	13,000		
	Heat Exchangers	1	L.S.	50,000	50,000		15,000	15,000	65,000		
	Transfer Pumps	1	L.S.	10,000	10,000		3,000	3,000	13,000		
	Digester Mixers	2	L.S.	70,000	140,000		21,000	42,000	182,000		
	Dewatering Centrifuges	2	L.S.	275,000	550,000			0	550,000		
	Polymer System (Tank, Pump)	1	L.S.	40,000	40,000		12,000	12,000	52,000		
	Dewatering Feed Pumps	1	L.S.	40,000	40,000			0	40,000		Vendor - install included
	Process Piping	1	L.S.	1,000,000	1,000,000		300,000	300,000	1,300,000		
	Heat Drying System - Dragon	1	L.S.	3,006,450	3,006,450		901,935	901,935	3,908,385		
	Silo Storage (Pellets)	1	L.S.	1,500,000	1,500,000		450,000	450,000	1,950,000		
					0		0	0	0		
					0			0	0		
					0			0	0		
					0			0	0		
								Division 11 Total:	8,859,885	$8,859,900	

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CAPITAL COST ESTIMATE

PROJECT: Guelph WWTP Biosolids Management Plan
PROJ. NO.: 120703 DATE: October-05
AUTHOR: Baldwin REV. NO.:
SUBJECT: OPTION 4 - HEAT DRYING WITH PHASED DIGESTION
FILENAME: 4-HeatDrying-PhasedDig-CostAnalysis.xls

REF SPEC SECT No	DESCRIPTION OF ITEM	Q'TY	UNIT	MATERIAL UNIT COST ($)	MATERIAL TOTAL COST ($)	% OF MAT'L (%)	INSTALLATION or UNIT COST ($)	INSTALLATION TOTAL COST ($)	TOTAL INSTALL & MAT'L ($)	SUB TOTAL COST ($)	COST DEVELOPMENT
DIVISION 12 - FURNISHINGS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 12 Total:	0	$0	
DIVISION 13 - SPECIAL CONSTRUCTION											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 13 Total:	0	$0	
DIVISION 14 - CONVEYING SYSTEMS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 14 Total:	0	$0	
DIVISION 15 - MECHANICAL											
					0			0	0		
	Mechanical Allowance - 15% of fixed equipment Cost	15%	L.S.	8,859,885	1,328,983			0	1,328,983		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
								Division 15 Total:	1,328,983	$1,329,000	
DIVISION 16 - ELECTRICAL											
					0			0	0		
	Electrical Allowance - 15% of fixed equipment cost	15%	L.S.	8,859,885	1,328,983			0	1,328,983		
	I&C Allowance - 5% of fixed equipment cost	5%	L.S.	8,859,885	442,994			0	442,994		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
								Division 16 Total:	1,771,977	$1,772,000	
									SUB-TOTAL:	$19,080,900	
ALLOWANCES											
Contractor's overhead and profit		10	%						1,908,090		
			%						0		
			%						0		
			%						0		
			%						0		
								Allowances Total:	1,908,090	$1,908,100	
									SUB-TOTAL:	$20,989,000	
ENGINEERING AND CONTINGENCY											
'Engineering (design and construction services)		15	%						3,148,350		
'Construction lump sum contingency allowance		25	%						5,247,250		
								Engineering and Contingency Total:	8,395,600	$8,395,600	
									SUB-TOTAL:	$29,384,600	
TAXES											
sales tax - federal		7	%						1,836,538		
sales tax - provincial		8	%						2,350,768		
Other taxes, patent fees, import duties and foreign exch.			%						0		
								Taxes Total:	4,187,306	$4,187,400	
LAND PURCHASE											
								Land Total:			
									GRAND TOTAL:	$33,570,000	

No	REVISION	DATE	NOTES
0			
1			
2			
3			
4			
5			

OPTION 4 - HEAT DRYING WITH PHASED DIGESTION

ULTIMATE YEAR O&M COSTS

Labour		Hourly Rate	Benefit Rate	Total Cost/Hour	Total Hours/Year	Total Annual Cost (rounded to nearest $1,000)	Production Factor?
0.25	Manager	50	1.35	$67.50	520	$35,000	
1	Supervisor	30	1.35	$40.50	2,080	$84,000	
6	Operator	22	1.35	$29.70	12,480	$371,000	
1.5	Maintenance	25	1.35	$33.75	3,120	$105,000	
						$595,000	**FIXED**
Operations		Unit Cost	Unit	Total Units/Year			
	Polymer - Thickening		4.50	$/kg	32,887	$148,000	
	Polymer - Dewatering		4.50	$/kg	29,818	$134,000	
	Electricity		0.08	$/kWh	2,433,274	$195,000	
	Natural Gas		0.25	$/m^3	620,905	$155,000	
	Natural Gas - Drying		0.25	$/m^3	1,672,788	$418,000	
	Operating Materials Allowance		20%		$632,000	$126,000	
						$1,176,000	**PRODUCTION**
Maintenance - Materials		% of Capital Cost/Year	Equipment Capital Cost				
	New Equipment	2%	$8,859,900			$177,000	
	Existing Equipment		1	L.S.	$100,000	$100,000	
						$0	
						$277,000	**FIXED**
Product Disposal			Cost per Unit (m^3)		Total Units/Year		
	Transport & Land Apply Liquid		10.00	$/m^3	0	$0	
	Transport & Land Apply Lystek		10.00	$/m^3	7,714	$77,000	
	Transport & Land Apply Cake		30.00	$/wt	0	$0	
	Transport & Land Apply Pellets		30.00	$/wt	4,287	$129,000	
	Transport & Landfill Cake		60.00	$/wt	0	$0	
						$206,000	**PRODUCTION**
Other			Cost per Unit	Total Units/Year			
						$0	
						$0	**PRODUCTION**
Sub-total Annual O&M Costs						**$2,254,000**	**COMBINED**
Credits		Credit per Unit		Total Units/ Year			
	Heat offset (from biogas)	0.15	$/m^3	2,148,641		$155,000	
	Electricity (from cogen)	0.08	$/kWh	8,863,145		$709,000	
Sub-total Annual O&M Credits						**$864,000**	**PRODUCTION**
Total Annual O&M Costs (Credits)						$1,390,000	
Present Worth O&M Costs						**$17,322,000**	

OPTION 4 - HEAT DRYING WITH PHASED DIGESTION

Actual DT Raw Solids Processed	Production Factor	Escalation Rate	Year	Time	Capital Cost Schedule	Revenue & Cash Savings Schedule	Combined Operations & Maintenance & Other Costs Schedule	Discount Rate	NPV
7,420	76%	1.0000	2005	Year 0	$33,570,000			1.0000	$33,570,000
7,537	77%	1.0250	2006	Year 1	0	-$685,000	$1,990,000	0.9750	$1,272,000
7,654	79%	1.0506	2007	Year 2	0	-$713,000	$2,057,000	0.9506	$1,278,000
7,771	80%	1.0769	2008	Year 3	0	-$742,000	$2,126,000	0.9269	$1,283,000
7,888	81%	1.1038	2009	Year 4	0	-$772,000	$2,197,000	0.9037	$1,288,000
8,005	82%	1.1314	2010	Year 5	0	-$803,000	$2,271,000	0.8811	$1,293,000
8,122	83%	1.1597	2011	Year 6	0	-$835,000	$2,347,000	0.8591	$1,299,000
8,239	85%	1.1887	2012	Year 7	0	-$868,000	$2,426,000	0.8376	$1,305,000
8,356	86%	1.2184	2013	Year 8	0	-$903,000	$2,506,000	0.8167	$1,309,000
8,473	87%	1.2489	2014	Year 9	0	-$938,000	$2,590,000	0.7962	$1,315,000
8,590	88%	1.2801	2015	Year 10	0	-$975,000	$2,676,000	0.7763	$1,321,000
8,707	89%	1.3121	2016	Year 11	0	-$1,013,000	$2,764,000	0.7569	$1,325,000
8,824	91%	1.3449	2017	Year 12	0	-$1,052,000	$2,856,000	0.7380	$1,331,000
8,941	92%	1.3785	2018	Year 13	0	-$1,093,000	$2,950,000	0.7195	$1,336,000
9,058	93%	1.4130	2019	Year 14	0	-$1,135,000	$3,047,000	0.7016	$1,341,000
9,174	94%	1.4483	2020	Year 15	0	-$1,178,000	$3,147,000	0.6840	$1,347,000
9,291	95%	1.4845	2021	Year 16	0	-$1,223,000	$3,251,000	0.6669	$1,353,000
9,408	97%	1.5216	2022	Year 17	0	-$1,269,000	$3,357,000	0.6502	$1,358,000
9,525	98%	1.5597	2023	Year 18	0	-$1,317,000	$3,467,000	0.6340	$1,363,000
9,642	99%	1.5987	2024	Year 19	0	-$1,367,000	$3,580,000	0.6181	$1,368,000
9,744	100%	1.6386	2025	Year 20	0	-$1,416,000	$3,693,000	0.6027	$1,372,000
									$60,027,000

Escalation Rate	2.5%		2.5%

OPTION 4 - HEAT DRYING WITH PHASED DIGESTION

Capital Cost	$33,570,000
O&M Annual Cost (Ultimate Year Production)	$2,254,000
O&M Annual Credit (Ultimate Year Production)	$864,000
Net O&M Annual Cost (ultimate Year Production)	$1,390,000
NPV	$60,027,000
Dry Tonnes Raw Solids Processed (20 year total)	180,371
Dry Tonnes Raw Solids Processed (Ultimate Year)	9,744
Capital Cost per Dry Tonne Raw Solids Processed	$186
O&M Annual Cost per Dry Tonne Raw Solids Processed (Ultimate Year)	$231
O&M Annual Credit per Dry Tonne Raw Solids Processed (Ultimate Year)	$89
Net O&M Annual Cost per Dry Tonne Raw Solids Processed (Ultimate Year)	$143
NPV per Dry Tonne Raw Solids Processed	$333

Option 5

Heat Drying with Primary-only Digestion

OPTION 5 - HEAT DRYING, PRIMARY ONLY DIGESTION

				Peak	Average
Sludge Loadings					
TWAS	Flow		m^3/d	200	200
	Solids		% ds	6.0%	6.0%
	Mass		kg/d	12,014	12,014
	Volatile solids		% VS	73.0%	73.0%
			kg/d	8,770	8,770
Primary Sludge	Flow		m^3/d	367	367
	Solids		% ds	4.0%	4.0%
	Mass		kg/d	14,683	14,683
	Volatile solids		% VS	68.0%	68.0%
			kg/d	9,985	9,985
Total Raw Sludge	Flow		m^3/d	567	567
	Solids		% ds	4.7%	4.7%
	Mass		kg/d	26,697	26,697
	Volatile solids		% VS	70.0%	70.0%
			kg/d	18,688	18,688
Anaerobic Digesters					
Number	Primary			3	3
	Secondary			1	1
Volume	Primary	Each	m^3	2,440	2,440
		Total	m^3	7,320	7,320
	Secondary	Each	m^3	2,350	2,350
		Total	m^3	2,350	2,350
Primary Digester	HRT		days	20	20
	Loading		kg VSS/m^3.d	1.4	1
Total Digester	HRT		days	26	26
	Loading		kg VSS/m^3.d	1.0	1
VSS destruction			%	60.0%	1
			kgVS des/d	5,991	5,991
Biogas production			m^3/d	5,392	5,392
	CH_4 content		%	60.0%	60.0%
Digested Sludge			m^3/d	367	367
			kg/d	8,693	8,693
			% ds	2.4%	2.4%
			% VS	46%	46%
Digested & Undigested WAS			m3/d	567	567
			kg/d	20,706	20,706
			% ds	3.6%	3.6%
			% VS	62%	62%
Total Heat Required for Sludge Feed					
	Sludge Flow Rate		wet kg/hr	15,295	15,295
	Specific Heat of Water		kJ/kg °C	4.1868	4.1868
	Av. Temp. of Raw Sludge		°C	15	15
	Digester Temp.		°C	35	35
	Heat Required		kJ/hr	1,280,755	1,280,755
	Natural Gas Equivalent		m^3/yr	299,184	299,184
Total Heat Required for Heat Losses			kJ/hr per m^3 c	27	27
	Heat Losses Occuring		% of time per	50.0%	50.0%
	Natural Gas Equivalent		m^3/yr	30,495	30,495

OPTION 5 - HEAT DRYING, PRIMARY ONLY DIGESTION

Liquid to Storage/Land				
		dt/yr		0
		dt/d		0.00
		m^3/d	0.00	0.00
		kg/d	0	0
		% ds	2.4%	2.4%
Storage	Days	d	240	240
Dewatering - Total				
Feed Sludge	Mass	dt/yr		7,558
		dt/d		21
	Flow	m^3/d	567	567
	Solids	% ds	3.6%	3.6%
	Mass	kg/d	20,706	20,706
	Volatile solids	% VS	61.6%	61.6%
		kg/d	12,764	12,764
Dewatering - BFPs				
Press Capacity		L/s	24	12
7 hrs/d; 5 d/wk operating		m^3/d	432	216
Feed Sludge	Flow	m^3/d	432	216
	Solids	% ds	3.6%	3.6%
	Mass	kg/d	15,767	7,884
	Volatile solids	% VS	61.6%	61.6%
		kg/d	9,719	4,860
BFP Cake	Flow	m^3/d	74	37
	Solids	% ds	18.0%	18.0%
	Mass	kg/d	13,402	6,701
	Volatile solids	% VS	61.6%	61.6%
		kg/d	8,262	4,131
	Capture	%	85.0%	85.0%
BFP Sidestream	Flow	m^3/d	358	179
	Solids	mg/L	6,615	6,615
	Mass	kg/d	2,365	1,183
	Volatile solids	% VS	62%	62%
		kg/d	1,458	729
Dewatering - Centrifuges				
Feed Sludge	Flow	m^3/d	135	351
7 hrs/d; 5 d/wk operating		L/s	3.8	10.0
	Solids	% ds	3.6%	3.6%
	Mass	kg/d	4,939	12,822
	Volatile solids	% VS	61.6%	61.6%
		kg/d	3,044	7,904
Centrifuge Cake	Flow	m^3/d	17	45
	Solids	% ds	28.0%	28.0%
	Mass	kg/d	4,889	12,694
	Volatile solids	% VS	61.6%	61.6%
		kg/d	3,014	7,825
	Capture	%	99.0%	99.0%
Centrifuge Sidestream	Flow	m^3/d	118	306
	Solids	mg/l	419	419
	Mass	kg/d	49	128
	Volatile solids	% VS	62%	62%
		kg/d	30	79

OPTION 5 - HEAT DRYING, PRIMARY ONLY DIGESTION

Lystek				
Feed Cake	Flow	m^3/d	33	17
	Solids	% ds	18.0%	18.0%
	Mass	kg/d	6000	3000
Lystek Material	Solids	% ds	14%	14%
Operating Capacity	7 day/week	dt/d	6	3
Production		m^3/wk	300	150
Annual capacity		dt/yr	360	720
Storage capacity		m^3	4,800	NA
Remaining Cake	Mass	kg/d	12,292	16,395
	Solids	% ds	22%	26%
Heat Drying				
Processing Capacity	dt/yr			6,478
	dt/d			20.8
	wt/yr			25,164
	tonnes/yr water			18,686
Product	dt/yr processed			6,478
	% solids			92%
	wt/yr			7,041
	tonnes/yr water out			563
Storage	tonnes			2,708
Heat Required	kWh/ tonne water			1,804
	water t/yr			18,122.590
	kWh/yr			33,709,315
	MJ			121,353,534
	kJ			1.2E+11
	m^3 natural gas			3,236,094
Boiler System				
Boiler Efficiency		%	80%	80%
Cogeneration System				
Electrical Conversion Efficiency		%	33%	33%
Thermal Recovery Efficiency		%	40%	40%
Electricity Produced				
Natural Gas Unit Energy		kJ/m^3	37,500	37,500
Biogas Unit Energy		kJ/m^3	22,500	22,500
Electricity Energy Per Unit Biogas		kJ/m^3	7,425	7,425
Biogas used for Cogen		m^3/d	5,392	5,392
Biogas used for Cogen		m^3/s	6.24E-02	6.24E-02
Cogen Electrical Energy Produced		kJ/s	463	463
Cogen Electrical Energy Produced		kW	463	463
Cogen Electrical Energy Produced		kWh/h	463	463
Cogen Electrical Energy Produced		kWh/y	4,058,959	4,058,959

OPTION 5 - HEAT DRYING, PRIMARY ONLY DIGESTION

A) RAW SLUDGE	Unit	Primary Sludge	TWAS	Total Sludge	Total kW	Service Factor	Operating Hours/Yr	Total kWh/yr
Required Capacity	m^3/d	367	0	367	NA	NA	NA	
	L/s	4.2	0.0	4.2	NA	NA	NA	
Existing Units								
Primary Pump Capacity - Max	L/s	NA	NA	40	22.50	0.75	1,460	24,638
Primary Pump Capacity - Ave	L/s	NA	NA	20	NA	NA	NA	
WAS Pump Capacity - Max	L/s	NA	NA	NA	NA	NA	NA	
WAS Pump Capacity - Ave	L/s	NA	NA	NA	NA	NA	NA	
New Units								
New Primary Pump Capacity	L/s	10	NA	NA	5.50	0.75	1,460	6,023
New WAS Pump Capacity	L/s	NA	10	NA	5.50	0.75	1,460	6,023
TWAS Thickening RDTs	L/s	NA		NA	20.00	0.75	8,760	131,400
TWAS Pump Capacity	L/s	NA		NA	20.00	0.75	8,760	131,400
Polymer								
Dose Rate	g/kg	NA	7.5					

B) PRIMARY DIGESTION	Unit	Primary	Secondary	Total	Total kW	Service Factor	Operating Hours	Total kWh/yr
Existing Units								
Total installed volume - primary	m^3	7320	2350	9670	NA	NA	NA	
Total working volume - primary	m^3	6588	2115	8703	NA	NA	NA	
New Units								
New digester diameter	m	0	0	NA	NA	NA	NA	
New digester depth	m	0	0	NA	NA	NA	NA	
New digester volume	m^3	0	0	NA	NA	NA	NA	
No. New Duty units	#	0	0	NA	NA	NA	NA	
Total Operational Units	#	0	0	NA	NA	NA	NA	
Total Standby Units	#	0	0	NA	NA	NA	NA	
No. new Standby units	#	0	0	NA	NA	NA	NA	
Total no. new units	#	0	0	NA	NA	NA	NA	
Digester working capacity	% of tot. cap.	90%	90%	NA	NA	NA	NA	
Total new digester working volume	m^3	0	0	0	NA	NA	NA	
Recirculation Pumps								
Number of Existing Units	#	3	1	4	11.25	0.75	8,760	73,913
Number of New Units	#	0	0	0	NA	NA	NA	
Heat Exchangers								
Number of Existing Units	#	2	1	3	NA	NA	NA	
Capacity - Each	MBTU/hr	1.5	1	2.5	NA	NA	NA	
Number of New Units	#	0	0	0	NA	NA	NA	
Capacity - Each	MBTU/hr	1.5	0	1.5	NA	NA	NA	
Transfer Pumps								
Number of Existing Units	#	1	1	2	3.75	0.75	1,460	4,106
Capacity - Each	L/s	18.9	15.8	34.7	NA	NA	NA	
Number of New Units	#	0	0	0	NA	NA	NA	
Capacity - Each	L/s	18.9	0.0	18.9	NA	NA	NA	
Mixers								
Number of Existing Units	#	12	0		67.20	0.75	8,760	441,504
Rating, each mixer	kW	7.5						
Number of New Units	#	0	0		NA	NA	NA	
Rating, each mixer	kW	7.5						
Performance								
Digestion VS reduction	% of VS	60%	0%	NA	NA	NA	NA	
Digester gas production	m^3/kg VSR	0.75	0.75	NA	NA	NA	NA	
Digester gas calorific value	kJ/m^3	22355	22355	NA	NA	NA	NA	
Boiler efficiency (average)	%	80%	80%	NA	NA	NA	NA	

C) LIQUID BIOSOLIDS	Unit	Total			Total kW	Service Factor	Operating Hours	Total kWh/yr
New Units								

OPTION 5 - HEAT DRYING, PRIMARY ONLY DIGESTION

D) DEWATERING	Unit	Total			Total kW	Service Factor	Operating Hours	Total kWh/yr
Existing Units								
New BFP 1 Operating Capacity	L/s	6.3			4.50	1.00	4,380	19,710
New BFP 2 Operating Capacity	L/s	6.3			4.50	1.00	4,380	19,710
BFP 3 Capacity	L/s	6.3			4.18	1.00	4,380	18,287
BFP 4 Capacity	L/s	6.3			4.18	1.00	4,380	18,287
Pumps - Polymer, Filtrate Feed & Sump	#	14			50.00	0.50	8,760	219,000
Polymer Pump Capacity - each	L/s	0.57						
Polymer Mixing Tank	#	2						
Ploymer Tank Capacity - Each	L	8800						
Ploymer Mixers	#	2			1.50	0.50	8,760	6,570
Supply and Exhaust Air Fans	#	10			5.05	1.00	4,380	22,119
Misc. - Air Compressor, Heater, Valves, etc					38.60	0.50	8,760	169,068
New Units								
Centrifuge 1 Capacity	L/s	6.3			46.00	1.00	4,380	201,480
Centrifuge 2 Capacity	L/s	6.3			46.00	1.00	4,380	201,480
Polymer Pumps	#	2			1.50	0.50	8,760	6,570
Polymer Mixing Tank	#	1			0.75	0.50	8,760	3,285
Feed Pumps								
Number of Existing Units	#	4			18.50	1.00	4,380	81,030
Capacity - Each	L/s	9.5						
Number of New Units	#	2			9.25	1.00	4,380	40,515
Capacity - Each	L/s	9.5						
Polymer								
Dose Rate	g/kg	6.0						
E) DEWATERED CAKE	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
Cross Screw Conveyor	#	1			2.20	1.00	4,380	9,636
Lift Screw Conveyor	#	1			2.20	1.00	4,380	9,636
Horizontal Screw Conveyor	#	2			5.00	1.00	4,380	21,900
New Units								
Cross Screw Conveyor	#	0			2.20	0.00	4,380	0
Lift Screw Conveyor	#	0			2.20	0.00	4,380	0
Horizontal Screw Conveyor	#	0			5.00	0.00	4,380	0
F) LYSTEK	**Unit**				**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
6 m^3/d system					54.81	0.50	6,240	170,999
G) HEAT DRYING	**Unit**				**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
New Units								
Heat Drying Process Train	#	1			69.00	1.00	7,512	518,328
PRODUCTION FACTOR								
Initial Year Biosolids Production Rate	7,420	dt/yr						
Ultimate Year Raw Biosolids Production Rate	9,744	dt/yr						

CH2M HILL

CAPITAL COST ESTIMATE

PROJECT: Guelph WWTP Biosolids Management Plan
PROJ. NO.: 120703 DATE: October-05
AUTHOR: Baldwin REV. NO.:
SUBJECT: OPTION 5 - HEAT DRYING, PRIMARY ONLY DIGESTION
FILENAME: 5-HeatDrying-PrimaryDig-CostAnalysis.xls

REF SPEC SECT No	DESCRIPTION OF ITEM	Q'TY	UNIT	MATERIAL UNIT COST ($)	MATERIAL TOTAL COST ($)	% OF MAT'L (%)	INSTALLATION or UNIT COST ($)	INSTALLATION TOTAL COST ($)	TOTAL INSTALL & MAT'L ($)	SUB TOTAL COST ($)	COST DEVELOPMENT
DIVISION 1 - GENERAL REQUIREMENTS											
	mobilization/demobilization	1	L.S.	200,000	200,000			0	200,000		Historical/Est. Judgement
	general conditions/bonds/insurance	1	L.S.	500,000	500,000			0	500,000		Historical/Est. Judgement
					0			0	0		
					0			0	0		
								Division 1 Total:	700,000	$700,000	
DIVISION 2 - SITEWORK											
					0			0	0		
	Site grading for digesters:, 2 @ 20 m dia	0	m^3	30	0			0	0		
	Compost Building Renovations	1	L.S.	2,000,000	2,000,000			0	2,000,000		
	Site grading for Lystek storage	600	m^3	30	18,000			0	18,000		
	Site services	1	L.S.	500,000	500,000			0	500,000		
	Dewatering	120	days	1,000	120,000			0	120,000		
	Relocate & Expand Fence	1,000	m	30	30,000			0	30,000		
	Compost System Decommissioning & Disposal	1	L.S.	2,000,000	2,000,000			0	2,000,000		
								Division 2 Total:	4,668,000	$4,668,000	
DIVISION 3 - CONCRETE											
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
	Lystek Storage - base	300	m^3	500	150,000			0	150,000		
	Lystek Storage - walls	290	m^3	1,100	319,000			0	319,000		
	Lystek Storage - roof	120	m^3	1,000	120,000			0	120,000		
					0			0	0		
					0			0	0		
					0			0	0		
	Miscellaneous Concrete (water stops, joints, etc)	1	L.S.	75,000	75,000			0	75,000		
								Division 3 Total:	664,000	$664,000	
DIVISION 4 - MASONRY											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 4 Total:	0	$0	
DIVISION 5 - METALS											
					0			0	0		
					0			0	0		
					0			0	0		
	Rock Anchors - Lystek storage, 3 m deep, 2 m spacing	110	m	650	71,500			0	71,500		
					0			0	0		
					0			0	0		
					0			0	0		
								Division 5 Total:	71,500	$71,500	
DIVISION 6 - WOOD AND PLASTICS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 6 Total:	0	$0	
DIVISION 7 - THERMAL AND MOISTURE PROTECTION											
					0			0	0		
					0			0	0		
	Lystek storage - base & walls & roof	2,000	m^2	60	120,000			0	120,000		
					0			0	0		
					0			0	0		
								Division 7 Total:	120,000	$120,000	
DIVISION 8 - DOORS AND WINDOWS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 8 Total:	0	$0	
DIVISION 9 - FINISHES											
					0			0	0		
	Architectural Allowance (Paint, finishes, etc)	1	L.S.	500,000	500,000			0	500,000		
					0			0	0		
								Division 9 Total:	500,000	$500,000	
DIVISION 10 - MANUFACTURED SPECIALTIES											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 10 Total:	0	$0	
DIVISION 11 - EQUIPMENT											
FIXED EQUIPMENT					0			0	0		
	Truck weigh scale facility	1	L.S.	50,000	50,000		15,000	15,000	65,000		
	Primary Pumps	2	L.S.	20,000	40,000		6,000	12,000	52,000		
	WAS Pumps	4	L.S.	20,000	80,000		6,000	24,000	104,000		
	WAS Thickening RDT	3	L.S.	125,000	375,000		37,500	112,500	487,500		
	TWAS Pumps	1	L.S.	60,000	60,000		18,000	18,000	78,000		
	Dewatering Centrifuges	2	L.S.	275,000	550,000			0	550,000		Vendor - install included
	Polymer System (Tank, Pump)	1	L.S.	40,000	40,000		12,000	12,000	52,000		
	Dewatering Feed Pumps	1	L.S.	40,000	40,000		12,000	12,000	52,000		
	Process Piping	1	L.S.	1,000,000	1,000,000		300,000	300,000	1,300,000		
	Heat Drying System - Dragon	1	L.S.	3,006,450	3,006,450		751,613	751,613	3,758,063		
	Silo Storage (Pellets)	1	L.S.	2,500,000	2,500,000			0	2,500,000		Vendor - install included
					0			0	0		
					0			0	0		
					0			0	0		
								Division 11 Total:	8,998,563	$8,998,600	

CH2M HILL

CAPITAL COST ESTIMATE

PROJECT: Guelph WWTP Biosolids Management Plan
PROJ. NO.: 120703 DATE: October-05
AUTHOR: Baldwin REV. NO.:
SUBJECT: OPTION 5 - HEAT DRYING, PRIMARY ONLY DIGESTION
FILENAME: 5-HeatDrying-PrimaryDig-CostAnalysis.xls

REF SPEC SECT No	DESCRIPTION OF ITEM	Q'TY	UNIT	MATERIAL UNIT COST ($)	MATERIAL TOTAL COST ($)	% OF MAT'L (%)	INSTALLATION or UNIT COST ($)	INSTALLATION TOTAL COST ($)	TOTAL INSTALL & MAT'L ($)	SUB TOTAL COST ($)	COST DEVELOPMENT
DIVISION 12 - FURNISHINGS											
					0			0	0		
					0			0	0		
					0			0	0		
							Division 12 Total:		0	$0	
DIVISION 13 - SPECIAL CONSTRUCTION											
					0			0	0		
					0			0	0		
					0			0	0		
							Division 13 Total:		0	$0	
DIVISION 14 - CONVEYING SYSTEMS											
					0			0	0		
	Conveyors (reconfigure & rebuild)	1	L.S	250,000	250,000			0	250,000		
					0			0	0		
							Division 14 Total:		250,000	$250,000	
DIVISION 15 - MECHANICAL											
					0			0	0		
	Mechanical Allowance - 15% of fixed equipment Cost	15%	LS	8,998,563	1,349,784			0	1,349,784		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
							Division 15 Total:		1,349,784	$1,349,800	
DIVISION 16 - ELECTRICAL											
					0			0	0		
	Electrical Allowance - 15% of fixed equipment cost	15%	LS	8,998,563	1,349,784			0	1,349,784		
	I&C Allowance - 5% if fixed equipment cost	5%	LS	8,998,563	449,928			0	449,928		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
							Division 16 Total:		1,799,713	$1,799,800	
									SUB-TOTAL:	$19,121,700	
ALLOWANCES											
	Contractor's overhead and profit	10	%						1,912,170		
			%						0		
			%						0		
			%						0		
			%						0		
							Allowances Total:		1,912,170	$1,912,200	
									SUB-TOTAL:	$21,033,900	
ENGINEERING AND CONTINGENCY											
	'Engineering (design and construction services)	15	%						3,155,085		
	'Construction lump sum contingency allowance	25	%						5,258,475		
							Engineering and Contingency Total:		8,413,560	$8,413,600	
									SUB-TOTAL:	$29,447,500	
TAXES											
	sales tax - federal	7	%						1,840,469		
	sales tax - provincial	8	%						2,355,800		
	Other taxes, patent fees, import duties and foreign exch.		%						0		
							Taxes Total:		4,196,269	$4,196,300	
LAND PURCHASE											
							Land Total:				
									GRAND TOTAL:	$33,640,000	

No	REVISION	DATE	NOTES
0			
1			
2			
3			
4			
5			

OPTION 5 - HEAT DRYING, PRIMARY ONLY DIGESTION
ULTIMATE YEAR O&M COSTS

Labour		Hourly Rate	Benefit Rate	Total Cost/Hour	Total Hours/Year	Total Annual Cost (rounded to nearest $1,000)	Production Factor?
0.25	Manager	50	1.35	$67.50	520	$35,000	
1	Supervisor	30	1.35	$40.50	2,080	$84,000	
6	Operator	22	1.35	$29.70	12,480	$371,000	
1.5	Maintenance	25	1.35	$33.75	3,120	$105,000	
						$595,000	**FIXED**
Operations			Unit Cost	Total Units/Year	Total Units/Year		
	Polymer - Thickening		4.50 $/kg		32,887	$148,000	
	Polymer - Dewatering		4.50 $/kg		19,037	$86,000	
	Electricity		0.08 $/kWh		2,576,615	$206,000	
	Natural Gas - Digestion		0.25 $/m^3		412,100	$103,000	
	Natural Gas - Drying		0.25 $/m^3		4,045,118	$1,011,000	
	Operating Materials Allowance		20%		$1,554,000	$311,000	
						$1,865,000	**PRODUCTION**
Maintenance - Materials		% of Capital Cost/Year	Equipment Capital Cost				
	New Equipment	2%	$8,998,600			$180,000	
	Existing Equipment		1 L.S.		$100,000	$100,000	
						$280,000	**FIXED**
Product Disposal		Cost per Unit (m^3)	Total Units/Year				
	Transport & Land Apply Liquid		10.00 $/m^3		0	$0	
	Transport & Land Apply Lystek		10.00 $/m^3		7,714	$77,000	
	Transport & Land Apply Cake		30.00 $/wt		0	$0	
	Transport & Land Apply Pellets		30.00 $/wt		7,041	$211,000	
	Transport & Landfill Cake		60.00 $/wt		0	$0	
						$288,000	**PRODUCTION**
Other			Cost per Unit	Total Units/Year			
						$0	
						$0	**PRODUCTION**
Sub-total Annual O&M Costs						**$3,028,000**	**COMBINED**
Credits		Credit per Unit		Total Units/ Year			
	Heat offset (from biogas)	0.15 $/m^3		983,990		$103,000	
	Electricity (from cogen)	0.08 $/kWh		4,058,959		$325,000	
Sub-total Annual O&M Credits						**$428,000**	**PRODUCTION**
Total Annual O&M Costs (Credits)						$2,600,000	
Present Worth O&M Costs						**$32,402,000**	

