DISPOSAL OPTIONS TO MITIGATE BSE RISKS
IN THE LOWER FRASER VALLEY, BRITISH COLUMBIA

by

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Abstract

The border closure to Canadian cattle and beef exports since the discovery of Bovine Spongiform Encephalopathy (BSE) in May and December of 2003 have had overwhelming effects on the Canadian economy. Estimates suggest that nearly $6 billion in total has been lost in the 1½ years since the border closure. Two additional cases have now been detected, both within two weeks of the announcement on December 29th 2004 that trade with the U.S. (Canada’s largest trading partner for cattle and beef products) was to resume in March 2005. The second discovery was a beef cow born after the ruminant feed ban was put in place in 1997 and fears that the border would remain closed have been validated. To date, trade of live cattle to the U.S has not resumed.

The biological wastes considered to have the highest probability of containing the BSE infectious agent known as the prion are termed specified risk materials (SRM). As such, SRMs have been prohibited from the human food chain in Canada since August of 2003 as a preventative measure against the human version of BSE known as variant Creutzfeldt Jakob Disease (vCJD). Like BSE, vCJD is attributed to the human consumption of BSE infected meat products. It is a fatal neurological disorder with no known vaccine or cure. Regulatory changes have been proposed to remove SRM from the entire animal feed chain as a measure to mitigate further incidences of BSE. Such a measure would result in large volumes of biological waste that have few acceptable disposal options creating substantial challenges for industry and government.

There are few options that are scientifically proven to reduce TSE infectivity through the destruction or inactivation of the infectious agent known as the prion. Findings of this research conclude that there does exist energy recovery disposal options that can serve to reduce release of these materials to soil, groundwater, and wildlife. The inclusion of rendered meat and bone meal co-fired in cement kilns and biodiesel production from tallow stand out as promising options to be considered in the Lower Mainland of British Columbia, Canada.
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Abbreviations & Terms

**Proximity principle** Seeks to promote the management of wastes as close to their point of production as possible.

**Precautionary principle** When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically (Wingspread Statement 1998)

### Measurements

<table>
<thead>
<tr>
<th>Term</th>
<th>Acronym</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>m (^2)</td>
<td>square metres</td>
</tr>
<tr>
<td>Energy</td>
<td>J</td>
<td>joule</td>
</tr>
<tr>
<td>Mass</td>
<td>kg</td>
<td>kilograms</td>
</tr>
<tr>
<td></td>
<td>ttonne (=1000kg)</td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>W</td>
<td>watt (1 joule/s)</td>
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<tr>
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</tr>
<tr>
<td></td>
<td>h</td>
<td>hour</td>
</tr>
<tr>
<td></td>
<td>y</td>
<td>year/ annum</td>
</tr>
<tr>
<td>Volume</td>
<td>m (^3)</td>
<td>cubic metres</td>
</tr>
</tbody>
</table>

### Additional units

- ktpa kilo-tonnes per annum (capacity)
- tds tonnes of dry solids

### Chemical Abbreviations

- CH\(_4\) methane
- CO\(_2\) carbon dioxide
- CO carbon monoxide
- H\(_2\) hydrogen
- H\(_2\)O water
- H\(_2\)S hydrogen sulphide
- K potassium
- N nitrogen
- NH\(_3\) ammonia
- NO\(_x\) nitrogen oxides
- P phosphorous

### Acronym

- TSE | Transmissible Spongiform Encephalopathy
- BSE | Bovine Spongiform Encephalopathy
- CJD | Creutzfeldt Jakob Disease
- SRM | Specified Risk Material
- MBM | Meat & Bone Meal
- RMBM | Ruminant MBM
- OTM | Older than 30 months in age
- UTM | Under 30 months in age
- LCW | Live Carcass Weight
- CFIA | Canadian Food Inspection Agency
- BCMAFF | British Columbia Ministry of Agriculture Food & Fisheries
- WLAP | Ministry of Water Land & Air Protection
- AAFC | Agriculture Agri-Food Canada
- EU | European Union

### Term & Meaning

- **Cow** | A female bovine unit that has had >= 1 offspring (calve)
- **Calve** | A young bovine unit < 6 months
- **Heifer** | A female bovine unit with 0 offspring
- **Dairy Cow** | A cow that is kept mainly for producing milk or rearing calves for the dairy herd
- **Beef Cow** | A cow kept mainly for producing and rearing calves for the beef herd
- **Bull** | Male calves that have not been castrated
- **Steer** | Male calves that are raised for beef production and usually castrated at 6 to 12 weeks
- **Heifer for Dairy Replacement** | Cattle bred on farm to replace culled breeding stock
- **Heifer for Beef Replacement** | “ ”
- **Heifer for Slaughter (Cull Cow)** | A cow that has been removed from the dairy herd to be sent to slaughter
- **Downer** | A diseased or injured animal unable to walk
Preface

