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Specified Risk Material Containment and Destruction Options and Evaluations for the Fraser Valley

Report Prepared for:

British Columbia Ministry of Agriculture and Lands

December 9, 2008

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Acknowledgements

Funding for this study was provided in part by the Canada-British Columbia Specified Risk Material (SRM) Management Program. The SRM Program is designed to assist the province's beef processing sector in complying with the Canadian Food Inspection Agency's enhanced feed ban regulations.

Agriculture and Agri-food Canada (AAFC) and the B.C. Ministry of Agriculture and Lands (BCMAL) are pleased to partner in the delivery of this program. Both bodies are committed to working with stakeholders to address issues of importance to the agriculture and agri-food industry of British Columbia.

Disclaimer

Opinions expressed in this report are those of the authors and not necessarily of AAFC or BCMAL. Ference Weicker & Company accepts full responsibility for the technical accuracy of its contents.

Executive Summary

Purpose of Study

The purpose of the study was to prepare a document that can be used as an information platform to address the strengths, weaknesses, opportunities and threats (SWOT) associated with various options for Specified Risk Material (SRM) containment and destruction. SRM is tissue that, in BSE-infected cattle, has been shown to contain the infective prion and can transmit disease. Beginning July 12, 2007, enhanced animal safeguards came into effect to help eliminate bovine spongiform encephalopathy (BSE), or mad cow disease, in Canada and these safeguards ban the use of SRM in all animal feeds, pet foods and fertilizers.

Key Findings

Our key findings are as follows:

Amount of SRM in the Fraser Valley

1. Most of the SRM generated in the Fraser Valley is currently collected by West Coast Reduction and transported by truck to their rendering plant in Calgary. The meat and bone meal produced from the SRM material is then hauled to a landfill in Coronation, Alberta.

2. The total amount of cattle slaughterhouse waste and dead stock collected from the Fraser Valley and transported to the West Coast Reduction rendering plant in Calgary is approximately 5500 tonnes (6060 tons) per year. All of this material is considered SRM because the SRM and non-SRM are mixed before they are transported to the Calgary plant. This volume does not include the SRM that is buried or composted by farmers, as accurate information on the amount of this source of SRM is not available.

Technologies Investigated

3. The options for SRM containment and destruction investigated were rendering, anaerobic digestion, aerobic digestion, lactic acid fermentation, composting, thermal depolymerization, alkaline hydrolysis, acid hydrolysis, thermal hydrolysis, plasma arc destruction, pyrolysis, landfilling, burial, incineration, gasification, plasma gasification and reductive thermal processing.

SRM Containment Options

4. The Canadian Food inspection Agency (CFIA) has approved landfilling and on-site burial as suitable for long-term SRM containment. However, the landfills operated by municipalities and regional districts in the Fraser Valley are not willing to accept slaughter waste, particularly slaughter waste containing SRM. If a regional landfill does agree to receive SRM, the CFIA imposes limits on the amount that can be accepted, depending on whether the receiving site is an engineered landfill or a non-engineered landfill. CFIA regulations do not limit the amount of on-site burial which can be undertaken on premises where SRM is generated. However, burial limits are applicable for non-contiguous properties associated with the premises of origin. While on-site burial may be a viable containment option for farmers, it is not typically feasible for slaughtering plants and dead stock collectors due to the limited amount of land available on their premises.

SRM Destruction Options

5. Of the technologies investigated, the technologies approved by the Canadian Food Inspection Agency (CFIA) for SRM destruction are alkaline hydrolysis, thermal hydrolysis, and incineration or gasification.

6. Most of the remaining technologies (e.g., rendering, composting, anaerobic/aerobic digestion, acid hydrolysis, lactic acid fermentation) are not suitable for SRM destruction because the conditions reached in the process are such that the SRM abnormal prion may not be destroyed.

7. Some technologies that could potentially be suitable for SRM destruction are plasma arc destruction, pyrolysis, plasma gasification and reductive thermal processing. However, the CFIA would have to first undertake a risk assessment of these technologies and approve their use for SRM destruction in Canada.

Incineration

8. Incineration is a feasible method of SRM disposal because it has been approved by the CFIA as an acceptable method of destroying the abnormal prion. Incineration is a proven technology for burning cattle carcasses as well as a variety of other wastes. The CFIA stipulates that, for incineration to be approved: (i) the SRM must be heated to a temperature of 850°C (1560°F) or above for at least 15 minutes, and until all organic material is reduced to ash containing no detectable proteins; (ii) SRM that has been reduced to a size of 50 mm in diameter or less must remain in the primary chamber at 900°C (1650°F) or above for at least two seconds, and until all organic material is reduced to ash containing no detectable proteins; and (iii) SRM volatilized within the primary chamber as flue gases and fly ash is further subjected to an additional residency time of at least two seconds in a secondary chamber at a minimum temperature of 850°C (1560°F). Exact residency times will vary depending on the size and nature of the organic material inputs being used in a particular scenario. Based on the preliminary information available, the costs of incineration appear to be similar to those currently paid by Fraser Valley slaughtering plants and dead stock collectors for the disposal of their SRM material. However, a more detailed analysis is required to more accurately determine likely associated costs.

9. While incineration is a potential alternative to the current methods of handling livestock waste tissue, there will likely be considerable public resistance to operating an incinerator that handles SRM in the Fraser Valley due to air and odour emissions. Even though incinerators appear capable of meeting the particulate air emissions standards of the BC Ministry of Environment, the municipal representatives contacted indicated that an incinerator will be opposed by the public because it will exacerbate the existing air quality problems in the Fraser Valley.

Gasification

10. Gasification appears to be a suitable method of SRM destruction in the Fraser Valley. Based on the available information, a gasification plant in the Fraser Valley could comply with existing environmental regulations. In addition, the establishment of a gasification plant in the Valley could potentially reduce the existing costs incurred by local slaughtering plants and dead stock collectors for disposal of SRM material, particularly if the plant were constructed large enough to handle a variety of other wastes such as poultry litter, and if the plant was able to generate revenues from the sale of electricity and surplus heat.

Alkaline Hydrolysis

11. Alkaline hydrolysis offers many advantages as a method of SRM destruction including the fact that no emissions are released into the atmosphere and that odour production is minimal. While previous alkaline hydrolysis units were limited in capacity, a number of larger units are now available that are capable of handling all of the waste generated by individual cattle slaughtering plants and dead stock collectors in the Fraser Valley.

12. The most significant disadvantage of alkaline hydrolysis is the disposal of the generated effluent which has a high pH and biochemical oxygen demand (BOD) content. In order for alkaline hydrolysis to be a viable and cost-effective method of SRM destruction, research is required to find markets for the effluent produced from the process in order to offset associated costs and in the interest of diverting the effluent from municipal sewer systems.

Thermal Hydrolysis

13. Thermal hydrolysis offers many advantages as a method of SRM destruction including the fact that it is environmentally friendly. Due to the nature of the bio-refining process, thermal hydrolysis also has greater potential than most other technologies to convert waste into high-value end products. Despite significant strides having been made toward full-scale development, no commercial plants are currently in operation in Canada. In addition, it will be necessary to handle a much larger volume of waste than the volume of SRM material generated in the Fraser Valley to combine the technology with other technologies such as anaerobic digestion to achieve economies of scale. A detailed feasibility study to determine overall viability is required to more clearly define the likely capital and operating costs of such a plant, including market research on the potential revenues from end products.

Conclusions

Based on the available information, the potential exists to use the four technologies approved by the CFIA for SRM destruction in the Fraser Valley. Incineration and alkaline hydrolysis are the two technologies most suitable for use on a small scale by farmers, individual slaughtering plants, and dead stock collectors in the Fraser Valley as well as other parts of BC. The two technologies most suited for the establishment of a centrally located plant to handle all of the SRM generated in the Fraser Valley are gasification and thermal hydrolysis. However, for these technologies to be viable, it would be necessary for the plant to handle a number of other wastes in order to achieve economies of scale and to generate revenues from end products such as fertilizer and energy. Other significant volumes of wastes generated in the Fraser Valley that could be handled by a centrally located plant are poultry litter and municipal waste. In addition, SRM from other parts of BC could be transported to such a plant. Because of the number and value of end products generated, gasification and thermal hydrolysis appear to have the greatest potential to minimize the tipping fees paid by BC slaughtering plants, dead stock collectors and farmers for the disposal of SRM.

Recommendations

Our recommendations to develop viable options for the destruction of SRM generated in the Fraser Valley are as follows:

1. Undertake a more detailed analysis of likely incineration costs for a small-scale incinerator that could be used by individual farmers, slaughtering plants and dead stock collectors. This analysis should include monitoring of the performance and costs incurred by, for example, the demonstration

incinerator recently purchased for disposal of SRM material in the Okanagan.

2. Conduct lab and pilot tests to determine the feasibility of a large-scale gasification plant in the Fraser Valley.

3. Undertake research to find markets for the effluent produced from alkaline hydrolysis technologies in order to offset the processing costs and to find an alternative to introducing the effluent into municipal sewer systems. The effluent from alkaline hydrolysis could potentially be used as a fertilizer or soil amendment, a feedstock for processes such as anaerobic digestion to generate methane for power production, and a nutrient cocktail for improving sewage treatment plant performance.

4. Conduct a detailed feasibility study to determine overall viability and total capital and operating costs of a large-scale thermal hydrolysis plant for the Fraser Valley, including market research on the potential revenues from end products.

5. Undertake a more detailed feasibility assessment of the emerging technologies that have the potential to be approved for SRM destruction. This step should including firing the SRM material in the proposed Vertus Technology reductive thermal processing (RTP) facility and the proposed PlascoEnergy plasma gasification facility.

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I. Introduction

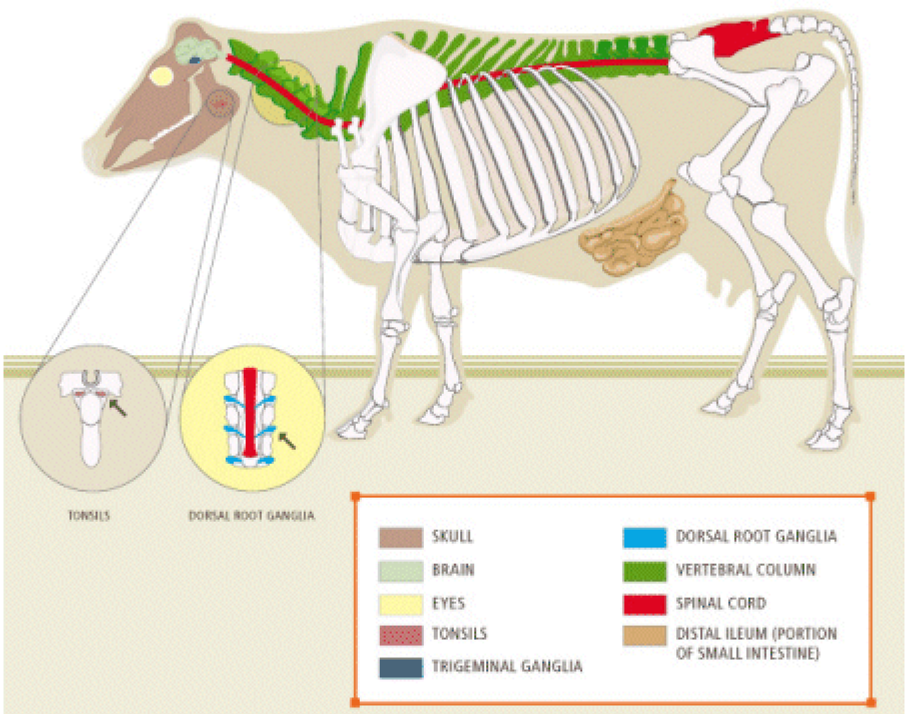
This chapter describes the purpose and methodology employed to undertake the assignment.

A. Background

Beginning July 12, 2007, enhanced animal safeguards came into effect to help eliminate bovine spongiform encephalopathy (BSE), or mad cow disease, in Canada. Certain cattle tissues capable of transmitting BSE, known as Specified Risk Material (SRM), are banned from all animal feeds, pet foods and fertilizers. These safeguards include requirements for the slaughtering and processing of cattle. The Canadian Food Inspection Agency (CFIA) is the federal government authority charged with the permitting and tracking of SRM throughout the country.

Specified Risk Material (SRM) is tissue that, In BSE-infected cattle, has been shown to contain the infective prion which can transmit disease. The following tissues are defined in Government of Canada regulations as SRM: skull, brain, trigeminal ganglia (nerves attached to the brain), eyes, tonsils, spinal cord, and dorsal root ganglia (nerves attached to the spinal cord) of cattle aged 30 months or older, and the distal ileum (part of the small intestine) of cattle of all ages. Figure 1.1 illustrates the location of SRM in a cow. The entire carcass or any part thereof of condemned cattle and cattle dead stock, regardless of age, must be treated as SRM if they contain SRM. Any inedible material that is mixed with SRM, such as floor waste or recovered solids from waste water, must also be treated as SRM.

Figure 1.1: Location of SRM in Cattle



Source: *CFIA Website*

To support the July 12, 2007 enactment of the country-wide enhanced feed ban regulations, the federal government signed a funding agreement with the Government of British Columbia to assist in the development of infrastructure necessary to manage SRM in accordance with the Canadian Food Inspection Agency directives. The federal/provincial government agreement that outlines the broad parameters for SRM handling and disposal is entitled the *Canada-British Columbia Agreement Establishing the Facilitation of the Disposal of Specified Risk Materials (SRM) Program*. The administration, management and implementation of SRM disposal solutions are carried out under a separate subservient program designed for British Columbia conditions and is entitled the *Canada–British Columbia Specified Risk Material (SRM) Management Program (SRMMP)*.

B. Current Handling of SRM in the Fraser Valley

All slaughterhouse waste in the Fraser Valley, including SRM, is currently being picked up and transported to a rendering plant in Calgary, Alberta that is operated by West Coast Reduction Ltd. As indicated in Table 1.1, the annual volume of ruminant waste collected by West Coast Reduction from four cattle slaughtering plants in the Fraser Valley is estimated to be approximately 3500 tonnes (3860 tons). The four plants are Johnston Packers, Pitt Meadows Meat, Scott's Meats and AGM Beef Farm. This ruminant volume includes both SRM and non-SRM. While two of the four slaughtering plants currently separate SRM from non-SRM materials, all SRM and non-SRM material is combined when it is picked up by West Coast Reduction. Consequently, West Coast Reduction classifies all ruminant material picked up at these locations as SRM for transportation and processing purposes.

As indicated in Table 1.1, the annual volume of ruminant dead stock waste collected by West Coast Reduction from the Fraser Valley via its three service providers is approximately 2000 tonnes (2200 tons). The three collectors are Dargatz Mink Farm, Carson Stock Farm and Canal Farms. They pick up sick or dead cattle and other animals such as horses from Fraser Valley farms.

The amount currently paid by slaughterhouses and dead stock collectors to West Coast Reduction for the pickup, transportation and handling of SRM-classified material ranges between $154 - $187 per tonne (7 to 8.5 cents per pound), depending on the volume handled.

Table 1.1: Annual Ruminant Volume of Waste Classified as SRM Collected by West Coast Reduction

Source of Waste	Volume (tonnes/tons)
Slaughtering plants	**3500 (3850)**
Dead stock collectors	**2000 (2200)**
Total	**5500 (6060)**

Source: *West Coast Reduction Ltd.*

The total volume of cattle waste classified as SRM collected by West Coast Reduction from Fraser Valley slaughtering plants and dead stock is estimated at 5500 tonnes (6060 tons). This material is first transported by West Coast Reduction to a temporary government-owned waste transfer station located in east Abbotsford. The material is then loaded into trailers and hauled to West Coast Reduction's rendering plant in Calgary, Alberta. The total weight of waste from the Fraser Valley going to the Calgary rendering plant is approximately 16,000 tonnes (17,600 tons) per year. Some of this weight is non-ruminant waste but, be-cause it is mixed with ruminant SRM, it is all considered as SRM.