OPTION 5 - HEAT DRYING, PRIMARY ONLY DIGESTION

Actual DT Raw Solids Processed	Production Factor	Escalation Rate	Year	Time	Capital Cost Schedule	Revenue & Cash Savings Schedule	Combined Operations & Maintenance & Other Costs Schedule	Discount Rate	NPV
7,420	76%	1.0000	2005	Year 0	$33,640,000			1.0000	$33,640,000
7,537	77%	1.0250	2006	Year 1	0	-$339,000	$2,604,000	0.9750	$2,208,000
7,654	79%	1.0506	2007	Year 2	0	-$353,000	$2,696,000	0.9506	$2,227,000
7,771	80%	1.0769	2008	Year 3	0	-$368,000	$2,791,000	0.9269	$2,246,000
7,888	81%	1.1038	2009	Year 4	0	-$382,000	$2,890,000	0.9037	$2,266,000
8,005	82%	1.1314	2010	Year 5	0	-$398,000	$2,991,000	0.8811	$2,285,000
8,122	83%	1.1597	2011	Year 6	0	-$414,000	$3,096,000	0.8591	$2,304,000
8,239	85%	1.1887	2012	Year 7	0	-$430,000	$3,204,000	0.8376	$2,323,000
8,356	86%	1.2184	2013	Year 8	0	-$447,000	$3,316,000	0.8167	$2,343,000
8,473	87%	1.2489	2014	Year 9	0	-$465,000	$3,431,000	0.7962	$2,362,000
8,590	88%	1.2801	2015	Year 10	0	-$483,000	$3,550,000	0.7763	$2,381,000
8,707	89%	1.3121	2016	Year 11	0	-$502,000	$3,672,000	0.7569	$2,399,000
8,824	91%	1.3449	2017	Year 12	0	-$521,000	$3,799,000	0.7380	$2,419,000
8,941	92%	1.3785	2018	Year 13	0	-$541,000	$3,929,000	0.7195	$2,438,000
9,058	93%	1.4130	2019	Year 14	0	-$562,000	$4,064,000	0.7016	$2,457,000
9,174	94%	1.4483	2020	Year 15	0	-$584,000	$4,203,000	0.6840	$2,475,000
9,291	95%	1.4845	2021	Year 16	0	-$606,000	$4,346,000	0.6669	$2,494,000
9,408	97%	1.5216	2022	Year 17	0	-$629,000	$4,494,000	0.6502	$2,513,000
9,525	98%	1.5597	2023	Year 18	0	-$653,000	$4,647,000	0.6340	$2,532,000
9,642	99%	1.5987	2024	Year 19	0	-$677,000	$4,805,000	0.6181	$2,552,000
9,744	100%	1.6386	2025	Year 20	0	-$701,000	$4,962,000	0.6027	$2,568,000
									$81,432,000
Escalation Rate		2.5%						2.5%	

OPTION 5 - HEAT DRYING, PRIMARY ONLY DIGESTION

Capital Cost	$33,640,000
O&M Annual Cost (Ultimate Year Production)	$3,028,000
O&M Annual Credit (Ultimate Year Production)	$428,000
Net O&M Annual Cost (ultimate Year Production)	$2,600,000
NPV	$81,432,000
Dry Tonnes Raw Solids Processed (20 year total)	180,371
Dry Tonnes Raw Solids Processed (Ultimate Year)	9,744
Capital Cost per Dry Tonne Raw Solids Processed	$187
O&M Annual Cost per Dry Tonne Raw Solids Processed (Ultimate Year)	$311
O&M Annual Credit per Dry Tonne Raw Solids Processed (Ultimate Year)	$44
Net O&M Annual Cost per Dry Tonne Raw Solids Processed (Ultimate Year)	$267
NPV per Dry Tonne Raw Solids Processed	$451

Option 6

Alkaline Stabilization

OPTION 6 - ALKALINE STABILIZATION

				Peak	Average
Sludge Loadings					
TWAS	Flow		m^3/d	200	200
	Solids		% ds	6.0%	6.0%
	Mass		kg/d	12,014	12,014
	Volatile solids		% VS	73.0%	73.0%
			kg/d	8,770	8,770
Primary Sludge	Flow		m^3/d	367	367
	Solids		% ds	4.0%	4.0%
	Mass		kg/d	14,683	14,683
	Volatile solids		% VS	68.0%	68.0%
			kg/d	9,985	9,985
Total Raw Sludge	Flow		m^3/d	567	567
	Solids		% ds	4.7%	4.7%
	Mass		kg/d	26,697	26,697
	Volatile solids		% VS	70.0%	70.0%
			kg/d	18,688	18,688
Anaerobic Digesters					
Number	Primary			5	5
	Secondary			1	1
Volume	Primary	Each	m^3	2,440	2,440
		Total	m^3	12,200	12,200
	Secondary	Each	m^3	2,350	2,350
		Total	m^3	2,350	2,350
Primary Digester	HRT		days	22	22
	Loading		kg VSS/m	1.5	2
Total Digester	HRT		days	26	26
	Loading		kg VSS/m	1.3	1.3
VSS destruction			%	60.0%	60.0%
			kgVS des/	11,213	11,213
Biogas production			m^3/d	10,091	10,091
	CH_4 content		%	60.0%	60.0%
Digested Sludge			m^3/d	567	567
			kg/d	15,484	15,484
			% ds	2.7%	2.7%
			% VS	48.3%	48.3%
Total Heat Required for Sludge Feed					
	Sludge Flow Rate		wet kg/hr	23,617	23,617
	Specific Heat of Water		kJ/kg °C	4.1868	4.1868
	Av. Temp. of Raw Sludge		°C	15	15
	Digester Temp.		°C	35	35
	Heat Required		kJ/hr	1,977,619	1,977,619
	Natural Gas Equivalent		m^3/yr	461,972	461,972
Total Heat Required for Heat Losses			kJ/hr per n	27	27
	Heat Losses Occuring		% of time	50.0%	50.0%
	Natural Gas Equivalent		m^3/yr	45,885	45,885

OPTION 6 - ALKALINE STABILIZATION

Liquid to Storage/Land				
		dt/yr		0
		dt/d		0.00
		m^3/d	0.00	0.00
		kg/d	0	0
		% ds	2.7%	2.7%
Storage	Days	d	240	240
Dewatering - Total				
Feed Sludge	Mass	dt/yr		5,652
		dt/d		15
	Flow	m^3/d	567	567
	Solids	% ds	2.7%	2.7%
	Mass	kg/d	15,484	15,484
	Volatile solids	% VS	48.3%	48.3%
		kg/d	7,475	7,475
Dewatering - BFPs				
Press Capacity		L/s	24	12
7 hrs/d; 5 d/wk operating		m^3/d	432	216
Feed Sludge	Flow	m^3/d	432	216
	Solids	% ds	2.7%	2.7%
	Mass	kg/d	11,801	5,901
	Volatile solids	% VS	48.3%	48.3%
		kg/d	5,697	2,849
BFP Cake	Flow	m^3/d	56	28
	Solids	% ds	18.0%	18.0%
	Mass	kg/d	10,031	5,016
	Volatile solids	% VS	48.3%	48.3%
		kg/d	4,843	2,421
	Capture	%	85.0%	85.0%
BFP Sidestream	Flow	m^3/d	376	188
	Solids	mg/L	4,705	4,705
	Mass	kg/d	1,770	885
	Volatile solids	% VS	48%	48%
		kg/d	855	427
Dewatering - Centrifuges				
Feed Sludge	Flow	m^3/d	135	351
7 hrs/d; 5 d/wk operating		L/s	3.8	9.9
	Solids	% ds	2.7%	2.7%
	Mass	kg/d	3,683	9,584
	Volatile solids	% VS	48.3%	48.3%
		kg/d	1,778	4,627
Centrifuge Cake	Flow	m^3/d	13	34
	Solids	% ds	28.0%	28.0%
	Mass	kg/d	3,646	9,488
	Volatile solids	% VS	48.3%	48.3%
		kg/d	1,760	4,580
	Capture	%	99.0%	99.0%
Centrifuge Sidestream	Flow	m^3/d	122	317
	Solids	mg/l	302	302
	Mass	kg/d	37	96
	Volatile solids	% VS	48%	48%
		kg/d	18	46

OPTION 6 - ALKALINE STABILIZATION

Lystek				
Feed Cake	Flow	m^3/d	33	17
	Solids	% ds	18.0%	18.0%
	Mass	kg/d	6000	3000
Lystek Material	Solids	% ds	14%	14%
Operating Capacity	7 day/week	dt/d	6	3
Production		m^3/wk	300	150
Annual capacity		dt/yr	360	720
Storage capacity		m^3	4,800 NA	
Remaining Cake	Mass	kg/d	7,677	11,503
	Solids	% ds	22%	26%
Alkaline Stabilization				
Biosolids Feed	dt/yr			4,572
	% solids			26%
	wt/yr			17,917
Raw mix	% solids			46%
Alkaline Admixture	% solids			62%
Dose	wt/yr			22,938
	dt/yr			14,222
	water t/yr			8,716
Dryer Feed	wt/yr			40,855
	dt/yr			18,793
	wt/hr max rate			13.6
Dryer Operating Schedu	d/wk			5
	wk/yr			50
	hr/d (working)			12.0
Dryer Capacity	tonnes/yr water in			22,062
	Product % solids			65%
	tonnes/yr water out			10,120
	tonnes/yr water evapourated			11,942
Heat Required for evapc	kWh/ tonne water			1,804
	kWh/yr			21,543,909
	MJ			77,558,073
	kJ			7.76E+10
	m^3 natural gas			2,068,215
Product	wt/yr			28,913
	dt/yr			18,793
Storage	wt/yr (4 mths)			9,638
Density	wt/m^3			0.70
	m^3			6,746
Boiler System				
Boiler Efficiency		%	80%	80%
Cogeneration System				
Electrical Conversion Efficiency		%	33%	33%
Thermal Recovery Efficiency		%	40%	40%
Electricity Produced				
Natural Gas Unit Energy		kJ/m^3	37,500	37,500
Biogas Unit Energy		kJ/m^3	22,500	22,500
Electricity Energy Per Unit Biogas		kJ/m^3	7,425	7,425
Biogas used for Cogen		m^3/d	10,091	10,091
Biogas used for Cogen		m^3/s	1.17E-01	1.17E-01
Cogen Electrical Energy Produced		kJ/s	867	867
Cogen Electrical Energy Produced		kW	867	867
Cogen Electrical Energy Produced		kWh/h	867	867
Cogen Electrical Energy Produced		kWh/y	7,596,982	7,596,982

OPTION 6 - ALKALINE STABILIZATION

A) RAW SLUDGE	Unit	Primary Sludge	TWAS	Total Sludge	Total kW	Service Factor	Operating Hours/Yr	Total kWh/yr
Required Capacity	m^3/d	367	200	567	NA	NA	NA	
	L/s	4.2	2.3	6.6	NA	NA	NA	
Existing Units								
Primary Pump Capacity - Max	L/s	NA	NA	40	22.50	0.75	1,460	24,638
Primary Pump Capacity - Ave	L/s	NA	NA	20	NA	NA	NA	
WAS Pump Capacity - Max	L/s	NA	NA	NA	NA	NA	NA	
WAS Pump Capacity - Ave	L/s	NA	NA	NA	NA	NA	NA	
New Units								
New Primary Pump Capacity	L/s	10	NA	NA	5.50	0.75	1,460	6,023
New WAS Pump Capacity	L/s	NA	10	NA	5.50	0.75	1,460	6,023
TWAS Thickening RDTs	L/s	NA		NA	20.00	0.75	8,760	131,400
TWAS Pump Capacity	L/s	NA		NA	20.00	0.75	8,760	131,400
Polymer								
Dose Rate	g/kg	NA	7.5					
B) PRIMARY DIGESTION	**Unit**	**Primary**	**Secondary**	**Total**	**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
Total installed volume - primary	m^3	7320	2350	9670	NA	NA	NA	
Total working volume - primary	m^3	6588	2115	8703	NA	NA	NA	
New Units								
New digester diameter	m	19.88	0	NA	NA	NA	NA	
New digester depth	m	7.92	0	NA	NA	NA	NA	
New digester volume	m^3	2,440	0	NA	NA	NA	NA	
No. New Duty units	#	2	0	NA	NA	NA	NA	
Total Operational Units	#	2	0	NA	NA	NA	NA	
Total Standby Units	#	0	0	NA	NA	NA	NA	
No. new Standby units	#	0	0	NA	NA	NA	NA	
Total no. new units	#	2	0	NA	NA	NA	NA	
Digester working capacity	% of tot. cap.	90%	90%	NA	NA	NA	NA	
Total new digester working volume	m^3	4,392	0	4,392	NA	NA	NA	
Recirculation Pumps								
Number of Existing Units	#	3	1	4	11.25	0.75	8,760	73,913
Number of New Units	#	2	0	2	5.63	0.75	8,760	36,956
Heat Exchangers								
Number of Existing Units	#	2	1	3	NA	NA	NA	
Capacity - Each	MBTU/hr	1.5	1	2.5	NA	NA	NA	
Number of New Units	#	1	0	1	NA	NA	NA	
Capacity - Each	MBTU/hr	1.5	0	1.5	NA	NA	NA	
Transfer Pumps								
Number of Existing Units	#	1	1	2	3.75	0.75	1,460	4,106
Capacity - Each	L/s	18.9	15.8	34.7	NA	NA	NA	
Number of New Units	#	1	0	1	1.88	0.75	1,460	2,053
Capacity - Each	L/s	18.9	0.0	18.9	NA	NA	NA	
Mixers								
Number of Existing Units	#	12	0		67.20	0.75	8,760	441,504
Rating, each mixer	kW	7.5						
Number of New Units	#	8	0		44.80	0.75	8,760	294,336
Rating, each mixer	kW	7.5						
Performance								
Digestion VS reduction	% of VS	60%	0%	NA	NA	NA	NA	
Digester gas production	m^3/kg VSR	0.75	0.75	NA	NA	NA	NA	
Digester gas calorific value	kJ/m^3	22355	22355	NA	NA	NA	NA	
Boiler efficiency (average)	%	80%	80%	NA	NA	NA	NA	
C) LIQUID BIOSOLIDS	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
New Units								

OPTION 6 - ALKALINE STABILIZATION

D) DEWATERING	Unit	Total			Total kW	Service Factor	Operating Hours	Total kWh/yr
Existing Units								
New BFP 1 Operating Capacity	L/s	6.3			4.50	1.00	4,380	19,710
New BFP 2 Operating Capacity	L/s	6.3			4.50	1.00	4,380	19,710
BFP 3 Capacity	L/s	6.3			4.18	1.00	4,380	18,287
BFP 4 Capacity	L/s	6.3			4.18	1.00	4,380	18,287
Pumps - Polymer, Filtrate Feed & Sump	#	14			50.00	0.50	8,760	219,000
Polymer Pump Capacity - each	L/s	0.57						
Polymer Mixing Tank	#	2						
Ploymer Tank Capacity - Each	L	8800						
Ploymer Mixers	#	2			1.50	0.50	8,760	6,570
Supply and Exhaust Air Fans	#	10			5.05	1.00	4,380	22,119
Misc. - Air Compressor, Heater, Valves, etc					38.60	0.50	8,760	169,068
New Units								
Centrifuge 1 Capacity	L/s	6.3			46.00	1.00	4,380	201,480
Centrifuge 2 Capacity	L/s	6.3			46.00	1.00	4,380	201,480
Polymer Pumps	#	2			1.50	0.50	8,760	6,570
Polymer Mixing Tank	#	1			0.75	0.50	8,760	3,285
Feed Pumps								
Number of Existing Units	#	4			18.50	1.00	4,380	81,030
Capacity - Each	L/s	9.5						
Number of New Units	#	2			9.25	1.00	4,380	40,515
Capacity - Each	L/s	9.5						
Polymer								
Dose Rate	g/kg	6.0						
E) DEWATERED CAKE	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
Cross Screw Conveyor	#	1			2.20	1.00	4,380	9,636
Lift Screw Conveyor	#	1			2.20	1.00	4,380	9,636
Horizontal Screw Conveyor	#	2			5.00	1.00	4,380	21,900
New Units								
Cross Screw Conveyor	#	0			2.20	0.00	3,753	0
Lift Screw Conveyor	#	1			2.20	1.00	3,753	8,256
Horizontal Screw Conveyor	#	0			5.00	0.00	3,753	0
F) LYSTEK	**Unit**				**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
6 m^3/d system					54.81	0.50	6,240	170,999
G) Alkaline Stabilization	**Unit**				**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
New Units								
Heat Drying Process Train	#	1			120	1.00	3,753	450,351
PRODUCTION FACTOR								
Initial Year Biosolids Production Rate	7,420	dt/yr						
Ultimate Year Raw Biosolids Production Rate	9,744	dt/yr						

CH2M HILL

CAPITAL COST ESTIMATE

PROJECT: Guelph WWTP Biosolids Management Plan
PROJ. NO.: 120703
AUTHOR: Baldwin
SUBJECT: OPTION 6 - ALKALINE STABILIZATION
FILENAME: 6-AlkStab-CostAnalysis.xls
DATE: October-05
REV. NO.:

REF SPEC SECT No	DESCRIPTION OF ITEM	Q'TY	UNIT	MATERIAL UNIT COST ($)	MATERIAL TOTAL COST ($)	% OF MAT'L (%)	INSTALLATION or UNIT COST ($)	INSTALLATION TOTAL COST ($)	TOTAL INSTALL & MAT'L ($)	SUB TOTAL COST ($)	COST DEVELOPMENT
DIVISION 1 - GENERAL REQUIREMENTS											
	mobilization/demobilization	1	L.S.	200,000	200,000			0	200,000		Historical/Est. Judgement
	general conditions/bonds/insurance	1	L.S.	500,000	500,000			0	500,000		Historical/Est. Judgement
					0			0	0		
					0			0	0		
								Division 1 Total:	700,000	$700,000	
DIVISION 2 - SITEWORK											
					0			0	0		
	Site grading for digesters:, 2 @ 20 m dia	395	m^3	30	11,856			0	11,856		
	Compost Building Renovations	1	L.S.	2,000,000	2,000,000			0	2,000,000		
	Site grading for Lystek storage	600	m^3	30	18,000			0	18,000		
	Site services	1	L.S.	500,000	500,000			0	500,000		
	Dewatering	150	days	1,000	150,000			0	150,000		
	Relocate & Expand Fence	1,000	m	30	30,000			0	30,000		
	Compost System Decommissioning & Disposal	1	L.S.	2,000,000	2,000,000			0	2,000,000		
								Division 2 Total:	4,709,856	$4,709,900	
DIVISION 3 - CONCRETE											
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
	Alkaline Product Storage - pad	675	m^3	500	337,318			0	337,318		
	Lystek Storage - base	300	m^3	500	150,000			0	150,000		
	Lystek Storage - walls	290	m^3	1,100	319,000			0	319,000		
	Lystek Storage - roof	120	m^3	1,000	120,000			0	120,000		
	Digesters - base	310	m^3	550	170,500			0	170,500		
	Digesters - walls	300	m^3	1,200	360,000			0	360,000		
	Digesters - roof	120	m^3	1,100	132,000			0	132,000		
	Miscellaneous Concrete (water stops, joints, etc)	1	L.S.	100,000	100,000			0	100,000		
								Division 3 Total:	1,688,818	$1,688,900	
DIVISION 4 - MASONRY											
					0			0	0		
	Digesters - walls	1,000	m^2	150	150,000			0	150,000		
					0			0	0		
								Division 4 Total:	150,000	$150,000	
DIVISION 5 - METALS											
					0			0	0		
					0			0	0		
	Alkaline Product Storage - roof & walls	2,233	m^2	25	55,826			0	55,826		
	Rock Anchors - Lystek storage, 3 m deep, 2 m spacing	110	m	650	71,500			0	71,500		
	Rock Anchors - Digesters 3 m deep, 2 m spacing	470	m	650	305,500			0	305,500		
					0			0	0		
					0			0	0		
								Division 5 Total:	432,826	$432,900	
DIVISION 6 - WOOD AND PLASTICS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 6 Total:	0	$0	
DIVISION 7 - THERMAL AND MOISTURE PROTECTION											
					0			0	0		
					0			0	0		
	Lystek storage - base & walls & roof	2,000	m^2	60	120,000			0	120,000		
	Digesters - base & walls & roof	1,610	m^2	60	96,600			0	96,600		
					0			0	0		
								Division 7 Total:	216,600	$216,600	
DIVISION 8 - DOORS AND WINDOWS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 8 Total:	0	$0	
DIVISION 9 - FINISHES											
					0			0	0		
	Architectural Allowance (Paint, finishes, etc)	1	L.S.	750,000	750,000			0	750,000		
					0			0	0		
								Division 9 Total:	750,000	$750,000	
DIVISION 10 - MANUFACTURED SPECIALTIES											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 10 Total:	0	$0	
DIVISION 11 - EQUIPMENT											
FIXED EQUIPMENT					0			0	0		
	Truck weigh scale facility	1	L.S.	50,000	50,000		15,000	15,000	65,000		
	Primary Pumps	2	L.S.	20,000	40,000		6,000	12,000	52,000		
	WAS Pumps	4	L.S.	20,000	80,000		6,000	24,000	104,000		
	WAS Thickening RDT	3	L.S.	125,000	375,000		37,500	112,500	487,500		
	TWAS Pumps	1	L.S.	60,000	60,000		18,000	18,000	78,000		
	Digester Recirculation Pumps	1	L.S.	25,000	25,000		7,500	7,500	32,500		
	Heat Exchangers	1	L.S.	150,000	150,000		45,000	45,000	195,000		
	Transfer Pumps	1	L.S.	25,000	25,000		7,500	7,500	32,500		
	Digester Mixers	8	L.S.	70,000	560,000		21,000	168,000	728,000		
	Dewatering Centrifuges	2	L.S.	275,000	550,000			0	550,000		Vendor - install included
	Polymer System (Tank, Pump)	1	L.S.	40,000	40,000		12,000	12,000	52,000		
	Dewatering Feed Pumps	1	L.S.	40,000	40,000		12,000	12,000	52,000		
	Process Piping	1	L.S.	1,000,000	1,000,000		300,000	300,000	1,300,000		
	Alkaline Stabilization System	1	L.S.	2,140,000	2,140,000		535,000	535,000	2,675,000		
					0		0	0	0		Vendor - install included
					0			0	0		
PORTABLE EQUIPMENT					0			0	0		
	Front End Loader	1	L.S.	150,000	150,000			0	150,000		
								Division 11 Total:	6,553,500	$6,553,500	

CH2M HILL

CAPITAL COST ESTIMATE

PROJECT: Guelph WWTP Biosolids Management Plan
PROJ. NO.: 120703 DATE: October-05
AUTHOR: Baldwin REV. NO.:
SUBJECT: OPTION 6 - ALKALINE STABILIZATION
FILENAME: 6-AlkStab-CostAnalysis.xls

REF SPEC SECT No	DESCRIPTION OF ITEM	Q'TY	UNIT	MATERIAL UNIT COST ($)	MATERIAL TOTAL COST ($)	MATERIAL % OF MAT'L (%)	INSTALLATION or UNIT COST ($)	INSTALLATION TOTAL COST ($)	TOTAL INSTALL & MAT'L ($)	SUB TOTAL COST ($)	COST DEVELOPMENT
DIVISION 12 - FURNISHINGS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 12 Total:	0	$0	
DIVISION 13 - SPECIAL CONSTRUCTION											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 13 Total:	0	$0	
DIVISION 14 - CONVEYING SYSTEMS											
					0			0	0		
	Conveyors (reconfigure & rebuild)	1	L.S.	250,000	250,000		75,000	75,000	325,000		
	Stacking Conveyor	1	L.S.	50,000	50,000		15,000	15,000	65,000		
								Division 14 Total:	390,000	$390,000	
DIVISION 15 - MECHANICAL											
					0			0	0		
	Mechanical Allowance - 15% of fixed equipment Cost	15%	LS	6,403,500	960,525			0	960,525		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
								Division 15 Total:	960,525	$960,600	
DIVISION 16 - ELECTRICAL											
					0			0	0		
	Electrical Allowance - 15% of fixed equipment cost	15%	LS	6,403,500	960,525			0	960,525		
	I&C Allowance - 5% if fixed equipment cost	5%	LS	6,403,500	320,175			0	320,175		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
								Division 16 Total:	1,280,700	$1,280,700	
									SUB-TOTAL:	$17,833,100	
ALLOWANCES											
Contractor's overhead and profit		10	%						1,783,310		
			%						0		
			%						0		
			%						0		
			%						0		
								Allowances Total:	1,783,310	$1,783,400	
									SUB-TOTAL:	$19,616,500	
ENGINEERING AND CONTINGENCY											
'Engineering (design and construction services)		15	%						2,942,475		
'Construction lump sum contingency allowance		25	%						4,904,125		
								Engineering and Contingency Total:	7,846,600	$7,846,600	
									SUB-TOTAL:	$27,463,100	
TAXES											
sales tax - federal		7	%						1,716,444		
sales tax - provincial		8	%						2,197,048		
Other taxes, patent fees, import duties and foreign exch.			%						0		
								Taxes Total:	3,913,492	$3,913,500	
LAND PURCHASE											
								Land Total:			
									GRAND TOTAL:	$31,380,000	

No	REVISION	DATE	NOTES
0			
1			
2			
3			
4			
5			

OPTION 6 - ALKALINE STABILIZATION

ULTIMATE YEAR O&M COSTS

Labour		Hourly Rate	Benefit Rate	Total Cost/Hour	Total Hours/Year	Total Annual Cost (rounded to nearest $1,000)	Production Factor?
0.25	Manager	50	1.35	$67.50	520	$35,000	
1	Supervisor	30	1.35	$40.50	2,080	$84,000	
6	Operator	22	1.35	$29.70	12,480	$371,000	
1.5	Maintenance	25	1.35	$33.75	3,120	$105,000	
						$595,000	**FIXED**
Operations			Unit Cost	Total Units/Year	Total Units/Year		
	Polymer - Thickening		4.50	$/kg	32,887	$148,000	
	Polymer - Dewatering		4.50	$/kg	33,911	$153,000	
	Electricity		0.08	$/kWh	2,850,240	$228,000	
	Natural Gas - Digestion		0.25	$/m^3	634,821	$159,000	
	Natural Gas - Product Drying		0.25	$/m^3	2,068,215	$517,000	
	Alkaline Admixture		30.00	$/wt	22,938	$688,000	
	Operating Materials Allowance		20%		$1,893,000	$379,000	
						$2,272,000	**PRODUCTION**
Maintenance - Materials		% of Capital Cost/Year	Equipment Capital Cost				
	New Equipment	2%	$6,553,500			$131,000	
	Existing Equipment		1	L.S.	$100,000	$100,000	
						$231,000	**FIXED**
Product Disposal		Cost per Unit (m^3)	Total Units/Year				
	Transport & Land Apply Liquid		10.00	$/m^3	0	$0	
	Transport & Land Apply Lystek		10.00	$/m^3	7,714	$77,000	
	Transport & Land Apply Cake		30.00	$/wt	0	$0	
	Transport & Land Apply Alkaline Product		25.00	$/wt	28,913	$723,000	
	Transport & Landfill Cake		60.00	$/wt	0	$0	
						$800,000	**PRODUCTION**
Other			Cost per Unit	Total Units/Year			
	Royalties & Fees		1	L.S.	$200,000	$200,000	
						$200,000	**PRODUCTION**
Sub-total Annual O&M Costs						**$4,098,000**	**COMBINED**
Credits		Credit per Unit		Total Units/ Year			
	Heat offset (from biogas)	0.15	$/m^3	1,841,693		$159,000	
	Electricity (from cogen)	0.08	$/kWh	7,596,982		$608,000	
Sub-total Annual O&M Credits						**$767,000**	**PRODUCTION**
Total Annual O&M Costs (Credits)						$3,331,000	
Present Worth O&M Costs						**$41,512,000**	

OPTION 6 - ALKALINE STABILIZATION

Actual DT Raw Solids Processed	Production Factor	Escalation Rate	Year	Time	Capital Cost Schedule	Revenue & Cash Savings Schedule	Combined Operations & Maintenance & Other Costs Schedule	Discount Rate	NPV
7,420	76%	1.0000	2005	Year 0	$31,380,000			1.0000	$31,380,000
7,537	77%	1.0250	2006	Year 1	0	-$608,000	$3,441,000	0.9750	$2,762,000
7,654	79%	1.0506	2007	Year 2	0	-$633,000	$3,568,000	0.9506	$2,790,000
7,771	80%	1.0769	2008	Year 3	0	-$659,000	$3,700,000	0.9269	$2,819,000
7,888	81%	1.1038	2009	Year 4	0	-$685,000	$3,835,000	0.9037	$2,847,000
8,005	82%	1.1314	2010	Year 5	0	-$713,000	$3,976,000	0.8811	$2,875,000
8,122	83%	1.1597	2011	Year 6	0	-$741,000	$4,121,000	0.8591	$2,904,000
8,239	85%	1.1887	2012	Year 7	0	-$771,000	$4,270,000	0.8376	$2,931,000
8,356	86%	1.2184	2013	Year 8	0	-$801,000	$4,425,000	0.8167	$2,960,000
8,473	87%	1.2489	2014	Year 9	0	-$833,000	$4,585,000	0.7962	$2,987,000
8,590	88%	1.2801	2015	Year 10	0	-$865,000	$4,749,000	0.7763	$3,015,000
8,707	89%	1.3121	2016	Year 11	0	-$899,000	$4,920,000	0.7569	$3,044,000
8,824	91%	1.3449	2017	Year 12	0	-$934,000	$5,096,000	0.7380	$3,072,000
8,941	92%	1.3785	2018	Year 13	0	-$970,000	$5,277,000	0.7195	$3,099,000
9,058	93%	1.4130	2019	Year 14	0	-$1,007,000	$5,464,000	0.7016	$3,127,000
9,174	94%	1.4483	2020	Year 15	0	-$1,046,000	$5,658,000	0.6840	$3,155,000
9,291	95%	1.4845	2021	Year 16	0	-$1,086,000	$5,858,000	0.6669	$3,183,000
9,408	97%	1.5216	2022	Year 17	0	-$1,127,000	$6,064,000	0.6502	$3,210,000
9,525	98%	1.5597	2023	Year 18	0	-$1,169,000	$6,277,000	0.6340	$3,238,000
9,642	99%	1.5987	2024	Year 19	0	-$1,213,000	$6,496,000	0.6181	$3,266,000
9,744	100%	1.6386	2025	Year 20	0	-$1,257,000	$6,715,000	0.6027	$3,289,000
									$91,953,000
Escalation Rate		2.5%						2.5%	

OPTION 6 - ALKALINE STABILIZATION

Capital Cost	$31,380,000
O&M Annual Cost (Ultimate Year Production)	$4,098,000
O&M Annual Credit (Ultimate Year Production)	$767,000
Net O&M Annual Cost (ultimate Year Production)	$3,331,000
NPV	$91,953,000
Dry Tonnes Raw Solids Processed (20 year total)	180,371
Dry Tonnes Raw Solids Processed (Ultimate Year)	9,744
Capital Cost per Dry Tonne Raw Solids Processed	$174
O&M Annual Cost per Dry Tonne Raw Solids Processed (Ultimate Year)	$421
O&M Annual Credit per Dry Tonne Raw Solids Processed (Ultimate Year)	$79
Net O&M Annual Cost per Dry Tonne Raw Solids Processed (Ultimate Year)	$342
NPV per Dry Tonne Raw Solids Processed	$510