This research was begun prior to the discovery of the first indigenous case of BSE in Canada in anticipation of BSE's implications on the availability of tallow for biodiesel production. Upon further investigation, it became apparent that Canadian incidence of BSE could have far more implications than simply being a question regarding tallow feedstock availabilities for biodiesel production. It appeared that Canada could be heading towards a waste management crisis connected to the lack of existing infrastructure for the safe disposal of bovine Specified Risk Materials, the most infectious materials of the cattle, in the event of a BSE outbreak.

Even in the absence of a domestic epidemic, the possibility of new regulations present a waste management challenge. Risk mitigation measures regulated in Europe to eradicate BSE and prevent its transmission across the species barrier to other livestock do not currently exist in Canada. The most critical of these - the removal of SRM from all livestock and pet feeds will likely be instituted in the near future. In recognition of the importance of this risk mitigation measure, or perhaps to satisfy the concerns of the 30 nations that continue to ban exports of all Canadian beef products, the Canadian government proposed in the Federal Gazette on December 10, 2004 that it intends to remove SRM from the animal feed chain entirely.

On December 29, 2004 a public announcement was made by the Canadian Food Inspection Agency that Canada might have discovered its third case of Bovine Spongiform Encephalopathy in a ten-year-old dairy cow from Alberta. This announcement came within two hours of a separate announcement stating that the U.S border would open on March 7, 2005 to live imports of Canadian cattle. It was shortly thereafter determined to be eight years old, born just before the 1997 ruminant to ruminant feed ban however the U.S maintained its position to resume trade with Canada for its live cattle and beef products. On January 2, 2005 the cow was confirmed as testing positive for BSE, Canada's second indigenous case. And on January 11th, a third indigenous case of BSE was detected in an Albertan beef cow born after the ruminant feed ban, causing greater concern about Canada’s risk mitigation measures. These incidents further raise the possibility of
regulations that require separation and disposal of SRM and it remains uncertain as to whether trade with the U.S. will resume as planned.¹

The goal of this research is to identify the most effective precautionary and economically feasible options related to disposal of SRM and other inedible ruminant wastes in light of the many scientific, market, and regulatory uncertainties that exist. A primary focus of this research was to identify options that involve energy recovery. It also seeks to conclude and communicate important lessons learned from the BSE epidemic experienced in Europe.

¹ It is important to note that BSE protection measures in the U.S. are similar to that of Canada, both in terms of monitoring, feed practices, and animal health. The fact that BSE does not exist in the U.S. is under question by many experts.
“There are lessons to be learned from the events of those years. We stress that identifying those lessons is more important than examining whether individuals should be criticized.”

UK BSE Inquiry Report, 2000 regarding the BSE epidemic in the UK
1.0 Project Rationale

Significant regulatory changes regarding animal health & feed regulations were proposed in the Canadian Federal Gazette on December 10, 2004 that could dramatically affect the entire livestock farming, meat processing, and feed industries. The most significant of these changes could impose a total ban on bovine specified risk materials (SRM)\(^2\) and ruminant proteins from entering the animal food chain, including all livestock and pet food. This measure would result in enormous volumes of biological waste that have few acceptable disposal options.

The biological wastes of greatest concern are termed specified risk materials (SRM) as these materials are considered to have the highest probability of containing the BSE infectious agent known as the prion. As such, SRMs have been prohibited from the human food chain in Canada since August of 2003 (since 1990 in the E.U.) as a preventative measure against the human version of BSE known as vCJD. Like BSE, vCJD is attributed to the human consumption of BSE infected beef products. Its is a fatal neurological disorder with no known vaccine or cure.

Primary factors influencing this research are as follows:

- Changing regulations as protective measures against occurrence of Bovine Spongiform Encephalopathy (BSE) in Canada may create a large waste stream from the livestock farming and meat processing sectors that previously had an end market. This waste stream is classified as Specified Risk Materials but may also include all ruminant meat and bone meal from slaughter, inambulatories, and dead-stock;

- Options for the disposal of these materials are limited, as neither BC's Water, Land & Air Protection Division nor the Regional Districts in the Fraser Valley will allow this material to be knowingly disposed of in regional landfills or waste water treatment plants. BC also lacks the incineration capacity that has provided relief for BSE related disposal in Europe and NIMBY issues often prevent new incineration projects from being approved for development.