Approximately 10% of the total cattle slaughterhouse waste generated from the four Fraser Valley slaughtering plants is estimated to be SRM. However, all of the material obtained from dead stock collectors is assumed to be SRM because the entire carcass or any part thereof of condemned cattle and cattle dead stock, regardless of age, must be treated as SRM. Consequently, the volume of Fraser Valley-based SRM handled by the West Coast Reduction plant in Calgary is estimated to be approximately 2400 tonnes (2650 tons) per year. Total amounts of SRM generated in the Fraser Valley are higher because a significant proportion includes the dead stock that are composted or buried by farmers on their own premises.

The products generated from the rendering of SRM material transported from the Fraser Valley to the Calgary plant are tallow and meat and bone meal (MBM). The meat and bone meal produced from the SRM material is hauled to a landfill in Coronation, Alberta while the tallow produced from this material is sold by West Coast Reduction for use in a wide variety of products.

C. Purpose of Study

The purpose of the study was to prepare a document that could be used as an information platform to address the strengths, weaknesses, opportunities and threats (SWOT) associated with various options for SRM containment and destruction. These options include rendering, anaerobic digestion, aerobic digestion, lactic acid fermentation, composting, thermal depolymerization, alkaline hydrolysis, acid hydrolysis, thermal hydrolysis, plasma arc destruction, pyrolysis, land filling, incineration and gasification.

D. Study Methodology

The major steps undertaken to perform the assignment were as follows:

1. Reviewed the available information on the sources and associated quantities of SRM and non-SRM generated within the Fraser Valley which require handling, containment and/or disposal.

2. Reviewed previous studies and conducted Internet and literature research to obtain available information on the technologies that could potentially be used for SRM and non-SRM containment and disposal in the Fraser Valley. The bibliography at the end of the report contains a list of the previous studies reviewed.

3. Examined the government regulations and legislation governing the containment and disposal of SRM in the Fraser Valley.

4. Conducted telephone and in-person interviews with key stakeholders impacted by SRM containment and disposal in the Fraser Valley.

5. Contacted representatives of Fraser Valley-based regional districts, municipalities, and the Government of BC to identify waste streams other than SRM, such as wood waste, green waste, poultry and turkey manure, compost and municipal solid waste that could be incorporated into viable SRM and non-SRM management/disposal solutions.

6. Contacted representatives of companies that have commercialized technologies that could potentially be used for SRM containment and disposal in the Fraser Valley.

7. Reviewed and summarized available information on the capital, operational and maintenance costs that would likely be incurred for SRM disposal in the Fraser Valley.

8. Developed recommendations to remove or mitigate potential barriers that may currently limit the availability of certain SRM management/disposal options.

E. Report Outline

The next chapter provides a SWOT analysis of the potential technologies for SRM containment and disposal. Chapters III to VI provide a more detailed description of the technologies that have been approved by the CFIA for SRM destruction in Canada.

II. SWOT Analysis of SRM Containment and Disposal Options

The following paragraphs provide a SWOT analysis of the potential technologies for SRM containment and disposal.

A. Landfilling

Slaughterhouse or dead stock waste containing SRM, when disposed of off-site within a landfill, is governed by CFIA requirements. The strengths, weaknesses, opportunities and threats of this SRM containment or disposal option are as follows:

Strengths/Opportunities

1. CFIA has classified the landfilling of SRM as a permanent method of containment of the abnormal prion.

2. CFIA has performed a risk assessment of landfilling as a method of disposal and has determined that landfilling poses a negligible risk of BSE transmission to domestic ruminants under the presumption that various hydrological criteria are satisfied.

3. The most significant advantages of landfill disposal are that infrastructure for disposing of SRM material already exists and capacity can be large.

4. The costs to dispose of SRM material in an existing landfill are likely to be low compared to most other alternatives, particularly for small volumes of SRM.

Weaknesses/Threats

1. The landfill operators contacted in the Fraser Valley are not willing to accept slaughter waste, particularly slaughter waste containing SRM. The disposal of slaughter waste is regulated in a Code of Practice under the *Environmental Management Act* and the *Waste Discharge Regulation*. Once a landfill has obtained approval from the CFIA to accept SRM, this activity must also be included in the landfill's Operational Certificate, which is approved by the Ministry of Environment. In addition, if the landfill is owned by a regional district or municipality, the regional district/municipality has the authority to accept or decline this waste. To determine whether landfilling of SRM is an option in the Fraser Valley, interviews were conducted with representatives of Metro Vancouver, the Fraser Valley Regional District, and several Fraser Valley municipalities including Langley, Mission, Chilliwack and Hope. These interviews determined that SRM disposal is not permitted in any of the landfills operated by regional districts or municipalities in the Fraser Valley. The reasons given for not accepting SRM material include the following:

    - High moisture content of the SRM causes problems including leakage;
    - Generation of methane and odour problems;
    - Likely resistance by the general public;
    - Inability of some landfills to meet CFIA containment requirements; and
    - The capacity and life cycle of some landfills would be compromised.

2. Establishing a new landfill to handle SRM in the Fraser Valley is a complex process. Under CFIA requirements, the owner/operator of a landfill must submit an application for a permit to handle SRM material. The CFIA then conducts an inspection to determine if the landfill meets CFIA requirements

with regard to separation, signage, operation, capping, drainage, groundwater protection, surface water management, leachate control, cover material, equipment, integrity breaches and records.

3. The volume of SRM generated in the Fraser Valley is not likely sufficient to attract a private operator to establish a new landfill dedicated to handling SRM.

4. Because landfilling of SRM material represents a method of containment rather than destruction, long-term management of the waste is required. The long-term security of this disposal option poses a potential threat. According to the report entitled *Carcass Disposal: A Comprehensive Review*, BSE infectivity is capable of long-term survival in the general environment, but does not permit any conclusions to be drawn with regard to the maximum period that it might survive under landfill conditions. Because landfilling does not result in the destruction of the abnormal prion, it is not perceived to be the safest method of containment for a number of reasons, most importantly that SRMs can contaminate soil and leachate, thereby creating groundwater risk. In addition, depending on location and proximity and access of landfills to wildlife, pets, or humans, there is a risk of transmission. A further issue relates to future land use once the landfill operation is terminated.

5. Compared to some other disposal options, landfilling does not generate usable byproducts of value.

As indicated above, landfilling is a method of containment rather than disposal. In addition, this option is not considered particularly feasible because landfill operators in the Fraser Valley are not willing to accept slaughter waste, especially waste containing SRM.

B. On-Site Burial

Farmers in the Fraser Valley may bury Specified Risk Material on their own premises. On-farm burial is not regulated by the CFIA. If farmers, slaughtering plants or dead stock collectors choose to bury on-site, applicable regulations include the *Environmental Management Act*, the *Agricultural Waste Control Regulation,* the *Waste Discharge Regulation*, and the *Code of Practice for the Slaughter and Poultry Processing Industries*. This provincial legislation, insofar as it affects on-site burial, currently does not differentiate between SRM and non-SRM waste. In conjunction with general on-farm disposal advice, however, the federally mandated CFIA recommends that, for example, composted SRM should not be applied to land that is expected to accommodate direct grazing by domestic ruminants for at least five years.

CFIA regulations also state that individuals or small businesses owning property not contiguous with the farm or premises of origin can apply for a permit to bury a limited quantity of SRM on the non-contiguous land. The non-contiguous site must meet the same basic requirements established by the CFIA for a natural landfill. The permit provided by CFIA for burial in non-contiguous premises authorizes the burial of not more than 350 kilograms (770 pounds) of material per week (equivalent to SRM from seven mature bovine carcasses) or 18,200 kilograms (40,000 pounds) per year (equivalent to approximately 30 intact mature bovine carcasses or SRM from 360 mature carcasses).

The strengths, weaknesses, opportunities and threats of this SRM containment/disposal option are as follows:

Strengths/Opportunities

1. The CFIA has classified the burial of SRM as a permanent method of containment of the abnormal prion.

2. The CFIA has performed a risk assessment of burial as a method of disposal and has determined that burial of SRM or carcasses from which the SRM has not been removed poses a negligible risk of BSE transmission to domestic ruminants.

3. The costs to dispose of SRM material by burial are low compared to most other alternatives, particularly for small volumes of SRM.

Weaknesses/Threats

1. Burial of SRM material represents a method of containment rather than of elimination, and long-term management of the waste is required. The long-term security of this disposal option poses a potential threat. The present evidence suggests that BSE infectivity is capable of long-term survival in the general environment, but does not permit any conclusions to be drawn with regard to the maximum period that it might survive under burial conditions. Because burial does not result in the destruction of the abnormal prion, this potential long-term survivability is an issue of concern, particularly regarding the impact on the value and possible uses of the land over the long term.

2. Compared to some other disposal options, burial does not generate usable byproducts of value.

3. The volume of SRM that can be buried by slaughtering plants and dead stock collectors is limited because most operations do not have a large amount of land to undertake burial on their premises. In addition, CFIA regulations limit the amount of SRM that can be buried by individuals or small businesses owning property not contiguous with the farm or premises of origin.

Burial is a method of containment rather than disposal. While this option is available to farmers, it is not particularly feasible for slaughtering plants and dead stock collectors in the Fraser Valley because they do not have a large amount of land for burial. In addition, the volume of SRM that can be buried is limited by CFIA regulations. Because burial does not result in the destruction of SRM, it is not an ideal option for farmers because it requires long-term management of the waste.

C. Rendering

Rendering of animal mortalities involves conversion of carcasses into three end products – namely, carcass meal (meat and bone meal (MBM)), tallow (or melted fat) and water – using mechanical processes (e.g., grinding, mixing, pressing, decanting and separating), thermal processes (e.g., cooking, evaporating, and drying), and sometimes chemical processes (e.g., solvent extraction). The main carcass rendering processes include size reduction followed by cooking and separation of fat, water, and protein materials using techniques such as screening, pressing, sequential centrifugation, solvent extraction, and drying. The resulting carcass meal can sometimes be used as an animal feed ingredient if it is non-SRM. Tallow can be used in livestock feed, production of fatty acids, or can be manufactured into a wide variety of uses such as soaps.

As indicated previously, the SRM generated in the Fraser Valley is currently shipped to a rendering plant in Calgary operated by West Coast Reduction Ltd. Along with dead stock supplied by separate service providers, West Coast Reduction gathers waste materials from slaughter plants, hauls these materials to a central waste transfer station in east Abbotsford, loads the by-product into trailers, and then transports these to its ruminant-only rendering plant in Calgary. The MBM resulting from rendering the SRM material is hauled to a landfill in Coronation, Alberta while the tallow produced from SRM and non-SRM is used for a variety of industrial products.

The strengths, weaknesses, opportunities and threats of this SRM containment/disposal option are as follows:

Strengths/Opportunities

1. Rendering of SRM can produce beneficial products that are outside the scope of human and animal food chains. As an illustration, tallow produced from rendering SRM material can be utilized for industrial purposes such as the manufacturing of pharmaceutical and cosmetic products, as well as the making of soap and detergents.

2. Rendering SRM into MBM results in an approximate 75% reduction in the volume of SRM material that is placed in the landfill in Coronation, Alberta.

Weaknesses/Threats

1. Rendering has not been approved by the CFIA as a disposal option for SRM because the temperatures in the rendering process are not high enough to destroy BSE prions. The emergence of BSE has largely been attributed to cattle being fed formulations that contained prior-infected meat and bone meal (MBM) obtained from the rendering of cattle slaughter waste. According to a report by the United Kingdom Department for Environment, Food and Rural Affairs (UKDEFRA) in 2000, epidemiological work carried out in 1988 revealed that compounds of animal feeds containing infective MBM were the primary mechanism by which BSE was spread throughout the United Kingdom. To help eliminate BSE in Canada, the Government of Canada banned SRM from all animal feeds, pet foods and fertilizers in July 2007. Consequently, MBM produced from SRM cannot be used as fertilizer or in animal feed.

2. The MBM resulting from rendering SRM is also considered SRM and must be disposed of using CFIA approved and permitted methods. As indicated previously, the MBM produced from Fraser Valley SRM is currently hauled from the Calgary rendering plant to a landfill in Coronation, Alberta. While the rendering of SRM material prior to landfilling will reduce pathogen infectivity, it will not deactivate the BSE prion if it exists in the materials being disposed.

3. The transfer of SRM from the Fraser Valley to a rendering plant in Calgary and then to a landfill in Coronation, Alberta results in considerable transportation and handling charges.

4. The volume of cattle slaughter waste generated in the Fraser Valley is too small to justify the establishment of a rendering facility to handle ruminant wastes in the Lower Mainland. While West Coast Reduction operates a rendering plant in the Lower Mainland, this facility does not handle ruminant wastes. According to a report entitled *Carcass Disposal: A Comprehensive Review* (see Bibliography), a rendering plant must process at least 50 to 65 metric tonnes (55 to 72 tons) per day to be economically feasible, assuming 20 working hours per day. While the establishment of a Fraser Valley rendering plant capable of accommodating slaughter waste would reduce current handling charges incurred by slaughtering plants and dead stock collectors, it is unlikely that such a rendering plant capable will be established in the Fraser Valley in the near future.

Rendering is not an SRM disposal option because the temperatures in the rendering process are not high enough to destroy the BSE prions. Rendering SRM into MBM does result in reduction of the volume of Fraser Valley SRM material that is placed into the landfill in Coronation, Alberta.

D. Composting

Carcass composting is a natural biological decomposition process that takes place in the presence of oxygen (air). Under optimum conditions, during the first phase of composting, the temperature of the compost pile increases, the organic components of mortalities break down into relatively small compounds, soft tissue decomposes, and bones partially soften. In the second phase, the remaining materials (mainly bones) break down fully and the compost turns into a consistent dark brown to black soil or "humus" with a musty odor containing non-pathogenic bacteria and plant nutrients.

Carcass composting systems require a variety of ingredients or co-composting materials, including carbon sources, bulking agents, and biofilter layers. Various materials can be used as a carbon source, including sawdust, straw, poultry litter, semi-dried screened manure, hay, shavings, paper, silage and leaves. Bulking agents or amendments usually have larger particle sizes than do carbon sources and the addition of bulk maintains adequate air spaces within the compost pile by preventing packing of materials. Bulking agents typically include materials such as sludge cake, spent horse bedding, wood chips, rotting hay bales and tree trimmings. A biofilter is a layer of carbon source and/or bulking agent material that: (1) enhances microbial activity by maintaining proper conditions of moisture, pH, nutrients and temperature; (2) deodorizes the gases released at ground level from the compost piles; and (3) prevents access by insects and birds and thus minimizes transmission of disease agents from mortalities to livestock or humans.

Commercial composting is governed by the *Organic Matter Recycling Regulation* (OMRR) which applies to the composting of organic wastes or other feedstock. This legislation regulates the discharge of leachate, composted or partially composted solids, and odour emissions. In addition, the OMRR sets standards for the quality of compost based on its metal content and pathogen count. Composting facilities in the Agricultural Land Reserve (ALR) set up in accordance with the OMRR are prohibited from using SRM as compost feedstock without the express written approval of the Agricultural Land Commission (ALC).