Option 7

Alkaline Stabilization with Phased Digestion

OPTION 7 - ALKALINE STABILIZATION WITH PHASED DIGESTION

					Peak	Average
Sludge Loadings						
TWAS		Flow		m^3/d	200	200
		Solids		% ds	6.0%	6.0%
		Mass		kg/d	12,014	12,014
		Volatile solids		% VS	73.0%	73.0%
				kg/d	8,770	8,770
Primary Sludge		Flow		m^3/d	367	367
		Solids		% ds	4.0%	4.0%
		Mass		kg/d	14,683	14,683
		Volatile solids		% VS	68.0%	68.0%
				kg/d	9,985	9,985
Total Raw Sludge		Flow		m^3/d	567	567
		Solids		% ds	4.7%	4.7%
		Mass		kg/d	26,697	26,697
		Volatile solids		% VS	70.0%	70.0%
				kg/d	18,688	18,688
Anaerobic Digesters						
Acid Phase					1	1
			Each	m^3	1,350	1,350
			HRT	days	2	2
Number	Primary				3	3
	Secondary				1	1
Volume	Primary		Each	m^3	2,440	2,440
			Total	m^3	7,320	7,320
	Secondary		Each	m^3	2,350	2,350
			Total	m^3	2,350	2,350
Primary Digester		HRT		days	13	13
		Loading		kg VSS/m^3.(	2.2	2.2
Total Digester		HRT		days	15	15
		Loading		kg VSS/m^3.(	1.7	1.3
VSS destruction				%	70.0%	70.0%
				kgVS des/d	13,082	13,082
Biogas production				m^3/d	11,773	11,773
		CH_4 content		%	60%	60%
Digested Sludge				m^3/d	567	567
				kg/d	13,615	13,615
				% ds	2.4%	2.4%
				% VS	41.2%	41%
Total Heat Required for Sludge Feed						
		Sludge Flow Rate		wet kg/hr	23,617	23,617
		Specific Heat of Water		kJ/kg °C	4.1868	4.1868
		Av. Temp. of Raw Sludge		°C	15	15
		Digester Temp.		°C	35	35
		Heat Required		kJ/hr	1,977,619	1,977,619
		Natural Gas Equivalent		m^3/yr	461,972	461,972
Total Heat Required for Heat Losses				kJ/hr per m^3	27	27
		Heat Losses Occuring		% of time pe	50.0%	50.0%
		Natural Gas Equivalent		m^3/yr	34,753	34,753

OPTION 7 - ALKALINE STABILIZATION WITH PHASED DIGESTION

Liquid to Storage/Land				
	Mass	dt/yr		0
	Mass	dt/d		0.00
	Flow	m^3/d		0.00
	Mass	kg/d		0
	Dry Solids	% ds		2.4%
Storage	Days	d		240
Dewatering - Total				Average
Feed Sludge	Mass	dt/yr		4,970
		dt/d		13.62
	Flow	m^3 /d	567	567
	Solids	% ds	2.4%	2.4%
	Mass	kg/d	13,615	13,615
	Volatile solids	% VS	41.2%	41.2%
		kg/d	5,606	5,606
Dewatering - BFPs			Peak	Average (Firm)
Press Capacity		L/s	24	12
7 hrs/d; 5 d/wk operating		m^3/d	432	216
Feed Sludge	Flow	m^3/d	432	216
	Solids	% ds	2.4%	2.4%
	Mass	kg/d	10,377	5,189
	Volatile solids	% VS	41.2%	41.2%
		kg/d	4,273	2,136
BFP Cake	Flow	m^3/d	49	25
	Solids	% ds	18.0%	18.0%
	Mass	kg/d	8,821	4,410
	Volatile solids	% VS	41.2%	41.2%
		kg/d	3,632	1,816
	Capture	%	85.0%	85.0%
BFP Sidestream	Flow	m^3/d	383	191
	Solids	mg/L	4,064	4,064
	Mass	kg/d	1,557	778
	Volatile solids	% VS	41%	41%
		kg/d	641	320
Dewatering - Centrifuges				
Feed Sludge	Flow	m^3/d	135	351
7 hrs/d; 5 d/wk operating		L/s	3.8	9.9
	Solids	% ds	2.4%	2.4%
	Mass	kg/d	3,238	8,427
	Volatile solids	% VS	41.2%	41.2%
		kg/d	1,333	3,470
Centrifuge Cake	Flow	m^3/d	11	30
	Solids	% ds	28.0%	28.0%
	Mass	kg/d	3,206	8,343
	Volatile solids	% VS	41.2%	41.2%
		kg/d	1,320	3,435
	Capture	%	99.0%	99.0%
Centrifuge Sidestream	Flow	m^3/d	123	321
	Solids	mg/L	263	263
	Mass	kg/d	32	84
	Volatile solids	% VS	41%	41%
		kg/d	13	35

OPTION 7 - ALKALINE STABILIZATION WITH PHASED DIGESTION

Lystek (utilizing BFP cake)				
Feed Cake	Flow	m^3/d	33	17
	Solids	% ds	18.0%	18.0%
	Mass	kg/d	6000	3000
Lystek Material	Solids	% ds	14%	14%
Operating Capacity	7 day/week	dt/d	6	3
Production		m^3/wk	300	150
Annual capacity		dt/yr	360	720
Storage capacity		m^3	4,800 NA	
Remaining Cake	Mass	kg/d	6,027	9,753
	Solids	% ds	22%	26%
Alkaline Stabilization				
Biosolids Feed	dt/yr			3,890
	% solids			26%
	wt/yr			15,008
Raw mix	% solids			46%
Alkaline Admixture	% solids			62%
Dose	wt/yr			18,836
	dt/yr			11,679
	water t/yr			7,158
Dryer Feed	wt/yr			33,844
	dt/yr			15,568
	wt/hr max rate			13.6
Dryer Operating Schedu	d/wk			5
	wk/yr			50
	hr/d (working)			10.0
Dryer Capacity	tonnes/yr water in			18,276
	Product % solids			65%
	tonnes/yr water out			8,383
	tonnes/yr water evapourated			9,893
Heat Required for evapc	kWh/ tonne water			1,804
	kWh/yr			17,846,683
	MJ			64,248,059
	kJ			6.4E+10
	m^3 natural gas			1,713,282
Product	wt/yr			23,951
	dt/yr			15,568
Storage	wt/yr (4 mths)			7,984
Density	wt/m^3			0.70
	m^3			5,589
Boiler System				
Boiler Efficiency		%	80%	80%
Cogeneration System				
Electrical Conversion Efficiency		%	33%	33%
Thermal Recovery Efficiency		%	40%	40%
Electricity Produced				
Natural Gas Unit Energy		kJ/m^3	37,500	37,500
Biogas Unit Energy		kJ/m^3	22,500	22,500
Electricity Energy Per Unit Biogas		kJ/m^3	7,425	7,425
Biogas used for Cogen		m^3/d	11,773	11,773
Biogas used for Cogen		m^3/s	1.36E-01	1.36E-01
Cogen Electrical Energy Produced		kJ/s	1,012	1,012
Cogen Electrical Energy Produced		kW	1,012	1,012
Cogen Electrical Energy Produced		kWh/h	1,012	1,012
Cogen Electrical Energy Produced		kWh/y	8,863,145	8,863,145

OPTION 7 - ALKALINE STABILIZATION WITH PHASED DIGESTION

A) RAW SLUDGE	Unit	Primary Sludge	TWAS	Total Sludge	Total kW	Service Factor	Operating Hours/Yr	Total kWh/yr
Required Capacity	m^3/d	367	200	567	NA	NA	NA	
	L/s	4.2	2.3	6.6	NA	NA	NA	
Existing Units								
Primary Pump Capacity - Max	L/s	NA	NA	40	22.50	0.75	1,460	24,638
Primary Pump Capacity - Ave	L/s	NA	NA	20	NA	NA	NA	
WAS Pump Capacity - Max	L/s	NA	NA	NA	NA	NA	NA	
WAS Pump Capacity - Ave	L/s	NA	NA	NA	NA	NA	NA	
New Units								
New Primary Pump Capacity	L/s	10	NA	NA	5.50	0.75	1,460	6,023
New WAS Pump Capacity	L/s	NA	10	NA	5.50	0.75	1,460	6,023
TWAS Thickening RDTs	L/s	NA		NA	20.00	0.75	8,760	131,400
TWAS Pump Capacity	L/s	NA		NA	20.00	0.75	8,760	131,400
Polymer								
Dose Rate	g/kg	NA	7.5					

B) PRIMARY DIGESTION	Unit	Primary	Secondary	Total	Total kW	Service Factor	Operating Hours	Total kWh/yr
Existing Units								
Total installed volume - primary	m^3	7320	2350	9670	NA	NA	NA	
Total working volume - primary	m^3	6588	2115	8703	NA	NA	NA	
New Units								
New digester diameter	m	10.37	0	NA	NA	NA	NA	
New digester depth	m	4	0	NA	NA	NA	NA	
New digester volume	m^3	1,350	0	NA	NA	NA	NA	
No. New Duty units	#	1	0	NA	NA	NA	NA	
Total Operational Units	#	1	0	NA	NA	NA	NA	
Total Standby Units	#	0	0	NA	NA	NA	NA	
No. new Standby units	#	0	0	NA	NA	NA	NA	
Total no. new units	#	1	0	NA	NA	NA	NA	
Digester working capacity	% of tot. cap.	90%	90%	NA	NA	NA	NA	
Total new digester working volume	m^3	1,215	0	1,215	NA	NA	NA	
Recirculation Pumps								
Number of Existing Units	#	3	1	4	11.25	0.75	8,760	73,913
Number of New Units	#	1	0	1	2.81	0.75	8,760	18,478
Heat Exchangers								
Number of Existing Units	#	2	1	3	NA	NA	NA	
Capacity - Each	MBTU/hr	1.5	1	2.5	NA	NA	NA	
Number of New Units	#	1	0	1	NA	NA	NA	
Capacity - Each	MBTU/hr	1.5	0	1.5	NA	NA	NA	
Transfer Pumps								
Number of Existing Units	#	1	1	2	3.75	0.75	1,460	4,106
Capacity - Each	L/s	18.9	15.8	34.7	NA	NA	NA	
Number of New Units	#	0	0	0	1.88	0.75	1,460	2,053
Capacity - Each	L/s	18.9	0.0	18.9	NA	NA	NA	
Mixers								
Number of Existing Units	#	12	0		67.20	0.75	8,760	441,504
Rating, each mixer	kW	7.5						
Number of New Units	#	2	0		11.20	0.75	8,760	73,584
Rating, each mixer	kW	7.5						
Performance								
Digestion VS reduction	% of VS	60%	0%	NA	NA	NA	NA	
Digester gas production	m^3/kg VSR	0.75	0.75	NA	NA	NA	NA	
Digester gas calorific value	kJ/m^3	22355	22355	NA	NA	NA	NA	
Boiler efficiency (average)	%	80%	80%	NA	NA	NA	NA	

C) LIQUID BIOSOLIDS	Unit	Total			Total kW	Service Factor	Operating Hours	Total kWh/yr
New Units								

OPTION 7 - ALKALINE STABILIZATION WITH PHASED DIGESTION

D) DEWATERING	Unit	Total			Total kW	Service Factor	Operating Hours	Total kWh/yr
Existing Units								
New BFP 1 Operating Capacity	L/s	6.3			4.50	1.00	4,380	19,710
New BFP 2 Operating Capacity	L/s	6.3			4.50	1.00	4,380	19,710
BFP 3 Capacity	L/s	6.3			4.18	1.00	4,380	18,287
BFP 4 Capacity	L/s	6.3			4.18	1.00	4,380	18,287
Pumps - Polymer, Filtrate Feed & Sump	#	14			50.00	0.50	8,760	219,000
Polymer Pump Capacity - each	L/s	0.57						
Polymer Mixing Tank	#	2						
Ploymer Tank Capacity - Each	L	8800						
Ploymer Mixers	#	2			1.50	0.50	8,760	6,570
Supply and Exhaust Air Fans	#	10			5.05	1.00	4,380	22,119
Misc. - Air Compressor, Heater, Valves, etc					38.60	0.50	8,760	169,068
New Units								
Centrifuge 1 Capacity	L/s	9.9			18.89	1.00	4,380	82,752
Centrifuge 2 Capacity	L/s	9.9			18.89	1.00	4,380	82,752
Polymer Pumps	#	2			1.50	0.50	8,760	6,570
Polymer Mixing Tank	#	1			0.75	0.50	8,760	3,285
Feed Pumps								
Number of Existing Units	#	4			18.50	1.00	4,380	81,030
Capacity - Each	L/s	9.5						
Number of New Units	#	2			9.25	1.00	4,380	40,515
Capacity - Each	L/s	9.5						
Polymer								
Dose Rate	g/kg	6.0						
E) DEWATERED CAKE TO LAND	**Unit**	**Total**			**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
Existing Units								
Cross Screw Conveyor	#	1			2.20	1.00	4,380	9,636
Lift Screw Conveyor	#	1			2.20	1.00	4,380	9,636
Horizontal Screw Conveyor	#	2			5.00	1.00	4,380	21,900
New Units								
Cross Screw Conveyor	#	0			2.20	0.00	4,380	0
Lift Screw Conveyor	#	1			2.20	0.00	3,111	0
Horizontal Screw Conveyor	#	0			5.00	0.00	4,380	0
F) LYSTEK	**Unit**				**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
6 m^3/d system					54.81	0.50	6,240	170,999
G) ALKALINE STABILIZATION	**Unit**				**Total kW**	**Service Factor**	**Operating Hours**	**Total kWh/yr**
New Units								
Alkaline Stabilization Process Train	#	1			120.00	1.00	3,111	373,279
PRODUCTION FACTOR								
Initial Year Biosolids Production Rate	7,420	dt/yr						
Ultimate Year Raw Biosolids Production Rate	9,744	dt/yr						

CH2M HILL

CAPITAL COST ESTIMATE

PROJECT: Guelph WWTP Biosolids Management Plan
PROJ. NO.: 120703 DATE: October-05
AUTHOR: Baldwin REV. NO.:
SUBJECT: OPTION 7 - ALKALINE STABILIZATION WITH PHASED DIGESTION
FILENAME: 7-AlkStab-PhasedDig-CostAnalysis.xls

REF SPEC SECT No	DESCRIPTION OF ITEM	Q'TY	UNIT	MATERIAL UNIT COST ($)	MATERIAL TOTAL COST ($)	MATERIAL % OF MAT'L (%)	INSTALLATION or UNIT COST ($)	INSTALLATION TOTAL COST ($)	TOTAL INSTALL & MAT'L ($)	SUB TOTAL COST ($)	COST DEVELOPMENT
DIVISION 1 - GENERAL REQUIREMENTS											
	mobilization/demobilization	1	L.S.	200,000	200,000			0	200,000		Historical/Est. Judgement
	general conditions/bonds/insurance	1	L.S.	500,000	500,000			0	500,000		Historical/Est. Judgement
					0			0	0		
					0			0	0		
								Division 1 Total:	700,000	$700,000	
DIVISION 2 - SITEWORK											
					0			0	0		
	Site grading for acid digester:, 1 @ 10.4 m dia	54	m^3	30	1,613			0	1,613		
	Compost Building Renovations	1	L.S.	2,000,000	2,000,000			0	2,000,000		
	Site grading for Lystek storage	600	m^3	30	18,000			0	18,000		
	Site services	1	L.S.	500,000	500,000			0	500,000		
	Dewatering	150	days	1,000	150,000			0	150,000		
	Relocate & Expand Fence	1,000	m	30	30,000			0	30,000		
	Compost System Decommissioning & Disposal	1	L.S.	2,000,000	2,000,000			0	2,000,000		
								Division 2 Total:	4,699,613	$4,699,700	
DIVISION 3 - CONCRETE											
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
	Alkaline Product Storage - pad	560	m^3	500	280,000			0	280,000		
	Lystek Storage - base	300	m^3	500	150,000			0	150,000		
	Lystek Storage - walls	290	m^3	1,100	319,000			0	319,000		
	Lystek Storage - roof	120	m^3	1,000	120,000			0	120,000		
	Digesters - base	40	m^3	550	22,000			0	22,000		
	Digesters - walls	80	m^3	1,200	96,000			0	96,000		
	Digesters - roof	20	m^3	1,100	22,000			0	22,000		
	Miscellaneous Concrete (water stops, joints, etc)	1	L.S.	200,000	200,000			0	200,000		
								Division 3 Total:	1,209,000	$1,209,000	
DIVISION 4 - MASONRY											
					0			0	0		
	Digesters - walls	130	m^2	150	19,500			0	19,500		
					0			0	0		
								Division 4 Total:	19,500	$19,500	
DIVISION 5 - METALS											
					0			0	0		
					0			0	0		
	Alkaline Product Storage - roof & walls	1,980	m^2	25	49,496			0	49,496		
	Rock Anchors - Lystek storage, 3 m deep, 2 m spacing	110	m	650	71,500			0	71,500		
	Rock Anchors - Digesters 3 m deep, 2 m spacing	130	m	650	84,500			0	84,500		
					0			0	0		
					0			0	0		
								Division 5 Total:	205,496	$205,500	
DIVISION 6 - WOOD AND PLASTICS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 6 Total:	0	$0	
DIVISION 7 - THERMAL AND MOISTURE PROTECTION											
					0			0	0		
					0			0	0		
	Lystek storage - base & walls & roof	2,000	m^2	60	120,000			0	120,000		
	Digesters - base & walls & roof	430	m^2	60	25,800			0	25,800		
					0			0	0		
								Division 7 Total:	145,800	$145,800	
DIVISION 8 - DOORS AND WINDOWS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 8 Total:	0	$0	
DIVISION 9 - FINISHES											
					0			0	0		
	Architectural Allowance (Paint, finishes, etc)	1	L.S.	500,000	500,000			0	500,000		
					0			0	0		
								Division 9 Total:	500,000	$500,000	
DIVISION 10 - MANUFACTURED SPECIALTIES											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 10 Total:	0	$0	
DIVISION 11 - EQUIPMENT											
FIXED EQUIPMENT					0			0	0		
	Truck weigh scale facility	1	L.S	50,000	50,000		15,000	15,000	65,000		
	Primary Pumps	2	L.S	20,000	40,000		6,000	12,000	52,000		
	WAS Pumps	4	L.S	20,000	80,000		6,000	24,000	104,000		
	WAS Thickening RDT	3	L.S.	125,000	375,000		37,500	112,500	487,500		
	TWAS Pumps	1	L.S.	60,000	60,000		18,000	18,000	78,000		
	Digester Recirculation Pumps	1	L.S.	10,000	10,000		3,000	3,000	13,000		
	Heat Exchangers	1	L.S.	50,000	50,000		15,000	15,000	65,000		
	Transfer Pumps	1	L.S.	10,000	10,000		3,000	3,000	13,000		
	Digester Mixers	2	L.S	70,000	140,000		21,000	42,000	182,000		
	Dewatering Centrifuges	2	L.S	275,000	550,000			0	550,000		
	Polymer System (Tank, Pump)	1	L.S.	40,000	40,000		12,000	12,000	52,000		
	Dewatering Feed Pumps	1	L.S.	40,000	40,000			0	40,000		Vendor - install included
	Process Piping	1	L.S.	1,000,000	1,000,000		300,000	300,000	1,300,000		
	Alkaline Stabilization System	1	L.S.	2,140,000	2,140,000		642,000	642,000	2,782,000		
					0		0	0	0		
					0		0	0	0		
PORTABLE EQUIPMENT					0			0	0		
	Front End Loader	1	L.S.	150,000	150,000			0	150,000		
					0			0	0		
								Division 11 Total:	5,933,500	$5,933,500	

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CAPITAL COST ESTIMATE

PROJECT: Guelph WWTP Biosolids Management Plan
PROJ. NO.: 120703 DATE: October-05
AUTHOR: Baldwin REV. NO.:
SUBJECT: OPTION 7 - ALKALINE STABILIZATION WITH PHASED DIGESTION
FILENAME: 7-AlkStab-PhasedDig-CostAnalysis.xls

REF SPEC SECT No	DESCRIPTION OF ITEM	Q'TY	UNIT	MATERIAL UNIT COST ($)	MATERIAL TOTAL COST ($)	% OF MAT'L (%)	INSTALLATION or UNIT COST ($)	INSTALLATION TOTAL COST ($)	TOTAL INSTALL & MAT'L ($)	SUB TOTAL COST ($)	COST DEVELOPMENT
DIVISION 12 - FURNISHINGS											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 12 Total:	0	$0	
DIVISION 13 - SPECIAL CONSTRUCTION											
					0			0	0		
					0			0	0		
					0			0	0		
								Division 13 Total:	0	$0	
DIVISION 14 - CONVEYING SYSTEMS											
					0			0	0		
	Conveyors (reconfigure & rebuild)	1	L.S.	250,000	250,000		75,000	75,000	325,000		
	Stacking Conveyor	1	L.S.	50,000	50,000		15,000	15,000	65,000		
								Division 14 Total:	390,000	$390,000	
DIVISION 15 - MECHANICAL											
					0			0	0		
	Mechanical Allowance - 15% of fixed equipment Cost	15%	L.S.	5,783,500	867,525			0	867,525		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
								Division 15 Total:	867,525	$867,600	
DIVISION 16 - ELECTRICAL											
					0			0	0		
	Electrical Allowance - 15% of fixed equipment cost	15%	L.S.	5,783,500	867,525			0	867,525		
	I&C Allowance - 5% of fixed equipment cost	5%	L.S.	5,783,500	289,175			0	289,175		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
					0			0	0		
								Division 16 Total:	1,156,700	$1,156,700	
									SUB-TOTAL:	$15,827,300	
ALLOWANCES											
Contractor's overhead and profit		10	%						1,582,730		
			%						0		
			%						0		
			%						0		
			%						0		
								Allowances Total:	1,582,730	$1,582,800	
									SUB-TOTAL:	$17,410,100	
ENGINEERING AND CONTINGENCY											
'Engineering (design and construction services)		15	%						2,611,515		
'Construction lump sum contingency allowance		25	%						4,352,525		
								Engineering and Contingency Total:	6,964,040	$6,964,100	
									SUB-TOTAL:	$24,374,200	
TAXES											
sales tax - federal		7	%						1,523,388		
sales tax - provincial		8	%						1,949,936		
Other taxes, patent fees, import duties and foreign exch.			%						0		
								Taxes Total:	3,473,324	$3,473,400	
LAND PURCHASE											
								Land Total:			
									GRAND TOTAL:	$27,850,000	

No	REVISION	DATE	NOTES
0			
1			
2			
3			
4			
5			

OPTION 7 - ALKALINE STABILIZATION WITH PHASED DIGESTION
ULTIMATE YEAR O&M COSTS

Labour		Hourly Rate	Benefit Rate	Total Cost/Hour	Total Hours/Year	Total Annual Cost (rounded to nearest $1,000)	Production Factor?
0.25	Manager	50	1.35	$67.50	520	$35,000	
1	Supervisor	30	1.35	$40.50	2,080	$84,000	
6	Operator	22	1.35	$29.70	12,480	$371,000	
1.5	Maintenance	25	1.35	$33.75	3,120	$105,000	
						$595,000	**FIXED**
Operations		Unit Cost	Unit	Total Units/Year			
	Polymer - Thickening		4.50	$/kg	32,887	$148,000	
	Polymer - Dewatering		4.50	$/kg	29,818	$134,000	
	Electricity		0.08	$/kWh	2,288,224	$183,000	
	Natural Gas - Digestion		0.25	$/m^3	620,905	$155,000	
	Natural Gas - Drying		0.25	$/m^3	1,713,282	$428,000	
	Alkaline Admixture		30.00	$/wt	18,836	$565,000	
	Operating Materials Allowance		20%		$1,613,000	$323,000	
						$1,936,000	**PRODUCTION**
Maintenance - Materials		% of Capital Cost/Year	Equipment Capital Cost				
	New Equipment	2%	$5,933,500			$119,000	
	Existing Equipment		1	L.S.	$100,000	$100,000	
						$0	
						$219,000	**FIXED**
Product Disposal			Cost per Unit (m^3)		Total Units/Year		
	Transport & Land Apply Liquid		10.00	$/m^3	0	$0	
	Transport & Land Apply Lystek		10.00	$/m^3	7,714	$77,000	
	Transport & Land Apply Cake		30.00	$/wt	0	$0	
	Transport & Land Apply Alkaline Product		25.00	$/wt	23,951	$599,000	
	Transport & Landfill Cake		60.00	$/wt	0	$0	
						$676,000	**PRODUCTION**
Other			Cost per Unit	Total Units/Year			
	Royalties & Fees		1	L.S.	$200,000	$200,000	
						$200,000	**PRODUCTION**
Sub-total Annual O&M Costs						**$3,626,000**	**COMBINED**
Credits		Credit per Unit		Total Units/ Year			
	Heat offset (from biogas)	0.15	$/m^3	2,148,641		$155,000	
	Electricity (from cogen)	0.08	$/kWh	8,863,145		$709,000	
Sub-total Annual O&M Credits						**$864,000**	**PRODUCTION**
Total Annual O&M Costs (Credits)						$2,762,000	
Present Worth O&M Costs						**$34,421,000**	

OPTION 7 - ALKALINE STABILIZATION WITH PHASED DIGESTION

Actual DT Raw Solids Processed	Production Factor	Escalation Rate	Year	Time	Capital Cost Schedule	Revenue & Cash Savings Schedule	Combined Operations & Maintenance & Other Costs Schedule	Discount Rate	NPV
7,420	76%	1.0000	2005	Year 0	$27,850,000			1.0000	$27,850,000
7,537	77%	1.0250	2006	Year 1	0	-$685,000	$3,064,000	0.9750	$2,320,000
7,654	79%	1.0506	2007	Year 2	0	-$713,000	$3,176,000	0.9506	$2,341,000
7,771	80%	1.0769	2008	Year 3	0	-$742,000	$3,292,000	0.9269	$2,363,000
7,888	81%	1.1038	2009	Year 4	0	-$772,000	$3,411,000	0.9037	$2,385,000
8,005	82%	1.1314	2010	Year 5	0	-$803,000	$3,535,000	0.8811	$2,407,000
8,122	83%	1.1597	2011	Year 6	0	-$835,000	$3,662,000	0.8591	$2,429,000
8,239	85%	1.1887	2012	Year 7	0	-$868,000	$3,794,000	0.8376	$2,451,000
8,356	86%	1.2184	2013	Year 8	0	-$903,000	$3,930,000	0.8167	$2,472,000
8,473	87%	1.2489	2014	Year 9	0	-$938,000	$4,070,000	0.7962	$2,494,000
8,590	88%	1.2801	2015	Year 10	0	-$975,000	$4,215,000	0.7763	$2,515,000
8,707	89%	1.3121	2016	Year 11	0	-$1,013,000	$4,365,000	0.7569	$2,537,000
8,824	91%	1.3449	2017	Year 12	0	-$1,052,000	$4,519,000	0.7380	$2,559,000
8,941	92%	1.3785	2018	Year 13	0	-$1,093,000	$4,679,000	0.7195	$2,580,000
9,058	93%	1.4130	2019	Year 14	0	-$1,135,000	$4,843,000	0.7016	$2,601,000
9,174	94%	1.4483	2020	Year 15	0	-$1,178,000	$5,013,000	0.6840	$2,623,000
9,291	95%	1.4845	2021	Year 16	0	-$1,223,000	$5,189,000	0.6669	$2,645,000
9,408	97%	1.5216	2022	Year 17	0	-$1,269,000	$5,370,000	0.6502	$2,667,000
9,525	98%	1.5597	2023	Year 18	0	-$1,317,000	$5,557,000	0.6340	$2,688,000
9,642	99%	1.5987	2024	Year 19	0	-$1,367,000	$5,750,000	0.6181	$2,709,000
9,744	100%	1.6386	2025	Year 20	0	-$1,416,000	$5,942,000	0.6027	$2,728,000
									$78,364,000
Escalation Rate		2.5%						2.5%	

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OPTION 7 - ALKALINE STABILIZATION WITH PHASED DIGESTION

Capital Cost	$27,850,000
O&M Annual Cost (Ultimate Year Production)	$3,626,000
O&M Annual Credit (Ultimate Year Production)	$864,000
Net O&M Annual Cost (ultimate Year Production)	$2,762,000
NPV	$78,364,000
Dry Tonnes Raw Solids Processed (20 year total)	180,371
Dry Tonnes Raw Solids Processed (Ultimate Year)	9,744
Capital Cost per Dry Tonne Raw Solids Processed	$154
O&M Annual Cost per Dry Tonne Raw Solids Processed (Ultimate Year)	$372
O&M Annual Credit per Dry Tonne Raw Solids Processed (Ultimate Year)	$89
Net O&M Annual Cost per Dry Tonne Raw Solids Processed (Ultimate Year)	$283
NPV per Dry Tonne Raw Solids Processed	$434

ATTACHMENT B

Fax

To:
Sally Baldwin
Company:
CH2M Hill, Waterloo
Fax:
519-579-8986
cc:
Marc Hunt, Alfa Laval

From:
Jamie Hodd
Contact details:
Jamie.hodd@alfalaval.com
Date:
March 29, 2005
Page:
1 of 7

Process Technology Division
Alfa Laval Inc.
101 Milner Avenue
Scarborough, Ontario
Canada
M1S 4S6
Tel: +1 416 299 6101
Direct: +1 416 297 6349
Fax: +1 416 299 5476
www.alfalaval.ca

Our ref.: PT05-218 **Your ref.: Guelph**

Quotation for Decanter Centrifuge, City of Guelph

Dear Sally:

Please find enclosed our budget quotation for your consideration as requested.

Scope of supply

With the fairly high number of cases to consider at this point, there are several centrifuge models that could be considered. These are summarized in the table below:

Operating hours per day	**Alt. #**	**System #1:** Mixed digested, 2.7% Feed, Alt 1: 2 * 200 m3/d ea. Alt 2: 3 * 110 m3/d ea.	**System #2:** Mixed digested, 2.7% Feed, Alt 1: 2 * 310 m3/d ea. Alt 2: 3 * 155 m3/d ea.	**System #3:** Prim. Dig./Raw WAS, 4.5% Feed, Alt 1: 2 * 275 m3/d ea. Alt 2: 3 * 140 m3/d ea.
16	1	2 * ALDEC G2-40, 12.5 m3/h each	2 * ALDEC G2-60, 19.4 m3/h each	2 * ALDEC G2-60, 17.2 m3/h each
16	2	3 * ALDEC 30, 6.9 m3/h each	3 * ALDEC G2-40, 9.7 m3/h each	3 * ALDEC G2-40, 8.8 m3/h each
24	1	2 * ALDEC 30, 8.3 m3/h each	2 * ALDEC G2-40, 12.9 m3/h each	2 * ALDEC G2-40, 11.5 m3/h each
24	2	3 * ALDEC 20, 4.6 m3/h each	3 * ALDEC 30, 6.5 m3/h each	3 * ALDEC 30, 5.8 m3/h each

Most likely candidates for this site would be the ALDEC 30, ALDEC G2-40, or ALDEC G2-60. Budget prices are summarized below.

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Quotation for Decanter Centrifuge, City of Guelph, PT05-218

Please note that a 30% cake is on the high side for mixed primary secondary sludges (25% is the typical target), and may only be achievable if the sludge is fairly easy to separate. This is based on the assumption that the primary to secondary ratio is approx. 50%. If the secondary content is less than 25%, or if the target dryness were closer to 25%, then the preferred size of machine may change.

Typically for a mixed anaerobic sludge, polymer consumption will range from 3 to 10 kg/t DS, and solids recovery will range from 95 to 98% (depending on desired dryness and polymer consumption). If a sample of the sludge exists and can be tested, a more accurate figure can be given.

Power requirements will be in the range of 1.7 to 2.2 kW / m3 feed for the ALDEC 30, and 1.3 to 1.9 kW / m3 of feed for the ALDEC G2-40 or G2-60. All units would use 575V / 3p / 60Hz power. Actual power requirements will depend on flowrate, model chosen, solids loading, and bowl speed. The above ranges are based on a high torque loading and maximum bowl speed for each model.

The scope of supply for the ALDEC 30 would include for each centrifuge:

- Eddy Current backdrive and controller.
- Star-Delta main motor.
- Standard wear protection package (tungsten carbide surfacing on conveyor flights and replaceable tungsten wear liners on solids discharge ports).
- Alfa Laval control and starter panel.
- One set of special tools and spares for one (1) year operation.
- Freight to jobsite.
- Installation and commissioning package.

Budget price for one (1) **ALDEC 30** decanter centrifuge: $125,000.00 CAD

The scope of supply for the ALDEC G2-40 or ALDEC G2-60 would include for each centrifuge:

- Direct Drive backdrive system, c/w controller and VFD motor.
- VFD soft-start main motor.
- Standard wear protection package (tungsten carbide surfacing on conveyor flights and replaceable stellite wear liners on feed inlet and solids discharge ports).
- Alfa Laval control and starter panel.
- One set of special tools and spares for one (1) year operation.
- Freight to jobsite.
- Installation and commissioning package.

An extended wear protection package is available as an option for either the G2-40 or G2-60 if desired.

Budget price for one (1) **ALDEC G2-40** decanter centrifuge: $200,000.00 CAD
Budget price for one (1) **ALDEC G2-60** decanter centrifuge: $275,000.00 CAD

www.alfalaval.ca

Quotation for Decanter Centrifuge, City of Guelph, PT05-218

Prices:	DDP – jobsite in Guelph, Ontario (freight included to jobsite), taxes extra.
Delivery:	Estimated at this time 22-24 weeks, after a technically and commercially clear order.
Payment:	Progress Payments. All payments are Net 30 days.
Validity:	90 days from date of quotation.
Terms:	Alfa Laval Standard terms & Conditions, copy attached. To download a copy of these terms please visit our web site at www.alfalaval.ca/terms.

Please feel free to call me or Marc Hunt if you have any additional questions. Thank you very much for your interest.

On behalf of Alfa Laval,

James Hodd, P. Eng.