\(^2\) SRM- the skull, brain, eyes, trigeminal ganglia, spinal cord, vertebral column, and of bovines 30 months or older and the distal ileum (small intestine) of cattle of all ages.
• Cattle and Dairy farmers deal with 1-5% annual on-farm mortality rates. Often these animals are older than 30 months (OTM) and in the highest risk category for BSE infectivity. With little or no value for the dead stock, there is virtually zero cost tolerance for the disposal of these animals and expensive disposal costs will result in the continuation or development of on-farm disposal methods that are hazardous (and perhaps illegal).

• The rendering industry may no longer collect and process these materials from producers or processors if the cost of doing so becomes economically prohibitive. As a result, they may be forced to charge large collection fees to account for the lack of market value and to pay for its end disposal at potentially great expense at a hazardous waste facility. If fees are increased beyond a certain threshold, BC slaughter capacity could be forced to shut down.

• Non-compliance with the current ruminant feed-ban is high, occurring at over 17% of the farms examined by the CFIA (Tolusso 2004). With a few hundred thousand multi-species hobby farms across Canada, it is very possible that the percentage of non-compliance is even higher. Recent evidence has also demonstrated that over 71% of domestically produced animal feed labelled and sold as only containing vegetable protein, contained unidentified animal proteins (Skelton 2004). It is not yet known whether this animal protein included ruminant material and/or SRM or the concentration level in the materials. Additionally, the European experience with BSE demonstrated that the potential for cross-contamination of ruminant feeds with non-ruminant feeds that include ruminant materials is extremely high. There are few existing safeguards in Canada to reduce the risk of transmission through cross-contamination.

• Industry estimates indicate SRM constitute approximately 13 kg in each head under 30 months (UTM) 40 kg in each head of cattle over 30 months of age (OTM) (Informa 2004). Based roughly on these figures and Canadian herd statistics, this amounts to nearly 500,000 tonnes of SRM alone existing in the standing Canadian cattle and calve population.
This thesis is structured to provide the rationale for this project by discussing the etiology of BSE as well as the political, regulatory, and economic frameworks in Chapter 1. Chapter 2 is a resource assessment that attempts to quantify the volume of materials that would be impacted by the proposed regulations. Chapter 3 provides an overview of waste mitigation and biomass conversion technologies that could serve as disposal options. In Chapter 4 these options are analyzed and assessed according to a set of criteria to determine which disposal method would be most effective and feasible for the animal by-products of concern within the context of existing realities. Chapter 5 is the conclusion and discusses insights learned from the European experience of BSE to help inform domestic decisions that will be made in the very near future.
1.1 Context

This remainder of this chapter will discuss the etiology of BSE as well as the political, economic, and regulatory framework to provide an understanding of the BSE related challenges Canada is facing. It is the goal of this chapter to establish the context within which the disposal options will be evaluated and to provide a strong case for Canada to follow the precautionary principle, and the lessons learned from Europe, when implementing changes to its Animal Health and Feed Regulations.

Federal non-compliance of the federal ruminant to ruminant feed ban imposed in 1997 was determined to be 17% (Personal Communication Clark 2004; Tolusso 2004). This means that on 17% of the farms visited, cattle are still being fed cattle proteins, the primary pathway identified for the spread of BSE.

The Vancouver Sun Headline on Thursday December 16, 2004 read, “Secret Tests Reveal Cattle Feed Contaminated by Animal Parts.” (Skelton 2004). According to the article, the CFIA initiated a hidden nationwide testing program in early 2004 for both domestic and imported feed to discern whether vegetable feeds contained animal parts. Of the 70 samples tested from both sources, 41 had animal proteins (58.6%). Of the 28 domestic feed samples tested, 20 had undeclared animal protein in them – 71.4%. In the article, Sergio Tolusso of the CFIA was quoted as saying they were unable to determine whether the animal proteins contained that of ruminants, as it is “virtually impossible to determine what species they might come from” (Skelton 2004).

Undoubtedly there could be strong industry and political pressures against conducting such a test, as a discovery of ruminant proteins in commercial vegetarian cattle feed could be even more devastating to the Canadian cattle industry. In such an instance, farm level non-compliance would be only the tip of the iceberg in comparison to wide scale non-compliance of regulatory law on the part of the feed and/or rendering industry. If necessary, the CFIA could explore using an ELISA test, available since 1991, “which can detect bovine and ovine proteins in a sizeable number of compound feedingsstuffs at incorporation rates as low as one per cent” to determine whether ruminants are indeed still in vegetable and/or ruminant labeled feeds (Bridgeman CB 2000).
As recently as December 30, 2004, in response to the recent detection of the third potential BSE case on December 29th 2004, an official of the CFIA said there is “no risk to humans from consumption” (CBC 2004). This is similar to the statement made by the British authorities during the initial outbreak of BSE in the UK that eventually lead to widespread disenchantment and mistrust of the British government by its citizens. History has demonstrated that government miss-communication of “low risk” and “no risk” with regards to BSE can have serious consequences for animal and human health and additionally can lead to a breakdown in citizen trust in government(Powell 1997). Certainly the probability of inter-species transmission is low but it has been proven possible.