On-farm composting of agricultural wastes (but not slaughter wastes) is accepted under the Agricultural Waste Control Regulation when materials transported in for on-farm composting are used on the farm. Mortalities are allowed to be composted only on the farm where the animals died. On-farm composting of SRM slaughter wastes is not controlled by the CFIA if it takes place on the same premises where the SRM is generated and if the product (compost) does not leave the premises of origin. The CFIA has advised provincial ministries (which have regulatory authority over on-farm composting) that it is not recommended that the compost produced from SRM and remaining on the premises be spread on land directly grazed by domestic ruminants for at least five years. The spreading of SRM compost produced off the farm, or SRM compost produced on the farm where the SRM compost feedstock is imported to the farm, is prohibited without the express approval of the ALC. The composting and sale of non-SRM solid slaughter wastes is subject to criteria identified in the Organic Matter Recycling Regulation.

The strengths, weaknesses, opportunities and threats of this SRM containment/disposal option are as follows:

Strengths/Opportunities

1. Mass composting has been identified by the CFIA on its website as a useful intermediate method to decrease the volume of SRM to be disposed. While composting does result in reductions in volume, the total amount of material to be handled (including, for example, bulking agents) in a composting operation may actually be higher than it would be for options such as rendering and burial.

2. Composting is a proven technology both at an on-farm and at a commercial scale.

3. Capital and operating expenses are low to moderate. According to the report entitled *Carcass Disposal: A Comprehensive Review* (see Bibliography), the total cost of composting ranges between Cdn $48 to $74 per tonne ($44 and $67 per ton).

4. Composting produces both nutrient-rich end product and low-grade heat which may be used for heating buildings.

5. Composting requires very little energy input except to operate mixers and aeration blowers.

6. The process has a limited environmental impact including no chimney stack, minimal aesthetic impact and low noise.

Weaknesses/Threats

1. CFIA has stated that mass composting is not an acceptable method of disposal. Under the CFIA's current working policy, only those methods posing no greater than a negligible risk of transmitting BSE to domestic ruminants are considered acceptable methods of disposal. In terms of SRM, the final compost will still be classified as SRM and thus will be subject to all regulatory and permitting requirements applicable to SRM.

2. Potential end uses for SRM compost are limited, and typically include disposal to a landfill or disposition in an area with negligible risk for exposure to domestic ruminants.

3. The end product has low value.

4. One risk is that pathogens can be spread through improper handling, maintenance or poor design.

5. Composting can generate odours, ammonia and leachate. Therefore, it must be conducted on an impermeable pad accompanied by measures for leachate control, leachate disposal, and odour containment.

While composting is a suitable option for on-farm containment, it is not a suitable SRM destruction option because the temperatures in the composting process are not high enough to destroy BSE prions. While composting does result in reductions in volume, the total amount of material to be handled (including, for example, bulking agents) in a composting operation may actually be higher than it would be for options such as rendering and burial.

E. Anaerobic Digestion

Anaerobic digestion is the microbiological decomposition of large-molecule organic substances into smaller-molecule organic substances in an airless environment, resulting in the production of biogas. A similar but less complete process takes place in the stomach.

Strengths/Opportunities

1. Anaerobic digestion is one of the few technologies capable of handling high moisture content.

2. Anaerobic digestion has a positive energy balance producing marketable value-added byproducts in the form of organic fertilizer; biogas from which heat alone, heat and electricity, or upgraded gases for introduction into the natural gas grid may be produced; and greenhouse gas (GHG) emission reduction credits which may be offered for sale.

3. The technology is capable of dealing with multiple waste streams simultaneously, including manure, urine, blood, milk, protein meals, agriculture residues and wastewater.

4. The anaerobic digestion process will reduce up to 90% of the odour emissions and eliminate pathogens.

5. Anaerobic digestion is a proven technology at both an on-farm and a commercial scale. Anaerobic digestion has been used for many years for processing a variety of wastes. Research has demonstrated that poultry carcasses can be processed using anaerobic digestion, and this technology has been used commercially.

Weaknesses/Threats

1. Anaerobic digestion has not been approved by the CFIA as a disposal option for SRM because the temperatures in the process are not high enough to destroy BSE prions.

2. SRMs would contaminate the rest of the digestate used in the anaerobic digester and would not be permitted for land application. In other words, the other materials such as sludge and liquids resulting from processing SRM would be regarded as SRM after processing and would have to be disposed of in a similar manner as the SRM fed into the anaerobic digestion process.

3. Carcass waste would have to be carefully introduced into existing operating facilities to avoid disturbing the delicate biological process. Only small amounts of carcass waste could be processed in existing facilities that currently process municipal or agriculture waste originating from vegetables, fruits, or manure. No on-farm anaerobic digestion facilities are currently operating in the Lower Mainland.

Anaerobic digestion has not been approved by the CFIA as an acceptable method of permanent destruction of abnormal prions that may be present in SRM because the temperatures used in the process are not high enough. However, once the abnormal prions in the SRM material have been destroyed by another technology, this material could be introduced into an anaerobic digestion facility followed by further production processes to generate heat and electricity via the introduction of power plants or reciprocating engines, or to generate upgraded gases for introduction into the natural gas grid.

F. Aerobic Digestion

Very little research has been undertaken regarding the use of aerobic digestion for SRM or carcass disposal. The report entitled *Options and Challenges Related to Emergency Disposal of Large Animals in the Fraser Valley* (see Bibliography) provides a brief description of Enhanced Autogenous Thermophylic Aerobic Digestion (EATAD) technology which is a continuous process of aerobically stabilizing organic matter in a liquid form. The EATAD system must be operated in an enclosed building under negative air pressure and with odour control equipment. Process water is evaporated and released into the atmosphere or discharged into a sewer. No commercial-scale operating aerobic digestion facilities exist in the Fraser Valley with the exception of a small demonstration facility operating in North Vancouver.

Strengths/Opportunities

1. The process has a relatively short processing time and produces both solid and liquid fertilizer materials.

Weaknesses/Threats

1. Aerobic digestion has not been approved by the CFIA as a disposal option for SRM because the temperatures in the process are not high enough to destroy BSE prions.

2. SRMs would contaminate the rest of the digestate used in the digester and would not be permitted for land application.

3. This method has not been tested for the disposal of large carcasses. According to a report entitled *Carcass Disposal: A Comprehensive Review* (see Bibliography), tests using poultry carcasses in an aerobic digester have resulted in a significant amount of undigested food waste.

4. Switching the process from one feedstock to another may upset the bacterial cultures used in the process.

5. No aerobic digestion facilities are currently operating in the Lower Mainland.

6. Odour and odour containment are the main concerns of this type of technology.

As with anaerobic digestion, aerobic digestion has not been approved by the CFIA as a disposal option for SRM because the temperatures in the process are not high enough to destroy BSE prions.

G. Incineration/Burning

Three types of incineration/burning have been used in the past for carcass disposal: fixed-facility incineration, air curtain burning, and open pile burning. Only fixed-facility incineration is suitable for SRM destruction. Registration and operating requirements for slaughter waste incinerators are specified in the *Code of Practice for the Slaughter and Poultry Processing Industries* for units with continuous loading rates under 400 kilograms per hour or batch loading rates under 400 kilograms per load. Larger fixed-facility incineration units require a permit administered by the BC Ministry of Environment under the *Environmental Management Act.*

Strengths/Opportunities

1. CFIA has performed a risk assessment on this method of destruction and determined that SRM incineration presents a negligible risk of transmission of bovine spongiform encephalopathy (BSE) to domestic ruminants. Based on the conclusion of this risk assessment, output from approved incinerators is not regulated by SRM controls – provided that it can be demonstrated that the ash produced does not contain amino acids.

2. The incineration of SRM (in any form) in a primary chamber at a temperature of 850°C (1560°F) or above for at least 15 minutes, or above 900°C (1650°F) for at least four seconds, and until all organic matter has been reduced to ash containing no detectable proteins, is approved by the CFIA as an acceptable method of destroying the abnormal BSE prion.

3. Incineration is a proven technology. Small and large fixed-facility incineration plants have been built in many parts of the world to deal with slaughterhouse waste and other animal waste. The largest facility in the United Kingdom is operated by BronzOak Thermal Processing Ltd. in Somerset and has a capacity of 2.4 tonnes (2.6 tons) per hour.

4. Incineration can process a variety of waste streams.

5. Material volume is reduced significantly as a result of incineration. Ash volumes, for example, are typically about 7% of input volumes.

Weaknesses/Threats

1. In spite of many incinerators' abilities to generate emission levels below maximum allowable levels as defined in applicable BC Ministry of Environment legislation, significant public resistance would likely be encountered if a sizable incineration project were proposed for the Fraser Valley. All municipal and regional government representatives contacted indicated that the public would not be in favour of an incineration project because it would exacerbate the existing air quality problems in the Fraser Valley. A municipal waste incinerator in Burnaby already exists, which could potentially handle SRM material. However, representatives of Metro Vancouver indicated that public resistance would be too great to consider handling SRM in this facility.

2. Incineration could also generate odour complaints from neighbouring residential areas.

Incineration is a feasible method of SRM disposal because it has been approved by the CFIA as an acceptable method of destroying the abnormal prion. However, due to existing air quality concerns in the Fraser Valley, there may be considerable public resistance to operating an incinerator that handles SRM. Because this option is feasible for SRM destruction, a more detailed discussion of incineration is provided in Chapter IV.

H. Gasification

Gasification is a method of organic matter disposal by which, under high heat and low oxygen, gases are generated and captured, leaving ash and some char. Operation of a gasification facility requires a permit administered by the BC Ministry of Environment under the *Environmental Management Act.*

Strengths/Opportunities

1. The combination of high temperatures at greater than 850°C and long retention times of greater than one hour makes gasification a technology suitable for SRM destruction. CFIA considers gasification a form of incineration, and the requirement for destruction of the abnormal prion in SRM (in any form) in a primary chamber is a temperature of 850°C (1560°F) for at least 15 minutes and until all organic matter has been reduced to ash. For SRM that has been reduced to a size of 50 mm in diameter or less, the minimum time in a primary chamber at 900°C (1650°F) or above is at least two seconds and until all organic matter has been reduced to ash.

2. Gasification can be used to handle a variety of wastes.

3. Gasification is a proven technology – there are many suppliers and it is possible to source locally.

4. The technology generates producer gas (syngas) or heat and electricity which can generate revenues to offset operating costs.

Weaknesses/Threats

1. Waste must be reduced in size and dried to lower the moisture level of the processing mix. The maximum moisture content that can be handled is approximately 30% which is considerably less than a typical approximate moisture content of 62% for SRM. Consequently, the SRM would have to be dried or mixed with a dry product before it can be fed into a gasification plant.

2. To reduce carcasses to a size that can be handled by the gasification plant, odours may be

generated from the pre-processing facility.

Gasification is a feasible method of SRM destruction because it meets the CFIA requirements of a temperature of 850°C (1560°F) or above for at least 15 minutes, or a temperature of 900°C (1650°F) or above for at least four seconds, and until all organic matter has been reduced to ash. Because this option is approved by the CFIA for SRM destruction, a more detailed discussion of gasification is provided in Chapter III.

I. Alkaline Hydrolysis

Through the action of a strong alkaline solution, high temperature and high pressure, organic material is processed into a sterile aqueous liquid consisting of low molecular weight peptides and amino acids. The liquid is claimed to be suitable for use as a fertilizer or in bio-diesel production according to the report entitled *Options and Challenges Related to Emergency Disposal of Large Animals in the Fraser Valley* (see Bibliography). Solid byproducts include mineral constituents such as bones and teeth of animals. This sterile material can easily be crushed and used as a soil additive.

Strengths/Opportunities

1. The CFIA has performed a risk assessment on alkaline hydrolysis of SRM and has determined that this method of destruction presents a negligible risk of transmission of bovine spongiform encephalopathy (BSE) to domestic ruminants. Based on the risk assessment, output products from approved alkaline hydrolysis units are not subject to further SRM regulatory controls. CFIA-approved alkaline hydrolysis of SRM requires processing SRM at a temperature of 150°C (300°F) and a pressure of at least 400 kPa (~60 psi) in a hydroxide solution for a period of not less than 180 minutes per cycle, in an enclosed pressure vessel that is suitable for the purpose required.

2. There is potential to transform the resulting liquid into usable products such as a soil additive, fertilizer or bio-diesel fuel.

3. The method has been tested in Europe and the US.

4. Alkaline hydrolysis is viewed as a more public health-friendly method than incineration in the US.

Weaknesses/Threats

1. This method will generate large quantities of effluent liquid with high organic loading. The high biochemical oxygen demand (BOD) level and pH of the liquid effluent may be a restriction if it is disposed of in a sewer.

2. Until recently, this method has been limited in processing capacity.

Alkaline hydrolysis is a feasible method of SRM disposal because it has been approved by the CFIA as an acceptable method of destroying the abnormal prion. A more detailed discussion of alkaline hydrolysis is provided in Chapter V.

J. Thermal Hydrolysis

Thermal hydrolysis is a bio-refining technology that utilizes high-temperature saturated steam which denatures pathogenic viruses, bacteria, prions and other disease agents. The original animal and plant material is broken down into amino acids, fatty acids and minerals which create valuable sterile nutrients. The technology involves sealed high-pressure batch reactors which can process high tonnages of organic waste in short cycle times.

Strengths/Opportunities

1. The CFIA has performed a risk assessment of thermal hydrolysis of SRM and has determined that thermal hydrolysis is an acceptable method of permanent destruction of abnormal prions that may be present in SRM. Based on the conclusion of this risk assessment, output products from approved thermal hydrolysis installations are not subject to further SRM regulatory controls. CFIA-approved thermal hydrolysis of SRM requires operation at temperatures of at least 180°C (360°F) and pressures of at least 1200 kPa (~175 psi) for a period of not less than 40 minutes per cycle in an enclosed pressure vessel that is suitable for the purpose required.

2. The thermal hydrolysis process is pollution free and eliminates odours.

3. The process can handle a wide variety of wastes.

4. Thermal hydrolysis can produce a variety of value-added byproducts (e.g., fertilizer and electricity as explained in Chapter VI) which can be used to generate revenues to offset operating costs.

Weaknesses/Threats

1. The technology is currently being commercialized.

2. Thermal hydrolysis plants will need to handle wastes in addition to SRM and will need to be combined with other technologies to achieve economies of scale to spread capital and overhead costs.

Thermal hydrolysis is a feasible method of SRM disposal because it has been approved by the CFIA as an acceptable method of destroying the abnormal prion. A more detailed discussion of thermal hydrolysis is provided in Chapter VI.

K. Acid Hydrolysis

Hydrolysis is a chemical reaction during which one or more water molecules are split into hydrogen and hydroxide ions which may go on to participate in further reactions. It is a type of reaction that is used to break down certain polymers, especially those made by step-growth polymerization. Such polymer degradation is catalyzed by acid attack, often increasing with the pH.

Strengths/Opportunities

1. Acid hydrolysis has been used to stabilize fish wastes. The proteolytic activity of enzymes in the visceral portion of fish, combined with pH adjustment, has been used for many years in reducing whole industrial fish and fish plant processing waste to hydrolyzed solubles for animal feed and liquid fertilizers. Acid hydrolysis is the most common technique used since the resultant solution can be stabilized against spoilage. The solubilized polypeptides and amino acids are highly functional and are excellent sources of amino acids for animals. Furthermore, the acid dissolves a high percentage of the bones and other minerals, leaving the solution high in minerals.