Attachments:
Decanter Specification sheet, ALDEC 30
General Arrangement Drawing, ALDEC 20/30

Decanter Specification sheet, ALDEC G2-40
General Arrangement Drawing, ALDEC G2-40/50

Decanter Specification sheet, ALDEC G2-60
General Arrangement Drawing, ALDEC G2-60/70

Decanter Centrifuge Data Sheet

High-performance Decanter Centrifuge

ALDEC 30

Dimension drawing: 61240440

General Information

Typical application	Environment
Flow configuration	Counter-current
Max. design temp.	100 Degrees Celsius
Contrifugal G-ratio	3030 G

Frame

Type	Box beam profile with integral casing - Wear liner / with hinges
Material	Mild steel
Color	Aluminium grey

Casing

Type	Box beam profile with integral casing - Wear liner / with hinges
Material	316 Stainless steel
Seals	Nitrile

Process Connnection

Feed tube	Feed tube, length 540, ø25
Polymer addition	See dimension drwg.
Solids outlet	See dimension drwg.
Liquid outlet	See dimension drwg.

Main Drive Assembly

Orientation	See dimension drwg.
Main motor size	20 Hp Baldor CSA 575V Y/D flange
Main motor data	3 x 575 V / 60 Hz
Main motor protection	Thermistor

Back-drive Assembly

Orientation	In-line
Type	Eddy Current Brake 132

Belt Guards and Gearbox Covers

Belt guards material	Painted mild steel
Gearbox cover material	Fiberglass

Bowl Assembly

Diameter	280 mm
Total length	1260 mm
Material	316 Stainless steel
Liquid outlet type	4 Plate dams
Liquid outlet radius	82 mm
Solids outlet type	360°-type with 6 wear liners
Solids outlet radius	84 mm

Conveyor Assembly

Conveyor design	Double cone
Feed zone design	Esbjerg
Material	316 Stainless steel

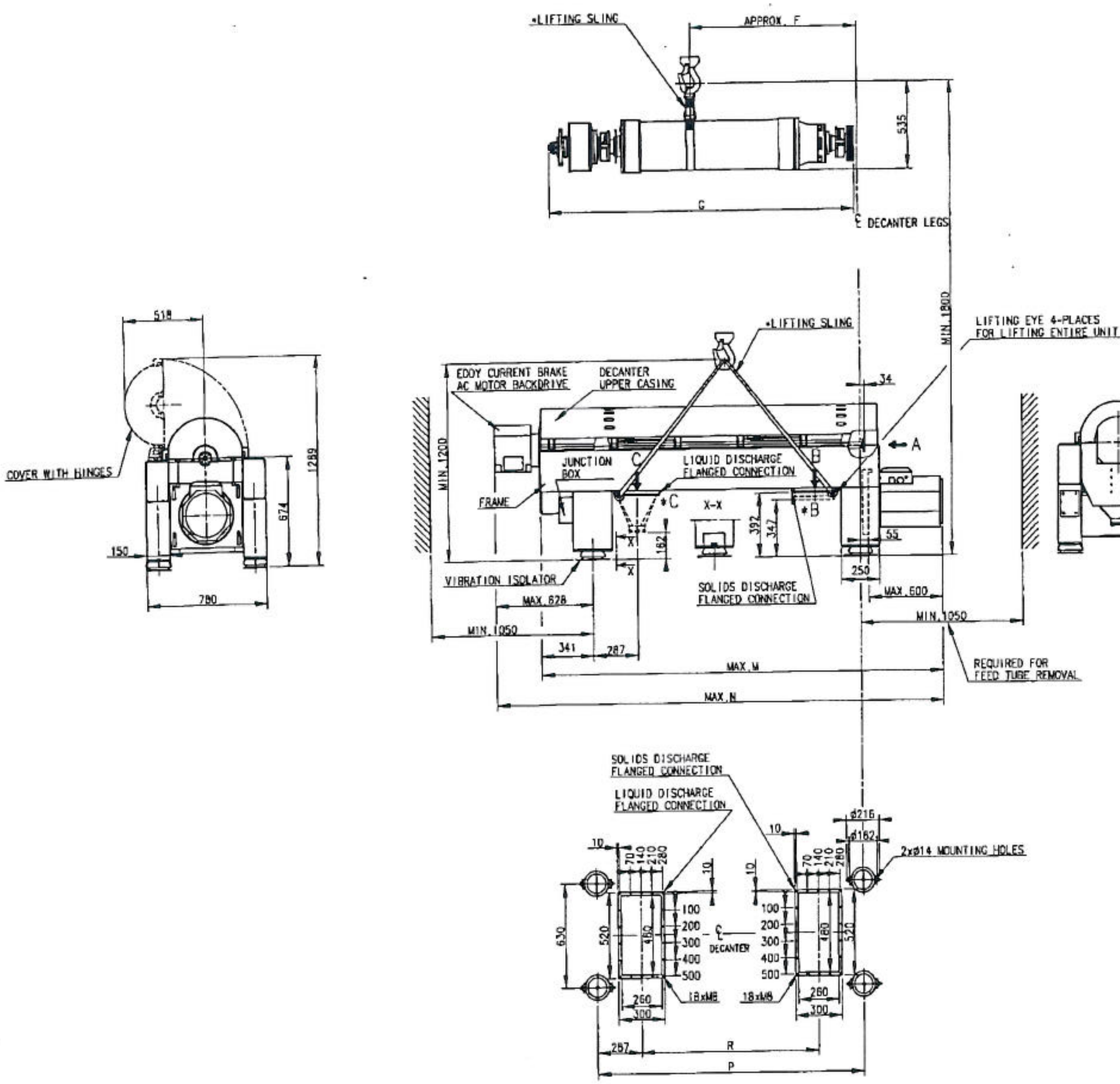
Gearbox

Type	Planetary - 2-stage
Lubrication	
Ratio	1:97.2
Torque	1.5 kNm

Erosion Protection

Conveyor flights	TM40 (flame sprayed tungsten carbide)
Feed zone	None
Bowl shell	None
Solids outlet	Wear bushing in Tungsten Carbide
Casing	Wear liner in upper casing
Paint	Standard

Version: 0
Date: 2005-03-29



APPROXIMATE WEIGHTS:

	ALDEC 20	ALDEC 30
TOTAL WEIGHT OF EMPTY DECANTER	1400kg/ 3080lbs	1500kg/3300lbs
ROTATING ASSY INCL. PILLOW BLOCKS	325kg/ 715lbs	350kg/ 780lbs
CPL.FRAME ASSY EXCL. MAIN MOTOR AND ROT. ASSY..	750kg/ 1650lbs	800kg/1770lbs
MAIN MOTOR	150kg/ 330lbs	150kg/ 330lbs
UPPER CASING	65kg/ 145lbs	75kg/ 165lbs
GEAR BOX	60kg/ 130lbs	60kg/ 130lbs
MIN.CRANE CAPACITY FOR LIFTING OF ROTATING ASSY:	450kg/ 1000lbs	450kg/1000lbs

LOADING DATA:

	ALDEC 20	ALDEC 30
DECANTER		
1. MAX. STATIC LOAD		
A- VERTICAL	14800 N	15800 N
B- HORISONTAL.....................	0 N	0 N
2. MAX. DYNAMIC LOAD AT RUN DOWN (ADD TO STATIC LOAD)		
A- VERTICAL	± 2000 N	± 2000 N
B- HORIZONTAL.....................	± 1000 N	± 1000 N
3. MAX. DYNAMIC LOAD AT OPERATING SPEED		
A- VERTICAL	50 N	50 N
B- HORISONTAL.....................	50 N	50 N

CONNECTIONS:

		DIMENSION / TYPE
A	FEED	ø25,4 (1")HOSE CONNECTION
B	SOLIDS OUTLET	RECTANGULAR FLANGE
*B	SOLIDS OUTLET FUNNEL......................	476 x 256 TUBE
C	LIQUID OUTLET	RECTANGULAR FLANGE
*C	LIQUID OUTLET FUNNEL	ø100 HOSE CONNECTION

MAIN DIMENSIONS:

TYPE	F	G	M	N	P	R
ALDEC 20	930	1680	2446	2733	1450	870
ALDEC 30	1070	1960	2726	3013	1730	1150

NOTES:

1- ALL CONNECTIONS MUST BE FLEXIBLE.

2- FOR PROPER VENTING OF DISCHARGE HOPPERS REFER TO THE INSTALLATION DRAWING. IMPROPER VENTING CAN LEAD TO LEAKAGE PROBLEMS.

3- CUSTOMER IS RESPONSIBLE FOR ANCHORING.

4- FOR FURTHER INFORMATION, SEE INSTALLATION DATA MANUAL AND INSTALLATION DRAWING

* OPTIONAL EQUIPMENT

14800N REPLACES 12500N
15800N REPLACES 13500N
MIN.1050 REPLACES MIN.1000
MIN.1050 REPLACES MIN.725
ALDEC 20 REPLACES 930/933
ALDEC 30 REPLACES 1070/962

DIMENSIONED DRAWING
ALDEC 20/30
GEAR BOX
Alfa Laval
Alfa Laval Copenhagen A/S
61240440

Decanter Centrifuge Data Sheet

High-performance Decanter Centrifuge

ALDEC G2-40

Dimension drawing: 61240065

General Information

Typical application	Environment G2
Flow configuration	Counter-current
Max. design temp.	100 Degrees Celsius
Contrifugal G-ratio	3157 G

Frame

Type	Box beam profile and separate casing - Wear liner / with hinges
Material	Mild steel
Color	Aluminium grey

Casing

Type	Box beam profile and separate casing - Wear liner / with hinges
Material	316 Stainless steel
Seals	Nitrile

Process Connnection

Feed tube	With external polymer addition, length 887, ø36
Polymer addition	See dimension drwg.
Solids outlet	See dimension drwg.
Liquid outlet	See dimension drwg.

Main Drive Assembly

Orientation	See dimension drwg.
Main motor size	30 Hp Baldor 575VD VFD flange mounted
Main motor data	3 x 575 V / 60 Hz
Main motor protection	Thermistor

Back-drive Assembly

Orientation	In-line
Type	7.5 HpMagne-Tek motor for VFD, NEMA (Cdn)

Belt Guards and Gearbox Covers

Belt guards material	Painted mild steel
Gearbox cover material	Fiberglass

Bowl Assembly

Diameter	353 mm
Total length	1460 mm
Material	316 Stainless steel
Liquid outlet type	4 Plate dams
Liquid outlet radius	101 mm
Solids outlet type	8 bushings
Solids outlet radius	99 mm

Conveyor Assembly

Conveyor design	Windows
Feed zone design	Esbjerg with exchangeable wear liners (EU)
Material	316 Stainless steel

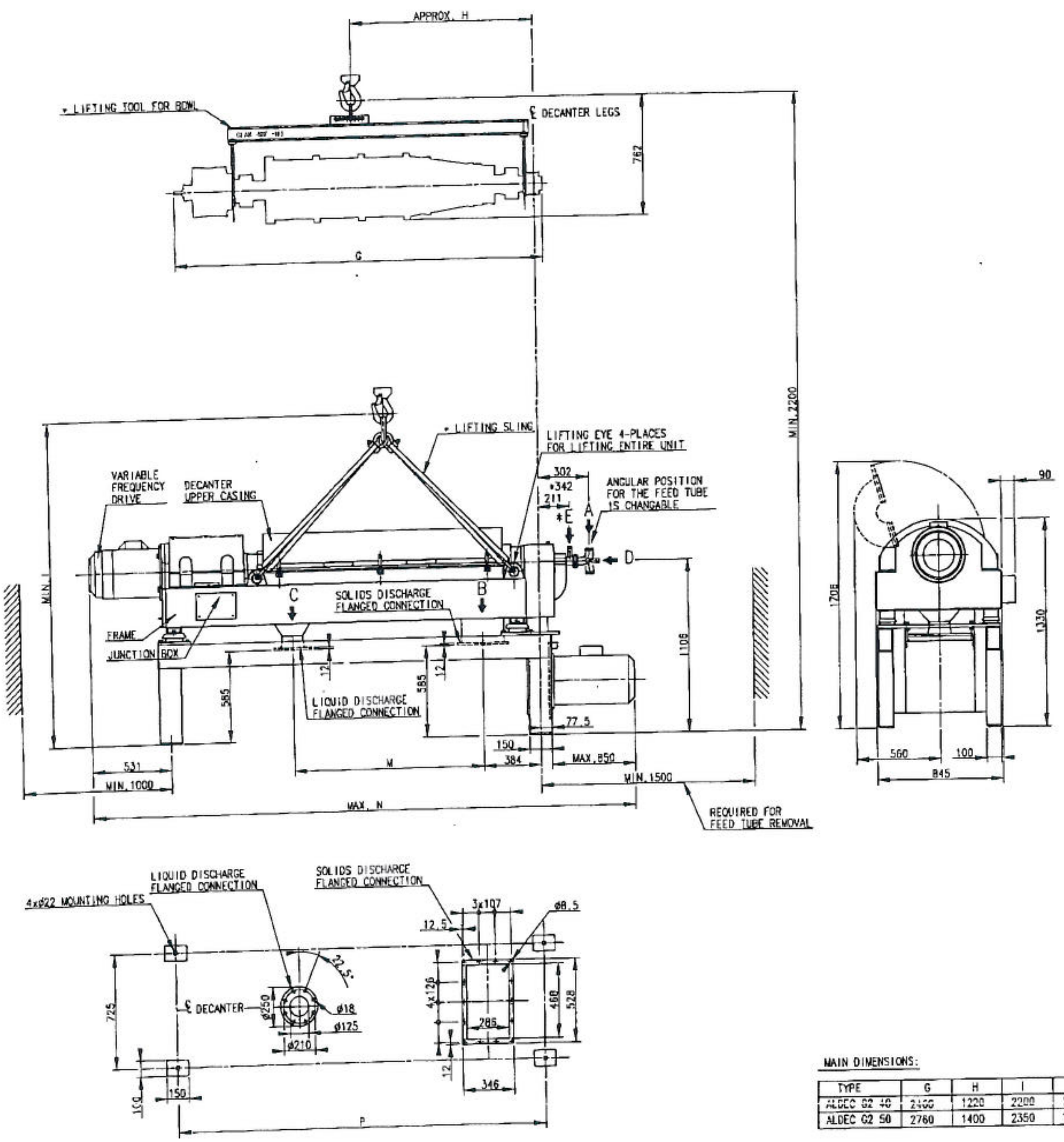
Gearbox

Type	Planetary - 2-stage DD
Lubrication	
Ratio	1:52
Torque	DD 3.5 kNm

Erosion Protection

Conveyor flights	TM42 (flame sprayed tungsten carbide)
Feed zone	Stellite wear liners
Bowl shell	None
Solids outlet	Wear bushing in stellite (short)
Casing	Wear liner in upper casing
Paint	Standard

Version: 0
Date: 2005-03-29



APPROXIMATE WEIGHTS:

	ALDEC G2 40	ALDEC G2 50
TOTAL WEIGHT OF EMPTY DECANTER	2400kg/ 5320lbs	2550kg/ 5650lbs
ROTATING ASSY INCL. PILLOW BLOCKS	650kg/ 1440lbs	750kg/ 1660lbs
DECANTER FRAME INCL. BACK DRIVE MOTOR AND ROT. ASSY..	1600kg/ 3550lbs	1730kg/ 3840lbs
SUBFRAME INCL. MAIN MOTOR	800kg/ 1770lbs	820kg/ 1830lbs
MAIN MOTOR	350kg/ 780lbs	350kg/ 780lbs
UPPER CASING	80kg/ 180lbs	90kg/ 200lbs
GEAR BOX	90kg/ 200lbs	90kg/ 200lbs
MIN. CRANE CAPACITY FOR LIFTING OF ROTATING ASSY:	1000kg/ 2210lbs	1150kg/ 2550lbs

LOADING DATA:

	ALDEC G2 40	ALDEC G2 50
DECANTER 1. MAX. STATIC LOAD		-
A- VERTICAL	25000 N	26500 N
B- HORISONTAL......................	0 N	0 N
2. MAX. DYNAMIC LOAD AT RUN DOWN (ADD TO STATIC LOAD)		
A- VERTICAL	±13700 N	±18600 N
B- HORIZONTAL......................	± 6900 N	± 9300 N
3. MAX. DYNAMIC LOAD AT OPERATING SPEED		
A- VERTICAL	750 N	750 N
B- HORISONTAL......................	750 N	750 N

ALL LOADS ARE EVENLY DISTRIBUTED ON THE VIBRATION ISOLATORS

CONNECTIONS:

	DIMENSION / TYPE
A FEED	Ø51 (2")HOSE CONNECTION
B SOLIDS OUTLET	RECTANGULAR FLANGE
C LIQUID OUTLET	CIRCULAR FLANGE
D POLYMER ADDITION	ISO 228-G 3/4
*E INTERNAL POLYMER ADDITION	ISO 228-G 3/4

NOTES:

1- ALL CONNECTIONS MUST BE FLEXIBLE.

2- FOR PROPER VENTING OF DISCHARGE HOPPERS REFER TO THE INSTALLATION DRAWING. IMPROPER VENTING CAN LEAD TO LEAKAGE PROBLEMS.

3- CUSTOMER IS RESPONSIBLE FOR ANCHORING.

4- FOR FURTHER INFORMATION, SEE INSTALLATION DATA MANUAL AND INSTALLATION DRAWING

DRAWING ONLY SHOWS ALDEC G2 40 TO SCALE
COMPLEMENTARY DRAWING 61240066

* OPTIONAL EQUIPMENT

MAIN DIMENSIONS:

TYPE	G	H	I	M	N	P
ALDEC G2 40	2400	1220	2200	1280	3955	2495
ALDEC G2 50	2760	1400	2350	1580	4255	2795

POLYMER TUBES ADDED

DIMENSIONED DRAWING
ALDEC G2 40/50
Alfa Laval
1:10
61240085

Decanter Centrifuge Data Sheet

High-performance Decanter Centrifuge

ALDEC G2-60

Dimension drawing: 61239744

General Information

Typical application	Environment G2
Flow configuration	Counter-current
Max. design temp.	100 Degrees Celsius
Contrifugal G-ratio	2657 G

Frame

Type	Box beam profile with integral casing -
Material	Mild steel
Color	Aluminium grey

Casing

Type	Box beam profile with integral casing -
Material	316 Stainless steel
Seals	Nitrile

Process Connnection

Feed tube	With external polymer addition, length 1010, ø36
Polymer addition	See dimension drwg.
Solids outlet	See dimension drwg.
Liquid outlet	See dimension drwg.

Main Drive Assembly

Orientation	See dimension drwg.
Main motor size	50 Hp Baldor 575VD VFD flange mounted
Main motor data	3 x 575 V / 60 Hz
Main motor protection	Thermistor

Back-drive Assembly

Orientation	In-line
Type	Direct-Drive 20 Hp VFD, NEMA (CAD)

Belt Guards and Gearbox Covers

Belt guards material	Painted mild steel
Gearbox cover material	Fiberglass

Bowl Assembly

Diameter	450 mm
Total length	1910 mm
Material	316 Stainless steel
Liquid outlet type	4 Plate dams
Liquid outlet radius	126 mm
Solids outlet type	10 bushings
Solids outlet radius	129 mm

Conveyor Assembly

Conveyor design	Windows / Double cone / 8 mm duplex flights in conical section
Feed zone design	Esbjerg with exchangeable wear liners (EU)
Material	316 Stainless steel

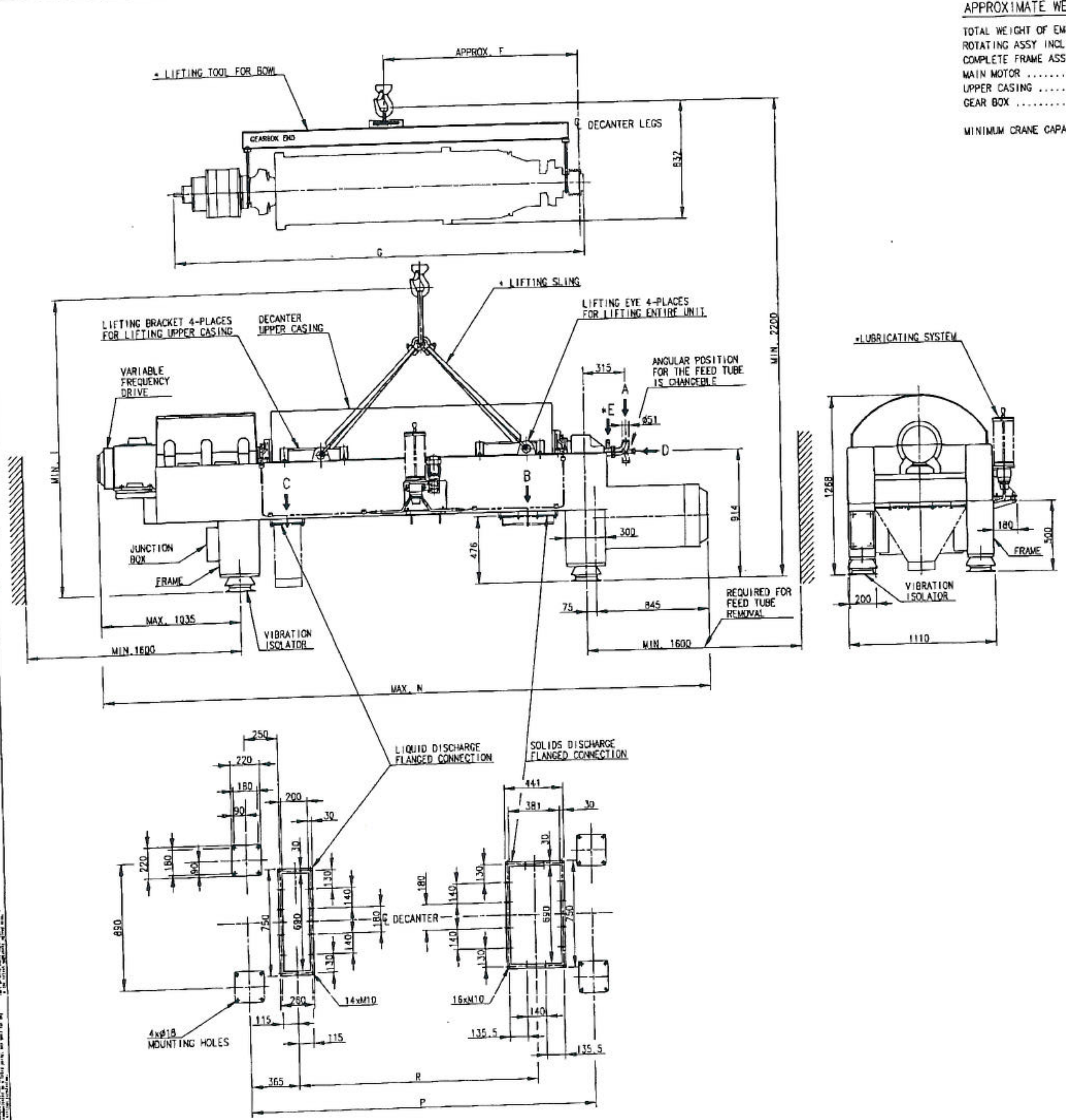
Gearbox

Type	Planetary - 2-stage DD
Lubrication	
Ratio	1:100.8
Torque	DD 8.0 kNm

Erosion Protection

Conveyor flights	TM42 (flame sprayed tungsten carbide)
Feed zone	Stellite wear liners
Bowl shell	None
Solids outlet	Wear bushing in stellite (short)
Casing	Wear liner in upper casing
Paint	Standard

Version: 0
Date: 2005-03-29



APPROXIMATE WEIGHTS:

	ALDEC G2-60	ALDEC G2-70
TOTAL WEIGHT OF EMPTY DECANTER	3500kg / 7600lbs	3900kg / 8600lbs
ROTATING ASSY INCL. PILLOW BLOCKS	900kg / 2000lbs	1080kg / 2400lbs
COMPLETE FRAME ASSY EXCL. MAIN MOTOR AND ROT. ASSY	1750kg / 3850lbs	1900kg / 4200lbs
MAIN MOTOR	420kg / 925lbs	420kg / 925lbs
UPPER CASING	100kg / 225lbs	115kg / 250lbs
GEAR BOX	150kg / 330lbs	150kg / 330lbs
MINIMUM CRANE CAPACITY FOR LIFTING OF ROTATING ASSEMBLY: H .	1500kg / 3310lbs	1800kg / 3970lbs

LOADING DATA:

	ALDEC G2-60	ALDEC G2-70
1. MAX. STATIC LOAD		
A- VERTICAL	38,000 N	42,000 N
B- HORIZONTAL	0 N	0 N
2. MAX. DYNAMIC LOAD AT RUN DOWN (ADD TO STATIC LOAD)		
A- VERTICAL	±24,500 N	±34,300 N
B- HORIZONTAL	±5,900 N	±8,800 N
3. MAX. DYNAMIC LOAD AT OPERATING SPEED		
A- VERTICAL	±1,000 N	±1,000 N
B- HORIZONTAL	±1,000 N	±1,000 N

ALL LOADS ARE EVENLY DISTRIBUTED ON THE VIBRATION ISOLATORS

CONNECTIONS:

		DIMENSION / TYPE
A	FEED	Ø51 (2") HOSE CONNECTION
B	SOLIDS OUTLET	RECTANGULAR FLANGE
*B	SOLIDS OUTLET	381x690
C	LIQUID OUTLET	RECTANGULAR FLANGE
*C	LIQUID OUTLET	Ø200 HOSE CONNECTION
D	POLYMER ADDITION	3/4" BSP HOSE CONNECTION
*E	POLYMER ADDITION	3/4" BSP HOSE CONNECTION

MAIN DIMENSIONS:

TYPE	F	G	I	P	R	N
ALDEC G2-60	1540	3054	2100	2600	1806	4555
ALDEC G2-70	1780	3504	2100	3050	2256	5005

NOTES:

1- ALL CONNECTIONS MUST BE FLEXIBLE.

2- FOR PROPER VENTING OF DISCHARGE HOPPERS REFER TO THE INSTALLATION DRAWING. IMPROPER VENTING CAN LEAD TO LEAKAGE PROBLEMS.

3- CUSTOMER IS RESPONSIBLE FOR ANCHORING.

4- FOR FURTHER INFORMATION, SEE INSTALLATION DATA MANUAL AND INSTALLATION DRAWING.

DRAWING ONLY SHOWS ALDEC G2-60 TO SCALE

COMPLEMENTARY DRAWING: 61239743

* OPTIONAL EQUIPMENT

DIMENSIONED DRAWING
ALDEC G2-60/70
1:10
Alfa Laval
Alfa Laval Copenhagen A/S
DENMARK
61239744

USFilter

A Siemens Business

DRAGON DRYER™

PROPOSAL

— For —

Ms. Sally Baldwin
CH2MHill
and the
City of Guelph, Ontario

USFilter
A Siemens Business

From the office of: Joey Herndon

1828 Metcalf Avenue Telephone: 229-227-8727
Thomasville, GA 31792 Facsimile: 229-228-0312

April 7, 2005

CH2M Hill
180 King street South
Suite 600
Waterloo, ON N2J 1P8
Canada

Attention: Ms. Sally Baldwin

Re: ***Dragon Dryer*®** **Indirect Rotating Chamber**
Heat Drying System for the City of Guelph, Ontario

Dear Ms. Baldwin:

Thank you for requesting a budget proposal for the Dragon Dryer® from *USFilter* Davco Products for the City of Guelph, Ontario.

The Series 10020 Dragon Dryer selected for this project is capable of processing up to 100 wet tons of municipal sludge per calendar day at 28% solids. I have included two proposals; both are Series 10020 Dragon Dryers, one using a sludge production rate of 4,270 dry tones per year (54 wet tons per day) and the other using 6,750 dry tons per year (92.27 wet tons per day) both at 28% solids. For both proposals I estimated the Natural Gas cost at $0.80 per Therm and the Electrical cost at $0.07 per kWh. Using these values and the given sludge production the Series 6012 will dry one wet ton for $19.20.

You will find under the "Drawing Tab" a plan and elevation drawing showing a suggested equipment layout. This is only a suggested layout. The Dragon Dryer is modular in construction and can be configured in many different ways.

One real advantage to drying biosolids is the reduced storage requirement for the biosolids prior to final disposal. Reducing the volume of biosolids also results in a decreased volume of truck traffic, which equals to… reduced cost, reduced maintenance, reduced headaches and above all, reduced liability. Another advantage of the Dragon Dryer is the ability to continuously process sludge during periods of inclement weather. The Dragon Dryer is truly a year round, operator friendly, biosolids processing system.

I am confident the installation of a Dragon Dryer will reduce your clients current biosolids disposal cost and greatly simplify their biosolids operation. The Dragon Dryer solids will be easier and <u>safer</u> to handle and considerably smaller in volume. And as a bonus, you will produce a product that you can easily and <u>safely</u> market for land application to landscapers, nurseries, golf courses and homeowners to mention a few.

USFilter Davco Products will be glad to provide a quote for the field installation of the Dragon Dryer resulting in ready to run process on a turnkey basis. The Dragon Dryer and its components are designed and fabricated in our 91,000 square foot ASME certified facility in

Thomasville, Georgia. Our Thomasville based field construction crews are all full time skilled, craftsmen experienced in the installation of Dragon Dryer systems. Building the dryer equipment in our own fabrication facility and field installing it with our full time employees allows us the project and quality controls that are very difficult to obtain using subcontract services.

From process philosophy to safety of operation, the Dragon Dryer System stands alone among biosolids heat dryers. The philosophy behind the development of the Dragon Dryer has always been to create an efficient heat drying system that will minimize the consumption of energy, maximize the reduction of biosolids volume, protect the environment from unwanted emissions, and offer a high degree of system safety and reliability.

Please give Mr. Ray Newman with ProAqua, Inc (416) 861-0237, our representative in Guelph, or me a call if you have any questions or if you would like to schedule a presentation on the operation of the Dragon Dryer.

Very truly yours,

***USFilter* Davco Products**

Joey Herndon
Dragon Dryer® Product Manager

Cc: Ray Barrett - USFilter
Ray Newman – ProAqua, Inc

MAJOR FEATURES

Dual Indirect Heat Source - The Dragon Dryer® uses conduction (indirect) drying, the safest of all drying technologies, which dries the biosolids without the material ever coming into direct contact with the heat source. The dryer uses a rotating dehydration chamber that is heated on the outside by three burners. Inside the chamber a hollow auger is heated by re-circulated hot oil. The heated auger provides positive displacement of the materials as they move through the dehydration chamber. The combination of the two heat mechanisms using 1100 – 1500 BTU's per pound of water evaporated provides for the maximum in heat transfer area. This significantly increases the efficiency of the biosolids drying.

Essentially No Air Emissions from Dryer - The complete isolation of the drying chamber from the combustion gases allows for a system with very low emissions. The clean burning high efficiency gas burners meet all federal and state regulations with respect to air emissions. The moisture removed from the sludge during the drying process is collected as steam and removed from the dryer using a blower. This blower maintains the dryer under a slight negative pressure preventing the escape of any odorous gases or dust. The steam passes through a venturi scrubber for the removal of entrained solids, and then into a condenser unit where the steam is condensed back into water, using plant effluent water as a cooling medium. The remaining airstream of approximately 200-500cfm is then subjected to common odor control technology. The condensed steam plus the plant effluent cooling water are returned back to the treatment plant.

Pathogen Kill and Vector Attraction Reduction - The Dragon Dryer® is a continuous single pass system with an adjustable sludge retention time.

Safety Considerations – USFilter Davco Products number one concern is safety. The Dragon Dryer's equipment has been through an exhaustive 3rd party safety review. Noteworthy points are:

- Designed per applicable guidelines of the NFPA 68, 69 and 654
  - Relief Management System (NFPA 68)
  - Inert Blanket (NFPA 69)
- Spark Detection System
- Safety Interlocks with Visual and Audible Alarms
- PLC Security Screens (pass code protected)
- Hot Oil Heater and Hollow Flight Auger
  - ASME design, built, tested and code stamped
  - Registered with the National Board
- Closed System Operating under a negative pressure
- Clean work area

The Dragon Dryer® does not use high-pressure steam, as a heat source, therefore there is no potentially dangerous boiler system to maintain. The Hot Oil System, which includes the hot oil unit (heater) and the hollow flight auger are designed, built, tested and code stamped per the ASME code guidelines. This is our customers' assurance that the Dragon Dryer meets the safety and quality criteria set by a nationally recognized standard.

Product Characteristics - The Dragon Dryer® dryer produces a granular material that is 75 to 100% dry solids. The volume of material is typically reduced by 60-70%. Depending on biosolids characteristics and process design parameters, the particle size will range between 1 mm and 4 mm, which makes the dried biosolids an ideal size for beneficial reuse. Typically, the nitrogen content will range between 2% and 6% of the dry weight. The dried biosolids also contain other organic based nutrients that, together with the nitrogen create a commercially desirable product.