1.1.1 Transmissible Spongiform Encephalopathy

Bovine Spongiform Encephalopathy (BSE) is a fatal disease affecting the nervous system of cattle and is the bovine expression of a larger order of diseases known as Transmissible Spongiform Encephalopathy (TSE). TSEs are referred to as Scrapie in sheep, Chronic Wasting Disease (CWD) in deer and elk, Transmissible Mink Encephalopathy (TME) in minks, Feline Spongiform Encephalopathy (FSE) in cats and in humans – Creutzfeldt-Jakob Disease (CJD), Gerstmann-Sträussler Syndrome (GSS), Kuru, and Fatal Familial Insomnia (FFI). TSE diseases cause the appearance of microscopic holes in the brain, giving it a sponge-like appearance, hence the term ‘spongiform’.

There are four primary methods for TSE transmission - sporadic, inherited (familial), lateral (intra-and interspecies) and iatrogenic (accidental exposure through medical, surgical, or accidental occupational procedures). The following sections will discuss these pathways in the context of the four major TSEs of concern for this research - BSE, Scrapie, Creutzfeldt Jakob Disease, and variant CJD (vCJD).

1.1.2 Bovine Spongiform Encephalopathy (BSE) and Scrapie

The origin of BSE in cattle may never be known with certainty, however scientific literature suggests that it probably originated early in the 1970s as a consequence of a sporadic or familial gene mutation in either the somatic cell or germ line, in one or more cattle. Perhaps due to increased susceptibility based on environmental conditions (e.g. copper or manganese levels in
the soil and/or organophosphate pesticides used to combat warble fly) it then spread laterally to other domestic cattle through cannibalistic ingestion of infected cattle through rendered feed (Bridgeman CB 2000).

The epidemic that ensued in the UK was concluded by Mr. John Wilesmith, Head of the Central Veterinary Laboratory Epidemiology Department in the UK, to have been caused by the consumption of meat and bone meal (MBM) made from infected animal carcasses that were incorporated in cattle feed (Bridgeman CB 2000). It appears the majority of the research community accepts this. It is important to comment that at the outset of the BSE crisis in the mid 80's, it was generally believed that the feeding of Scrapie infected sheep materials laterally crossed the species barrier and caused BSE in cows. This hypothesis is no longer in favor, for the reasons following.

Scrapie has been recorded as a disease in sheep populations for over 250 years and some estimates indicate it exists in as much as 70% of the current sheep population. Cattle had been fed sheep since the practice of recycling dead and diseased animals to livestock began in the 1880s and predominated throughout most of Europe and North America after the 1920s. The large number of cases of BSE in the UK in comparison to the rest of the EU suggests that if cattle were susceptible to Scrapie, it would have crossed the species barrier long ago and additionally; there would have been more index cases outside the UK.

---

3 There is no definitive proof for any of these hypotheses
4 Species barrier effect – "Natural barriers which resist the transmission of TSEs from one species to another. The ‘barrier’ becomes evident through observation of the incubation time. When crossing into a new species, the incubation period at first passage is significantly longer than those seen at later passages in the same species. (Bridgeman CB 2000 V2:52)
Table 1 below illustrates the known transmissibility of TSE like prions across and within species.

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Agent</th>
<th>Cow</th>
<th>Sheep &amp; Goats</th>
<th>Deer &amp; Elk</th>
<th>Pigs</th>
<th>Mice</th>
<th>Human</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow</td>
<td>I, S, L</td>
<td>I</td>
<td>I</td>
<td>NI</td>
<td>I</td>
<td>NI</td>
<td></td>
</tr>
<tr>
<td>Sheep &amp; Goats</td>
<td>I, L⁵</td>
<td>F,S,I,L</td>
<td>I</td>
<td>NI</td>
<td>I</td>
<td>NI</td>
<td></td>
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<tr>
<td>Deer &amp; Elk</td>
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<tr>
<td>Mice</td>
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<td>NI</td>
<td>I, L</td>
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<tr>
<td>Human</td>
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<td>U</td>
<td>NI</td>
<td>NT</td>
<td>S, I, L,F</td>
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</tr>
</tbody>
</table>