2. Acid hydrolysis is an emerging method for the disposal of poultry carcasses because it provides

long-term stabilization of the carcasses, contributes to a dramatic decrease in the level of pathogenic microorganisms, and results in a transportable product that can be processed by a rendering facility into a suitable animal feed ingredient.

3. Acid preservation of mortalities through the introduction of inorganic acids such as sulfuric acid or phosphoric acid has proved effective. Because of safety concerns with handling sulfuric acid stock solution, however, use of phosphoric acid may be more practical. Effective carcass preservation involves grinding carcasses to allow for even distribution of acid and requires a corrosion-resistant storage structure capable of handling the desired quantity of mortalities before delivery to a rendering facility.

Weaknesses/Threats

1. The CFIA has not conducted a risk assessment for this technology.

Acid hydrolysis has not been approved by CFIA as a suitable method for the destruction of SRM. This process should be viewed as an intermediate step in carcass disposal.

L. Pyrolysis

Pyrolysis is a method of organic matter disposal that uses high heat (650°C – 850°C) and low oxygen to generate gases (which are collected), charcoal and oil. The process can be conducted in up-flow reactors or in retort (horizontal screw) reactors. Waste must be reduced in size and mixed with dry wood to lower the moisture level of the processing mix.

Energystics Technologies Ltd. has developed a novel pyrolysis technology, called ETL EnergyBeamTM, which uses a proprietary technology to concentrate and direct electromagnetic waves at solid, liquid or gaseous targets. Rather than converting electrical energy to thermal energy in a conductive medium, this technology directly couples electromagnetic energy with a target material to produce heat. The target absorbs energy, generating temperatures that exceed the melting or vaporization points of the target materials. These temperatures provide the ability to disassociate strong molecular bonds in hazardous materials. Because the technology does not utilize a conductive medium, only a relatively small energy input is required. Advantages of the technology reportedly include instantaneous controllable heating, a lack of hydrocarbon pollutants or harmful emissions, and reduced energy requirements. Additionally, the technology is reportedly scalable and lends itself to continuous operation and automation. However, the technology has yet to be tested on intact carcasses.

Strengths/Opportunities

1. Effluent gases can be used for the generation of electricity using steam boilers or gas turbines while other end products such as charcoal and oil can be used for energy production.

2. The process results in the production of a reusable energy source.

3. More energy is produced than consumed.

Weaknesses/Threats

1. CFIA has not conducted a risk assessment of this technology.

2. Drying of SRM material will likely be required to reduce the moisture content to about 15%.

3. In the case of processing slaughter waste, odour may be generated from the pre-processing facility.

Pyrolysis has not been approved by the CFIA as an acceptable method of SRM destruction because no one has applied for a risk assessment of this technology. According to CFIA representatives, pyrolysis is a form of incineration. Consequently, for this method to be approved, the SRM would have to be heated to a temperature of 850°C (1560°F) or above for at least 15 minutes, or 900°C (1650°F) or above for at least four seconds.

M. Thermal Depolymerization

Thermal depolymerization was developed by Paul Baskis in the 1980s to reduce complex organic materials to light crude oil. The process mimics the natural geological processes thought to be involved in the production of fossil fuels. Under pressure and heat, long-chain polymers of hydrogen, oxygen and carbon decompose into short-chain petroleum hydrocarbons. Many methods to create hydrocarbons use considerable energy to remove water from the materials. This method instead requires water, as the water both improves the heating process and supplies hydrogen and oxygen for the chemical reactions.

A thermal depolymerization plant was recently constructed at the ConAgra Foods turkey plant in Carthage, Missouri to digest up to 60 tonnes (66 tons) of turkey slaughter waste per day. According to a report entitled *Carcass Disposal: A Comprehensive Review*, the Con-Agra plant will convert turkey offal – guts, skin, bones, fat, blood and feathers – into a variety of products. During the first stage, fats, proteins, and carbohydrates will be broken down into carboxylic oil by undergoing heat and pressure reactions. The second stage reaction will strip off carboxyl groups (a carbon atom, two oxygen atoms, and a hydrogen atom) from the fatty acids and break the remaining hydrocarbon chains into smaller fragments to produce light oil which can be used as is, or refined into lighter fuels such as naphtha, gasoline, and kerosene. The process is also expected to yield fertilizer-grade minerals derived mostly from bones and carbon solids.

Thermal depolymerization works by heating organic matter under pressure in very controlled conditions with the addition of carbon monoxide and steam to produce useful organic products such as bio-fuel. The feedstock material is first ground into smaller particles. It is then fed into a reaction chamber where it is heated to around 250°C (480°F) and subjected to a pressure of 42 kg/cm^2 (~ 600 psi) for approximately 15 minutes, after which the pressure is released rapidly to boil off most of the water. The result is a mix of crude hydrocarbons and solid materials, which are separated out for further processing. The hydrocarbons are sent to a second-stage reactor where they are heated to 500°C (930°F), further breaking down the longer chains; the resulting petroleum is then distilled in a manner similar to conventional oil refining.

Strengths/Opportunities

1. The process results in the production of a reusable energy source.

2. More energy is produced than consumed.

3. The residue material remaining after the thermal depolymerization process should be minimal and consist of largely inorganic inert material that could be used as an agricultural soil amendment or placed in a landfill.

Weaknesses/Threats

1. Thermal depolymerization has not been approved by the CFIA as a method of SRM destruction.

2. It will be necessary to pre-process the SRM before it can be added into the reactors.

3. This method has not been tested for large animal carcass destruction.

4. There is a lack of existing operational facilities.

5. While cost data are lacking, costs are expected to be high for the construction and operation of facilities for SRM destruction alone.

Thermal depolymerization has not been approved by the CFIA as an acceptable method of SRM destruction.

N. Plasma Arc Destruction

This is a disposal method whereby very high temperatures are created by ionization of a gas in an electric arc. High temperatures transform organic material into a gas that contains mostly hydrogen and vitrified ash. The production of plasma results from the ionization of matter by modifying the temperature and electrical characteristics of a substance. Ionization of a gas produces free electrons and ions among the gas atoms, and will respond to magnetic fields allowing control of the plasma. Plasma is a gas that has been ionized by the electric arc of a plasma torch and can therefore respond to electrical and magnetic fields. Almost any type of gas (oxygen, nitrogen, carbon monoxide, air, etc.) in a wide range of pressures varying from vacuum to 21 kg/ cm^2 (~ 20 atmospheres) can be used to produce plasma. The origin of industrial uses of plasma can be found in the development of tungsten inert gas welding by defense industries when a better method of welding steel was required. Plasma technology was further developed for use in cutting metals and for cleaning material surfaces during manufacturing processes.

Plasma arc torches operate over a wide range of temperatures, from 1500°C (2700°F) to over 7000°C (12,600°F), approximately 1000°C hotter than the surface of the sun. The plasma torch and copper electrodes are water-cooled and the average life of the electrodes ranges from 200 to 500 hours of operation. Electrical requirements are met with a DC power supply unit, and commercial units are available in power capacities ranging from about 100 KW to 10 MW.

The plasma arc process is a potential solution to a variety of pollution problems. Utilization of the plasma arc process to dispose of wastes has been conducted in both mobile and fixed-facility forms. In-depth studies of the mobile form, Plasma Remediation of In-Situ Materials (PRISM), have been conducted at the Georgia Tech Plasma Applications Research Facility. The PRISM process relies on extremely hot plasma arc torches to vitrify or gasify hazardous wastes, contaminated soils, or the contents of landfills via vertical boreholes. Since materials do not have to be excavated or otherwise handled, PRISM can vitrify the material with reduced costs and less chance of further contamination. The resulting rock-like substance is highly resistant to leaching.

Fixed-facility configurations of plasma arc units have been used in Hawaii, France and Japan as commercial tools in the waste disposal sector, as well as in other industries such as steelmaking and precious metal recovery. Fixed hearth plasma arc units in operation for the disposal of waste organics start at processing capacities of 40 kilograms (88 pounds) per day. The Solena Group and Westinghouse have installed over 40 plasma arc waste disposal facilities around the world. Several disposal projects have utilized fixed hearth plasma arc technologies to incinerate hazardous wastes while capturing waste gases for energy production. A pilot project headed by Westinghouse to process 76,000 cubic metres (~ 2.7 million cubic feet) per year of harbour sediment is underway in New York/New Jersey with plans to construct a full scale facility capable of processing 380,000 cubic metres (~ 13.4 million cubic feet) per year.

A hybrid technology is being tested in Ontario which consists of plasma arc destruction combined with gasification and energy production. The application of the technology is in municipal waste management. Another municipal waste processing facility in Lubsko, Poland is using plasma pyrolysis to produce a high-energy synthetic gas composed of 80% hydrogen and carbon monoxide. Steam is injected into the reaction chamber resulting in gasification in a few seconds. Without oxygen, no fumes, ashes, dioxins or furans are formed.

Strengths/Opportunities

1. Plasma arc destruction has the ability to treat most waste materials.
2. The technology results in the production of a reusable energy source.
3. More energy is produced than consumed.
4. The environmental implications are minimal; any remaining residues are inert.

Weaknesses/Threats

1. Plasma arc destruction has not been approved by the CFIA as a method of SRM destruction.
2. A limited number of operating facilities presently exists.
3. The SRM will have to be pre-processed before disposal.
4. While cost data are lacking, the cost will likely be too high to justify construction and operation of facilities for SRM disposal alone.

Although this technology may be capable of SRM destruction, the CFIA has not conducted a risk assessment of plasma arc technology.

O. Plasma Gasification

Plasma gasification is a process promoted by the private PlascoEnergy Group that uses a proprietary technology to convert municipal household, commercial or industrial waste into electrical power and other products. This technology is mainly focused on the disposal of municipal solid waste.

The process employed for the plasma gasification technology, as described in the report entitled *Economic Assessment of Combustion Technologies for Specified Risk Material Disposal in British Columbia,* is that waste is fed into the primary chamber of the converter where the material is gasified by heat recovered from the gases exiting the refining chamber. Within the refining chamber, there are two plasma torches. The gasified product from the primary chamber contains carbon monoxide, hydrogen, tars and un-reacted carbon. This gas is refined into a cleaner and lighter gas in the secondary chamber. Process air and plasma heat are combined with the gas and the plasma heat is adjusted to maintain the desired process chamber conditions. All long-chain hydrocarbons are destroyed in the process.

With the Plasco Conversion System, the gas is cleaned prior to generating electricity. After passing through the heat recovery unit, the gas flows to the Gas Quality Control Suite where the gas is cooled and cleaned of particulates, metals and acid components. The solid residue from the primary chamber is sent to a separate high-temperature chamber equipped with a plasma torch where it is melted. Plasma heat is used to stabilize the solids by driving off any remaining volatile compounds. Any volatile gas is passed through several cleaning steps before being combined with the main gas stream. The melted material is poured into a water bath where rapid cooling creates small solid pellets. This vitrified residue is an inert, non-hazardous, glass-like solid. Leachability tests have been conducted on the solid material emerging from the process and have confirmed that it does not leach and is not toxic. At the end of the conversion process, more than 90% of the residual waste sent to a PlascoEnergy facility is recycled into valuable products. For each tonne of waste, approximately 1.3 kilograms (2.9 pounds) of heavy metals and filter screening require disposal. The moisture recovered from the waste is cleaned, and is suitable for irrigation or for use in industrial processes.

Strengths/Opportunities

1. PlascoEnergy finances the construction and commissioning of its own facilities. PlascoEnergy earns revenues primarily through the sale of electricity and tipping fees for the waste processed.

2. The primary requirements to build a facility are a guaranteed waste stream, guaranteed sale of electricity, and a location. The facilities are built in identical 100 tonne (110 ton) per day modules. This ensures the highest level of quality and allows a facility to be constructed and commissioned in a single year.

Weaknesses/Threats

1. Confirmation of the applicability to destroy SRM is required as the CFIA has not approved this technology for SRM destruction.

2. It would be necessary to combine SRM with other materials to provide a sufficiently large waste stream to feed a 100 tonne (110 ton) per day plant.

3. There is a lack of commercial plants used for the combustion of SRM and slaughterhouse waste.

Although this technology may be capable of SRM destruction, the CFIA has not conducted a risk assessment of plasma gasification technology.

P. Reductive Thermal Processing

According to the report entitled *Economic Assessment of Combustion Technologies for Specified Risk Material Disposal in British Columbia,* the reductive thermal processing (RTP) technology marketed by Vertus Technologies incorporates sophisticated thermal processing systems to create a continuous solid materials/fuel treatment method that separates the fuel from the non-fuel (unwanted air contaminants, toxins, and moisture) components. RTP technology is suitable for treating materials to more than 1000 °C in a contained and controlled manner. Unlike fixed temperature systems, RTP is highly flexible allowing for wide ranges of input material moisture levels, ash contents, heat content and material consistency. The rotating nature of the system allows efficient and thorough transport of materials through the system. The system is easily sterilized before and after material processing. During the processing of materials that contain volatile carbon compounds, a combustible gas containing these volatile carbon compounds and many hazardous air contaminants are driven into the gas phase and into a combustion system where they are converted to carbon dioxide, steam, and to a small extent, nitrogen oxides. The combusted fuel gas, now a flue gas, is treated with a sophisticated emission control system that collects and neutralizes particulate matter, acid gases, and any non-combustible species such as heavy metals. RTP technology allows collection of ash and other non-combustible mineral material and converts them to usable/saleable materials which can be utilized as raw materials in many other industries.

Vertus plans to construct and perform an operational pilot test of its RTP material processing facility in early 2009 in the Vancouver area. This facility will treat waste materials with the intention of generating a clean burning solid fuel for use in various industries including the greenhouse industry. Several sites for a facility are now under investigation.

Strengths/Opportunities

1. Vertus RTP technology will solve two regional problems: (1) the need for treatment and disposal of cellulose-based waste streams; and (2) the need for clean-burning solid fuels.

2. Vertus RTP technology is modular and can be implemented in a range of sizes as dictated by site needs.

3. Vertus employs a build-own-operate business model which eliminates up-front capital costs. Vertus Technologies typically negotiates a fee per ton of material processed.

Weaknesses/Threats

1. The CFIA has not approved this technology for SRM destruction. The report entitled *Economic Assessment of Combustion Technologies for Specified Risk Material Disposal in British Columbia* states that a possible disadvantage of RTP technology is that it will not operate as predicted for the SRM waste.

Although this technology may be capable of SRM destruction, the CFIA has not conducted a risk assessment of reductive thermal processing technology.

Q. Lactic Acid Fermentation

According to the report entitled *Carcass Disposal: A Comprehensive Review*, lactic acid fermentation should be viewed as a means to preserve carcasses until they can be rendered or disposed of in another manner. This report indicates that lactic acid fermentation is a process that provides a way to store carcasses for at least 25 weeks and produces an end product that may be both pathogen-free and nutrient-rich. The process of lactic acid fermentation is simple and requires little equipment except for a tank and a grinder.

Fermentation is an anaerobic process that can proceed in any size non-corrosive container, provided it is sealed and vented for carbon dioxide release. Carcasses are ground into fine particles, mixed with fermentable carbohydrate sources and culture inoculants, and then added to a fermentation container. Grinding aids in homogenizing the ingredients. Lactose, glucose, sucrose, whey, whey permeates, and molasses are all suitable carbohydrate sources. The carbohydrate sources are fermented to lactic acid by *Lactobacillus acidophilus*. Under optimal conditions, including a fermentation temperature of about 35°C (95°F), the pH of fresh carcasses is reduced to less than 4.5 within two days. Fermentation with *Lactobacillus acidophilus* destroys many bacteria including Salmonella spp. There may be some microorganisms that can survive the fermentation process, but these can be destroyed by heat treatment through rendering.