Multiple Control Points – The Dragon Dryer is unique in many different ways. With the Dragon Dryer municipalities are able to control the dryers' operation and in doing so effect the efficiency of the drying process and, to a certain extent effect the end product quality. The Dragon Dryer is the on single pass indirect heat dryer that can make this claim. Different ways to adjust the dryers' operation include:

- The feed rate into the dryer from the feed hopper.
- The hot oil temperature.
- The three individually controlled burners under the dehydration chamber. These burners control the temperature for the,
    - Cohesive zone
    - Shearing zone
    - Finishing zone
- The variable speed drives for the,
    - Hollow Flight Auger
    - Dehydration Chamber

The Dragon Dryer® heat-drying system is the future for biosolids disposal here today! Contact us today so that together we can assess your biosolids needs and determine the best solution for your particular operation.

"The Dragon way to Class A"

USFilter

Davco Products
P.O. Box 2100
Thomasville, Georgia 31799
1-800-841-1550 – extension 8727
Fax – (229) 228-0312
E-mail – herndojh@usfilter.com

USFilter

A Siemens Business

DRAGON DRYER®

Safety

There is a potential for fire and/or explosion problems associated with drying biosolids. In a continuing effort to make the Dragon Dryer the safest and most reliable biosolids dryer in the market place, USFilter employed an independent company, Packer Engineering, to conduct a safety audit of the Dragon Dryer system. As a result, several opportunities for improving the overall safety features of the Dragon Dryer system were identified.

The following items have been implemented or improved in the Dragon Dryer's design and are now standard features.

- ***Designed per applicable guidelines of the National Fire Protection Association (NFPA)***
  - **Relief Management System (NFPA 68)**
    - In the event a dust explosion does occur, the dryer unit and the dry product storage vessel are equipped with explosion relief vents that will relieve a sudden over-pressurization. When a deflagration event occurs, the sudden release of energy and the associated increase in temperature causes an over-pressurization. In order to mitigate the effects of the over- pressurization, rupture discs and panels are installed to provide a means for the pressure and air volume to be vented in a safe manner. Using the methods dictated in NFPA 68 guidelines the vents are sized and rated based on the volume of the vessel they are protecting and the dust characteristics present.
  - **Inert Blanket (NFPA 69)**
    - All combustion and explosive reactions require a minimum oxygen concentration. The MOC for dried biosolids combustion is in the range of 6 -10% by volume. Maintaining the oxygen concentration below the MOC will significantly reduce the probability of combustion or explosion. During normal operation steam is produced from the water in the sludge. As a result, an inert steam blanket is provided over the entire dryer volume, reducing the oxygen concentration. However, at startup and shutdown, supplemental water is injected into the drying chamber to produce steam in sufficient quantity to minimize the oxygen concentration per NFPA 69 guidelines.
    - For a dust explosion to occur, a flammable atmosphere must be present. Test have shown that the minimum explosive concentration (MEC) of dried biosolids range from 53 to 320 g/m^3. Through the Dragon Dryers system safeguards the water spray and steam minimize dust concentrations in the dryer system.
  - **Components Designed and Supplied (NFPA 654)**
    - NFPA 654 set standards for the prevention of fire and dust explosions from the manufacturing processing and handling of combustible particulate solids. NFPA 654 is used in the design of the Dragon Dryer's material handling equipment and electrical components.

➢ **Electrical and Building Classification (NFPA 499 and NFPA 820)**

- NFPA 499 guideline and NFPA 820 guidelines are used to determine the electrical and building classification of the dryer equipment and the dryer location. The determination of the classification of the dryer facility falls under the "authority having jurisdiction", typically the local fire authority. The dryer facility is typically classified three ways;

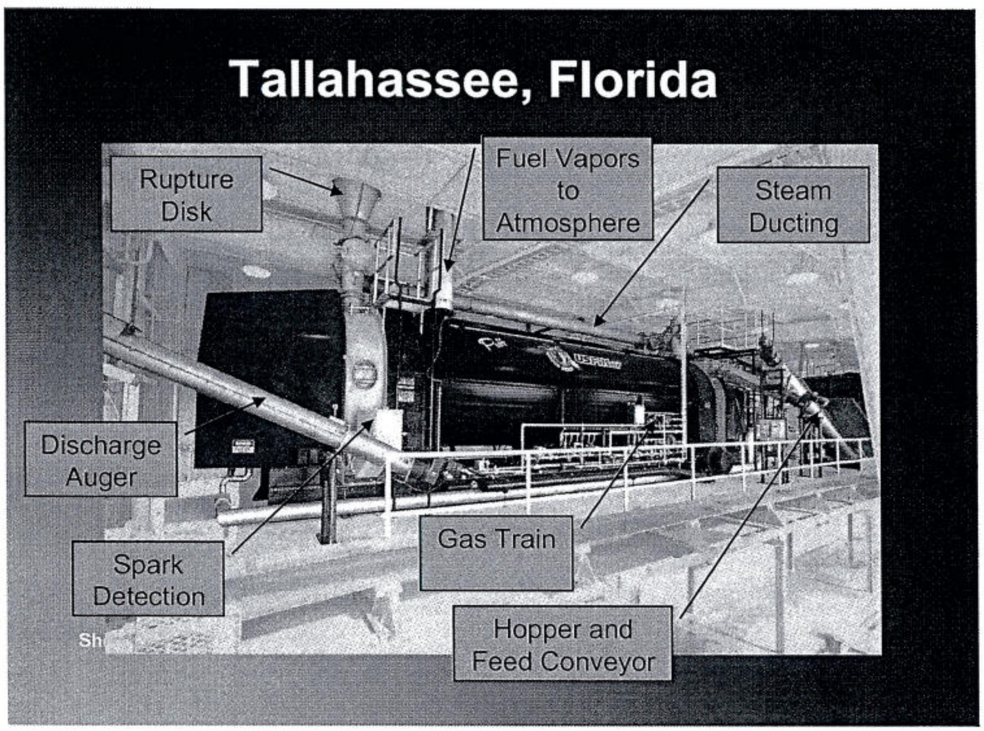
1- Class II, Division 1- "in which combustible dust is in the air under normal operating conditions in quantities sufficient to produce explosive or ignitable mixture or where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitable mixtures to be produced."

2- Class II, Division 2-" where combustible dust is not normally in the air in quantities sufficient to produce explosive or ignitable mixtures, and dust accumulations are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus, but combustible dust may be in suspension in the air as a result of infrequent malfunctioning of handling or processing equipment."

3- Unclassified- "Release of ignitable dust suspensions from some operation and apparatus is so infrequent that area classification is not necessary.

❖ ***Spark Detection System***

➢ Working in conjunction with the product temperature safeguards, a Factory Mutual approved spark detection system monitors and responds to prevent any sparks or embers from entering the storage vessel through the product conveyors. In the event the system detects a spark or ember an alarm will sound, the product will be doused with water and diverted away from the storage vessel until a preset time after no more sparks are detected.



❖ ***Safety Interlocks with Visual and Audible Alarms***

➢ PLC Security Screens (pass code protected)

- The different operation screens of the Dragon Dryer's HMI are pass code protected as a security and safety feature. The Dragon Dryer's Electrical Engineers work with

the municipal management team to establish the security levels of their employees with relation to the HMI's operational controls (screens).
- The control system is housed within a UL labeled NEMA 4 enclosure.

- ***Hot Oil Heater and Hollow Flight Auger***
  - ASME design, built, tested and code stamped.
  - Registered with the National Board.
  - All new systems will have the Oil Heat Exchanger isolated as per NFPA 221.

- ***Dragon Dryer System Feed Hopper***
  - Feed hoppers on new installations will be supplied with a weigh scale sensor for level determination and will be monitored by the systems PLC. This will provide valuable information to the PLC and aid in the safe operation of the dryer and its components.

- ***Closed System***

The Dragon Dryer Dehydration Chamber operates under a negative pressure, which helps to maintain a clean and safe work environment within the dryer building.

From process philosophy to safety of operation, the Dragon Dryer® System stands alone among indirect biosolids dryers. The philosophy behind the development of the Dragon Dryer has always been to create a safe and effective sludge drying system that will minimize the consumption of energy, maximize the reduction of biosolids volume, protect the environment from unwanted emissions, and offer a high degree of reliability. This has not changed and USFilter guarantees it!

DEFINITIONS

ASME – American Society of Mechanical Engineers

Deflagration – A Deflagration is an explosion in which the reaction front moves at a speed less than the speed of sound in the medium driven by the rate of heat transfer.

Any material that will burn in air when in a solid form may explode when it is in the form of a finely divided suspended powder. Biosolids are composed primarily of carbohydrates, proteins and fats, and will burn readily in the solid form. In order for a deflagration to occur, there must be (1) dust present in an explosive concentration range, (2) oxygen present and (3) a source of ignition.

HMI - Human - Machine Interface

K_{st} - Maximum Volume Scaled Rate of Pressure Rise (bar-m/s)

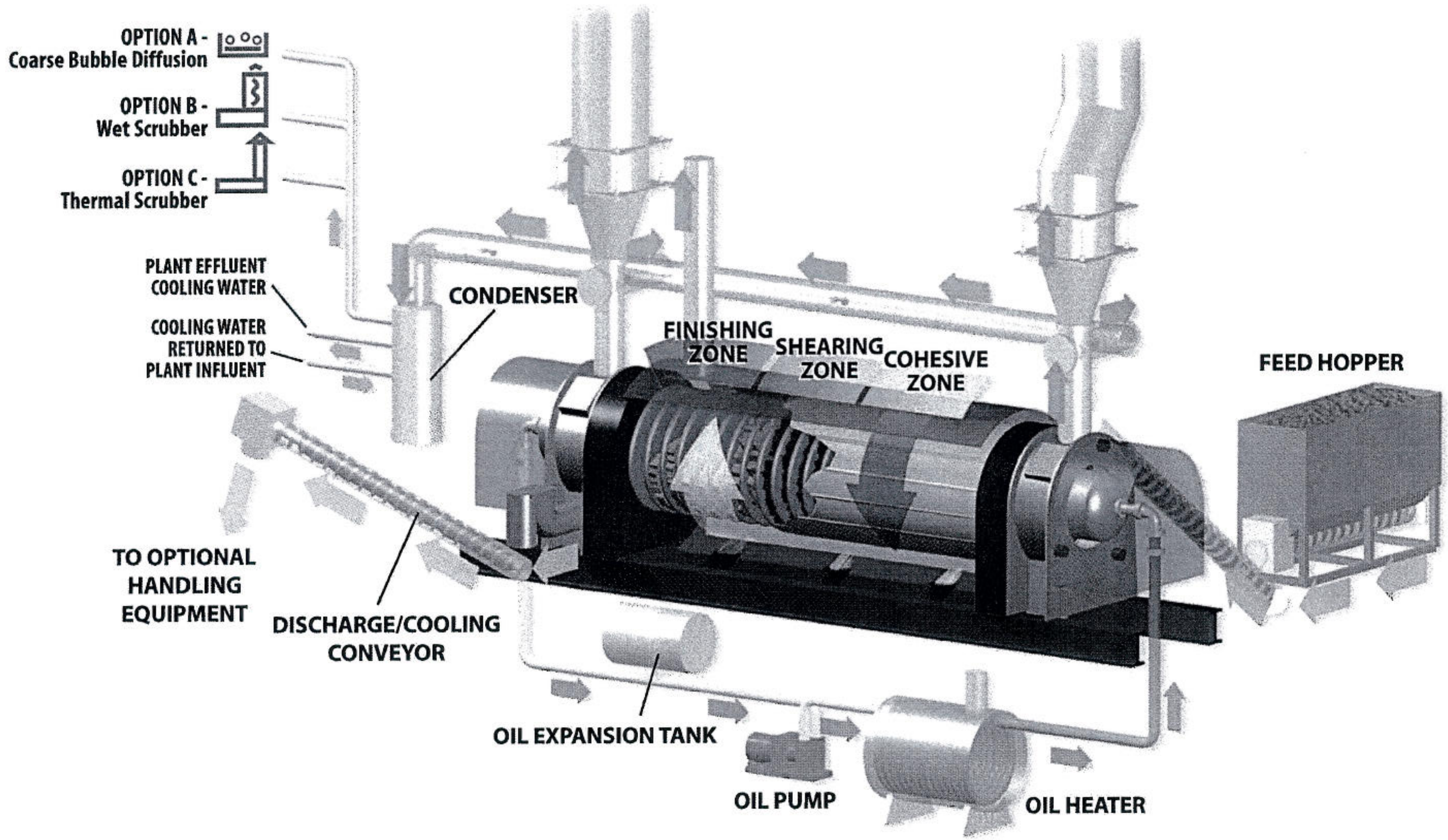
MEC- Minimum Explosion Concentration (g/m3)

MOC - Minimum Oxygen Concentration

P_{max} - Maximum Explosion Pressure (bar-g)

PLC - Programmable Logic Computer

THE NATIONAL BOARD - The National Board of Boiler and Pressure Vessel Inspectors was created in 1919 to promote greater safety to life and property through uniformity in the construction, installation, repair, maintenance, and inspection of boilers and pressure vessels. The National Board membership oversees adherence to codes involving the construction and repair of boilers and pressure vessels.



OPTION A - Coarse Bubble Diffusion
OPTION B - Wet Scrubber
OPTION C - Thermal Scrubber
PLANT EFFLUENT COOLING WATER
COOLING WATER RETURNED TO PLANT INFLUENT
CONDENSER
FINISHING ZONE
SHEARING ZONE
COHESIVE ZONE
FEED HOPPER
TO OPTIONAL HANDLING EQUIPMENT
DISCHARGE/COOLING CONVEYOR
OIL EXPANSION TANK
OIL PUMP
OIL HEATER

DRAGON DRYER®
INDIRECT BIOSOLIDS DRYING SYSTEM
PROPOSAL

Prepare especially for:

Ms. Sally Baldwin

CH2MHill

For a Wastewater Treatment Facility in

City of Guelph, Ontario

4,270 dry metric tonnes/year (54 wet tons @ 28% dry solids) operating 6 days per wiik, 24-hours per day, 52 weeks per year.

April 7, 2005

DAVCO PRODUCTS

Thomasville, Georgia 31792

USFilter

A Siemens Business

DRAGON DRYER®
INDIRECT BIOSOLIDS DRYING SYSTEM
PROPOSAL

Prepare especially for:

Ms. Sally Baldwin

CH2MHill

For a Wastewater Treatment Facility in

City of Guelph, Ontario

April 7, 2005

DAVCO PRODUCTS
Thomasville, Georgia 31792

USFilter
A Siemens Business

Proposal for USFilter Davco Products
Series 10020 Dragon Dryer®

Customer: **CH2MHill**	Date: **04/07/05**
	Prop. No: **050170-AO**

Design Parameters

Total quantity, wet tons per **calendar** day	**54.00**
Sludge cake percent dry solids entering dryer	**20**
Product dryness required	**90**
Gas cost, $/Therm (100 ft3)	**$0.80**
Electrical cost, $/kWh.	**$0.070**

USFilter Davco Products , is pleased to propose a Dragon Dryer® sludge drying system to meet your needs for the above project. This is a budgetary estimate only, based on the above design parameters.

Dryer model selected	**Series 10020**
Capacity, wet tons per day per dryer	**100.00**
Number of Dryers Required	**1**
Required hours of operation per week per dryer	**90.7**
Number of 24 hour of operation per week	**3.78**
Length of dryer, feet	**48'**
Width of dryer, feet	**10'-6"**
Height of dryer, feet	**12'6"**
Recommended minimum building size, ft2	**see attached drawing**
Excess dryer capacity, wet tons per 24 hour day	**46**

Product Characteristics Total

Product dry solids	**90**
Tons of dried biosolids produced per operating day	**21.8**
Cubic feet of dried biosolids produced per operating day	**968**

Operations & Maintenance (Per Dryer)

Estimated operating BTU/hour per dryer	**9,398,148**
Estimated average operating kW Total	**69**
Estimated gas usage, $ per operating day per dryer	**$1,804.44**
Estimated electrical usage, $ per operating day per dryer	**$115.30**
Estimated total utilities, $ per operating day per dryer	**$1,919.75**
Utilities operating cost per wet ton	**$19.20**
Utilities operating cost per dry ton	**$95.99**

Annual Cost

		$/Year
Labor cost , estimate		**$23,587**
Estimated annual utilities cost		**$377,345**
Maintenance, annual cost		**$18,833**
	Sub- total	**$419,766**
Product biosolids sales @	$5.00 Per Ton	**$21,403**
Estimated Annual Total Operations Cost		**$398,363**

Dryer Cost Estimate **$2,226,716**

Clarifications:
Basic Dryer unit only, which includes the equipment listed under "Scope of Supply".
Quoted price is FOB Thomasville, GA

Note: This is a budgetary estimate within 10-15 percent. A detailed firm quotation with any optional equipment and installation services can be prepared if desired.

Scope of Supply:
20 cubic yard feed hopper with variable speed screw.
One Series 10020 Dragon Dryer with Airlock Conveyor.
Covered discharge conveyor.
Drum combustion system consisting of a complete gas train, 4-2.0MM Btu output.
ASME code stamped thermal oil system and expansion tank with pump,10MM Btu output.
Dehydration Chamber pressure relief management system designed per NFPA.
Dehydration Chamber inert purge system designed per the NFPA code.
Condenser/Venturi with high speed pressure fan.
NEMA 4 UL listed system control panel with PLC and flame management.
Spare Parts consisting of (1) set of replacement drum and auger seals.
(3) Operational & Maintenance Manuals.
Installation supervision.
Start-up and operator training services.

Optional Equipment Not Included In The Above Pricing:

Sludge Feed/Holding Bins-
Up to 50 cubic yards are available.

Conveyors and Material Handling Equipment -
Enclosed conveyors can be furnished as necessary to provide a complete integrated system.

Product Storage Equipment -
Custom built Storage Silo's with pneumatic loading and automatic truck unloading.

Odor Scrubbers-
Complete packaged chemical scrubbers.

Dewatering Equipment-
Belt Presses, Centrifuges complete with polymer systems.

Product Screening-
Integral to the dryer system or stand alone.

Equipment Installation -
USFilter Davco Products has full field construction capabilities
and we are proud to offer the Dragon Dryer system on a installed basis in
a new or existing building.

DRAGON DRYER®
INDIRECT BIOSOLIDS DRYING SYSTEM
PROPOSAL

Prepare especially for:

Ms. Sally Baldwin

CH2MHill

For a Wastewater Treatment Facility in the

City of Guelph, Ontario

6,750 dry metric tonnes/year (92.2 wet tons @ 28% dry solids) operating 6 days per wiik, 24-hours per day, 48 weeks per year.

April 7, 2005

DAVCO PRODUCTS

Thomasville, Georgia 31792

USFilter

A Siemens Business

Proposal for USFilter Davco Products
Series 10020 Dragon Dryer®

Customer: **CH2MHill**	Date: **04/07/05**
	Prop. No: **050170-AO**

Design Parameters

Total quantity, wet tons per **calendar** day	**92.27**
Sludge cake percent dry solids entering dryer	**20**
Product dryness required	**90**
Gas cost, $/Therm (100 ft3)	**$0.80**
Electrical cost, $/kWh.	**$0.070**

USFilter Davco Products , is pleased to propose a Dragon Dryer® sludge drying system to meet your needs for the above project. This is a budgetary estimate only, based on the above design parameters.

Dryer model selected	**Series 10020**
Capacity, wet tons per day per dryer	**100.00**
Number of Dryers Required	**1**
Required hours of operation per week per dryer	**155.0**
Number of 24 hour of operation per week	**6.46**
Length of dryer, feet	**48'**
Width of dryer, feet	**10'-6"**
Height of dryer, feet	**12'6"**
Recommended minimum building size, ft2	**see attached drawing**
Excess dryer capacity, wet tons per 24 hour day	**8**

Product Characteristics Total

Product dry solids	**90**
Tons of dried biosolids produced per operating day	**21.8**
Cubic feet of dried biosolids produced per operating day	**968**

Operations & Maintenance (Per Dryer)

Estimated operating BTU/hour per dryer	**9,398,148**
Estimated average operating kW Total	**69**
Estimated gas usage, $ per operating day per dryer	**$1,804.44**
Estimated electrical usage, $ per operating day per dryer	**$115.30**
Estimated total utilities, $ per operating day per dryer	**$1,919.75**
Utilities operating cost per wet ton	**$19.20**
Utilities operating cost per dry ton	**$95.99**

Annual Cost

		$/Year
Labor cost , estimate		**$40,304**
Estimated annual utilities cost		**$644,771**
Maintenance, annual cost		**$18,833**
	Sub- total	**$703,908**
Product biosolids sales @	$5.00 Per Ton	**$36,572**
Estimated Annual Total Operations Cost		**$667,337**

Dryer Cost Estimate	**$2,226,716**

Clarifications:
Basic Dryer unit only, which includes the equipment listed under "Scope of Supply".
Quoted price is FOB Guelph, Ontario

Note: This is a budgetary estimate within 10-15 percent. A detailed firm quotation with any optional equipment and installation services can be prepared if desired.

Scope of Supply:
20 cubic yard feed hopper with variable speed screw.
One Series 10020 Dragon Dryer with Airlock Conveyor.
Covered discharge conveyor.
Drum combustion system consisting of a complete gas train, 4-2.0MM Btu output.
ASME code stamped thermal oil system and expansion tank with pump,10MM Btu output.
Dehydration Chamber pressure relief management system designed per NFPA.
Dehydration Chamber inert purge system designed per the NFPA code.
Condenser/Venturi with high speed pressure fan.
NEMA 4 UL listed system control panel with PLC and flame management.
Spare Parts consisting of (1) set of replacement drum and auger seals.
(3) Operational & Maintenance Manuals.
Installation supervision.
Start-up and operator training services.

Optional Equipment Not Included In The Above Pricing:

Sludge Feed/Holding Bins-
Up to 50 cubic yards are available.

Conveyors and Material Handling Equipment -
Enclosed conveyors can be furnished as necessary to provide a complete integrated system.

Product Storage Equipment -
Custom built Storage Silo's with pneumatic loading and automatic truck unloading.

Odor Scrubbers-
Complete packaged chemical scrubbers.

Dewatering Equipment-
Belt Presses, Centrifuges complete with polymer systems.

Product Screening-
Integral to the dryer system or stand alone.

Equipment Installation -
USFilter Davco Products has full field construction capabilities
and we are proud to offer the Dragon Dryer system on a installed basis in
a new or existing building.

Calculation of Daily Energy

Biosolids, % dry solids	20
Biosolids, Tons per day	100
Nat. Gas Cost, $/100cubic ft.	$0.80
Natural Gas, BTUs/Cubic Ft.	1000
Electrical Cost, $/KWH.	$0.07
Temperature at boiling point	212
Ambient temperature, Deg. F.	70
Moisture of Dried Product	90
Total installed horsepower,	115
Operating hours per day	24
Operating Hours per week	90.72
Volatile Content, percent	70

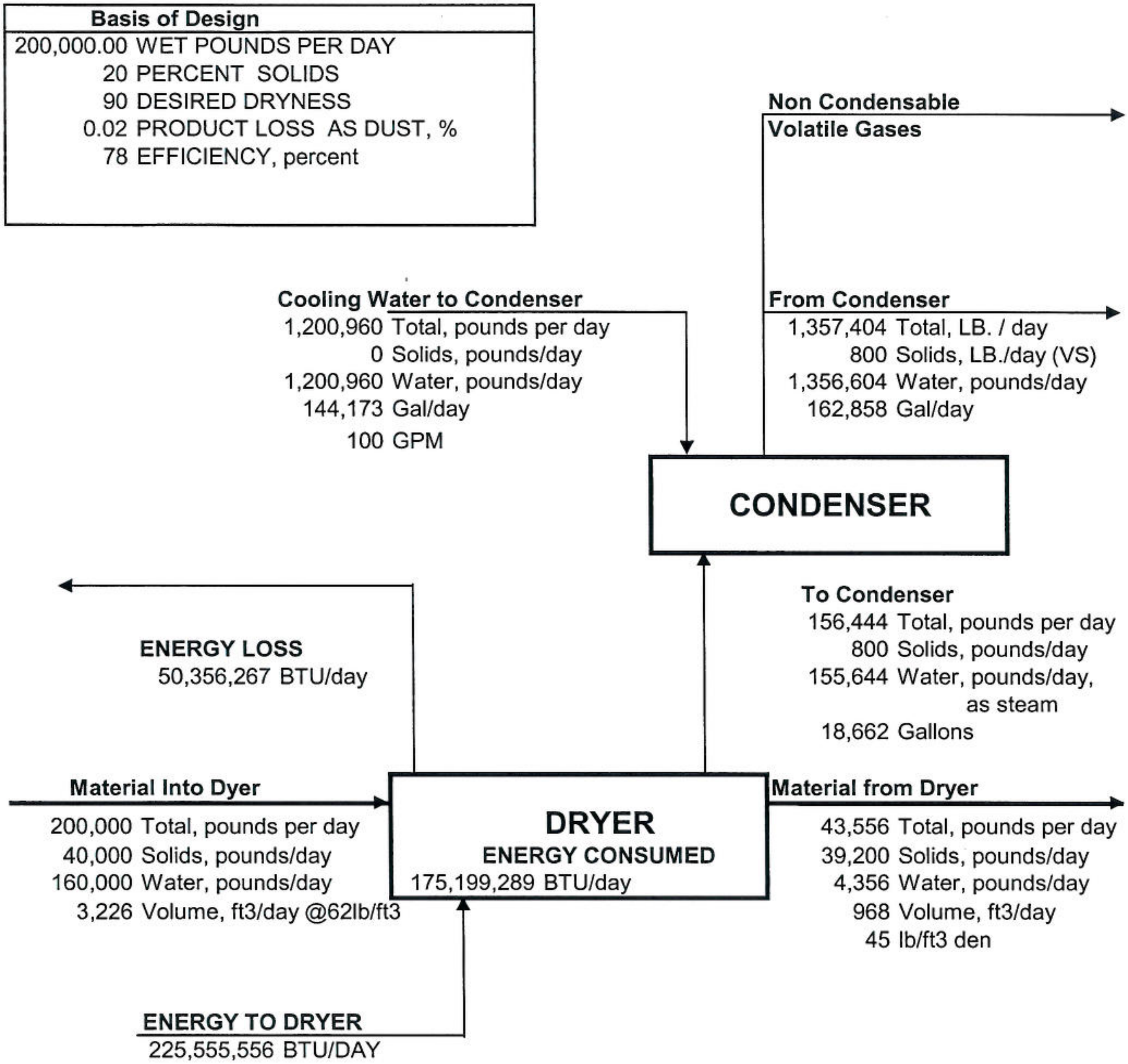
USFilter's Davis Products
Series 10020 Dragon Dryer

Operated 24 hours/Day

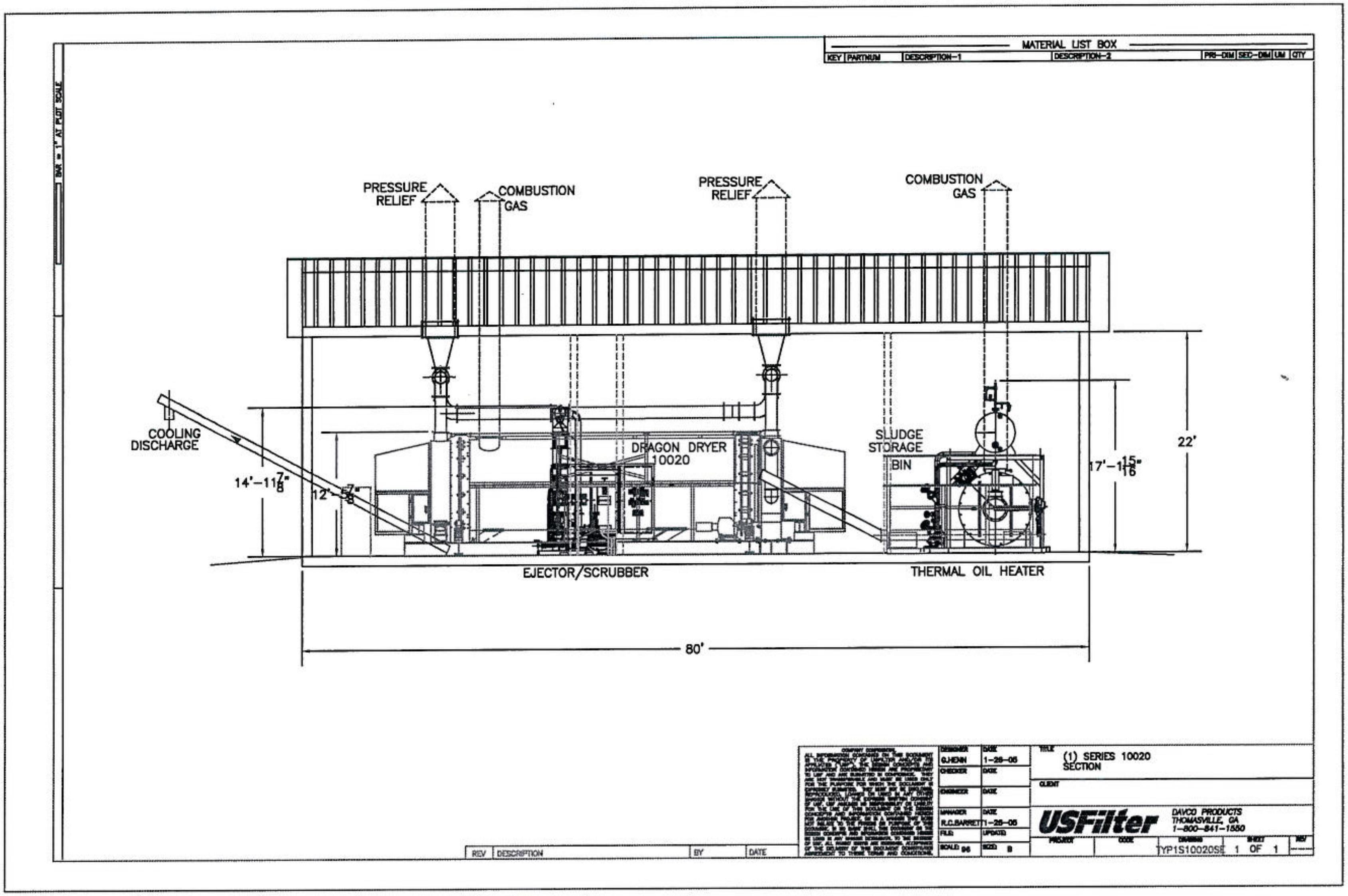
City of Guelph, Ontario

Total Pounds	Pounds 0 Solids	Pounds water Removed	Pounds H2o Remaining	Specific Heat (BTU/LB/Fo	Temperature Rise, Deg.F	Theo. BTUs Required	Cubic FT. Gas	Natural Gas Cost, $	Electrical $/day
200,000.00									
	28,000.00	VOLATILE	Volatile	0.4	142	1,590,400	1,590	$12.72	0
	12,000.00	ASH	Ash	0.22	142	374,880	375	$3.00	0
		155,556		1	142	22,088,889	22,089	$176.71	0
			4,444	1	142	631,111	631	$5.05	0
				Sub Total		24,310,400	0	$197.48	115
	Latent Heat of Vaporization for Water @970 BTU/Lb.H2O					150,888,889	150,889	$1,207.11	0
				TOTAL		175,199,289	175,199	$1,404.59	0
				ESTIMATED ACTUAL BTU		225,555,556	225,556	$1,804.44	0
						Theoretical Operating Cost			$1,519.90
						Actual Operating Cost			$1,919.75

Theoretical BTU's per pound of water	1,126
Actual BTUs per pound of water	1450
Efficiency, %	77.7
Actual Projected Daily Gas Cost	$1,804.44
Actual Projected Daily Elect Cost	$115.30
Actual Projected Daily Total Cost	$1,919.75
Cost per Wet Ton	$19.20
Cost per dry Ton	$95.99
Estimated Operating BTU/hour	9,398,148



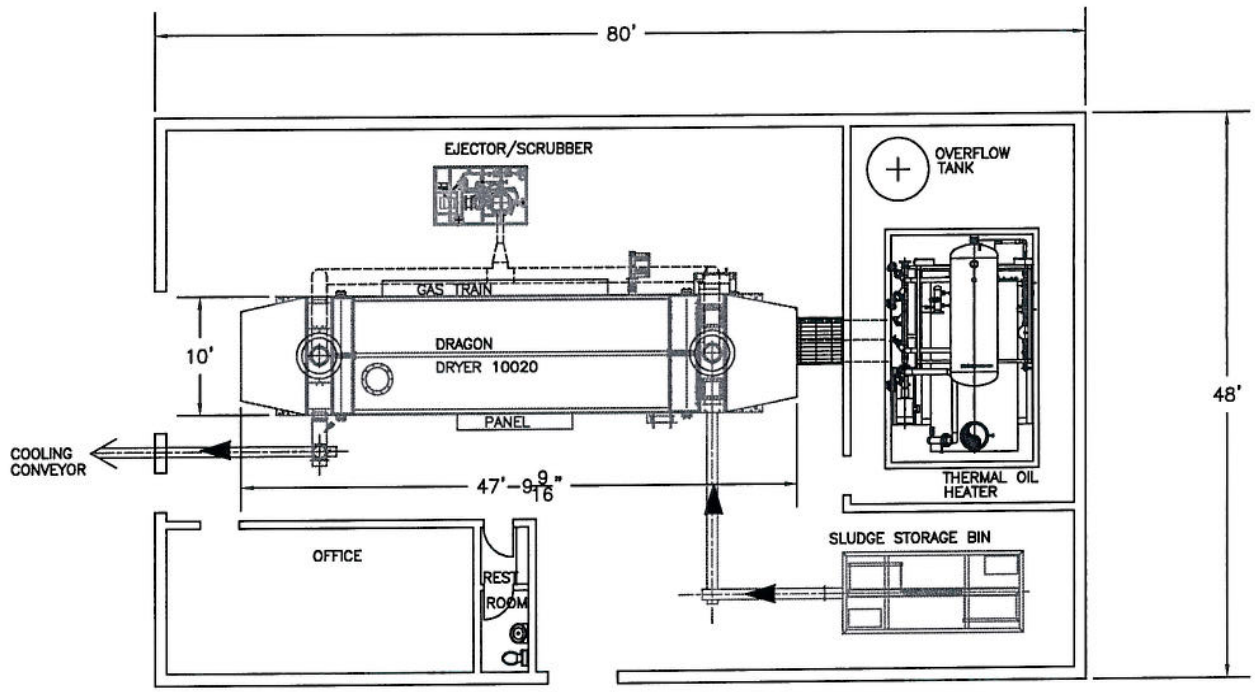
City of Guelph, Ontario
USFilter's Dragon Dryer
Mass Balance


MATERIAL LIST BOX
KEY PARTNUM DESCRIPTION-1 DESCRIPTION-2 PRI-DIM SEC-DIM UM QTY
BAR = 1" AT PLOT SCALE
PRESSURE RELIEF
COMBUSTION GAS
PRESSURE RELIEF
COMBUSTION GAS
COOLING DISCHARGE
14'-11 7/8"
12'-5 7/8"
DRAGON DRYER 10020
SLUDGE STORAGE BIN
17'-1 15/16"
22'
EJECTOR/SCRUBBER
THERMAL OIL HEATER
80'
REV DESCRIPTION BY DATE
DESIGNER G.HENN DATE 1-26-05
CHECKER DATE
ENGINEER DATE
MANAGER R.C.BARRETT DATE 1-26-05
FILE: UPDATED
SCALE: 96 SIZE: B
TITLE (1) SERIES 10020 SECTION
CLIENT
USFilter
DAVCO PRODUCTS
THOMASVILLE, GA
1-800-841-1550
PROJECT CODE DRAWING SHEET REV
TYP1S10020SE 1 OF 1

BAR = 1" AT PLOT SCALE

MATERIAL LIST BOX

KEY	PARTNUM	DESCRIPTION-1	DESCRIPTION-2	PRI-DIM	SEC-DIM	UM	QTY



REV	DESCRIPTION	BY	DATE

COMPANY CONFIDENTIAL

DESIGNER	DATE
G.HENN	1-17-05
CHECKER	DATE
ENGINEER	DATE
MANAGER	DATE
R.BARRETT	1-17-05
FILE	UPDATED
SCALE 100	SIZE B

TITLE (1) SERIES 10020 PLAN

CLIENT

USFilter

DAVCO PRODUCTS
THOMASVILLE, GA
1-800-841-1550

PROJECT	CODE	DRAWING	SHEET	REV
		TYP1S10020P	OF	000

MessageFrom: Baldwin, Sally/KWO
Sent: Monday, February 28, 2005 2:57 PM
To: Burrowes, Peter/KWO
Subject: Berlie quote for Guelph

By phone:

4,270 dt/yr $4,950,000 incl. installation
6,750 dt/yr $6,750,000 incl. installation
Storage 4 of 100 m3 silos $500,000 incl installation
(no fire suppressant/options)

N-VIRO SYSTEMS
CANADA INC.