Notes: F= Familial (genetic or maternal); S=Sporadic; I = Iatrogenic; L= Lateral (ingestion); NT= Not Tested; NI = No Test Identified; NO=Transmission Not Proven; U= Unknown

Sources: (Matthews, 2003; EU, 1998; OIE, 2001; Belay, 2004; Sigurdson, 2003; Bridgeman, 2000)

It is known that there have been over 183,000 cases of confirmed BSE in the UK alone since 1986. (Ferguson, 2004) There is also evidence to support a possible link between BSE and a variant of Creutzfeldt-Jakob Disease (vCJD) where to date there have been 153 confirmed deaths in Europe (147 in UK as of December 6th 2004) recorded since 1995 (UKCJD 2004).

“The link between BSE and vCJD, suggested on the circumstantial evidence that the two conditions were associated in both time and space almost exclusively in the UK, was soon supported by experimental and biochemical results. Chief among these were the strain typing results in mice that revealed in 1997 that BSE and vCJD had similar incubation periods and lesion profiles in the brain. Type 4 glycosylation patterns were found in both, and studies using transgenic mice in which the murine prion gene had been replaced by the bovine gene strongly suggested that the infective agent was identical in both conditions. Present evidence seems overwhelming.”

(Bridgeman CB 2000: V8-74)

⁵ A goat was confirmed to have BSE in France in Feb 2005
1.1.3 Creutzfeldt Jakob Disease and variant CJD (vCJD)

CJD is a rare human TSE discovered by two scientists independently, Jakob and Creutzfeldt, in 1920. Their descriptions of patients both referred to dementia and a fatal degenerative neurological disorder (Bridgeman CB 2000). Incidence of CJD is now found to occur at about one in a million per year globally affecting most usually adults in middle to old age. Its occurrence is attributed to being sporadic in 85% of cases, hereditary in 5-10%, and acquired iatrogenically in less than 1% (with most cases involving human growth hormone injections, eye or brain surgery) (EUROCJD 2004). See Table 2 for the determined etiology for deaths of known and probably CJD and vCJD worldwide from 1990 to 2004.

vCJD had not been witnessed prior to 1995 and affects a demographic of the population significantly younger than typical for CJD (median age at death is 29 compared with 67 for CJD) (UKCJD 2004). Both CJD and vCJD are nightmarish diseases for the patient and their families. Symptoms of both include memory loss and confusion, leading to progressive dementia, ataxia (blindness and loss of speech) leading to death within 4 to 14 months of the onset of symptoms. Several differences between classical CJD and variant CJD have been identified including age of onset, the characteristics of electro-encephalogram, and in the disease pathology. The only way to confirm a diagnosis of CJD is by brain biopsy or autopsy, although autopsy after death is much safer for the patient and more accurate.

---

6 The disease arises simply as a chance event inside the brain
### Table 2 Deaths of Definite and Probably CJD and vCJD (UKCJD 2004)

<table>
<thead>
<tr>
<th>Year</th>
<th>Referrals</th>
<th>Year</th>
<th>Sporadic</th>
<th>Iatrogenic</th>
<th>Familial</th>
<th>GSS</th>
<th>vCJD</th>
<th>Total Deaths</th>
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<td>4</td>
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<td>0</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td>55</td>
</tr>
</tbody>
</table>

Total Referrals: 1913  Total Deaths: 756  46  42  23  147  1014

Deaths from definite vCJD (confirmed): 106
Deaths from probable vCJD (without neuropathological confirmation): 39
Deaths from probable vCJD (neuropathological confirmation pending): 2

There are a number of hypotheses as to cause of vCJD, however none have yet been unquestionably proven either. There is strong evidence to show that BSE can cross the species barrier to humans' iatrogenically from injected medicinal products, surgical implantation using bovine tissues, or by direct inoculation of bovine tissue injected accidentally.

Human consumption of infectious tissue and/or SRM from bovines in the form of hamburger meat or mechanically recovered meat (MRM) that was known to have parts of brain and/or spinal materials including dorsal root ganglia is also still strongly believed by many in the scientific community to be the cause of vCJD. As mentioned earlier, Canada has only banned these
materials from the human food chain since August of 2003\textsuperscript{7}, however as of September 30\textsuperscript{th} 2004 there has only been one confirmed case of vCJD in Canada and 224 cases of CJD as of June 30th 2004. Table 3 below shows the number of referrals and cases of vCJD that have been confirmed globally from 1996 through June 30, 2004.