Strengths/Opportunities

1. The process allows the SRM material to be stored up to 25 weeks until it can be processed.

2. The technology does not have any significant environmental effects if the products of fermentation are rendered and/or processed into marketable products.

Weaknesses/Threats

1. Lactic acid fermentation has not been approved by the CFIA as a disposal option for SRM because the temperatures in the fermentation process are not high enough to destroy the abnormal prion.

2. The process requires a carbohydrate source and a culture of *Lactobacillus acidophilus.*

Lactic acid fermentation has not been approved by the CFIA as a suitable method for the destruction of SRM. Because the temperatures are not high enough to destroy the abnormal prion, the process should be viewed as a possible intermediate method in the destruction process.

R. Summary

As indicated in the previous paragraphs of this chapter, the technologies that have been approved for SRM destruction by the CFIA are as follows:

1. Incineration/gasification
2. Alkaline hydrolysis
3. Thermal hydrolysis

The following chapters provide a more detailed description of the above technologies and their suitability for SRM disposal.

III. Gasification

This chapter summarizes the available information on the use of gasification technology for SRM destruction.

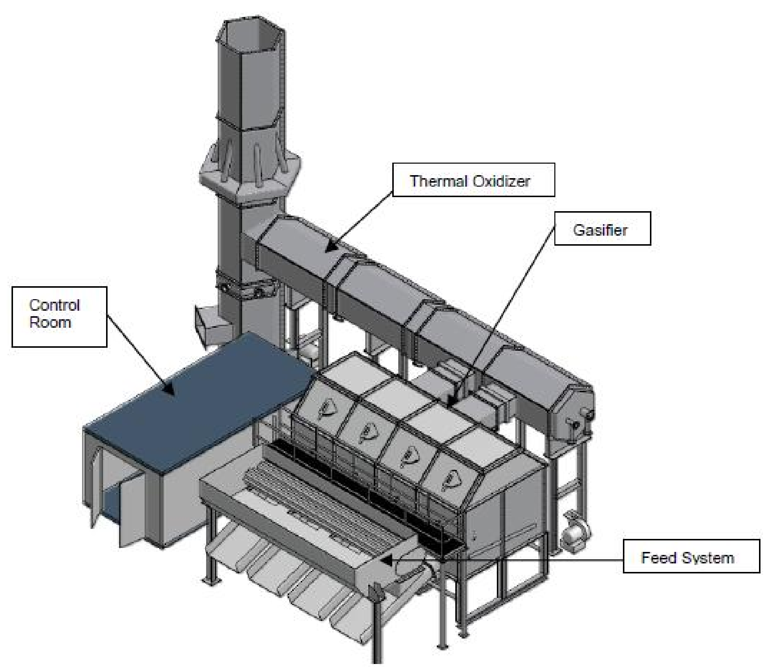
A. Description of Gasification Technologies

Two types of gasification that appear capable of large-scale destruction of SRM and other wastes in the Fraser Valley are fixed bed gasification and fluidized bed gasification. An economic assessment of these two technologies for use in BC has recently been undertaken by Stantec Consulting on behalf of the BC Ministry of Agriculture and Lands, and the results are provided in a report entitled *Economic Assessment of Combustion Technologies for Specified Risk Material Disposal in British Columbia.* This report also compares the economics of fixed and fluidized bed gasification technologies with fluidized bed combustion technology, which is a sophisticated incineration technology. The following paragraphs provide a brief description of the gasification technologies investigated while Chapter IV provides a description of the fluidized bed incineration technology used for comparative purposes in this report.

1. Fixed Bed Gasification

The fixed bed gasification system considered most appropriate for SRM destruction is the updraft-type fixed bed. The fuel (biomass and SRM) is introduced near the top of the reactor and moves downward. The oxidant (air) is introduced into the bottom and flows upward with the produced gas extracted at the top of the vessel. There is some drying of the fuel within the reactor; however, the maximum moisture level in the fuel must be no greater than approximately 20%. Figure 3.1 provides a schematic of a fixed bed gasification system.

Figure 3.1: Diagram of Westwood Fixed Bed Gasification System



Source: *Economic Assessment of Combustion Technologies for Specified Risk Material Disposal in British Columbia*

Some advantages of this technology are as follows:

- Simpler design than fluidized bed gasification;
- Many suppliers – may be possible to source locally which should result in good after-sales service;
- The modules are small in size and therefore easy to transport and install;
- Commercially available for handling biomass; and
- Hot cleanup of syngas may be possible prior to the combustion stage of the process, resulting in cleaner combustion.

Some disadvantages of this technology are as follows:

- Requires less than 20% moisture content of the fuel; therefore, fuel drying is required;
- Limited test experience with fuels similar to SRM;
- Limited in capacity to an output of approximately 5 MW;
- Small number of installed units and no commercial units gasifying SRM;
- Tars produced in the reactor may lead to slagging and fouling in downstream heat exchange devices and associated operating problems; and
- Tar may be produced in the producer gas requiring cleanup prior to use.

2. Fluidized Bed Gasification

In a typical fluidized bed gasifier, the fluidizing air enters the furnace below the grate which fluidizes the inert bed and suspends the fuel during the gasification process. The amount of air entering the reactor is limited such that oxidization of the syngas does not occur. The produced syngas exits at the top of the reactor and enters the cyclone separator which removes particulates from the hot syngas. The fuel enters the reactor from above the bed and falls on to the fluidized bed where the fluidized motion of the inert bed distributes the fuel throughout the bed.

The large size of fluidized bed gasification units for biomass and SRM necessitates the use of a single unit located at a central site. This arrangement offers the economy of scale of a central plant, resulting in the common services for fuel delivery and ash disposal systems being minimized.

Commercialization of biomass gasification is in a relatively early stage of development. There is, therefore, not a great deal of information on availability or reliability. Potential operational trouble spots of this technology include moisture content in the fuel greater than 30% which may cause handling difficulty and increased drying equipment requirements, as well as increased producer gas clean-up requirements to remove tars and other contaminants. The issues with slagging and fouling as described for fixed bed gasification are valid for fluidized gasification as well.

Some advantages of this technology are as follows:

- Potential of the producer gas having a higher heating value than for fixed bed gasifiers if using oxygen or steam as an oxidant;
- Capability of handling a wide range of feed stocks up to 30% moisture – better than fixed bed type;
- Higher capacities and better performance possible than with fixed bed gasifiers;
- Better suited for centrally located plant than fixed bed due to the higher availability of a single unit; and
- Hot gas cleanup prior to oxidation may be possible, resulting in cleaner combustion.

Some disadvantages of this technology are as follows:

- More complicated design and more additional equipment required compared to fixed bed;
- Higher capital costs than fixed bed gasifiers due to additional equipment requirements;
- Potential for tars in produced syngas, and the gas may require cleaning before use depending on final use of the gas; and
- Newly emerging technology for biomass and expected reliability is unknown.

B. Type of Waste Handled

Gasification technology is capable of handling a wide range of wastes. The study entitled *Economic Assessment of Combustion Technologies for Specified Risk Material Disposal in British Columbia* examined the capability of the three combustion technologies described in the previous section to handle the following four scenarios of SRM and other waste streams in the Fraser Valley:

Fuel Scenario #1:
- SRM (ruminant-based slaughterhouse waste and dead stock) – 25 tonnes (28 tons) per day
- Additional fuel for uniformity of feedstock: wood waste – 25 tonnes (28 tons) per day

Fuel Scenario #2:
- SRM as in Scenario #1 plus a mixed of non-SRM livestock waste tissues (mainly from pork and beef) – 105 tonnes (116 tons) per day
- Additional fuel for uniformity of feedstock: wood waste – 105 tonnes (116 tons) per day (estimated)

Fuel Scenario #3:
- As in Scenario #2 plus spent hens – 120 tonnes (132 tons) per day
- Additional fuel for uniformity of feedstock: wood waste – 120 tonnes (132 tons) per day (estimated)

Fuel Scenario #4:
- As in Scenario #3 plus broiler and turkey litter – 425 tonnes (470 tons) per day
- Additional fuel for uniformity of feedstock: No wood waste because the dry turkey and broiler litter are assumed to create a mix adequate for uniform combustion.

Fuel Scenario #4 includes the combustion of 305 tonnes (336 tons) per day of broiler and turkey litter which amounts to approximately 100,000 tonnes (110,000 tons) per year. Table 3.1 indicates that there exists an ample amount of broiler and turkey manure to supply this plant. The total volume of broiler, layer and turkey manure generated in the Fraser Valley is estimated to be approximately 472,000 tonnes (520,000 tons) per year.

Table 3.1: Volume of Poultry Manure in the Fraser Valley

Type of Manure	Estimated Annually Generated Waste Volume (tonnes/tons)		
	Fraser Valley Regional District	Metro Vancouver Regional District	Total
Broiler	193,058 (212,808)	68,216 (75,194)	261,274 (288,002)
Layer	116,192 (128,078)	41,046 (45,245)	157,238 (173,323)
Turkey	32,209 (35,504)	21,309 (23,489)	53,518 (58,993)
Total	**341,459 (376,390)**	**130,571 (143,928)**	**472,030 (520,319)**

Source: *BC Ministry of Agriculture and Lands*

C. Economic Assessment

The study entitled *Economic Assessment of Combustion Technologies for Specified Risk Material Disposal in British Columbia* indicated that the capital costs for Fuel Scenario #1 (which consists of 25 tonnes (28 tons) per day of SRM material and an equivalent amount of wood waste) range from Cdn $4.4 million for a fixed bed gasification plant to Cdn $7.6 million for a fluidized bed gasification plant. The capital costs for Fuel Scenario #4 (425 tonnes (470 tons) per day of SRM, slaughterhouse waste, spent hens and turkey and broiler litter) range from $27.8 million for a fixed bed gasification plant to $45.3 million for a fluidized bed gasification plant. As indicated in Table 3.2, the capital costs are the lowest for the fixed bed gasification technology for all four fuel scenarios while the capital costs are highest for the fluidized bed gasification technology for all fuel scenarios except Scenario #1. The estimated capital costs provided in Table 3.2 includes the fuel system for SRM and other fuels, gasifier/combustion system, balance of plant, drying equipment, power generation plant, emissions clean-up equipment, engineering, construction and commissioning costs.

Table 3.2: Capital Costs for Each Combustion Technology and Fuel Scenario (Cdn $ millions)

Combustion Technology	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Fixed bed gasification	$4.4	$15.3	$16.9	$27.8
Fluidized bed gasification	$6.9	$25.7	$28.9	$45.3
Fluidized bed combustion	$7.6	$16.3	$18.1	$30.7

Source: *Economic Assessment of Combustion Technologies for Specified Risk Material Disposal in BC.*

As indicated in Table 3.3, the tipping fees based on combined heat and power production, and including electrical sales, for a plant to process 25 tonnes (28 tons) per day of SRM material and an equivalent amount of wood waste (Scenario #1) range from $11.67 per tonne (0.5 cents a pound) for a fixed bed gasification plant to $102 per tonne (5 cents a pound) for a fluidized bed combustion plant.

Table 3.3: Tipping Fee for Each Combustion Technology and Fuel Scenario (Cdn $ per tonne)

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Tipping fee excluding electrical sales				
Fixed bed gasification	$130	$123	$123	$222
Fluidized bed gasification	$165	$158	$158	$276
Fluidized bed combustion	$159	$123	$123	$213
Tipping fee including electrical sales				
Fixed bed gasification	$11.67	$(3.19)	$(4.83)	$(35.42)
Fluidized bed gasification	$34.97	$19.65	$18.13	$(5.10)
Fluidized bed combustion	$102	$58	$57	$50

Source: *Economic Assessment of Combustion Technologies for Specified Risk Material Disposal in BC.*

As the size of the plant increases to accommodate other wastes, the potential exists to reduce the tipping fees considerably. As indicated in Table 3.3, both a fixed bed and a fluidized gasification plant result in positive revenues for Fuel Scenario #4 (425 tonnes (470 tons) per day of SRM, other slaughterhouse waste, spent hens, broiler and poultry litter). As an illustration, the revenues from electrical sales for a fixed bed gasification plant based on Fuel Scenario #4 are projected to be $35.42 per tonne (1.6 cents per pound) or approximately $1.4 million per year greater than the annual operating costs and amortized capital costs. Consequently, the establishment of a large fixed bed or fluidized bed gasification plant to handle SRM, as well as other agricultural wastes such as turkey and broiler litter, appears to provide the most feasible option based on the analysis undertaken to date.

The study entitled *Economic Assessment of Combustion Technologies for Specified Risk Material Disposal in British Columbia* concluded that gasification provides the following advantages compared to combustion or incineration:

- Produced gas can be cleaned and filtered to remove problem chemicals before burning;
- Produced gas is more versatile than the solid fuel because it can be used in boilers, process heaters, turbines, and engines;
- Gasification is suitable for a wide range of biomass feed stocks without change to the process; and
- Gasification is suitable for processing waste fuels and provides safe removal of biohazards and entrainment of heavy metals in non-reactive slag.

The report also provides the following recommendations for future study:

- Conduct lab tests on the various fuel blends to determine the ultimate and proximate analysis.
- Study the feasibility of establishing a Biomal processing facility in the Fraser Valley.
- Initiate pilot plant testing to combust SRM and slaughterhouse material using existing power stations or new biomass power plants being developed in conjunction with the BC Hydro's latest power call.
- Study the feasibility of firing the SRM material in the proposed Vertus Technology RTP facility (described in the previous chapter).
- Study the feasibility of firing the SRM material in the proposed PlascoEnergy plasma gasification facility (described in the previous chapter).

D. Environmental Considerations

According to representatives of Stantec, the air emissions from a gasification plant would meet the emissions standards established in the *Code of Practice for the Slaughter and Poultry Processing Industries* by the BC Ministry of Environment (MOE) for slaughter and poultry processing waste disposal. MOE standards for total particulates must be below 50 mg/cubic meter and opacity must be below 10% averaged over six consecutive minutes. As a comparison, Stantec representatives indicated that the air emissions of a gasification plant are estimated to be about 15 mg/cubic meter. Further information on emissions requirements is available in the *Code of Practice for the Slaughter and Poultry Processing Industries* at http://www.env.gov.bc.ca/epd/industrial/regs/codes/slaughter.

A report entitled *An Assessment of Gasification as an Alternative Technology for the Disposal of Slaughterhouse Waste,* prepared by Thompson Rivers University (TRU) on behalf of the Investment Agriculture Foundation, states that air emissions from gasification of SRM could meet BC standards for all gases regulated for municipal waste disposal. A test was conducted by Thompson Rivers University on August 18, 2005 in Kamloops, BC using a commercially available gasifier designed to recover energy from waste plastic. In this test, various mixtures of slaughterhouse waste (20%, 40% and 60%) and wood pellets were burned. Stack emissions and temperature profiles were continuously monitored during the test, and chemical analyses of the fuel stocks and residual ash were carried out. At no time did the emissions exceed the permitted 10% opacity. Quantitative measurement of the stack emissions confirmed very low loadings of emissions with particulates less than 0.05 kg/hour, and very low discharge rates that averaged 43.2 mg/Sm^3 at 11% O_2. This low rate of production was confirmed by the analysis of a parallel emissions sample analyzed in TRU's labs. Overall, 96% of the particulates were smaller than 10um in size and 85% were smaller than 2.5um. These levels are all well within those acceptable for incinerators disposing of municipal waste in BC.