Corporate Head Office
1307 Highway 2 East
Post Office Box 280
Maitland, Ontario
K0E 1P0

Telephone: 613-348-3302
Fax: 613-348-1050

E-Mail:
wallin@recorder.ca

RECEIVED
MAR 0 3 2005
CH2M HILL LTD.

February 28, 2005

Via Fax: (519) 579-8986

Ms. Sally Baldwin
CH_2M Hill Canada Ltd.
100 King Street, South
Waterloo, Ontario N2J 1P8

Re City of Guelph – Proposed N-Viro Biosolids Management Facility

Dear Ms. Baldwin:

We are pleased to respond to your February 8, 2005, request for a biosolids management proposal.

We have provided cost estimates for three operating options – the two outlined in your letter (5 days per week, 16 hours per day and 7 days per week, 24 hours per day) plus an option for 5 days per week, 8 hours per day. Design criteria and capital and operating costs are shown in the appended tables.

While the capital cost is slightly more for Option 3, the operating costs are considerably less, resulting in the lowest overall annual cost. We are recommending this option. It will have a capital cost of $3,619,000 with an annual operating cost of $665,100, or $156 per dry tonne and $47 per wet tonne of solids. We have not included the cost to amortize due to the variability of borrowing rates but the maximum should add less than 50% to the annual costs. We typically use a 20-year amortization period.

Following are details on the design assumptions, equipment and operating costs:

Dewatered Cake

The design is based on a dewatered cake of 30% as indicated in your letter. However, the N-Viro Soil process is quite flexible and can accommodate solids levels in the range of 25 to 35%. Of course, the alkaline admixture dosage would vary to provide the target figure of 46% mixed solids entering the dryer.

Toronto Office
205 Wynford Drive, #302
North York, Ontario
M3C 3P4

Telephone: 416-423-3998
Fax: 416-423-0299

Mixer

We are proposing the use of the CemenTech proportioner/mixer, a CSP 2-15 (15 tons per hour capacity of mixed solids) for option 3 and a CSP 2-10 (10 tons per hour capacity) for Options 1 and 2. They have the same physical dimensions, with motor modifications to meet the required throughput. A sketch of the proportioner/mixer is attached.

At each of our existing facilities, the dewatered sludge drops directly into the sludge "day bin" on the proportioner/mixer. This eliminates the need for additional conveyors and avoids the potential to change the sludge characteristics which result from certain types of conveying devices. If it were possible to arrange direct discharge with the proposed, additional dewatering equipment there would be considerable advantage.

Dryer

We are proposing the Duske, single-pass, rotary-drum dryer. The preferred option would have a CSD-6000, which is capable of evaporating up to 6,000 lb. of water per hour and has a capacity of 10.9 tonnes of mixed solids per hour. Duske models CSD-3000 and CSD-1500 are proposed for the other two options. A sketch showing the relevant dimensions of each of the models is attached.

Conveyors

The proposal incorporates a belt conveyor from the mixer to the dryer and screw-conveyors (stainless steel) from the dryer to the heat-pulse cells. It may be possible to use some of the conveyors in the existing compost facility, thereby reducing costs.

Odour Control

A Venturi scrubber followed by a condenser/separator is proposed for particulate removal and for condensing and cooling the air flow. Ammonia removal will be achieved through this system as well.

An organic media biofilter completes the odour-control system. The biofilter will be approximately 1,800 square feet.

It is possible that the existing biofilter, other pollution control facilities or components could be used, thereby reducing the projected pollution control costs.

Storage

As advised, we have proposed 4 months' product storage. The required area is based on a maximum pile height of 20 feet; hence, the need for a stacking conveyor. The product will be in the range of 60 – 65% solids.

Product Marketing

N-Viro Canada's proposal includes the cost of marketing and distributing the final product. There is no cost to the city beyond the processing stage. The product has received widespread acceptance in the agricultural sector, so much so that the product from N-Viro's two Ontario plants is in a continuously oversold position.

The product is marketed by established farm products' distributors through agreement with N-Viro Canada. This ensures that it will be professionally applied and only at agronomic rates.

The product is approved by the Canadian Food Inspection Agency (CFIA) under Ag Canada's Federal Fertilizers Act. No land application approvals are required from the Province.

Product Revenue

The farm products' distributor pays for the product at the "gate". N-Viro Canada will enter into an agreement with the city whereby the city could receive revenue of up to $5.00 per product tonne (based on a 50/50 split), a return of approximately $68,500 per year at design volumes. This would partially offset the annual costs.

Existing Facilities

We have had an opportunity to examine the existing biosolids composting facility and the abandoned buildings at the west end of the wastewater treatment plant property.

The equipment for the N-Viro technology could be accommodated with ease in the composting building, avoiding the need for additional processing footage. Only the product storage building would be required. Closer review of existing equipment should indicate that certain components could be used, reducing capital costs indicated.

The abandoned buildings also appear to be of sufficient size to accommodate the N-Viro equipment. The concrete structure would house the proportioner/mixer, dryer and scrubbing system. If additional dewatering is to be provided, it could be placed on the roof, allowing the dewatered cake to discharge directly into the mixer. The open-sided, metal clad building could be readily expanded to meet the product storage requirements.

Summary

N-Viro Canada's proposed N-Viro Soil technology provides a simple alternative or supplement to the existing biosolids composting facility. Among its many attributes are:

- It is a proven technology with over 13 years of combined, successful operating experience at Ontario's two existing , similar facilities
- The product is a safe, low-odour, granular, soil-like material that has many beneficial reuse options
- The product's soil-like characteristics ensure that it will not run off into surface waters or infiltrate groundwaters
- The product has received widespread acceptance in the agricultural community, with oversold situations at both existing plants
- Revenue potential for the city
- It meets the requirements of Ag Canada's Fertilizers Act
- The product meets the US EPA 503 Regulation for a Class "A" designation
- N-Viro Canada carries product liability insurance for all its facilities. This, plus the pathogen destruction and process and product control, minimize any risk to the city.

We would be pleased to meet with you and city officials to discuss the proposal. If there are any questions please call me at (613) 348-3302 or Grant Mills at (905) 566-9464.

Yours truly,

N-VIRO SYSTEMS CANADA INC.

R. E. Wallin,
President and Chief Executive Officer

CITY OF GUELPH
TABLE 1
DESIGN CRITERIA

PROPOSED N-VIRO SOIL FACILITY **4,270 Dry Tonnes /yr.**			
	Option 1 5 days/week 16 hours/day	**Option 2** 7 days/week 24 hours/day	**Option 3** 5 days/week 8 hours/day
Sludge Production (Dry Tonnes per Day) (Dry Tonnes per Year)	16.4 4,270	11.7 4,270	16.4 4,270
Sludge Cake (Percent Total Solids)	30	30	30
Sludge Production (Wet Tonnes per Day) (Wet Tonnes per Year)	54.7 14,200	39.0 14,200	54.7 14,200
Percent Total Solids of Mixture (%TS)	46	46	46
Alkaline Admixture Dosage (%)	30	30	30
Alkaline Admixture Usage (Tonnes per Day) (Tonnes per Year)	16.4 4,270	11.7 4,270	16.4 4,270
Dryer Feed (Tonnes per Hour) Dryer Feed (Tonnes per Day)	4.4 71.1	2.1 50.7	8.8 71.1
Dryer Operating Hours per Day	16	24	8
Average Dryer Product (%TS)	62	62	62
N-Viro Soil Product (Tonnes per Day) (Tonnes per Year)	52.7 13,700	37.6 13,700	52.7 13,700
Water Evaporated (Pounds per Hour)	2,530 [1]	1,200 [2]	5,060 [3]
Total BTU Consumption(Million BTU per Day)	56.7	40.3	56.7
Dryer Air Flow (Cubic Feet per Minute)	7,500	3,750	15,000
Alkaline Admixture Density(Pounds per Cu. Ft.)	55	55	55
Alkaline Admixture Storage Silos (Cu. Ft.)	3,000	3,000	3,000
Number of Days of CKD Storage	4	6	4
Number of Production Days per year	260	365	260

1. use CSD-3,000 dryer; capacity 3,000 lb. water evaporated /hr and 5.45 mixed tonnes/hr.
2. use CSD-1,500 dryer; capacity 1,500 lb. water evaporated /hr and 2.75 mixed tonnes/hr.
3. use CSD-6,000 dryer, capacity 6,000 lb. water evaporated /hr and 10.9 mixed tonnes/hr.

CITY OF GUELPH

TABLE 2

CAPITAL COST ESTIMATE

PROPOSED N-VIRO SOIL FACILITY

	Option 1 5 days /week 16 hours /day	**Option 2** 7 days / week 24 hours /day	**Option 3** 5 days / week 8 hours /day
Insurance and bonds	$ 50,000	$ 50,000	$ 50,000
Product storage building (12,000 sq. ft. @ $40 sq.ft.)	480,000	480,000	480,000
Major Equipment			
Mixer and AA silos	446,000	446,000	460,000
Dryer	700,000	608,000	807,000
Conveyors	150,000	150,000	170,000
Odour Control	375,000	300,000	663,000
Stacking Conveyor	40,000	40,000	40,000
Electrical	130,000	130,000	130,000
Instrumentation	50,000	50,000	50,000
Site modifications	100,000	100,000	100,000
Sub Total	$ 2,521,000	$ 2,354,000	$ 2,950,000
5% Contingency allowance	126,000	118,000	147,000
Total construction cost	2,647,000	2,472,000	3,097,000
12% engineering	318,000	297,000	372,000
Total construction & engineering	2,965,000	2,769,000	3,469,000
N-Viro Royalty	150,000	150,000	150,000
Total project estimate	$ 3,115,000	$ 2,919,000	$ 3,619,000

CITY OF GUELPH

TABLE 3

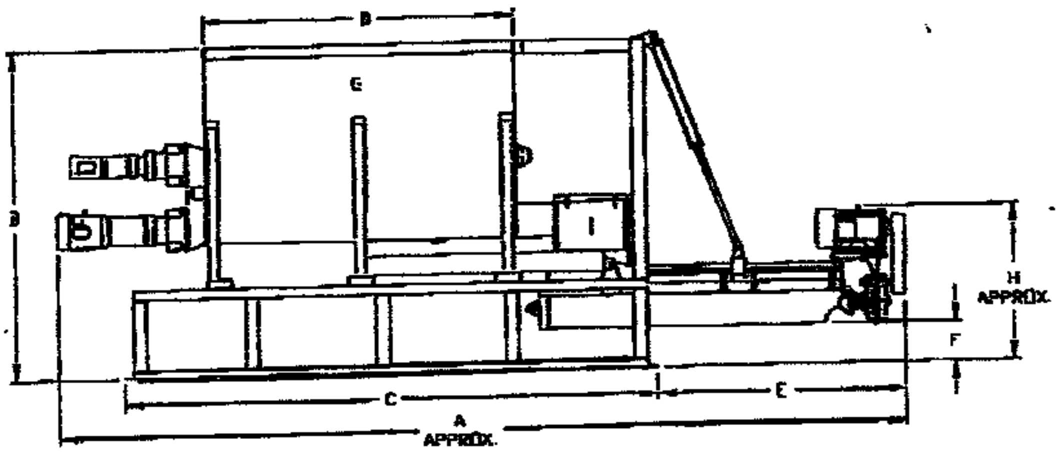
OPERATING COST ESTIMATE

PROPOSED N-VIRO SOIL FACILITY

	Option 1 5 days / week 16 hours / day	Option 2 7 days/week 24 hours/day	Option 3 5 days/week 8 hours/day
1. Staffing			
N-Viro Manager	$ 55,000	$ 55,000	$ 55,000
Operating labour	120,000	280,000	40,000
2. Energy			
Electrical (@ $0.07 / kwh.)	43,100	70,000	35,000
Natural gas (@ $0.27 / cu.m.)	112,000	112,000	112,000
3. Supplies			
Alkaline admixture (@ $30 / tonne)	128,100	128,100	128,100
Maintenance	25,000	25,000	25,000
4. QA / QC and Chemicals	20,000	20,000	20,000
5. General, Administration and Contingency	50,000	50,000	50,000
6. N-Viro Services	200,000	200,000	200,000
	$ 753,200	$ 940,100	$ 665,100
Operating cost: per dry tonne (4,270)	$176	$220	$156
per wet tonne (14,200)	53	66	47

Leaders in volumetric Proportioning
And Continuous Mixing Systems
1700 North 14th Street – Indianola, Iowa 50125
Phone: 800 / 247-2464 or 515 / 961-7407 FAX 515 / 961-7409
Www.cementech.com

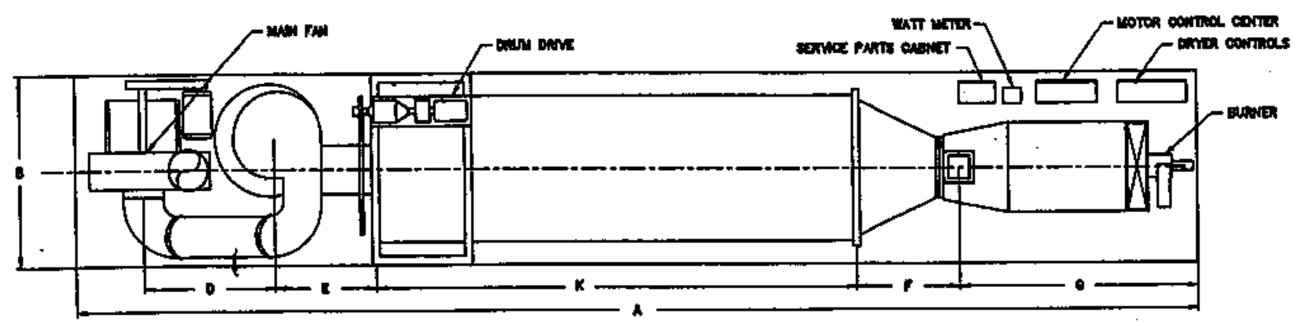
CSP2-10

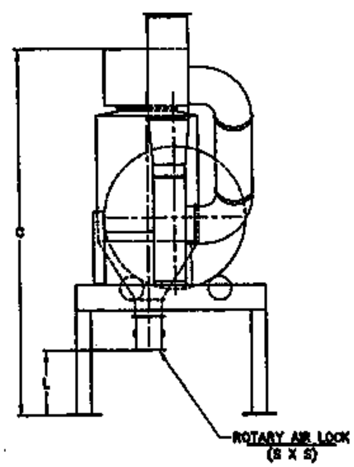


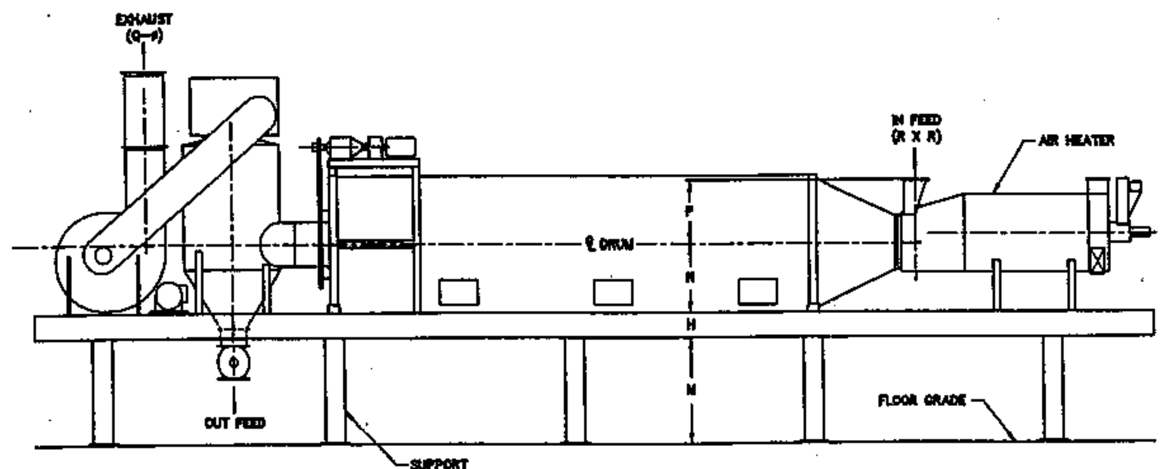
CSP2-10 DIMENSIONS AND DATA

DIMENSION	
A	21' – 8"
B	8' – 6"
C	13' – 9"
D	8' – 0"
E	6' – 4"
F	1' – 0"
G	126 CU.FT.
H	4' – 0"
I	MIX BOX
MIXER DIAMETER	12"
SLUDGE BIN WIDTH	6' – 0"
HP MIXER	15 HP
HP AGITATOR	2 HP
HP SLUDGE AUGER	3 HP
VOLTAGE	460 VAC
EMPTY WEIGHT	6,160 LBS.

	CSD-6000	CSD-3000	CSD-1500
A	65'-0"	49'-0"	38'-6"
B	8'-5 1/2"	8'-6"	6'-4"
C	16'-8"	14'-7"	12'-2"
D	6'-6"	5'-3"	4'-6"
E	5'-0"	4'-0"	3'-6"
F	5'-9 1/2"	5'-1 1/2"	3'-7"
G	15'-11 1/2"	12'-0"	8'-1"
H	1'-2"	1'-0"	10"
K	28'-6"	20'-0"	16'-6"
L	2'-8"	2'-2"	2'-2"
M	4'-6"	3'-1"	3'-6"
N	3'-3 1/2"	3'-8"	2'-6"
P	2'-4"	2'-0"	1'-10 1/2"
Q	23"	17"	12"
R	14"	12"	9"
S	14"	12"	12"







SINGLE PASS ROTARY DRYER

UNLESS OTHERWISE NOTED ALL DIMENSIONS ARE IN X'-X"
TOLERANCES ARE:
MACHINING: .XX = ±.010, .XXX = ±.005
FABRICATION: X/X = ±1/32", X" = ±1"
BREAK ALL SHARP EDGES
DEBURR ALL HOLES

cemen tech INC.
1400 North 14th Street, Indianola, Iowa 50125

SCALE NONE 24	APPROVED BY	DRAWN BY DJ	
DATE 7/21/94		REVISED	
C:\TEMP\DRYER2			
DWG TYPE—DESCRIPTION GENERAL DIMENSION			
USED ON CSD-6000 CSD-3000 CSD-1500	DRAWING NUMBER 400-S94-1111	REV LTR N/C	

ATTACHMENT C

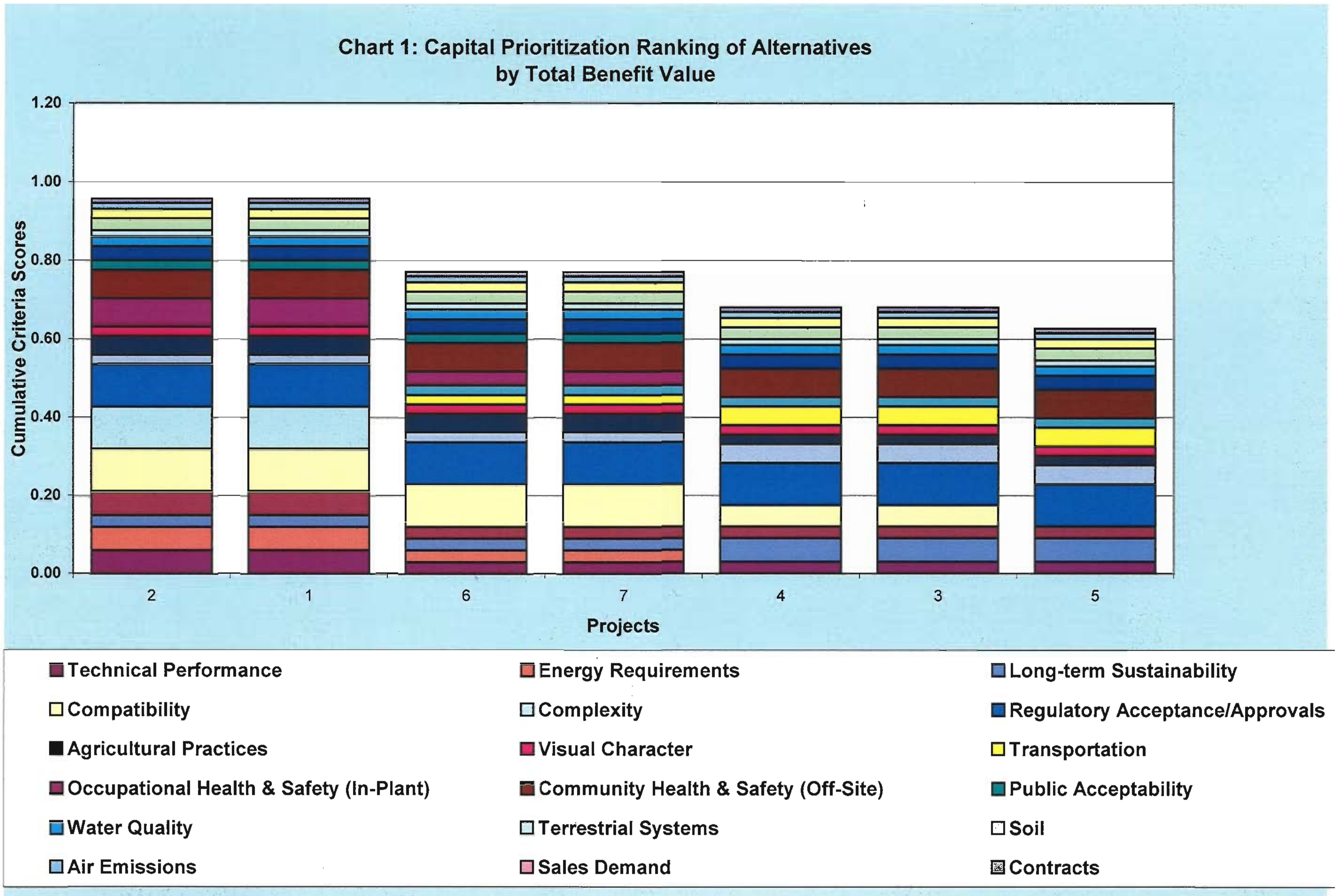


Chart 1: Capital Prioritization Ranking of Alternatives
by Total Benefit Value
Cumulative Criteria Scores
1.20
1.00
0.80
0.60
0.40
0.20
0.00
2
1
6
7
4
3
5
Projects
Technical Performance
Energy Requirements
Long-term Sustainability
Compatibility
Complexity
Regulatory Acceptance/Approvals
Agricultural Practices
Visual Character
Transportation
Occupational Health & Safety (In-Plant)
Community Health & Safety (Off-Site)
Public Acceptability
Water Quality
Terrestrial Systems
Soil
Air Emissions
Sales Demand
Contracts

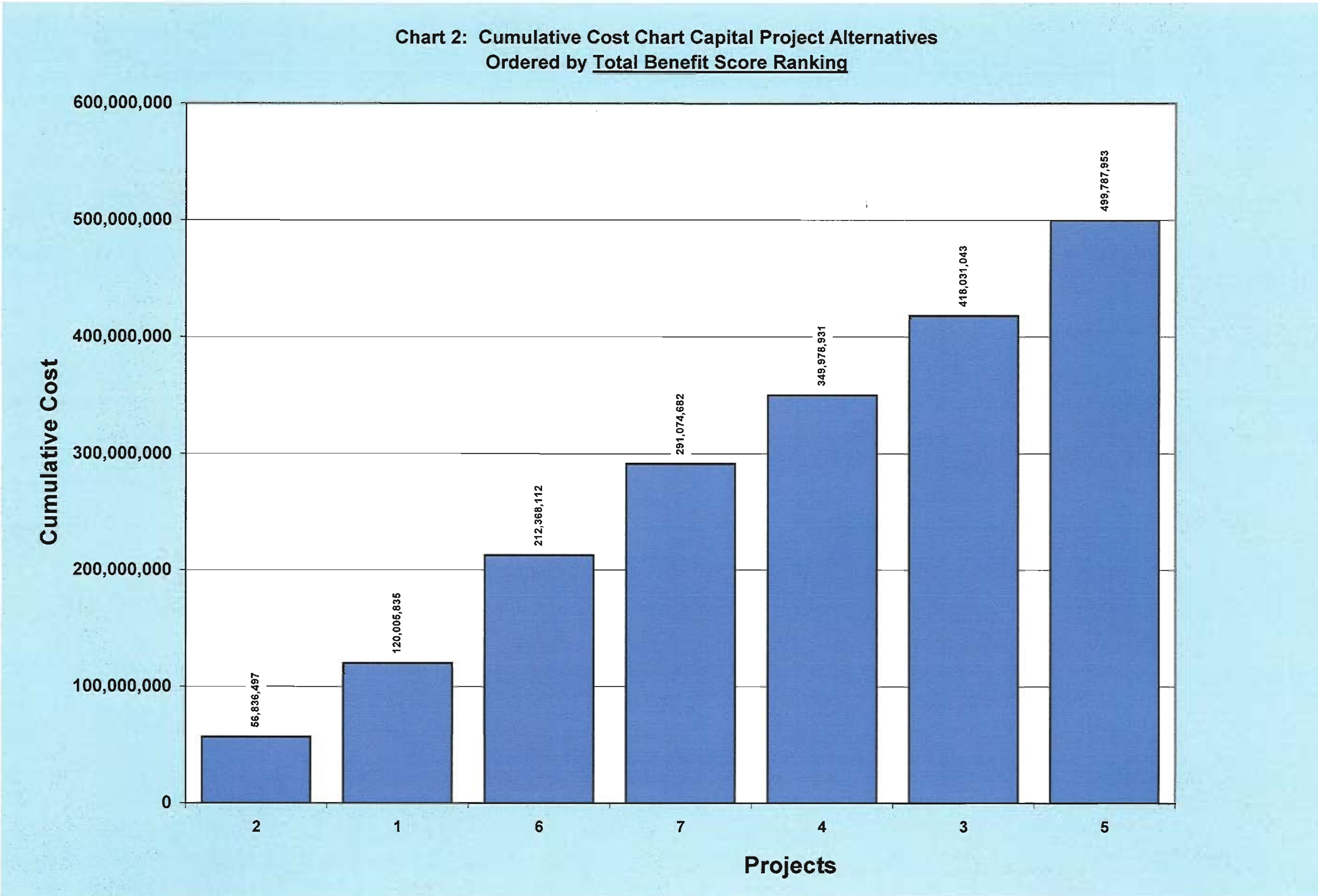


Chart 2: Cumulative Cost Chart Capital Project Alternatives
Ordered by Total Benefit Score Ranking
Cumulative Cost
600,000,000
500,000,000
400,000,000
300,000,000
200,000,000
100,000,000
0
56,836,497
120,005,835
212,368,112
291,074,682
349,978,931
418,031,043
499,787,953
2
1
6
7
4
3
5
Projects

Chart 3: Cumulative Benefit-Cost Chart for Long-Term Alternatives, Ordered by Benefit-Cost Ranking