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|}
\hline
COUNTRY & NUMBER OF REFERRALS & NUMBER OF vCJD CASES \\
& AGED < 50 SINCE 1996 & \\
\hline
Australia & 56* & 0 \\
Austria & 93 & 0 \\
Canada & 42+ & 1 \\
France & 915 & 7 \\
Germany & 128** & 0 \\
Italy & 195 & 1 \\
Netherlands & 21 & 0 \\
Slovakia & 83**** & 0 \\
Spain & 37 & 0 \\
Switzerland & 21 & 0 \\
UK & 320*** & 145 \\
\hline
\end{tabular}
\caption{vCJD by Country (EUROCJD 2004)}
\end{table}

* including 4 familial cases and 36 cases excluded in Australia (not previously presented)
** at onset; *** excluding suspect familial or iatrogenic CJD; ****to 31 March 2004
+ to 30 June 2004

It should be noted that that misdiagnoses of dementias such as Alzheimer’s, Huntington’s and CJD could be high. In the absence of post-mortem biopsies, it is impossible to tell how many are false positive diagnoses. The following excerpt comes from a report published in Neurology, the journal published by the American Academy of Neurology, in 1989:

“Based on 54 demented patients consecutively autopsied at the University of Pittsburgh, we studied the accuracy of clinicians in predicting the pathological diagnosis. Thirty-nine patients (72.%) had Alzheimer’s disease, while 15 (27.7%)...”

\textsuperscript{7} The U.S. did not ban SRM from the human food supply in January 2004.
had other CNS Diseases (four multi-infarct dementia; three Creutzfeldt Jakob disease; two thalamic and sub cortical gliosis; three Parkinson’s; one progressive supranuclear palsy; one Huntington’s disease and one unclassified.) Two neurologists independently reviewed the clinical records of each patient without knowledge of the patient’s identity or clinical or pathological diagnoses; each clinician reached a clinical diagnosis based on criteria derived from those of the NINCDS/ADRA. In 34 (63%) cases both clinicians were correct, in nine (17%) one was correct, and in 11 (20%) neither was correct. Theses results showed that in patients with clinical diagnosis of dementia, the etiology cannot be accurately predicted during life.”

Dr. F. Boller, OL Lope and J Moosy, Department of Neurology, Veterans Administration Medical Center, Pittsburgh, PA.

1.1.4 Prions

Although the exact cause of BSE is still unknown, it is widely attributed to the presence of an abnormal protein called a prion. A prion is the term created by the scientist Stanley Prusiner who published his hypothesis on the proteinaceous infectious particle in 1982. A very insightful history on key discoveries regarding the prion is provided in the UK BSE Inquiry published by:

“By 1983 Prusiner had isolated the prion protein from infected hamster brains that had been enriched for Scrapie infectivity,” and “proposed that deposition of prion protein in the brain caused the damage characteristic of Scrapie...” Later work by Prusiner in 1985 showed that prion protein was a component of the normal cell and was encoded by the host genome... The amino acid sequence of the scrapie-associated prion protein (PrPSc) was found to be the same as the normal prion protein (PrPC). Prusiner showed that PrPSc was partially resistant to digestion by protease enzymes, while PrPC showed no resistance to enzyme digestion. He postulated that the protease resistance was due to a modification of the three-dimensional structure of the prion protein, and that this conformational change had the ability to convert normal PrPC into PrPSc by a form of chain reaction. The abbreviation PrPsc came to be used for the abnormal isoform of the prion protein in all TSEs, not just scrapie.”

"As we shall see in relation to the pathogenesis of TSEs, alteration in the three-dimensional structure of the prion protein is associated with resistance to degradation,
and results in the accumulation of insoluble aggregates with the consequent destruction of nerve cells which is the hallmark of such diseases.” (Bridgeman CB 2000: V2-36)

Prusiner's research was ridiculed and the medical and scientific community ostracized him for over a decade for his assertions that prions lacked DNA and RNA, the presence of which was considered to be essential for all biological life. He later was vindicated and awarded the Nobel Prize in Medicine in 1997 for his research.

Prions replicate by transforming normal cellular prion proteins into abnormal proteins and accumulate in the central nervous system (CNS), e.g. brain and spinal column. The incubation period can range from months to 40 years before symptoms arise. Many aspects concerning prions still remain unexplained, including the means by which the infective agent (PrPsc) converts the host’s normal prion protein into the protease-resistant, disease-producing formation.

![Proposed three-dimensional structure](image)

**Figure 1 - Proposed three-dimensional structure (a) PrP^C and (b) PrP^Sc.** The structure of the normal prion protein, PrPC, is characterized by four α-helices. Conversion of PrPC to the disease-associated form of PrPSc results in the loss of two of the helical structures (shown shaded in brown), which are converted to linear structures known as β-sheets. It is this conversion that is associated with the acquisition of prion infectivity.