The gasification test undertaken by Thompson Rivers University also monitored a number of other emission gases and the general conclusions were as follows:

- Carbon monoxide (CO) levels were generally very low;
- Sulphur oxide (SOx) emissions were generally very low as well;
- Nitrogen oxides (NOx) emissions showed the greatest variability; and
- The levels of chloride gas content and total hydrocarbons were within the air emissions restrictions of the permit from the BC Ministry of the Environment.

E. Summary

Gasification appears to be a suitable method of SRM destruction in the Fraser Valley. Based on the available information, a gasification plant in the Fraser Valley could comply with existing environmental regulations. In addition, the establishment of a gasification plant in the Valley could potentially reduce the existing costs incurred by local slaughtering plants and dead stock collectors for disposal of SRM material, particularly if the plant were constructed large enough to handle a variety of other wastes such as poultry litter, and the plant was able to generate revenues from the sale of electricity. There may be public resistance to the establishment of a gasification plant because it could be perceived as similar to an incinerator which has been opposed by the public due to air emissions and odour problems.

IV. Incineration

This chapter summarizes the available information on the use of incineration for SRM destruction.

A. Description of Technology

Fixed-facility incineration includes (a) small on-farm incinerators, (b) small and large incineration facilities, (c) crematoria, and (d) power plant incinerators. Typically fueled by diesel, natural gas or propane, fixed-facility incinerators are, in essence, chambers in which the incineration process is contained. Fixed-facility incineration of carcasses is a convection process in which carcass material is burned to ash in a controlled atmosphere. Newer designs of incinerators are fitted with afterburner chambers designed to completely burn particulate matter exiting from the main combustion chamber. Incinerators have been used for years to incinerate both whole carcasses and carcass material.

The report entitled *Desktop Study on Available Incineration Technologies* undertaken by Golder Associates Innovative Applications (GAIA) on behalf of the BC Investment Agriculture Foundation indicates that there are a wide range of small, medium and large incinerators available for SRM destruction. Based upon a request for information, GAIA compiled a list of incinerator suppliers for each of the following incinerator sizes:

- Small: from 1 kilogram (2.2 pounds) per hour to 150 kilograms (330 pounds) per hour
- Medium: 150 kilograms (330 pounds) per hour to 400 kilograms (880 pounds) per hour
- Large: 400 kilograms (880 pounds) per hour and higher

The report entitled *Economic Assessment of Combustion Technologies for Specified Risk Material Disposal in British Columbia* provides a description of a sophisticated fluidized bed incineration technology that is suitable for handling large volumes of waste. The process involved in fluidized bed combustion is similar to fluidized bed gasification technology with the exception that additional oxygen is introduced to the furnace to allow complete combustion of the fuel. The gas produced by the pyrolysis of the fuel off the bed is oxidized in the same chamber or furnace which produces a hot flue gas. The hot flue gas then passes over heat exchange surfaces to produce steam for heat or power generation or hot water for heating systems. The hot flue gas is cleaned by an electrostatic precipitator or other component prior to discharge to the atmosphere.

This combustion technology is currently in commercial operation in Sweden at four power plants. The total amount of SRM material and slaughterhouse waste currently being disposed of is approximately 85,000 tonnes per year. The scheme is attractive in that the preparation of the SRM takes place in a central location and involves a relatively low energy process. The SRM is ground into a pumpable consistency. This is a much less energy intensive process than rendering. The product is referred to as Biomal. The advantage of feeding Biomal into the boiler is the stabilized nature of the fuel stream. It has also been found that the NOx emissions have dropped due to the ammonia in the Biomal product.

Some advantages of this technology are as follows:

- Suitable for large central power plant producing steam and/or electricity;
- Can combust biomass and other low grade fuels such as SRM that are difficult or impractical to burn with conventional methods due to thermal inertia of the inert bed;
- Proven biomass combustion and power generation technology; and
- The published temperature range is acceptable for the destruction of SRM, provided that the residence time is greater than 15 minutes.

Some disadvantages of this technology are as follows:

- Fuel must be carefully sized and processed to ensure steady heat input into the boiler;
- Produces power and heat and not producer gas (which is a more flexible final product);
- May require a steam host such as a pulp mill to use the steam produced for the most efficient arrangement;
- Operation of the boiler plant may require more operations personnel and higher qualifications due to the high pressure steam operation and advanced equipment such as steam turbines and generators required for efficient power production; and
- Potential regulatory hurdles for central plant.

B. Type of Waste Handled

Incinerators are capable of handling a wide variety of wastes. As an illustration, the types of wastes proposed for incineration in the fluidized bed combustion technology described in the previous chapter include SRM, other slaughterhouse waste, spent hens, wood waste and poultry litter. Incinerators are also capable of burning municipal solid waste and hazardous materials.

C. Economic Assessment

The existing information indicates that fixed-facility incineration costs are quite variable. As an illustration, the report entitled *Carcass Disposal: A Comprehensive Review* states the cost of fixed-facility incineration in the US ranges from Cdn $109 to $2200 per tonne (5 cents to $1 per pound) of carcass material.

The report entitled *North Okanagan/Thompson Slaughterhouse Waste Disposal* contains an assessment of the capital and operating costs to incinerate SRM waste as well as non-SRM slaughter waste. The estimated capital costs for different volumes and waste scenarios ranged from Cdn $625,000 for an incinerator handling only SRM waste (42 to 138 tonnes (46 to 152 tons) per year) to $5.3 million for an incinerator handling between 5,600 and 8,630 tonnes (6,170 and 9,510 tons) per year of slaughterhouse waste. As indicated in Table 4.1, the study demonstrated that the total costs, including capital and operating costs, for an incinerator that handles only SRM waste are prohibitive (i.e., over $500 per tonne or 23 cents per pound). However, the total costs for an incinerator handling all slaughterhouse waste ranged from $115 to $196 per tonne (5 cents to 9 cents per pound). In general, the cost per tonne decreases as the volume of waste incinerated increases due to economies of scale. In addition, the cost per tonne was lower with a heat recovery system than without a heat recovery system.

Table 4.1: Incinerator Capital Costs

Annual Waste Generated (tonnes(tons))	Daily Waste Incinerated (kilograms(pounds))	Capital Cost	Total Cost Per Tonne (Pound)	
			Without Heat Recovery System	With Heat Recovery System
All slaughterhouse waste				
2,530 (2,790)	10,000 (22,000)	$2,250,000	$218 ($0.10	$196 ($.09)
4,400 (4,850)	15,000 (33,000)	$2,250,000	$165 ($0.08)	$157 ($0.07)
8,630 (9,510)	30,000 (66,000)	$5,315,000	$142 ($0.06)	$115 ($0.05)
5,600 (6,170)	20,000 (44,000)	$5,315,000	$214 ($0.10)	$173 ($0.08)
SRM waste only				
42 (46)	195 (215)	$625,000	$3,205 ($1.45)	N/A
138 (152)	650 (717)	$625,000	$1,547 $0.77)	N/A
611 (673)	3,000 (3,307)	$1,305,000	$588 ($0.27)	$575 ($0.26)
326 (359)	1,500 (1,654)	$1,305,000	$779 ($0.35)	$754 ($0.34)

Source: *North Okanagan/Thompson Slaughterhouse Waste Disposal*

As indicated in Table 4.2, the report entitled *Desktop Study on Available Incineration Technologies* states that the average cost is $142,000 for a small incinerator, $623,000 for a medium sized incinerator and $1.8 million for a large incinerator.

Table 4.2: Incinerator Capital Costs

	Size of Incinerator		
	Small	**Medium**	**Large**
Burn Rate (kilograms (pounds) per hour)			
Range	23 – 136 (51 – 300)	150 – 680 (331 – 1500)	450 – 1,000 (992 – 2200)
Average	38 (84)	305 (672)	620 (1367)
Capital Cost			
Range	$5600 - $633,000	$100,000 - $2,500,000	$580,000 - $4,000,000
Average	$142,000	$623,000	$1,800,000

Source: *Desktop Study on Available Incineration Technologies*

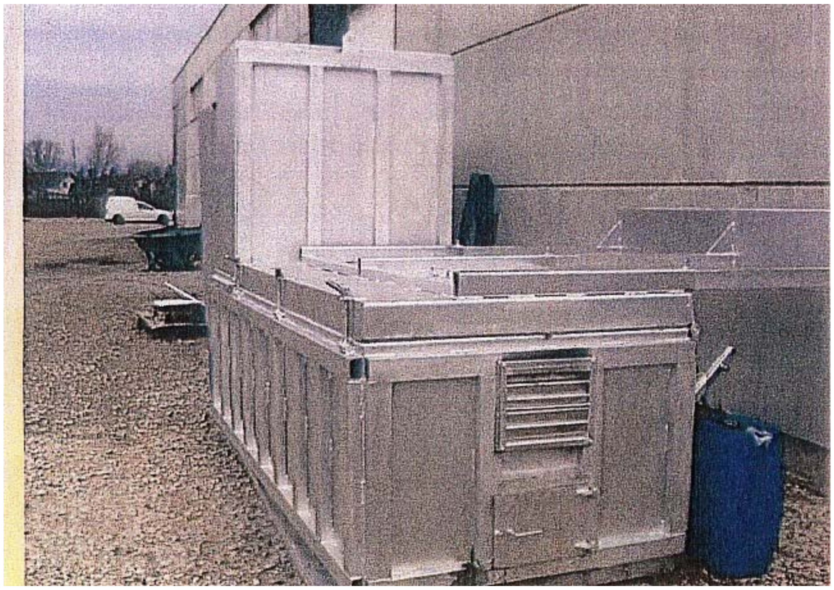
As indicated in Chapter 1, approximately 5500 tonnes (6060 tons) per year of SRM and non-SRM material are currently picked up by West Coast Reduction in the Fraser Valley from slaughtering plants and dead stock collectors. If all of this material was burned in a centrally located incinerator, the facility would have to operate at a rate of approximately 20 tonnes (22 tons) per day or 1,000 kilograms (2,200 pounds) per hour. This burn rate assumes that the incinerator would be operated for about 250 days per year and 20 hours per day. Based on the capital cost estimates indicated in Tables 4.1 and 4.2, the capital costs for an incinerator capable of burning all of the SRM and non-SRM material currently collected by West Coast Reduction would be in the range of $4 to $5 million.

As indicated in Chapter 1, by separating out the SRM from the non-SRM material generated in the Fraser Valley, the volume of SRM only is estimated to be approximately 2,400 tonnes (2,650 tons) per year. If all of this SRM material were hauled and burned in a centrally located incinerator in the Fraser Valley, the incinerator would have to be operated at a rate of approximately 9.6 tonnes (10.6 tons) per day, assuming that the incinerator would be operated for 250 days per year and 20 hours per day. Based on the capital cost estimates indicated in Tables 4.1 and Table 4.2, the costs for an incinerator capable of burning only SRM waste generated by slaughtering plants and dead stock collectors in the Fraser Valley would be in the range of $0.75 to $1.5 million.

The capital costs and available operating cost information reported in the study entitled *Desktop Study on Available Incineration Technologies* was utilized by staff of the Investment Agriculture Foundation to undertake a preliminary analysis of the likely costs for each of the different models of incinerators that cost information was provided for. This analysis assumed that the total volume to be incinerated was 8,000 tonnes (8,800 tons) per year. By removing the outliers from the data, the average incineration cost, including amortized capital costs and annual operating costs, of these incinerators was about $300 per tonne or $0.14 per pound.

Funding from the Canada-British Columbia Specified Risk Material (SRM) Management Program (SRMMP) has recently been provided for the purchase of an incinerator to demonstrate the feasibility of incinerating SRM waste in the Okanagan. The specific incinerator that has been purchased is a Model 2600(HF) from INCINER8, a company located in Southport, England (Figure 4.1). According to the sales brochure, this incinerator has the capacity to handle up to 1200 kilograms (2,650 pounds) of slaughter waste and will burn up to 300 kilograms (660 pounds) per hour. The unit is a top loading design and has a heavy duty refractory cement lining. The unit operates at over 1,000°C (1,830°F) in the primary chamber to ensure complete combustion. This model also has a secondary chamber and burner to ensure a complete re-burn of any smoke and emissions.

Figure 4.1: Picture of Inciner8 Model 2600(HF) Incinerator



Source: *Inciner8*

The capital costs of the Model 2600(HF) incinerator are approximately $65,000, including spare parts and freight, to transport the incinerator from England to the Lower Mainland. The capital costs of the Model 2600(HF) incinerator are considerably lower than the incinerators with similar burn rates that are described in the report entitled *Desktop Study on Available Incineration Technologies.* As indicated in Table 4.2, the average burn rate of the medium-sized incinerators described in this report is 305 kilograms (672 pounds) per hour and the average capital cost is Cdn $625,000.

A preliminary analysis of the capital and operating costs of the Model 2600(HF) incinerator is provided in Appendix 2. This analysis assumes that an individual slaughtering plant or dead stock collector in the Fraser Valley would purchase an incinerator strictly for its own use because the costs of transporting SRM waste to a central location are considerable. In addition, it is assumed that SRM waste would not be separated from the rest of the cattle waste (i.e. non-SRM). The financial analysis in Appendix 2 assumes that the annual volume of cattle waste that would be incinerated is 1,400 tonnes per year which is about the volume of cattle waste currently picked up annually from the two largest cattle slaughtering plants in the Fraser Valley (Table 1.1). The analysis in Appendix 2 indicates that the total cost, including amortized capital costs and operating costs, to burn SRM with this incinerator would be approximately $151 per tonne (7 cents per pound). However, a more detailed analysis of the performance of the Model 2600(HF) is required to accurately determine incineration costs. Monitoring of the performance of the demonstration model recently purchased for use in the Okanagan will provide a more accurate assessment of the actual burn rate, fuel usage and total costs of incineration.

The most economical method of incinerating SRM would be to use an existing incinerator such as the municipal waste incinerator in Burnaby. However, representatives of Metro Vancouver indicated that public resistance would be too great to consider handling SRM in this facility. Another option is to burn SRM in existing cement kilns such as those operated by Lafarge Cement in the Lower Mainland. However, according to representatives of Lafarge Cement, they would not consider burning SRM material because of the negative perception they might receive regarding the final product and the fact that the SRM would have to be processed into a fine material before it could be fed into the cement kilns. While slaughterhouse waste is burned in cement kilns in other parts of the world, the waste is first rendered and the resulting meat and bone meal is then used as fuel. Lafarge Cement is currently considering the possibility of using the meat and bone meal produced from SRM material by the West Coast Reduction plant in Calgary as a fuel source for their cement kilns in Alberta. Should this occur, it will not likely result in a significant change in current SRM handling costs in the Fraser Valley.

D. Environmental Considerations

The Ministry of Environment has established a *Code of Practice for the Slaughter and Poultry Processing Industries* that addresses discharges to the environment from the applicable industries under provisions of the *Environmental Management Act* (EMA) and the Waste Discharge Regulation (WDR). The air emissions requirements for total particulate must be below 50 mg/cubic metre, and opacity must be below 10% averaged over six consecutive minutes. Small fixed-facility incinerators may be operated on slaughter facilities provided one has applied for registration as required by the Code from the BC Ministry of Environment. A copy of the Code of Practice can be found on the Ministry of Environment website at http://www.env.gov.bc.ca/epd/industrial/regs/codes/slaughter.

The report entitled *Desktop Study on Available Incineration Technologies* states that a number of potential incinerator suppliers informed GAIA that the total particulate levels of regular incinerators could not be maintained at 50 mg/cubic metre. Some suppliers stated that the addition of a scrubber upgrade or air pollution control device would be necessary in order to meet the standard of 50 mg/cubic metre. The following other sources of information referred to in the report indicate that this standard can be met by incinerators:

1. Eco Waste Solutions conducted a study of a CleanAire cremator system with a 250 kilogram (550 pound) capacity and reported 13 to 21 mg/cubic meter particulate for swine and poultry waste.