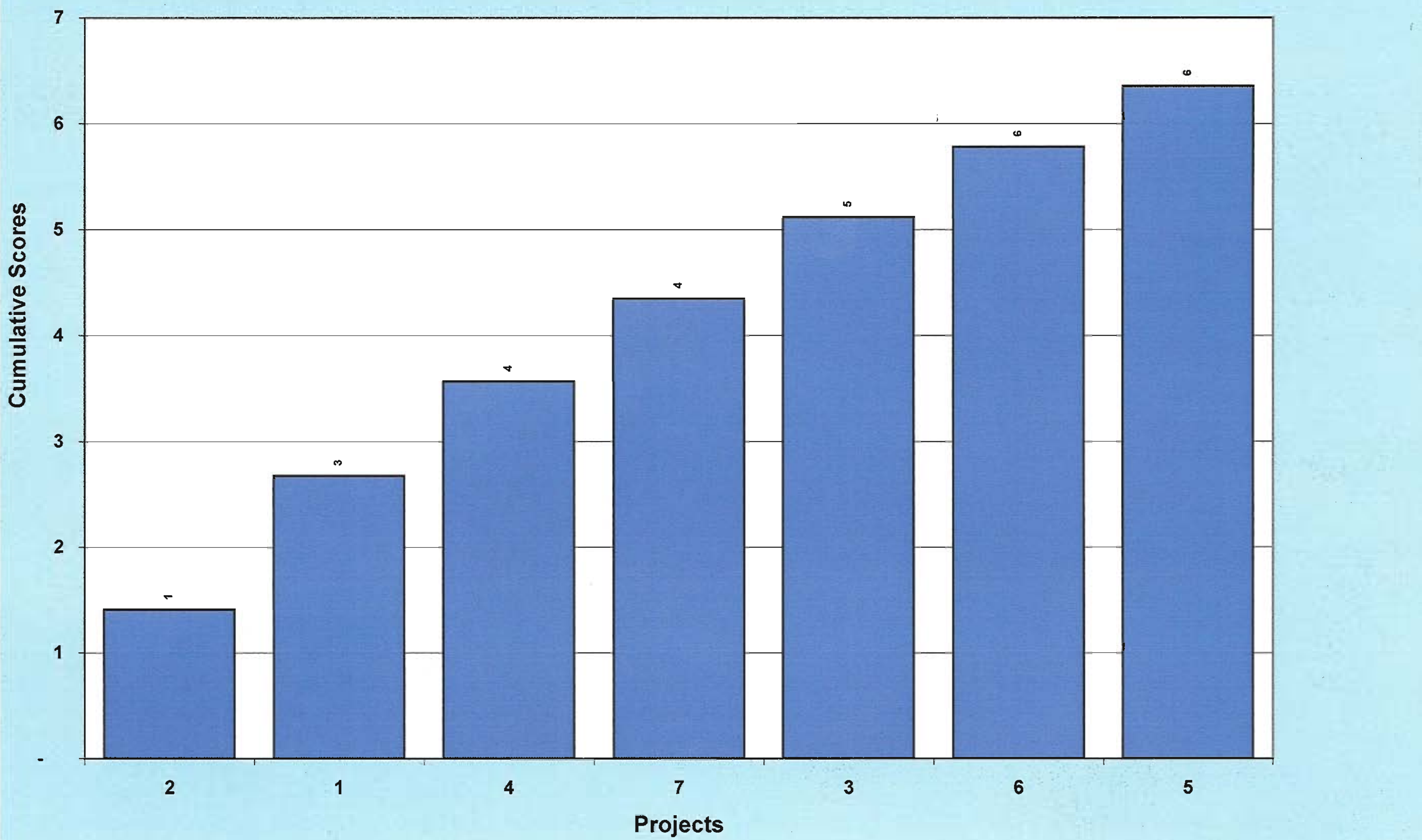
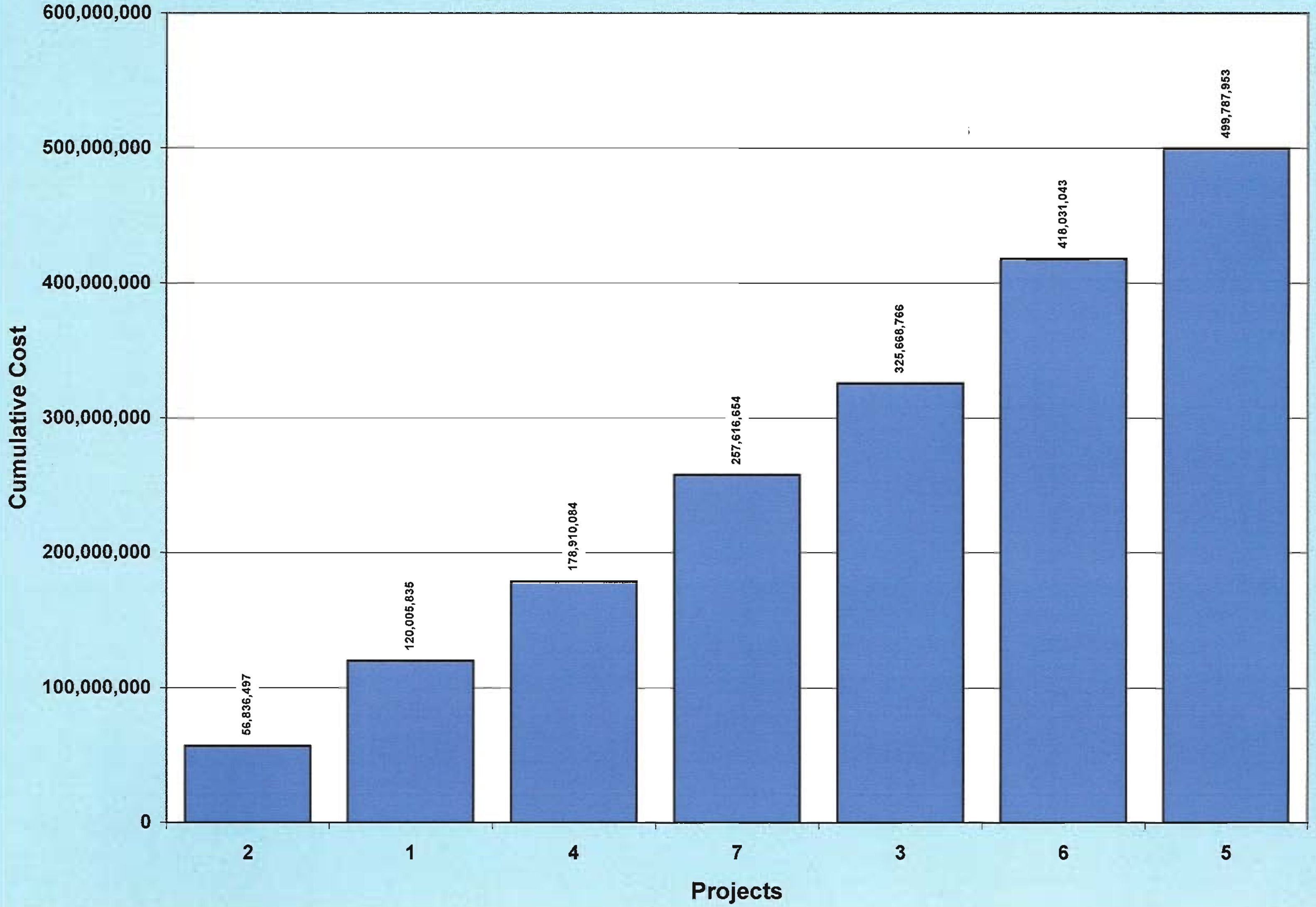


Chart 4: Cumulative Cost Chart of Long-Term Alternative Capital Projects
Ordered by Benefit-Cost Ranking



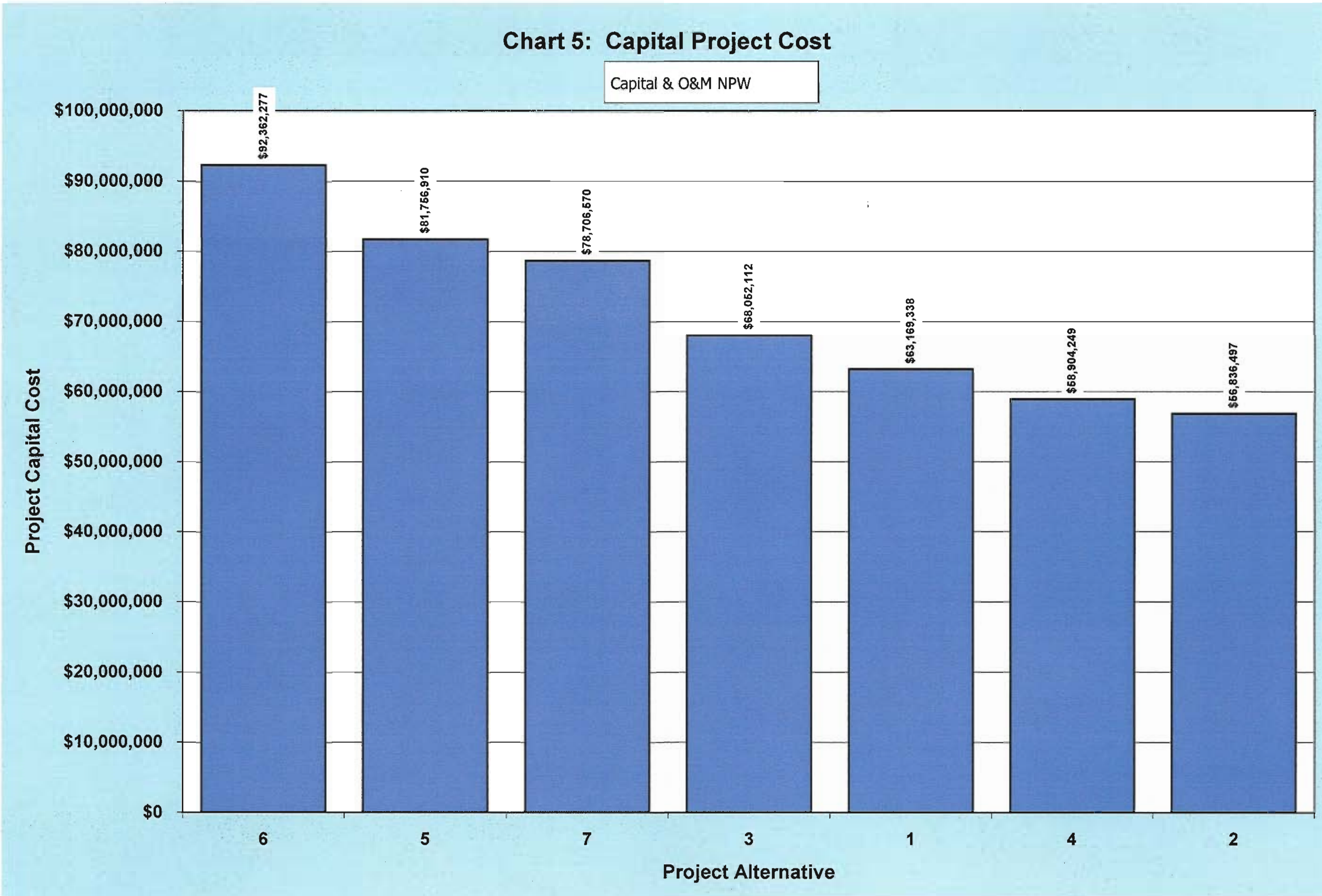


Chart 5: Capital Project Cost
Capital & O&M NPW
Project Capital Cost
$100,000,000
$90,000,000
$80,000,000
$70,000,000
$60,000,000
$50,000,000
$40,000,000
$30,000,000
$20,000,000
$10,000,000
$0
$92,362,277
$81,756,910
$78,706,670
$68,052,112
$63,169,338
$58,904,249
$56,836,497
6
5
7
3
1
4
2
Project Alternative

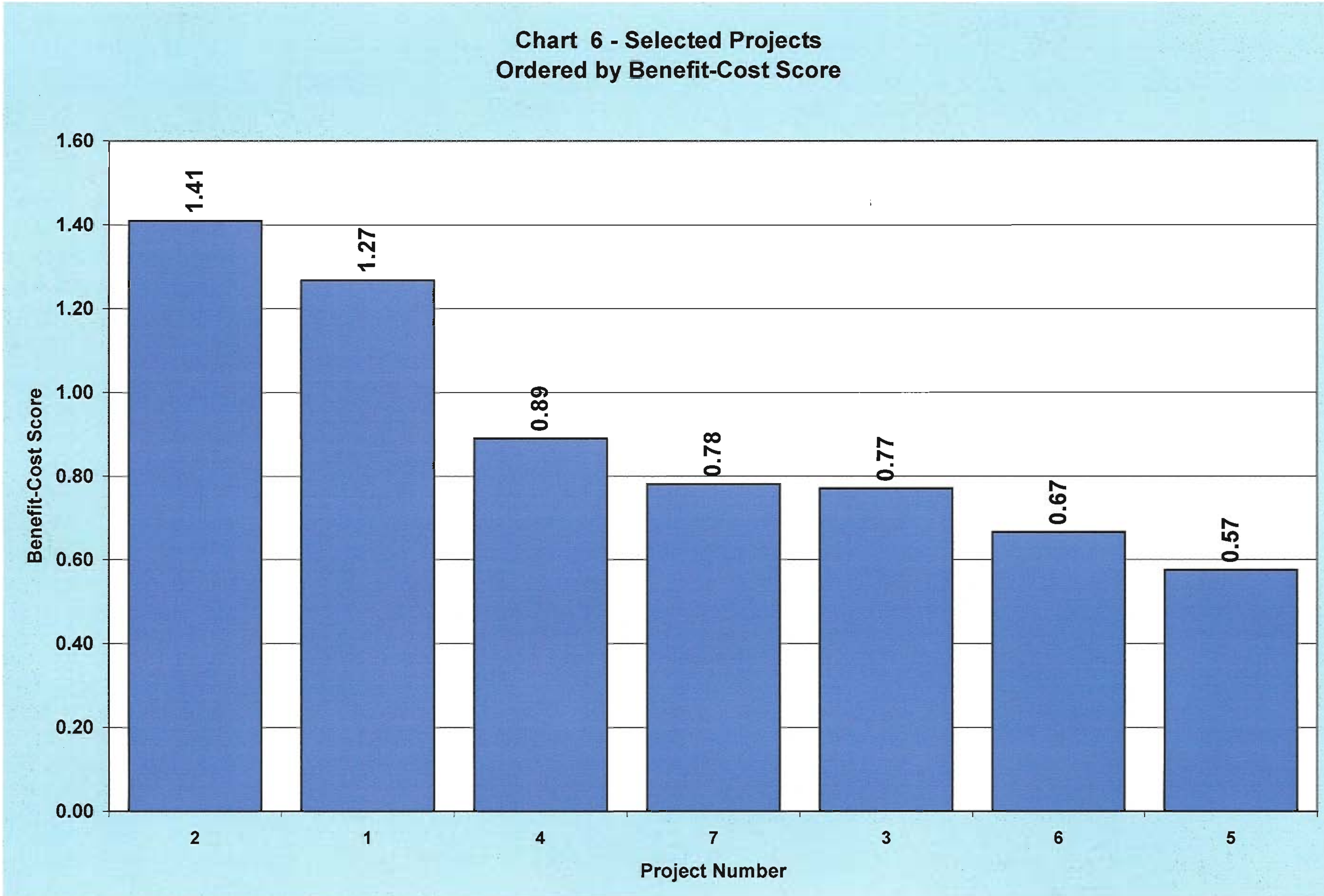


Chart 6 - Selected Projects
Ordered by Benefit-Cost Score
Benefit-Cost Score
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1.41
1.27
0.89
0.78
0.77
0.67
0.57
2
1
4
7
3
6
5
Project Number

Appendix G

Recommended Strategy and Implementation Plan Overview

City of Guelph Biosolids Management Plan Recommended Strategy and Implementation Plan

PREPARED FOR:	James Etienne, City of Guelph
PREPARED BY:	Peter Burrowes, CH2M HILL Sally Baldwin, CH2M HILL
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DATE:	November 2005

1. Recommended Strategy

Seven feasible biosolids management strategies for the Guelph WWTP were developed and evaluated in TM 4-III. It was determined that the preferred strategy, which maximizes the City's existing investments at the WWTP, includes the following:

- Maintain the existing biosolids management technologies, and expand process capacities as required
  - WAS thickening;
  - Digestion;
  - Dewatering;
  - Lystek treatment and land application;
  - Dewatered cake land application;
  - Composting and compost beneficial use; and
  - Emergency liquid biosolids land application; dewatered cake and/or compost landfilling, if required.
- Construct storage facilities for Lystek-treated biosolids and composted biosolids to maximize beneficial use.
- Consider alternative further treatment technologies as the compost facility comes to the end of its useful life, to maintain a diversified program.
- Develop a plan to implement this strategy. The implementation plan must include measures to reduce the City's risk and liabilities.

This memorandum provides an overview of the recommended strategy and develops the implementation plan for the Guelph WWTP Biosolids Management Plan.

2. Strategy Overview

The City currently processes the biosolids generated by the conventional activated sludge wastewater treatment plant with anaerobic digestion and belt-press dewatering. The dewatered cake is primarily land applied or landfilled. The dewatered cake may also be composted in the in-vessel facility, but partly due to a lack of market for the composted biosolids, the composting facility is primarily used to increase the solids content of the cake so that it is accepted by, and easier to dispose of at, the landfill.

The review of the existing biosolids management program and the analysis of feasible alternative biosolids management options indicated that the existing method of management is the most economical for the City and provides the greatest benefit per unit cost, as discussed in TM4-IIIB. It is anticipated that there will be sufficient agricultural land available to land apply biosolids over the period of this study. There will be a need to provide additional storage for Lystek-treated biosolids and composted biosolids to maximize beneficial use and reduce dependency on landfilling. Additionally, market development for compost is required, with initial results showing potential interest from sod farmers and soil blenders in the area.

The compost facility was commissioned in 1995. As with most industrial machinery, it is anticipated that with continued maintenance, it will have a reliable life of approximately 20 years. Consistent with the findings of TM2, significant refurbishment of the compost facility will likely be required in approximately 8 to 12 years to maintain reliable processing capacity. The analysis of alternative biosolids management options found that biosolids as a compost feedstock cannot meet the provincial guidelines, resulting in a compost product for unrestricted use. Long-term investment in biosolids management processes would therefore be better directed to alternatives to maintain a diversified program. The evaluation of options found that alkaline stabilization and heat drying are feasible technologies for Guelph to implement, but int the future, regulatory changes and any new and emerging technologies should also be considered when determining the preferred strategy. In the future, the concept of partnering with private enterprises and/or other municipalities may also be appropriate to incorporate into the City's strategy. The concept of municipalities partnering lends itself to management solutions that could benefit all of the partners. These include adopting common best management practices and shared central facilities or contracting services effectively by utilizing contracts that fairly share risk between partners. This method of management could reduce each partner's costs. Municipalities will still have to proactively monitor programs that are contracted to the private sector to satisfy public concerns.

The following principles are key components included in the implementation plan:

- The City will continue to produce a digested biosolids product at its treatment plants.
- The City will maximize beneficial use of biosolids by maintaining the ability to produce diversified products and providing storage. Products will include Lystek-treated biosolids as an economical liquid-type product, dewatered cake in the land application season, and composted biosolids that can be easily stored and utilized on agricultural land or in other applications, such as sod farming and soil blending.
- The utilization of biosolids on agricultural land will be the mainstay of the City's biosolids management plan.
- The City will strive to improve the quality of the product to address public concerns regarding potential health issues.

- The City will continue to maintain a landfill contract for disposal of biosolids when beneficial use is not available.
- The City will contract with the private sector, as appropriate, to manage its land application of biosolids in an environmentally responsible and economical manner satisfactory to the City, its residents, and the farming community.
- The City will manage its risks and liabilities for biosolids use and disposal by entering into contracts and management arrangements that reduce the risks, while fairly apportioning the risks between the City and the private sector. The City will ensure effective management of the contract(s), including monitoring of the contractor's methods, operations, and record keeping. The City will also utilize stakeholder committees to review its programs.
- The City will consider partnering with other municipalities, and/or the private sector, to develop other biosolids products and markets that compliment this program, as the composting facility reaches the end of its useful life. The mix of the future biosolids products will reflect the markets and will be adjusted periodically according to market trends. The evaluation will also weigh the costs of private sector solutions with the costs of building additional storage facilities.
- Should partnering not be the sole solution, the City will further investigate alkaline stabilization and heat drying for long-term implementation to replace the compost facility. The market and regulatory trends will be considered, as well as other (emerging) technologies if appropriate, to meet future demands and requirements.
- The City will implement a communication and education program with its stakeholders and the general public to provide them with a better understanding of biosolids management in Ontario and the City of Guelph. The goal of this program will be managing potential liabilities and risks associated with the management program. The program should be geared to increase public backing for the program supported by sound science.

3. Implementation Plan Development

Implementing the strategy presented above requires an approach that addresses the entire duration of the management plan and that includes risk management. Because the implementation is influenced by practices in other municipalities, such as availability of land for use, landfills and potential partnering opportunities, it is prudent to understand how municipalities in southern Ontario and other jurisdictions are managing their biosolids.

The proposed implementation plan provides for the City to carry out some activities directly and others in conjunction with other parties, which include private sector proponents and, potentially, partner municipalities. The plan should allow the City to continue managing biosolids effectively while implementing plan components in an orderly, systematic fashion. During the initial five years of the plan, the City will be able to prepare for processes and facilities that will be required for capacity purposes, and begin developing long-term strategies for implementation at the end of the compost facility's useful life. A review of the Guelph Biosolids Management Plan is scheduled at the end of five years and every five years thereafter, thus conforming to MEA Class EA procedures for

Master Plans. The review allows the City to adjust the implementation plan to suit changes that may be required to update the plan for the next five-year period.

Since the Biosolids Management Plan study began in 2002 and as the study has proceeded, a number of programs identified have been initiated or implemented at the WWTP, including the following:

- WAS thickening trials
- Request for engineering proposals to expand the digestion process capacity
- Review of the dewatering needs and equipment tender
- Review of compost woodchips suppliers
- Investigation of the compost outfeed device and custom retrofitting
- Landfill contract negotiation
- Biosolids land application tender and contract negotiations
- Nutrient management strategy

The status of these programs and activities has been included in the implementation plan.

3.1 Biosolids Management in Southern Ontario

Table 1 summarizes biosolids management programs in Southern Ontario, including program type and size of operation. The locations listed collectively manage about 566 dry tonnes per day (Dt/d) of biosolids. The biosolids management programs include land application of liquid digested biosolids; land application of dewatered biosolids; land application of heat dried biosolids; land application of alkaline stabilized biosolids and incineration of biosolids and landfilling of ash. All digested (using the USEPA designation - Class B) biosolids are managed in Southern Ontario in accordance with the Nutrient Management Act, its Regulations, and "Guidelines for the Utilization of Biosolids and Other Wastes on Agricultural Land", (latest edition). In accordance with the MOE Design Guidelines, anaerobic or aerobic digestion is the preferred method of stabilization for liquid and dewatered biosolids. For anaerobic digestion, the MOE Design Guidelines require one or two-stage digestion, with processing in primary digesters at about 35°C for a nominal minimum hydraulic retention time of fifteen (15) days. Management practices in the guidelines stipulate crop types, minimum times between application and harvesting or use and minimum separation distances from wells, residences and watercourses. These management practices, together with the minimum requirements for anaerobic or aerobic digestion, are intended to protect public health.

TABLE 1
SUMMARY OF BIOSOLIDS MANAGEMENT IN SOUTHERN ONTARIO

Location	Biosolids Production		Description of Current Biosolids Management Program
	Dt/d	m^3/d	
City of Peterborough	3.5	74	Liquid application of digested biosolids
Region of Durham – except Pickering	10	550	Liquid application of digested biosolids, winter storage and incineration of excess at Duffin Creek WWTP
York Region and Region of Durham – Pickering	90	N/A	Incineration of raw and digested biosolids
City of Barrie	5	192	Liquid application of digested biosolids
City of Collingwood	2	52	Liquid application of digested biosolids

TABLE 1
SUMMARY OF BIOSOLIDS MANAGEMENT IN SOUTHERN ONTARIO

Location	Biosolids Production		Description of Current Biosolids Management Program
	Dt/d	m^3/d	
City of Toronto – Highland Creek	39	N/A	Incineration of raw sludge
City of Toronto – Ashbridges Bay	145	N/A	Land application and landfilling of dewatered digested biosolids, dryer being rehabilitated
Region of Peel – Lakeview	64	N/A	Incineration and ash disposal on plant site
Region of Halton	27	1,040	Liquid application of digested biosolids
City of Brantford	7	230	Liquid application of digested biosolids
City of Hamilton	60	N/A	Land application of dewatered digested biosolids
Region of Niagara	29	890	Liquid application of digested biosolids and alkaline stabilization of dewatered digested biosolids
City of Guelph	**10**	**N/A**	Land application and landfilling of dewatered digested biosolids
Region of Waterloo	29	822	Liquid application of digested biosolids
City of St. Thomas	0.3	11	Liquid application of digested biosolids
City of London – Greenway	11	N/A	Incineration of raw sludge from 3 London plants
City of Leamington	6	N/A	Land application of advanced alkaline stabilized biosolids
City of Sarnia	6	N/A	Advanced alkaline stabilized biosolids sold for soil blending
City of Windsor	22	N/A	Landfilling raw dewatered biosolids, dryer shutdown
Total Biosolids Production	**566**		

The City of Toronto, the Regions of Peel and Durham, and the City of London operate incinerators. The Region of Durham recently invested in a significant incineration facility upgrade, and landfilled dewatered cake during the construction period. The City of Toronto's Ashbridges Bay plant replaced incineration with heat drying and land application in 2001; however, the dryer system suffered from a fire and has not been repaired to date, although it is reported that the dryer will be rehabilitated within the next year. Incineration is now utilized for about 25 percent of Southern Ontario's biosolids; the remainder is managed through land application and landfilling when land application is not available.

Liquid land application and, to a lesser extent, dewatered land application, are well-established in Ontario. Liquid land application has been formally practiced since the original Land Application Guidelines were established in 1972. Land application of dewatered biosolids has only recently begun in a large scale, with the City of Toronto, City of Hamilton and Region of Ottawa moving to land application programs. These programs are addressing issues associated with odours from storage of dewatered biosolids, but they have not been completely solved.

Of the other biosolids management options noted in Table 5.1, the private sector is still developing reliable utilization methods or markets. The heat drying system in Windsor, which is owned and operated by Azurix Company (formerly Prism/Berlie), began operation in 1999. Azurix has applied for a license under the Federal Fertilizer Act to market the product. This heat drying system has spent the majority of the last three years out of service. Initially due to fire damage, the City landfilled dewatered biosolids while repairs to the facility were being made; however, the City has found that landfilling is currently more economically viable, and is continuing with this method at present. Another facility at Smith

Falls in Eastern Ontario has been producing a heat-dried product since 1995, but does not have a well-established market for year-round utilization of the dried biosolids. Similar facilities in the U.S. market their products primarily to bulk fertilizer blenders for incorporation into chemical fertilizers. The advanced alkaline stabilization facility in Leamington has been in operation since 1998 and N-Viro, who is contracted to distribute the product, has a license to market the product under the Federal Fertilizer Act. The product is sold to farmers in Southwest Ontario. A similar N-Viro facility is also located in the City of Sarnia, and has been in operation since 2001. The alkaline stabilized biosolids are sold to a local soil blender. The Region of Niagara is also contracting with N-Viro, to alkaline stabilize and distribute approximately 50 percent of its biosolids. The facility is currently under construction.

The private sector may begin to play a major role in developing markets for biosolids utilization in Ontario. Through contracts with municipalities, the private sector contractors will continue to provide transportation and land application services, as well as providing facilities for further processing, such as in Windsor, Leamington and the Region of Niagara, and develop markets to utilize this higher quality product. Some pioneering is required to overcome regulatory and social barriers, which will make development of new markets challenging; as such, the private sector may be better suited to achieve this.

Incineration has been practiced in Southern Ontario since the early 1950s, when the first incinerators began operating at Ashbridges Bay in Toronto. Incineration has been used by the bigger generators of biosolids and at one time included the City of Toronto (Ashbridges Bay and Highland Creek), the City of Hamilton (Woodward Avenue), the City of London (Greenway), the Regions of York, Durham (Duffin Creek) and the Region of Peel (Lakeview). The by-product of incineration, ash, was landfilled onsite and at municipal landfills or recycled as light weight aggregate.

The private operations contractor shut down the Woodward Avenue incinerators a few years ago to reduce costs and appease the neighbours. The dewatered biosolids are land applied. The Ashbridges Bay incinerators have also been phased out and were replaced by a combination of dewatered biosolids land application and heat drying. The program began in 1996, when a portion of the dewatered biosolids was diverted to land application. This change was initiated by public pressure on the City of Toronto when the City was determining how to manage their biosolids after the existing incinerators reached the end of their useful operating life. Since the fire in the heat drying facility, the dewatered biosolids that cannot be land applied are landfilled, and the City is re-addressing its biosolids management program needs.

The Regions of Peel and Durham recently carried out biosolids management studies to select a long-term biosolids management strategy, and both determined to continue to incinerate.

Some of the larger biosolids producers will likely continue to incinerate during the future; however, if they decide to discontinue incineration, there will be another increase in the distribution and supply of land-destined products. Should this happen, there will be added demand on the agricultural land available for land application of biosolids in Southern Ontario.

3.2 Biosolids Management in Other Jurisdictions

Wastewater treatment plants in Eastern Ontario anaerobically or aerobically digest their biosolids and utilize biosolids by land application. The smaller plants typically utilize aerobic digestion. The larger plants, including the Robert O. Pickard Centre, Ottawa, Cornwall, Brockville, and Kingston, anaerobically digest their biosolids. The Ottawa and Kingston biosolids are dewatered before land application. As previously noted, the Town of Smith's Falls heat dries its biosolids and produces a pelletized product.

In New Brunswick, the largest plant is located in Moncton. Raw primary biosolids are dewatered and alkaline stabilized prior to utilization. The Greater Moncton Sewerage Commission has a diversified utilization program, which includes land application, both agricultural and sod farming, application to forests, and composting.

In Quebec, the larger plants either heat dry or incinerate their biosolids. In Montreal, biosolids are managed by a combination of incineration and heat drying. Heat drying is utilized in Quebec City, Laval and Gatineau, whereas Longueuil incinerates its biosolids. A number of other municipalities utilize land application.

Winnipeg is the largest city in Manitoba. Biosolids are anaerobically digested and dewatered prior to land application.

In Saskatewan, Saskatoon and Regina anaerobically digest their biosolids and land-apply them. The Regina biosolids are dewatered prior to land application.

In Alberta, most wastewater plants anaerobically digest their biosolids, including Edmonton, Calgary, the Capital Region, and Lethbridge. The Edmonton biosolids are currently land applied, as well as being co-composted with municipal solid waste from the City. The other cities land-apply their biosolids.

In British Columbia, most wastewater plants anaerobically digest their biosolids, including Lions Gate, Annacis Island and Lulu in Vancouver, Matsqui and Prince George. The Vancouver plants are either using thermophyllic digestion or are upgrading to thermophyllic. There are a number of smaller plants that utilize autothermal aerobic digestion (ATAD). Biosolids management practices include land application, land reclamation, and landfilling.

In the United States and Europe, the primary biosolids management practices are land application, incineration and landfilling. In the United States, both Class B and Class A biosolids are land applied. (Class A and Class B are USEPA classifications designating levels of biosolids stabilization and pathogen reduction, with Class A having the lower level of residual pathogens and bacteria, and having less stringent land application requirements due to the associated reduce risk.) Processing technologies that are used to produce Class A biosolids include heat drying, alkaline stabilization, and composting. Various forms of thermophyllic digestion are being developed to produce Class A biosolids. Pre-pasteurization is also being used prior to anaerobic digestion to produce Class A biosolids.

In Europe, approximately 50% of the biosolids are landfilled, 30% are used in agriculture, and the remainder are incinerated, ocean dumped, or otherwise disposed of. Most of the larger countries have either banned or moved away from landfilling of biosolids. Additionally, regulations have been introduced, which require lower pollutant concentrations in biosolids that are land applied. This has resulted in either increased treatment or a move to incineration. Germany, the largest producer of biosolids in the EU, relies on land application and incineration for its biosolids. A report by the Department of the Environment, Transport and the Regions of the United Kingdom Government indicated that by 2005, with the cessation of ocean dumping, the distribution of biosolids utilization will be 60% land application, 36% incinerated or gasified and 4% landfilled. The composting rate has risen in Europe over the past three years. In Switzerland, for example, land application has been banned and biosolids are managed through incineration. This is partly due to the nature of the country, for example, shallow overburden soils in the mountainous landscape.

4. Implementation of Plan Components

The recommended biosolids management program is sustainable for the duration of the planning period, meets regulatory requirements, and satisfies the City's need to serve its customers economically and responsibly. The program is premised on the City's core value of environmental responsibility, resulting in a plan to recycle the biosolids through utilization programs.

The current agricultural land application program, using dewatered biosolids, is vulnerable to several factors that could jeopardize the long-term viability of the current program. The biosolids only satisfy the nitrogen fertilizer requirements of a small percentage of the agricultural land in the area. As the Nutrient Management Act rolls into force, however, animal manure couldconsume the land currently available for biosolids land application. Should this happen, the biosolids would have to be transported to more distant locations, making the program more expensive to manage. Jurisdictional concerns may also increase the difficulty in managing the biosolids.

The Nutrient Management Act (NMA) was enacted in June 2002. The legislation is intended to be a comprehensive province-wide approach to managing all nutrients on agricultural land. The impetus of the Act is protection of soil and water quality in Ontario's rural environment, while ensuring that farmers can invest in and operate their farms with confidence. The Ontario Ministry of Agriculture and Food (OMAF) and the Ministry of Environment (MOE) are responsible for governing the Act, as well as the 13-part Regulation that outlines standards and the four protocols which provide more detail to the Regulation. The Regulation and related protocols were enacted July 1, 2003, with implementation beginning September 30, 2003.

At this point, the Regulation primarily pertains to livestock farmers, but there are some land application standards that apply to biosolids (non-agricultural source material), as well as some requirements for municipal generators. As of September 30, 2003, no biosolids can be applied within 20m of a watercourse (as defined by the NMA Regulation), the use of high trajectory irrigation guns for land application is banned, and no application of municipal biosolids can take place between December 1 and March 31 of the following year. In addition, the Regulation set a schedule for implementation of Nutrient Management Strategies (NMS) for municipal generators of nutrients, dependent upon size.