**Source:** BSE Inquiry Report: V2-37
While the scientific community cannot fully explain its baffling existence, epidemiological studies and individual experiences have demonstrated the severe negative effects PrP^Sc prions have on mammals, especially humans. Prions are resistant to being destroyed through methods that are effective for destroying all other pathogens such as autoclaving, incineration, and UV radiation.

The difficulty in destroying prions provides impetus for establishing the most effective measures to prevent the spread of infection by limiting animal and human exposure to infectious materials. Thus, the effectiveness of a particular regulatory action is dependant upon the disposal methods available to limit the potential for prion transmission.

1.1.5 Meat Processing

The Canadian meat processing industry, consisting of abattoirs (slaughterhouses) and meat packers, produces dressed carcasses sold on a wholesale basis to butchers and other meat processing plants where they are further prepared for human consumption. In many instances, abattoirs produce trimmed and boned cuts sold directly to retail outlets (UNEP 2000).

The boned meat available for human consumption is on average only 40% of the total carcass weight from a 430kg cattle (NSW Agriculture 2004). The remaining materials are removed during the various stages of meat processing, much of which is considered not fit for human consumption, and termed animal by-products (ABP). These materials include bone, fat, heads, hair, hides, and offal. A small percentage of ABP, such as hides, goes to leather production, while the remaining majority is rendered into meat and bone meal (MBM) and tallow. These rendered products have traditionally become feed material for both livestock and pet food as well as used in a variety of industrial and pharmaceutical products.

There are 43 registered abattoirs in BC, of which 39 are provincial and 4 are federal. In addition to these registered facilities, there are 69 non-registered/non-inspected establishments that slaughter animals and/or prepare beef cuts from whole carcasses (BCMAFF 2004). In the Lower

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8 Autoclaves are typically used in hospitals, microbiology labs, and other places that need to sterilize a variety of objects. It uses pressure and high temperature steam, and is effective at inactivating most known bacteria, viruses, and fungi.
Mainland-Southwest region, all facilities are registered (4 provincial and 1 federal), and almost all meat-processing wastes are collected at the processor's location of operation and then transported to transfer facility where they are sent by rail to a rendering plant in Alberta. The specification of registered and non-registered facilities informs what markets are available to a particular facility.

The rendered inedible waste then becomes meat and bone meal for domestic and international livestock. Tallow derived from rendering is used both in feed and as a feedstock for a variety of industrial products. Large volumes of these materials are then transported back to Vancouver and then shipped to China.

The cost of waste collection to the processors has been volatile, due to BSE and related market pressures, such as the drop in domestic and world commodity prices for rendered ruminant byproducts (meat and bone meal (MBM), blood meal and other "inedible" by-product derivatives) have caused prices to fluctuate. Collection prices are also subject to the market power exerted by the very few companies that dominate the rendering industry.

Industry estimates indicate SRM constitute approximately 40 kg in each head of cattle over 30 months of age, and 13 kg in each head under 30 months (Informa 2004). Based roughly on these and Canadian herd statistics, this amounts to nearly 500,000 tonnes of SRM existing in the standing cattle and calve population. Regional information regarding these volumes is addressed in detail in Chapter 2.

A number of pathways for prion transmission exist at BC abattoirs. Firstly, SRM and non-SRM materials are not handled any differently when cutting, handling or disposing of, whereas it is recommended from the European experience that separate cutting instruments be utilized to prevent risk of transmission to humans via both consumption of edible materials or when used in pharmaceuticals. In multi-species slaughter facilities, SRM materials are neither stained nor separated from non-ruminant materials, and thus become indistinguishable in collection.

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9 Bovine materials are used directly in pharmaceuticals. Several injectable medicines are derived directly from bovine sources including hormones such as insulin and glucagons derived from bovine pancreases, and protein products such as aprotonin and heparin are derived from lungs and intestinal mucous respectively. Gelatin is also widely used as a pill coating and tallow as a constituent for creams and ointments. (UK)
containers. These materials may then risk transmission via cross-contamination into ruminant feed.

1.1.6 Current Disposal Methods

Rendering and Feed

The latest data available suggests that Canada produces roughly 2-3 million tonnes of raw animal waste from all livestock processing of ruminants, poultry, pigs, and fish into 550,000 tonnes of MBM annually. Nearly 70% of which is processed from bovine materials (CFIA 2003). Oil, tallow, lard and fat volumes can be estimated to be in the range of 200-300,000 tonnes annually.