2. Representatives of Trecan, an incinerator manufacturer, stated that the results of a test on an animal waste incinerator were an average of 8.38 mg/cubic meter and the unit had no scrubber. As a result, the company was confident in being able to meet the maximum standard of 50 mg/cubic meter.

The report entitled *North Okanagan/Thompson Slaughterhouse Waste Disposal* indicated that all of the incinerators discussed in the report are designed to meet European Economic Community (EEC) emissions standards as outlined in EEC Directive 2000/76/EC. The report also stated that if the incinerators meet EEC standards, they would likely be acceptable for use in Canada.

While most incinerators are able to meet maximum allowable air emission standards, significant public resistance would likely be encountered if a significant incineration project were proposed for the Fraser Valley. The municipal and regional government representatives contacted during the study stated that the public would not be in favour of an incineration project because it would exacerbate the existing air quality problems in the Fraser Valley. They also stated that incineration could also generate odour complaints from neighbouring residential areas.

The ash produced from incineration can be disposed of in landfills. As indicated in Chapter 2, the CFIA has stipulated that the output from approved incinerators is not regulated by SRM controls – provided that it can be demonstrated that the ash produced does not contain amino acids. The amount of ash produced is estimated to be approximately 7% of the weight of SRM material incinerated. As indicated in Appendix 2, the amount of ash generated from incinerating 1400 tonnes (1540 tons) of cattle waste is approximately 98 tonnes (108 tons) per year.

E. Summary

Incineration is a feasible method of SRM disposal because it has been approved by the CFIA as an acceptable method of destroying the abnormal prion. Incineration is a proven technology for burning cattle carcasses as well as a variety of other wastes. Based on the preliminary information available, the costs of incineration appear to be similar to the costs currently paid by Fraser Valley slaughtering plants and dead stock collectors for the disposal of their SRM material. However, a more detailed analysis is required to more accurately determine likely incineration costs. Part of the analysis required is to monitor the performance and costs incurred by the demonstration incinerator recently purchased for disposal of SRM material in the Okanagan.

While SRM incineration is a potential alternative to the current handling of SRM material, there will likely be considerable public resistance to operating an incinerator that handles SRM in the Fraser Valley due to air and odour emissions. Even though incinerators appear capable of meeting the particulate air emissions standards of the BC Ministry of Environment, the municipal representatives contacted indicated that an incinerator will be opposed by the public because it will exacerbate the existing air quality problems in the Fraser Valley.

V. Alkaline Hydrolysis

This chapter assesses the suitability of alkaline hydrolysis for SRM destruction in the Fraser Valley.

A. Description of Technology

According to the report entitled *Carcass Disposal: A Comprehensive Review*, alkaline hydrolysis uses sodium hydroxide or potassium hydroxide to catalyze the hydrolysis of biological material such as protein, nucleic acids, carbohydrates, and lipids into a sterile aqueous solution consisting of small peptides, amino acids, sugars and soaps. Heat is also applied at 150°C (300°F) to significantly accelerate the process. The only solid byproducts of alkaline hydrolysis are the mineral constituents of the bones and teeth of vertebrates. The undigested residue, which typically constitutes approximately two percent of the original weight and volume of the carcass material, is sterile and easily crushed into a powder that may be used as a soil additive.

Proteins – the major solid constituent of all animal cells and tissues – are degraded into salts of free amino acids. Some amino acids (e.g., arginine, asparagines, glutamine, and serine) are completely destroyed while others are racemized (i.e., structurally modified from a left-handed configuration to a mixture of left-handed and right-handed molecules). The temperature conditions and alkali concentrations of this process destroy the protein coats of viruses and the peptide bonds of prions. During alkaline hydrolysis, both lipids and nucleic acids are destroyed.

Carbohydrates represent the cell and tissue constituents most slowly affected by alkaline hydrolysis. Both glycogen (in animals) and starch (in plants) are immediately solubized; however, the actual breakdown of these polymers requires much longer treatment than is required for other polymers. Once broken down, the constituent monosaccharides (i.e., glucose, galactose, and mannose) are rapidly destroyed by the hot aqueous solution. Significantly, large carbohydrate molecules such as cellulose are resistant to alkaline hydrolysis digestion. Items such as paper, string, undigested plant fibers, and wood shavings, although sterilized by the process, are not digestible by alkaline hydrolysis.

Alkaline hydrolysis is carried out in a tissue digester that consists of an insulated, steam-jacketed, stainless-steel pressure vessel with a lid that is manually or automatically clamped. The vessel contains a retainer basket for bone remnants and other materials (e.g., indigestible cellulose-based materials, latex, metal, etc.). The vessel is operated at up to 4.9 kg/cm^2 (70 psi) to achieve a processing temperature of 150°C
(122 °F). One individual can load and operate an alkaline hydrolysis unit. In addition to loading and operating, personnel resources must also be devoted to testing and monitoring of the effluent (e.g. temperature and pH) prior to release into the sanitary sewer system. Once loaded with carcasses, the system is activated by the push of a button and is thereafter computer-controlled. The weight of tissue in the vessel is determined by built-in load cells, a proportionate amount of alkali and water is automatically added, and the vessel is sealed pressure tight by way of an automatic valve. The contents are heated and continuously mixed by a fluid circulating system.

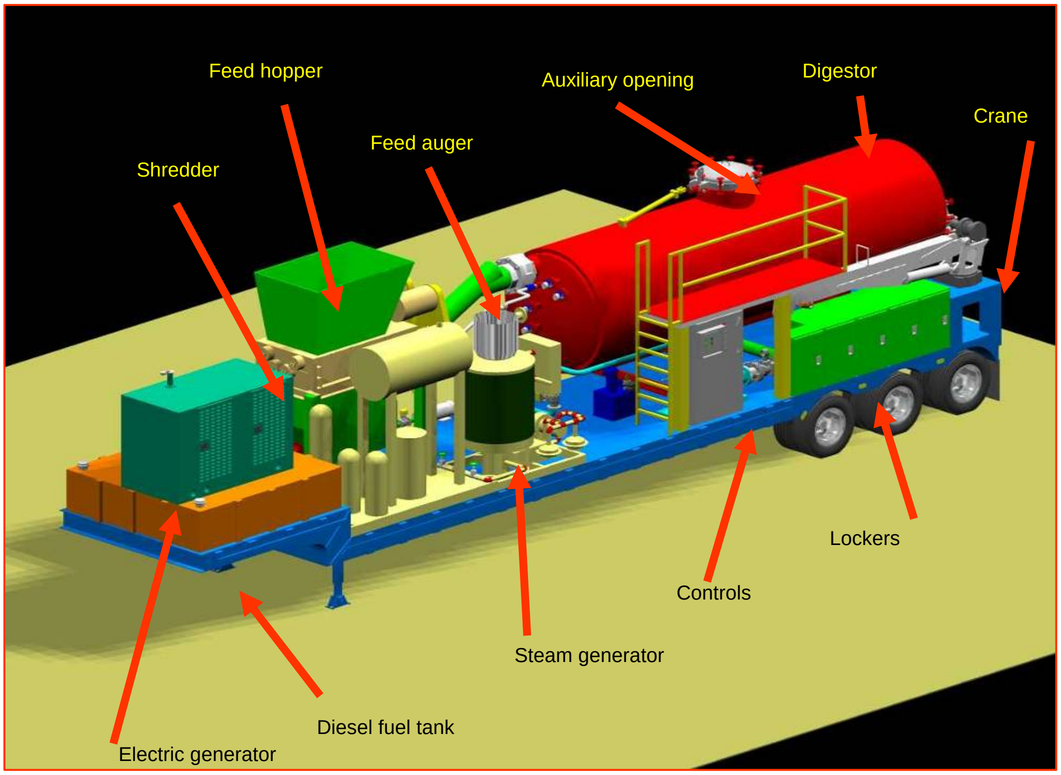
According to the report entitled *Carcass Disposal: A Comprehensive Review*, the total process time required for alkaline hydrolysis digestion of carcass material is three to eight hours. The precise processing time largely depends on the disease agent(s) of concern. For material infected with Transmissible Spongiform Encephalopathies (TSEs) or potentially TSE-infected material, six hours are recommended.

B. Alkaline Hydrolysis Applications

Alkaline hydrolysis technology has been and is currently being used in many institutions, laboratories, and animal disease diagnostic facilities to dispose of carcasses and other forms of biological waste. The report entitled *Carcass Disposal: A Comprehensive Review* lists the specific sites where 27 units have been built between 1993 and 2003 ranging in capacities from 5 to 3,200 kilograms (11 to 7,000 pounds) per load. While previous alkaline hydrolysis units were limited in capacity, a number of larger units are now available. According to the report entitled *Carcass Disposal: A Comprehensive Review*, the largest alkaline hydrolysis unit currently available has a capacity of 4500 kilograms (10,000 pounds) of biological material. The unit is manufactured by Waste Reduction by Waste Reduction Inc. and is eight feet in diameter and just over eight feet high. This unit requires a minimum room height of 24 feet.

Biofuel System Technologies has recently introduced a larger capacity unit called the BioLiquidator to provide an affordable alkaline hydrolysis system for carcass disposal capable of handling large horses, cows, most zoo animals, pathological waste and anatomic waste. Biofuel System Technologies is a Canadian company based in Winnipeg with a branch office in Victoria. The BioLiquidator was designed in a joint venture with LEI Products in Madisonville, Kentucky. The company brochure states that, until now, alkaline hydrolysis equipment has been too expensive for agricultural use and that the BioLiquidator is affordable, uses less energy, and can be purchased as a stationary mobile unit but transportable on a trailer behind a pick-up truck. BioLiquidator stationary and mobile units are available in 1130 kilogram (2500 pound), 1590 kilogram (3500 pound), and 4540 kilogram (10,000 pound) capacities. Even larger units can be constructed to accommodate permanent sites. Figure 5.1 illustrates the key components of a 4540 kilogram (10,000 pound) mobile alkaline hydrolysis unit supplied by Biofuel System Technologies.

Figure 5.1: Diagram of Mobile Alkaline Hydrolysis Equipment



Source: *Biofuel System Technologies*

The cycle time for large carcasses in the smaller BioLiquidator models is 16 to 24 hours. However, the cycle time to handle carcasses in the 4540 kilogram (10,000 pound) model is four hours (90 minutes for heating up, 60 minutes for cooking and 30 minutes for emptying). The BioLiquidator can be fueled by diesel oil, electricity, natural gas, propane or methane. The larger unit can be equipped with a slicer/shredder to chop up the SRM material before it is fed into the digester. The unit can accommodate any loading angle to facilitate operation. Once loaded, alkali is added to the tank. The type of alkali required for operation is dry KOH, dry NaOH, liquid KOH, or liquid NaOH. The BioLiquidator units are totally computerized and can be operated by one person.

There are BioLiquidators currently operating in the United States, including a 4540 kilogram (10,000 pound) high pressure unit. Biofuel System Technologies is currently working with the CFIA to have the BioLiquidator approved for use in Canada and has passed through the first stages of the approval process.

C. Economic Assessment

According to the report entitled *Carcass Disposal: A Comprehensive Review*, the cost of disposal of animal carcasses via alkaline hydrolysis is Cdn $352 per tonne (16 cents per pound) of carcass material processed, excluding the initial capital costs of the digester (Table 5.1).

Table 5.1: Cost Estimates for Operation of Alkaline Hydrolysis Tissue Digester with 900 Kilogram (2000 Pound) Capacity

Item	Cost ($Cdn)	
	Per Tonne	Per Pound
Steam, water, electricity	$22	$0.01
Chemicals (NaOH, KOH)	$44	$0.02
Personnel (4 hours/day for 2 cycles)	$88	$0.04
Sanitary sewer costs	$154	$0.07
Maintenance and repair	$44	$0.02
Total	$352	$0.16

Source: *Carcass Disposal: A Comprehensive Review*

The report entitled *Carcass Disposal: A Comprehensive Review* stated that the capital costs of a mobile trailer unit consisting of a digestion vessel, boiler, and containment tank is approximately Cdn $1.3 million (supplied by Waste Reduction by Waste Reduction Inc.). This unit would be capable of digesting 1800 kilograms (4000 pounds) of carcasses every eight hours.

The capital costs of the BioLiquidator digester units appear to be considerably lower than the digester units sold by Waste Reduction by Waste Reduction Inc. As indicated in Table 5.2, the capital costs for the smallest stationary BioLiquidator unit with a 1130 kilogram (2500 pound) capacity are Cdn $69,500.

Table 5.2: Cost Estimates for BioLiquidator Alkaline Hydrolysis Digesters

Item	Description	Cost
Stationary Unit Models		
S-2500	Digests 230 – 1130 kilograms (500 – 2500 pounds) in a single cycle	$69,500
S-3500	Digests 340 – 1370 kilograms (750 – 3000 pounds) in a single cycle	$81,500
S-10000	Digests 4,540 kilograms (10,000 pounds) per cycle	$1,200,000
Mobile Unit Models		
M-2500	Digests 230 – 1130 kilograms (500 – 2500 pounds) in a single cycle	$87,500
M-3500	Digests 340 – 1370 kilograms (750 – 3000 pounds) in a single cycle	$91,500

Source: *Biofuel System Technologies*

According to representatives of Biofuel System Technologies, the total operating cost of the 4540 kilogram (10,000 pound) digester unit is approximately Cdn $220 per tonne (10 cents per pound), including labour but not amortization of capital costs or the costs associated with sanitary sewer disposal. The processing cost of the smaller BioLiquidator units would be slightly less than the larger unit because they use agitation and less heat to accomplish the digesting process. A representative of Biofuel System Technologies has indicated that the processing costs can be potentially offset by the sale of the effluent as liquid fertilizer. The company has found markets on the prairies for the fertilizer produced from BioLiquidator effluent and have been offered up to $198 per tonne (9 cents per pound) for the product. Other potential uses of the effluent are that it can be put into a methane-producing system to generate power.

D. Environmental Considerations

The alkaline hydrolysis process releases no emissions into the atmosphere and results in only minor odour production. According to the report entitled *Carcass Disposal: A Comprehensive Review,* the end product is a sterile, coffee-coloured alkaline solution with a soap-like odour that can be released into a sanitary sewer. This may require careful monitoring of temperature (to ensure release of the effluent at or above 190°C, a temperature below which the effluent solidifies), pH, and biochemical oxygen demand (BOD). The pH of undiluted hydrolyzate is normally between 10.3 and 11.5. For those sewer districts that have upper limits of pH 9 or 10, bubbling carbon dioxide into the hydrolyzate at the end of the digestion process can lower the pH to the range of pH 8 or less.

The average BOD of undiluted hydrolyzate is approximately 70,000 mg/L. Although the BOD is high, the carbon-containing molecules in the hydrolyzate have been broken down to single amino acids, small peptides and fatty acids, all of which are nutrients for the microorganisms of sanitary treatment plants. In fact, some sewer districts prefer to receive the hydrolyzate at night to keep the bacteria alive so they are ready to go to work when the bolus of waste arrives first thing the following morning. These aspects notwithstanding, the report entitled *Carcass Disposal: A Comprehensive Review* states that disposal of effluent from alkaline hydrolysis units is a significant issue and must be so treated when considering this technology. In fact, some operators are contemplating alternative means of handling effluent, including solidification of effluent prior to disposal. The volume of effluent produced from the alkaline hydrolysis process is indicated in Table 5.3.