The City of Guelph completed its first NMS in late 2004, and is required to update it annually and resubmit it for approval at least once every five years. The NMS is a tool to document the volume of biosolids that are generated, how they are stored, and how they will be used. The NMS must also link to documents related to end use, such as land application Certificates of Approval and farm nutrient management plans, as well as broker agreements for any "intermediate" handlers, such as a hauler or land application contractor. Another key component is a contingency plan that documents actions to be taken during times when the intended end use cannot be carried out. Once a municipal generator has an NMS in place, the Regulation requires 240 days of storage for municipal biosolids, unless an alternative disposal method is provided, such as landfilling.

Recent incidents, such as the Walkerton E. coli epidemic, have heightened public awareness of land application programs that include biosolids, septage, and animal manure. This could lead to public pressure requiring products that have been further processed to reduce pathogens to levels equivalent to a Class A biosolids, as defined by the USEPA. In the U.S., there have been recent cases of municipalities banning land application of Class B (equivalent to Guelph's anaerobically digested biosolids) and requiring Class A products. While there are no regulatory requirements either in Ontario or the U.S., the possibility of public pressure driving the industry towards a Class A level of product would require further processing of all the biosolids to achieve this.

The private sector component of the program includes transportation and land application, as well as development of other product markets for the composted biosolids in the short-term and future products in the long-term. Additionally, the City may examine the feasibility of co-marketing biosolids compost with the already successful organic waste compost from the Wet-Dry Facility. Potential markets for the biosolids compost include sod farmers and soil blenders.

4.1 Existing Process Capacity and Equipment Upgrades

Table 2 summarizes the existing processes that have been previously identified as requiring equipment upgrades and/or additional process capacity to meet the needs of this biosolids management plan. Table 2 also identifies the process need, its driver and the anticipated schedule.

TABLE 2
EXISTING PROCESS CAPACITY AND EQUIPMENT UPGRADES

Unit Process	Need	Driver	Result	Schedule
WAS Thickening	• Stage 1: Complete the demonstration • Stage 2: Design, procure and construct full-scale WAS thickening	• Increased sludge production limiting effectiveness of co-thickening in the primaries • Digester capacity limitations	• Improved settling of primary solids • Increased raw solids content, decreased volume • Potentially reduce required scale of digester expansion	• Stage 1: 2005-2007 • Stage 2: 2008-2010
Digestion	• Increase digestion capacity (primary or alternative such as two-phase)	• Current capacity is not sufficient for demand; digesters are overloaded • No excess capacity is available to allow a digester to be taken off-line for maintenance; all digesters require cleaning	• Sufficient capacity for demand • Sufficient treatment of biosolids to meet regulatory requirements for land applied biosolids • Ability to take units off-line for maintenance	• 2006-2009

TABLE 2
EXISTING PROCESS CAPACITY AND EQUIPMENT UPGRADES

Unit Process	Need	Driver	Result	Schedule
Dewatering	• Increased dewatering capacity • Two-stage process anticipated: 1) Replace two oldest belt presses (equipment currently under procurement) 2) Replace remaining two belt presses; consider higher solids equipment, such as centrifuges. Program to include pilot testing	• Two oldest presses have come to the end of their useful life • Two other presses are rapidly approaching the end of their useful life • Lower solids content cake is required for Lystek and higher solids content cake is required for landfilling and will economize when land applying of further processing cake	• Reliable equipment • Reduced operating hours, increased efficiency and reduced costs • Cake properties (solids content) suitable for diversified end uses	• Stage 1: 2005-2006 • Stage 2: 2007-2009
Lystek facility	• Complete installation and commissioning for full-scale ($6m^3$) facility – December 2005 • Install and implement storage for Lystek treated biosolids	• Economical and technically sound management process required storage to fully implement reliable program	• Viable Lystek land application program • Maximize investment in equipment • Maximize beneficial use of biosolids	• 2007-2010
Compost facility	• Continue equipment upgrades as required, including retrofitting of custom outfeed devices to vessels • Construct and utilize covered compost storage pad; existing unused facilities may be retrofitted	• Upgrades required to improve system reliability and reduce unscheduled down-time • Storage required to allow compost to mature and be suitable for a variety of markets • Storage to reduce dependency on landfilling	• Viable composting during winter months, with extended summer maintenance period of major upgrades and repairs allowed for in plan • Reliable product with feasible market • Maximize beneficial use of biosolids	• Upgrades: ongoing, as identified, for remainder of compost facility useful life • Storage: 2006-2007

4.2 Land Application Contract

Currently, private sector contractors operate most of the land application programs in Ontario. The involvement of the municipalities in the programs varies significantly and may include record keeping, assessment of sites, ownership and operation of storage facilities, development of public education programs and auditing. contract conditions, scope, and length may also vary significantly. For example, in Niagara, the contractor operates the Region-owned storage facility. For comparison, the Cities of Barrie and Brantford own and operate their storage facilities and contract out the transportation and land application. The Cities of Collingwood and Kingston lease storage capacity from contractor who owns and operates the storage facilities. The Regions of Halton and Waterloo are similar to Niagara, where the Region owns the storage facility, while the contractor manages the facility.

Some of the contract factors are discussed below and in Table 3. As previously mentioned, the City of Guelph tendered for a new land application contract in 2005. The procurement process, developed by the City, consisted of developing a tender document and requesting tenders from contractors. The tenders were reviewed to confirm the contractors met the minimum requirements of the tender and that each tender was complete. The qualified tenders were then evaluated against pre-determined criteria and a preferred contractor selected. The City is currently negotiating the terms with the preferred contractor. It is anticipated that the contract will be signed and effective for a five year period commencing with the 2006 land application season.

Recommendations for inclusion in the contract and future tendering processes, considered as best practices for the City, are also included in Table 3.

TABLE 3
COMPARISON OF LAND APPLICATION PRACTICES AND CONTRACT CONDITIONS

Contract Factor	Advantages	Disadvantages	Recommendation
Contract Cost Breakdown	• Reduce risk of cost increases to contractor • Allow optimization of land application program costs, including mechanical thickening, higher solids products and storage facility siting • Allow contract separation to two or more contracts if contract becomes too big for one contractor	• Increased administrative costs • Increased potential for contract changes	• Include cost requirement breakdown in tender and contract
Longer Contract Length	• Longer contract lengths reduces risk to contractor by allowing capital costs to be amortized over longer period • Increases number of contractors able to bid on contract • Promote contractor commitment to the community	• City tied into contract for longer period of time • Potential escalation of contract costs due to uncertainty in long term labour and fuel costs	• Five-year contract with option to extend contract
Escalation Clauses	• Reduces uncertainty in contractors future costs • May reduce contract costs	• Potential increase in City's budgeted costs	• Fuel cost escalation clause recommended due to current uncertainty in future fuel costs. Escalation based on actual fuel expenditures or clause negotiated with City based on expected fuel costs
Performance Bonds	• Increased reliability of contractor obligations being fulfilled • A letter of Credit gives the City ready access to monies to effect changes in emergency situations.	• May reduce tender competition • Increased contract costs	• Bond valued at one year of the contact
Contractor Storage Facility O&M	• Contractor best able to manage capacity	• Increased contract costs • Reduced control over method of operation and equipment maintenance	• Allow market to determine most viable solution: City owned or included in contractors scope with methods of operation and equipment maintenance specified in contract documents

TABLE 3
COMPARISON OF LAND APPLICATION PRACTICES AND CONTRACT CONDITIONS

Contract Factor	Advantages	Disadvantages	Recommendation
Dual-Named Application Site Approvals	• City maintains quality assurance over land application program • City not liable for impacts on contractor • Reduce risk of contractor monopoly • Assurance of land availability	• Increased City staff time for reviewing and approving contractor proposed land application sites • Potential increase in liability • Joint responsibility for provision of enough sites	• Approvals be in both the contractors' and the City's name with responsibility for provision of potential sites by contractor for City approval
Record-Keeping by City	• City maintains quality assurance over program • Flexibility to adapt to future regulatory changes without contract amendments • Improve City's information for future planning and land management • Better risk management record	• Increased City staff time for administration • Potential increased liability	• City participate with contractor in development, entry into and review of the record-keeping system
Public Consultation – Contractor Participation	• Public acceptance and development of goodwill with farming community would improve the long term stability of the program	• Slight increase in contract costs	• The City should maintain a permanent Public Advisory Committee composed of stakeholders – farmers, contractor, and public citizens group
Minimum Equipment Requirements	• Improves program reliability. Sufficient equipment will ensure a reliable program in years where poor weather conditions limit the number of application days. • Reduces potential impacts on roads and farm application sites. Appropriate application equipment minimizes soil compaction, minimizes risk of odours and run-off/leaching, and ensures a consistent application rate.	• Increases contractor capital costs	• Specify minimum equipment requirements, including number and types of equipment.

The City's participation with the contractor in obtaining site approvals would provide additional assurance to the public that guidelines are being followed and may reduce future liabilities to the City. In most programs, the contractor obtains the site Certificate of Approvals (C of A). In some cases, the contractor is named as the proponent in the C of A. In other cases, both the municipality and the contractor are named as co-proponents. The Region of Halton obtains site approvals and both the Region and contractor are named proponents. In Durham Region and Barrie, the contractor obtains the C of A's and both the municipality and contractor are co-proponents. The Durham and Barrie approach is most appropriate for Guelph. (The contractor obtains the C of As specifying the City as the only biosolids source.)

Most of the contracts in other municipalities are of five year durations (i.e. Barrie, Brantford, Durham Region, Halton Region, Kingston), except for smaller municipalities, where contracts are typically renegotiated each year. Due to the size of the Guelph contract, a five-year contract, with options for extension is recommended. This will allow the contractor to amortize the equipment costs over a reasonable time frame and lower the contract costs. Five years also corresponds with the first review under the Class EA master planning process.

Record-keeping has become more important in the past year, to demonstrate compliance with the Nutrient Management Act. In most cases, the contractor is responsible for the keeping land application records, with municipalities compiling biosolids quality and quantity records. However, many of the larger municipalities are now taking a more active role in record-keeping, including Halton Region and Peterborough. It is recommended that Guelph develops a single record-keeping system, combining City and contractor records, with both parties having access to all the records.

Contract cost break downs, such as escalation clauses for fuel cost and other elements, could be included to minimize risks of future cost increases to the contractor and possibly reduce the contract costs.

Once the contract is executed, the City must administer it to ensure that both the City's and the community's interests are protected. The City's biosolids coordinator is the designated staff member responsible for overseeing the administration of the contract. These duties include the following:

- Establish and implement procedures to verify biosolids quantities picked up by the contractor;
- Establish and implement procedures to verify submissions and approvals;
- Establish and implement procedures to verify biosolids are being sampled and monitored and that records required by the MOE and the contract are being prepared and made available to the City;
- Establish and implement procedures to verify that conditions of the Certificates of Approval (C of A) related to activities at the application sites are being complied with;
- Establish and implement recordkeeping requirements of the Nutrient Management Act; and
- Set up monthly activity reports.

The City must set up auditing procedures to properly monitor that the contractor is performing the activities of the contract. Auditing may be performed by the City, or alternatively by an unbiased third party, which may give additional transparency to the program for the stakeholders and public. The following is a list of recommended auditing activities:

1. Review forms completed by truck drivers for completeness and accuracy.
2. Reconcile with monthly report by contractor.
3. Check biosolids processing, storage and loading facilities including:
    - Storage levels
    - Equipment and road conditions
    - Housekeeping
    - Log book reports

- Weekly inspection.

4. Spot check C of As for land application sites.
5. Spot check for transportation route road damages and report.
6. Maintain some "visual presence" at application sites and be available for questions from farmers and the public during application events.
7. Respond to correspondence from neighbours.
8. Respond to complaints from municipal politicians regarding roads, traffic, odours, and general concerns.
9. Audit records of field complaints to contractor by farmers, neighbours, and general public.
10. Review results of laboratory tests for biosolids quality.
11. Prepare reports for Public Works Committee on biosolids issues including:
    - Availability
    - Quality
    - Quantity
12. Respond to questions from the media.

Administering of the contract is anticipated to require full time attention approximately two days per week between December and April and approximately three days per week for the rest of the year.

4.3 Future Processing Needs

As discussed previously, the composting facility's useful life is anticipated to be approximately half of this plan's duration. The analysis of alternatives determined that composting in the future is currently not a preferred alternative diversification strategy because of the regulatory climate respecting biosolids compost in Ontario. Because of this, it is difficult to justify the costs associated with a significant overhaul and future operation of the compost system when total renovation is required.

Two processing alternatives were found to be feasible for Guelph: heat drying and alkaline stabilization. These and other alternatives, including incineration, are also feasible if partnering with other municipalities is desired and successful.

It is anticipated that the five year review of this plan will address the remaining reliable operational life of the compost facility and recommend the path forward for implementation of the preferred replacement program. During the period preceding the five year review, it is recommended that the City initiate discussions with potential private and municipal partners to determine the preferred management method. The five year review study will document this process and recommend the process and implementation plan to achieve the goals within the regulatory framework. Following the five year review, conceptual planning, design and construction will be required to implement the program. If performed in partnership with others, this may take longer than typical expectations.

While this study has found that heat drying is the economically and technically preferred management option to replace composting at Guelph at present, the five year review should also consider any regulatory changes, market issues, technology advances and partnering opportunities that may arise during that period. Currently identified issues include the increased alkaline stabilized biosolids that will be on the market when the Niagara facility is commissioned and the potential closing of the Michigan border to landfilling of Canadian wastes.

4.4 Contingency Planning and Landfill Contract

The City currently has a landfill contract with the Green Lane landfill, near London, ON. This contract was negotiated in 2004 for all City non-hazardous wastes. Dewatered biosolids are currently landfilled under the contract conditions. However, the belt presses do not produce a cake with sufficiently high solids content for suitable handling at the landfill. The City therefore utilizes some equipment in the compost facility to blend the cake with woodchips, which produces a higher solids blended product. The recommended dewatering equipment replacements will eliminate this need in the future. Furthermore, this management plan will reduce dependency on landfilling.

The City's biosolids management auditing procedures should also include proper monitoring of the landfill contract to measure and track contractor performance compliance. Periodic auditing is recommended.

A landfill contract should be maintained at all times over the period of this biosolids management plan to ensure that a feasible plan is available, as required under the Nutrient Management Act (where biosolids product storage of less than 240 days for land application programs is available).

4.5 Permits and Approval Requirements

Implementation of the plan will require the upgrade of some existing facilities and construction of new facilities. The various types and levels of approvals required for implementation are described below. Each of the regulatory acts, as well as local requirements, is addressed.

4.5.1 Class EA Approvals (Environmental Assessment Act)

Recommended component activities and programs identified in the Master Plan will require additional Class EA approval before their implementation. In all cases, the Master Plan document will provide the required project rationale and background data and must be clearly referenced in specific Class EA studies and reports.

Operational process improvements and upgrades to existing plants, up to the existing rated capacity, will typically fall under Schedule A or Schedule B requirements. These types of projects include WAS thickening, digestion and dewatering upgrades and Lystek and compost facility improvements, summarized in Table 2. With the completion of this Master Plan, all Schedule A activities may proceed to implementation without the need for additional assessment. Schedule B activities may require additional assessment, depending on the specific undertaking and consultation with the stakeholders local to the project. A project file must be maintained for Schedule B activities and a 30-day review period must also be completed prior to project implementation.

Where proposed activities will require capacity increases beyond rated, or are located at a new site, the City will be required to complete the planning requirements for a Schedule C

Class EA, including the preparation of an Environmental Study Report. The WWTP is approved for activities required to provide treatment up to a rated capacity of 73.3 MLD, the maximum flow for which is the reason that this Biosolids Management Plan was developed.

City used facilities that are owned and operated by the private sector typically are not subject to the Class EA process.

4.5.2 Certificates of Approval – Sewage (Ontario Water Resources Act)

Upgrades at the wastewater plant will require amendments to the existing C of A. If the City were to construct a facility at a new location, a new C of A would be required. City used facilities that are owned and operated by the private sector do not fall under the Act and do not need a C of A.

4.5.3 Certificates of Approval – Air (Environmental Protection Act)

Upgrades at the wastewater plants may require amendments to existing C of A and consolidation of all previous C of As. These permits cover emissions of contaminants, including odour and noise. For example, installation of additional boilers, if required, for increased digestion capacity, will require an amendment to a plant's C of A for its boilers. The MOE also currently requires that any facility applying for an amendment consolidates all previous C of As into one C of A. City-used facilities owned and operated by the private sector will require a C of A. C of As are designated Class I instruments under the Environmental Bill of Rights (EBR) and are advertised on the EBR Registry during a 30-day public comment period.

4.5.4 Certificates of Approval – System (Environmental Protection Act)

Biosolids land application contractors require an Organic Waste Management System C of A to transport waste material to the application site or between plant and off-site storage facility, if applicable. C of As are designated Class I instruments under the Environmental Bill of Rights (EBR) and are advertised on the EBR Registry during a 30-day public comment period.

4.5.5 Certificates of Approval – Sites (Environmental Protection Act)

Each land application site requires an Organic Soil Conditioning Site C of A. C of As are designated Class I instruments under the Environmental Bill of Rights (EBR) and are advertised on the EBR Registry during a 30-day public comment period.

4.5.6 Local Government Permits

Upgrades at the wastewater plant may require building permits. New facilities at other locations will require building permits and may require planning approval.

5. Risk Management Analysis and Recommendations

The management of risk is paramount as the City proceeds with the implementation of the biosolids management strategy. The first step in managing risk is to prepare a risk profile. This exercise included the identification of specific risk issues, evaluating the potential liability posed by each issue to the City, and then identifying the required actions, if any, to reduce or minimize the medium to high risk issues. This information constitutes the risk management plan and the issues and required actions are summarized in Table 4.

TABLE 4
RISK MANAGEMENT ANALYSIS AND RECOMMENDATIONS

Risk Issues	Potential Liabilities to City	Actions Required
City & Regulatory		
Biosolids Technologies – wrong selection	Low, because there are several ways to utilize/dispose and a diversified program is recommended	
Biosolids Technologies – poor reliability	Low, because of diversified nature of program, scheduled maintenance periods for all components and contingency planning	Develop, implement and audit contingency plan; perform routine and scheduled maintenance
Best Practices	Low	
Roads/Load Restrictions	Low/Manageable	
Monitoring of Land Application Contract – lack of	High	Develop Monitoring Plan and implement. Include application practices, as well as farming practices
Biosolids Volume vs. Other Agricultural Waste and nutrients from outside of area (land availability for nutrients and perceived risks)	Low to Medium	Require proactive communication program
Biosolids Characteristics - Off Spec Biosolids	Low/Manageable	Develop, implement and audit contingency plan for disposal
Contract failure	Medium, if contract fails other contractors are available	Ensure contract includes default and termination language
Site C of A – securing in a timely manner	Low to Medium	Ensure contract includes suitable language to have sufficient land base Communicate with MOE
Odours	Medium to High	Application by injection or incorporate within 8 hours of surface application
Total Watershed Management	Low	Consider partnering with others to carry out total watershed management plan
Financial Considerations		
Program Costs – unanticipated escalation	Low to Medium	Typically self correcting due to industry competition Ensure contracts include escalation clauses
Farmer Compensation	Low	Requires proactive communication program
Indemnification	Low	
Public/Farmer Perceptions	Medium	City needs communication programs with farmers - benefits and economic, and public - benefits and risks. May include Municipal Fairs, Farming Communities, Public Liaison Committees, and/or Web Page with FAQ. Need dedicated managers to address issues.
Contingency Plan	Low to Medium	Maintain and audit landfill contract

In summary, the City can reduce and manage potential liability associated with the biosolids management strategy by improving overall communication with stakeholders, by maintaining an ongoing understanding of the current market in Ontario for biosolids management, and by continuing to implement the monitoring program developed for compliance with the Nutrient Management Act. This will increase public assurance that the programs and activities are being carried out as contracted and according to regulatory protocols.

5.1 EMS Program Management Option

The Guelph Biosolids Management Plan has many important and interconnected components. Given the growing public profile of biosolids, its management and associated risks, the City must consider and recognize the roles and responsibilities of its internal departments that are critical to the program's success. In the management and performance evaluation of the overall program, the City must also consider and recognize the roles and responsibilities of its contractors, suppliers, and the landowners that participate in the program.

It is recommended that the City consider adopting an Environmental Management System (EMS) approach for its strategy implementation. An EMS is based on the foundations of quality management and continual improvements and is an iterative process of Plan-Do-Check-Act. This approach has been adopted by the National Biosolids Partnership, established in 1997, whose membership includes the Association of Metropolitan Sewerage Agencies (AMSA), the USEPA and the Water Environment Federation. It was adopted in response to their collective need to improve public acceptance of their biosolids management programs, to reduce risks, and to improve productivity.

The elements of an EMS for biosolids include the following:

- **Development –** of a policy and making a commitment to an EMS framework
- **Planning** – to identify critical control points, determine legal, regulatory and other requirements and to establish desired outcomes/public expectations
- **Implementation** – including the assignment of roles and responsibilities, providing training to increase skills and knowledge, establish communication programs, standard operating procedures and institute corrective actions to resolve problems
- **Measurement/Corrective Action** – assess success in meeting requirements, goals, objectives and performance standards and in instituting corrective actions
- **Management review –** periodically to assure effectiveness of the EMS.

Developing an EMS is an effective management approach to:

- Establish and protect the integrity of a program
- Encourage local involvement
- Build community and stakeholder support into the program
- Maintain recognition that the program meets health and safety requirements
- Build credibility of public agencies and suppliers
- Guarantee regulatory compliance
- Avoid costly mistakes
- Realize financial efficiencies

An EMS framework provides a comprehensive approach to managing all aspects of a biosolids management program.

6. Summary and Implementation Schedule

6.1 Study Conclusions

The Guelph Biosolids Management Plan study included a review of the City's current biosolids management program and an analysis of alternative management (processing, disposal and utilization) options. The following represent the study conclusions generated:

1. **The existing method of management, that is, anaerobic digestion, dewatering, and land application of Lystek-treated, composted and dewatered biosolids, is the most economical for the City and has a successful track record.** Due to the current lack of storage, landfilling of dewatered biosolids and composted biosolids are utilized when required. Land application of liquid biosolids may be utilized for scheduled equipment shutdowns or during emergency situations.

   It was estimated that there will be sufficient agricultural land available to land apply biosolids over the long term. This conclusion assumes that there are no political or social barriers to this method of biosolids management. The City's procurement process and contract terms was also reviewed. It is recommended that the City will continue to contract with the private sector to manage its biosolids in an environmentally responsible and economical manner to the satisfaction of the City and its residents and the farming community.

2. **The City needs to consider construction of storage facilities for Lystek-treated biosolids and composted biosolids to be able to maximize beneficial use of biosolids, improve viability of the land application program and reduce dependency on landfilling. Alternative markets for compost should also be developed.** Because the City currently has no storage facilities, land application can occur at the rate of the process capacity of Lystek treatment and dewatering. Sites applications would be more economical if sufficient material were available to complete site at the rate of the application equipment. Storage also allows some homogenization of the product, resulting in a more consistent material.

   It is not recommended that the City invest in storage facilities for dewatered cake, as the industry has not yet solved the problems with this technology. Storage for Lystek-treated biosolids and composted biosolids are economical (compared to liquid biosolids storage) and the technologies are well-understood and proven reliable.

   Maintaining a landfill contract is also recommended as an important part of the strategy, for contingency and emergency biosolids disposal.

3. **The City needs to develop a plan for replacement of the composting facility at the end of its useful life.** The City should continue to maintain a diversified biosolids management strategy; however, the current regulatory framework does not support unrestricted use of biosolids compost. Alternative treatment technologies, including heat drying and alkaline stabilization, produce a product, at similar cost, that may be federally registered as a fertilizer and is therefore a higher value product.

The City should use the available time, prior to the next five-year biosolids management plan update, to investigate partnering with other municipalities and private companies to determine if a suitable opportunity exists. This could be achieved by initiating discussions with potential partners (Other Municipalities or private companies) to develop co-operative initiatives and to establish networks for investigating new strategy alternatives. This method of management could reduce each partner's costs. Municipalities will still have to proactively monitor programs that are contracted to the private sector to satisfy public concerns. The concept of municipalities partnering lends itself to management solutions that could provide benefits to all of the partners including adopting common best management practices and shared central facilities or contracting services effectively by utilizing contracts that fairly share risk between partners.

If the City determines that onsite replacement of the compost facility is preferred, this study concluded that heat drying or alkaline stabilization would currently be the preferred process. However, this recommendation should be revisited in the future, with respect to the market, regulatory trends and emerging technologies, to confirm the analysis.

6.2 Implementation Plan

The study conclusions provided the basis for developing an Implementation Plan. The implementation plan identifies specific initiatives to maintain, improve and maximize the current land application program, to maintain the contingency disposal option, and to develop and plan for facility replacement. Accordingly, the Implementation Plan includes initiatives in three specific areas.

1. **Land Application Program – "Continuous Improvement"**

   The current land application program, with contingency landfill disposal, can be further supported and maintained into the future by implementing initiatives involving monitoring and quality control, communications, stakeholder involvement, improved procurement process, compost market development and appropriate storage capacity.

2. **Facility Replacement/Expansion Planning**

   To ensure a reliable, sustainable and diversified biosolids management program over the next 20+ years, the City must implement a number of initiatives. These include digestion and dewatering process improvements/expansion and compost processing replacement, as well as consideration of final markets, product quality enhancement and co-operative or Private, Public, Partnership (PPP) options. Contingency planning will be needed and can realistically be adjusted as options become available.

3. **Program Management**

   The management of risk is paramount as the City proceeds with the implementation of the biosolids management strategy. The City can reduce and manage potential liability associated with the biosolids management strategy by implementing the following initiatives:

- Increase the awareness and understanding of City staff of the Ontario context for biosolids management through collaborative discussions with other municipalities and industry sector parties.
- Implement a monitoring program to increase public assurance that the City's programs and activities are being carried out as contracted and according to regulatory protocols.
- Consider adopting an Environmental Management System (EMS) approach for its strategy implementation.
- Take co-responsibility and co-ownership of land application site approval with the contractor.

7. Schedule

Implementing the strategy presented above requires developing a schedule to address the entire time period of the Guelph Biosolids Management Plan and to include incorporating risk management. The proposed implementation schedule is illustrated in Figure 1 and the capital cash flow projection of implementation is shown in Figure 2.

It is recommended that the implementation schedule is reviewed and updated at least every five years to assist in capital budget forecasting. Significantly, the reliable capacity and life of the compost facility should be reassessed within five years of full-time operation, as recommended in this strategy. (The preferred strategy includes operation of the compost facility using one vessel six months per year, two vessels two months per year, and a four month shut-down/maintenance period in the summer. Additional curing and storage is provided on an outdoor pad.)

The main components of the Guelph Biosolids Management Plan are:

- Three-stream biosolids management program with the City continuing to produce a Lystek 'liquid' product, dewatered cake and composted biosolids:
  - Lystek processing to have a two-month scheduled maintenance period per year;
  - Composting to have a four-month scheduled maintenance period per year;
  - Storage for Lystek and composted biosolids to maximize beneficial use and reduce landfill dependency.
- Process capacity and equipment upgrades to meet biosolids production requirements:
  - Implementation of full-scale WAS thickening;
  - Digestion expansion, compatible with the existing system;
  - Dewatering equipment replacement of all belt filter presses (two currently in tender), with ability to produce lower solids cake (for Lystek treatment) and higher solids cake (for further processing or landfilling);
  - Compost facility upgrades, including completion of custom out-feed device replacement, and ongoing equipment maintenance
- Implement the procurement process developed for the new land application contract. The land application contract to be arranged for five years, and renewable, will allow implementation and adjustment to the plan.

- Develop alternative compost markets in sod farming, soil blending or others, and obtain the appropriate approvals.
- Develop a plan for future partnering with the private sector or other municipalities, or ultimately replace the compost facility.
- Develop and implement a communications and education plan.
- Develop a risk management plan that incorporates elements to address the Biosolids Management Plan, including a contracting strategy to reduce risk, a contract monitoring plan, a public opinion tracking program, and an oversight committee.
- Implement a review and reassessment of the Biosolids Management Plan within five years.

FIGURE 1
IMPLEMENTATION SCHEDULE

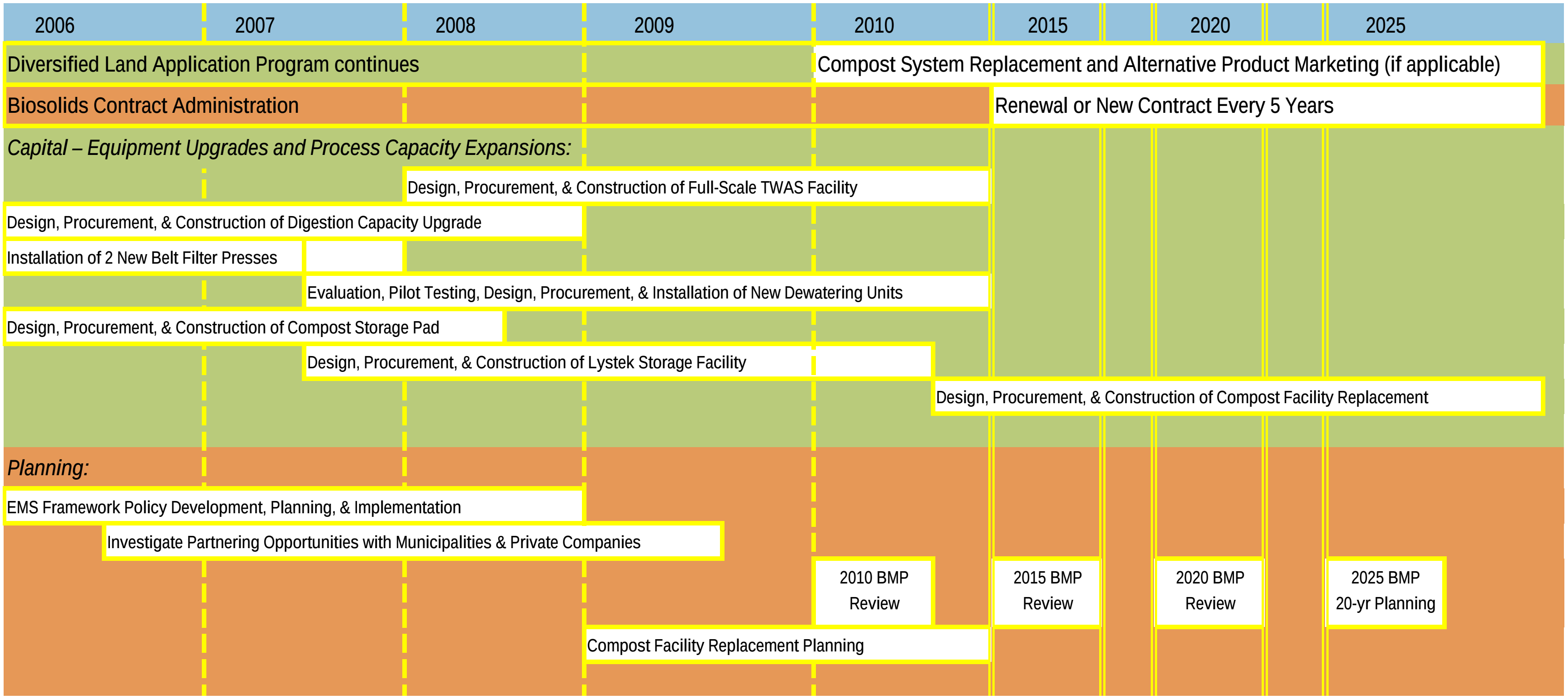

FIGURE 2
CAPITAL CASH FLOW PROJECTION FOR IMPLEMENTATION OF RECOMMENDED SOLUTION

(2005 Dollars, $1,000,000)

	Total Cost	**2006**	**2007**	**2008**	**2009**	**2010**	**2011-2015**	**2016-2020**	**2021-2025**
WAS Thickening	$2.2	$0.0	$0.0	$0.4	$1.1	$0.6	$0.0	$0.0	$0.0
Digestion	$7.7	$1.9	$4.2	$1.5	$0.0	$0.0	$0.0	$0.0	$0.0
Dewatering	$2.2	$0.0	$0.2	$1.5	$0.4	$0.0	$0.0	$0.0	$0.0
Composting	$4.2	$1.0	$1.3	$0.8	$0.6	$0.4	$0.0	$0.0	$0.0
Miscellaneous	$2.7	$0.3	$0.6	$0.9	$0.6	$0.3	$0.0	$0.0	$0.0
Compost System Replacement	$13.0	$0.0	$0.0	$0.0	$0.0	$0.0	$2.6	$9.8	$0.7
Annual Total Cost	**$31.9**	**$3.3**	**$6.3**	**$5.2**	**$2.7**	**$1.3**	**$2.6**	**$9.8**	**$0.7**