Table 5.3: Volume of Hydrolyzate and Total Effluent Produced Per Cycle from the Alkaline Hydrolysis Process

Unit Capacity (kilograms/pounds)	Hydrolyzate* (litres)	Total Effluent** (litres)
230/500	606	1,212
680/1,500	1,666	3,635
910/2,000	2,196	4,392
1,800/4,000	4,733	9,466
3,630/8,000	9,466	18,931
4,540/10,000	11,927	23,853

Source: *Carcass Disposal: A Comprehensive Review*

* Undiluted effluent produced per cycle.
** Includes hydrolyzate, cooling water, rinse water, and co-flush.

A representative of Biofuel System Technologies indicated that their patented process uses alkaline hydrolysis to digest tissue and convert the tissue and water into a sterile, aqueous solution that is suitable for land application as a fertilizer. The effluent is made up of small peptides, amino acids, sugars, and soaps with a pH between 10.5 and 11.5 (depending on the amount of alkali used and the total time of the digestion process). The effluent has a very high carbon value which enhances soil performance as a growth medium and absorbs carbon dioxide which benefits the atmosphere and the plants that use it. The fertilizer value of BioLiquidator effluent is shown in Table 5.4.

Table 5.4: Fertilizer Value of BioLiquidator Hydrolyzate when Processed Using KOH (Potassium Hydroxide) as the Alkali

	Tissue to Water Ratio / Potassium Hydroxide %*			
	40:60 / 21%*	50:50 / 21%*	60:40 / 21%*	Dehydrated (to 50% moisture content)
pH	11	11	11	11
Nitrogen (N)	1%	1.5%	2%	9%
Phosphorous (P)	0.33%	0.5%	0.66%	3%
Potassium (K)	2.4%	3.6%	4.8%	21.6%

Source: *Biofuel System Technologies*

* Assumes a 45% liquid KOH solution is used. If a dry form is used, the percentage of alkali is 10%.

Additional nutrient value is available in the bone remnants, which are a solid end product of the process. The bulk of the phosphorus resulting from digestion would be in the insoluble Ca-phosphate of the animal bones. This is a desirable form for the phosphate as it would leach out and cause problems in streams and lakes if it were soluble. In this form, the plants can utilize it over time as it is biologically released to the plants. Any alkylating drugs, bacterial, plant and animal toxins given to the animals would also be destroyed by the hot alkaline digestion.

E. Summary

Alkaline hydrolysis has many advantages as a method of SRM destruction including the following:

- Complete destruction of pathogens, including prions;
  - Approved by the CFIA as a method of SRM destruction (to date, the CFIA has approved the Waste Reduction by Waste Reduction Inc (WR2) alkaline process only);
- Releases no emissions into the atmosphere and results in only minor odour production; and
- Combines sterilization and digestion into one operation.

While previous alkaline hydrolysis units were limited in capacity, a number of larger units are now available such as the 10,000 pound units produced by Biofuel System Technologies and Waste Reduction by Waste Reduction Inc. The alkaline hydrolysis units provided by these companies are large enough to handle all of the waste generated by individual cattle slaughtering plants and dead stock collectors in the Fraser Valley.

In order for alkaline hydrolysis to be a cost-effective method of SRM destruction, research is required to find markets for the effluent produced from the alkaline hydrolysis process in order to offset the operational costs and divert the effluent from municipal sewer systems. The effluent from alkaline hydrolysis could potentially be used as a fertilizer/soil amendment; a feedstock for processes such as anaerobic digestion to generate methane for power production; and a nutrient cocktail for improving sewage treatment plant performance.

VI. Thermal Hydrolysis

This chapter assesses the suitability of thermal hydrolysis for SRM destruction in the Fraser Valley.

A. Description of Technology

Thermal hydrolysis is a bio-refining technology that utilizes high-temperature saturated steam which denatures pathogenic viruses, bacteria, prions and other disease agents. The original animal and plant material is broken down into amino acids, fatty acids and minerals which create valuable sterile nutrients. The technology involves sealed high-pressure batch reactors which can process high tonnages of organic waste in short cycle times.

The leading company in Canada with regard to the thermal hydrolysis technology is Biosphere Technologies Inc. which has been engaged in the research and development of the BioRefinex thermal hydrolysis process for over ten years. Patents have been granted in all of the major industrial and agricultural countries of the world.

The BioRefinex technology is designed to process a wide range of residential, commercial, agricultural and industrial organic waste streams. The proprietary technology processes infectious and high-risk organic material and converts this material into a high-nutrient organic fertilizer or feedstock to an anaerobic digester for the production of biogas which can be converted into thermal and/or electrical energy.

BioRefinex's technology processes material at 180°C under 12 kg/cm^2 (12 atmospheres) of pressure for 40 minutes. Material is processed in a batch form in sealed vessels to ensure that all input material is subject to high temperatures and pressures and to ensure public health safety and traceability. At these high temperatures, thermal hydrolysis has been shown to fracture long-chain molecules and reduce complex proteins into amino acids and peptides, resulting in the destruction of all viruses, bacteria and micro-organisms. As indicated in Chapter 2, thermal hydrolysis is capable of inactivating prions believed to be responsible for Transmissible Spongiform Encephalopathy (TSE) diseases. The CFIA has performed a risk assessment of the thermal hydrolysis of SRM and has determined that thermal hydrolysis is an acceptable method of permanent destruction of abnormal prions that may be present in SRM. Based on the conclusion of this risk assessment, output products from approved thermal hydrolysis installations are not subject to further SRM regulatory controls.

A standard two-vessel BioRefinex configuration can process up to 7.3 tonnes (8 tons) every two-hour cycle in reciprocating batch production. The BioRefinex technology can process whole carcasses up to 1.1 tonnes (2500 pounds) without the need for pre-butchering or breaking and can process mixed loads of material including SRM, animal bedding, meat and bone meal, other animal byproducts, poultry and other organic wastes at the same time.

The thermal hydrolysis technology has a number of significant advantages over traditional methods of processing high-risk organic materials including the following:

- Proven destruction of a wide range of pathogens and conversion of infectious and high-risk material into valuable output material that can be safely landfilled or used as a fertilizer or feedstock for an anaerobic digester;
- Ability to handle a wide ranges of materials simultaneously;
- Ease of environmental permitting, siting and regulatory approval;
- Sealed batch process allows in-situ monitoring, uniformity of results and traceability; and
- Short processing time (1 to 4 hours per cycle), depending on type of input material and use and desired moisture content of output.

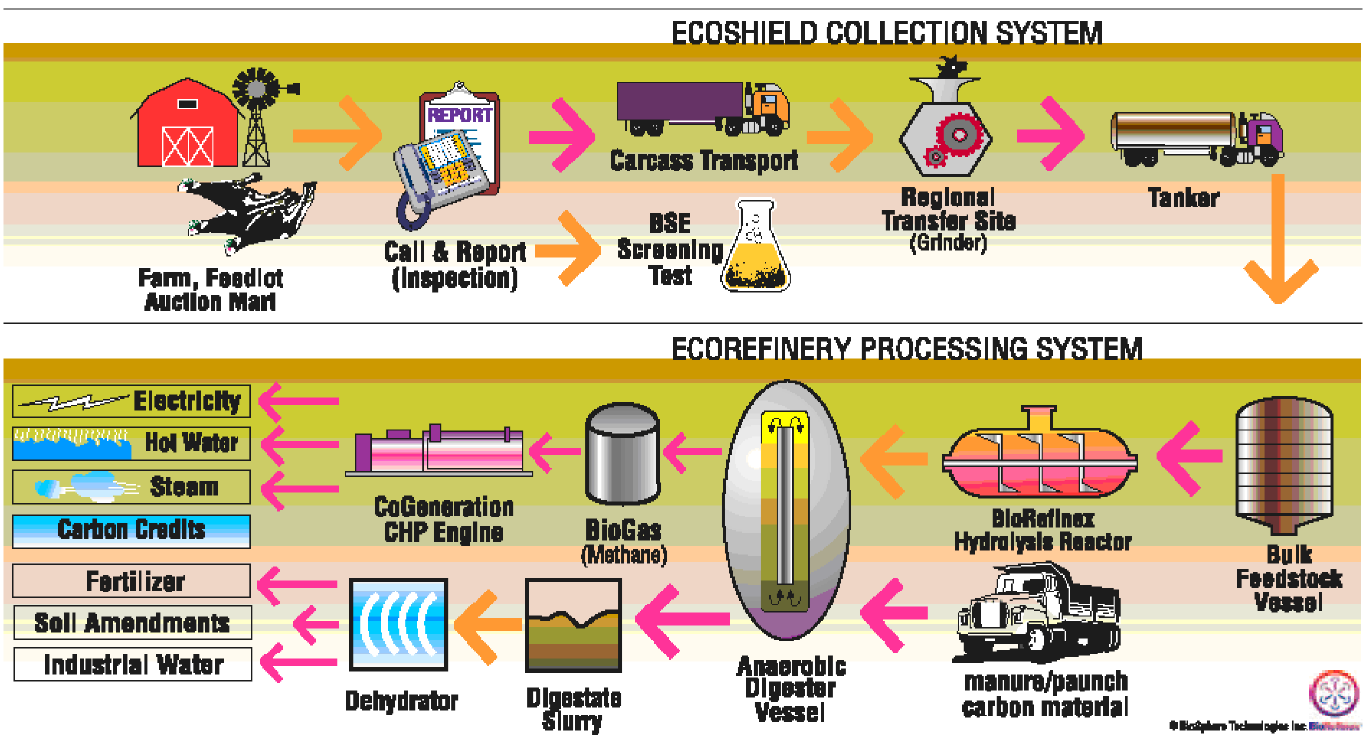
An additional advantage of the thermal hydrolysis process is that it improves the efficiency of anaerobic digesters for the generation of thermal and/or electrical energy. The anaerobic digestion of organic resources is generally considered to be a four-step process in a symbiotic action of a complex consortium of different kinds of bacteria:

- Hydrolysis
- Acidogenesis
- Acetogenesis
- Methanogenesis

In the first hydrolysis step, solid reactants have to be rendered soluble. From a chemical point of view, hydrolysis means the breakdown of long-chain biomolecules by reaction with water. The resulting short-chain hydrolysis products, which are water soluble, can easily be converted into biogas by anaerobic microorganisms. Thermal hydrolysis uses increased pressure and temperature to split up the organic components, resulting in the subsequent fermentation step occurring much faster, more completely, and with an increased gas yield compared to a conventional anaerobic process.

Figure 6.1 provides a diagram of the biorefining system employing the BioRefinex technology for municipal and agricultural organic wastes. The BioRefinex process integrated with anaerobic digestion transforms these materials into safe and valuable industrial product streams including electricity, hot water, steam, fertilizer, soil amendments and industrial water. The process also enables generation of revenue from carbon credits.

Figure 6.1: Diagram of BioRefinex Biorefining System



Source: *Biosphere Technologies Inc.*

B. Thermal Hydrolysis Applications

The BioRefinex technology is currently being commercialized. A pilot test plant is operated by the company in Canmore, Alberta. There are three projects underway in Canada, two in Alberta and one in Quebec, that have licensed the BioRefinex technology.

C. Economic Assessment

According to Erick Schmidt, President of Biosphere Technologies, the capital cost of a complete BioRefinex system, including BioRefinex reactors, processing equipment, anaerobic digester vessels, cogeneration units, and modular buildings, is approximately $25 million. This system would be capable of processing 100 tonnes of waste per day. Feasibility studies of BioRefinex systems in other jurisdictions have indicated an internal rate of return (IRR) of 12% to 15%. A detailed feasibility study would have to be undertaken to deter-mine the likely operating costs and rate of return of an application of this technology for the Fraser Valley. To offset the capital costs of a complete BioRefinex system, it would be necessary to process a large volume of waste in addition to SRM as well as to maximize the revenue from end products such as electricity, fertilizer and steam. The possibility of exploring revenues from carbon credits should be examined as a further economic advantage.

D. Environmental Considerations

Thermal hydrolysis has no noxious odours, air emissions or effluents associated with other processing technologies.

E. Summary

Thermal hydrolysis offers many advantages as a method of SRM destruction including the fact that it is environmentally friendly. Because of its bio-refining process, thermal hydrolysis has greater potential than most other technologies to convert waste into high-value end products. However, the technology is currently being commercialized and no commercial thermal hydrolysis plants are currently in operation in Canada. In addition, it will be necessary to handle a much larger volume of waste than the volume of SRM material generated in the Fraser Valley and it will be necessary to combine the thermal hydrolysis technology with other technologies such as anaerobic digestion to achieve economies of scale. A detailed feasibility study is required to determine the likely capital costs, operating costs, and viability of such a plant, including market research on potential revenues from end products.

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Glossary

Definitions

Specified Risk Material (SRM) is tissue that, in BSE-infected cattle, has been shown to contain the infective prion which can transmit disease. The following tissues are defined in Government of Canada regulations as SRM: skull, brain, trigeminal ganglia (nerves attached to the brain), eyes, tonsils, spinal cord, and dorsal root ganglia (nerves attached to the spinal cord) of cattle aged 30 months or older, and the distal ileum (part of the small intestine) of cattle of all ages.

Transmissible Spongiform Encephalopathies (TSEs) are a group of diseases that affect the central nervous system. These diseases are fatal and are characterized by spongy degeneration of the brain. Bovine spongiform encephalopathy (BSE), which affects cattle and is commonly referred to as "mad cow disease", belongs to the TSE group of diseases. Scrapie is a TSE that affects sheep and goats. Chronic wasting disease (CWD) is a TSE that affects cervids such as mule deer, white tail deer and elk.

Acronyms

SRM – Specified Risk Material

BOD - Biochemical Oxygen Demand

GHG – Greenhouse Gases

ALC – Agricultural Land Commission

TSE - Transmissible Spongiform Encephalopathies

MBM - Meat and Bone Meal

Appendix 1

Preliminary Analysis of Incineration Costs for Inciner8 Model A2600(HF) Incinerator

Preliminary Analysis of Incineration Costs for Inciner8 Model A2600(HF) Incinerator

Incinerator Operating Assumptions

Burn rate (kilograms per hour)	250
Operational hours per day	18
Pre-heat hours per day	1
Number of days per week in operation	6
Tonnes of waste incinerated per year	**1,400**

Capital Costs

Item	Detail	Cost
A2600(HF) Incinerator	Purchase price (freight included)	$ 64,550
	Spare parts	3,200
	Installation cost	1,250
	Import duty, brokerage fees, inspection fees, shipping insurance	5,730
Fuel tank		4,500
Drum handling tractor		18,000
Site preparation cost	Concrete pad	3,000
Power	Installation of electrical power connection	1,860
Total		102,090
PST		7,146
Total Capital Costs		**$ 109,236**

Annual Incineration Costs

Item	Detail	Cost
Incinerator fuel	11 litres per hour @ 75% efficiency = 87,000 litres of furnace oil @$1.40 per litre	$121,800
Labour	4 hours per day (1 hour first load, 1 hour second load, 2 hours unload ash) @ $25 per hour	31,200
Ash hauling costs	98 tonnes @ $220 per tonne	21560
Ash landfill tipping fees	$60 per tonne	5,880
Incinerator repairs	5% of capital cost	3,040
Emission monitoring	Annual costs	5,000
Tractor repairs	10% of capital cost	1,800
Tractor fuel	624 hours per year @ 6 litres of diesel fuel per hour @ $1.40 per litre	5,240
Electricity	1186 kW per year	90
Amortized capital costs	10 years @ 7%	15,150
Total Annual Costs		**$210,760**
Cost per Tonne		**$151**
Cost per Pound		**$0.07**