Currently, rendering is the primary method of disposal of slaughterhouse wastes in Lower Mainland -Southwest (LM-SW) region, and accounts for nearly 77% of current disposal (BCMAFF 2004). The primary steps in the rendering process include sizing (chopping or grinding to slurry), evaporation & cooking (usually in steam jacketed stainless steel vessels), separation of tallow and proteins (usually via centrifuge), and drying (spray drying in the case of blood).

Meat-and-bone-meal, blood meal, poultry by-product meal and hydrolyzed feather meal\(^\text{10}\) then become inputs in commercial livestock and pet feed. It has only been since 1997 that Canada prohibited the feeding of the protein from cattle, sheep, goats, bison, elk or deer (also known as ruminants) to other ruminants, although non-compliance has proven to be a major concern and SRM is still included in non-cattle feeds. Beef tallow is also used in commercial feeds, and there is currently no Canadian limit on the inclusion of protein particles.

Commercial feed is the largest operating expense for all farms in BC second to wages, room & board. In BC, livestock producers spent over $363 million on feed in 2002, nearly 20% of total gross operating expenses for the sector (BCMAFF 2004).

\(^\text{10}\) Poultry feathers that have been decomposed into meal by reacting with hot water
In Canada there are about 550 commercial feed mills. According to the Sun article, in an initial inspection in March of 2003, 21% were not complying with federal regulations and several of these mills had “major non-compliance issues” (Skelton 2004).

Dairy cows are generally fed higher concentrations of animal proteins than beef cattle in order to facilitate higher milk yields and typically receive concentrates as soon as a week after birth. Beef cattle generally do not receive concentrated feed until at least 6 months of age, however, since dairy cows eventually are slaughtered for beef products, this distinction in terms of transmission risk may be minor (Bridgeman CB 2000).

The remaining methods for slaughterhouse waste disposal include wildlife (leaving carcass above ground), burial (digging hole in ground and covering carcass with soil), composting, and pet food (after rendering). Landfill is allowed in other parts of the province but prohibited in the LM-SW. These and alternative disposal methods are discussed in greater detail in Chapter 3.
Canadian Specified Risk Material—

- a) the skull, brain, trigeminal ganglia, eyes, tonsils, spinal cord and dorsal root ganglia of cattle aged 30 months or older; and
- b) the distal ileum of cattle of all ages.
1.2 Economic Impact of BSE

1.2.1 Impact on Canada

“Canada’s beef industry is the single largest commodity source of farm cash receipts. Beef production’s contribution to the rest of the economy was $20 billion in 2003 (down from $30 billion in 2002) and were generated in processing, retail, food service, and transportation sectors.” (CFIA 2004)

After the discovery in Canada of a single case of BSE in May 2003, swift sanctions dramatically affected the exportability of Canadian beef products and dealt a crushing blow to one of Canada's major industries. Prior to that May, Canada was the 3rd largest exporter of beef in the world with a 2002 export market of 4.1 billion dollars, exporting nearly 15 percent of total world beef exports behind the U.S (16.5%) and Australia (21%). In 2003, ninety-two percent of Canada's exports went to two countries, the United States (82%) and Mexico (10%) but because of said sanctions, in June, July, and August of 2003, beef exports dropped to virtually zero (CanFax 2004; Seeber 2004). Brazil subsequently assumed the 3rd position, now with 17% of the export market while Canada has dropped to 8% (ranked 5th)(CanFax 2004).

In mid September 2003, the U.S and Mexico partially opened its borders to Canadian boneless fresh or frozen bovine meat from animals 30 months or younger which helped the industry to recover somewhat. Then the discovery of an infected Holstein cow in Washington State in December 2003, later traced back to an Albertan farm, came just when discussions about reopening of U.S borders to Canadian livestock were to begin. To date, all live cattle exports to the U.S. are still prohibited (Sgaard 2004) and as a result Canada's herd had grown to over 16.8 million head this July, up 6 % from 15.7m in July 2003 (USDA 2004).

On December 29, 2004 the United States announced it would reopen its borders to live imports of Canadian cattle in March 2005, however within 2 hours, the 2nd BSE case was discovered in a ten-year-old dairy cow from Alberta.

Over 30 nations continue to ban all Canadian beef products (CFIA 2004), yet Canadian beef exports (almost exclusively to the U.S and Mexico) from January to August 2004 totaled $1.294
billion dollars, up from $880 million over the same period in 2003, but still down roughly $220 million for the period in 2002 ($1.519b) (Hovis 2004).

The crisis has also had a large impact on animal by-products such as meat and bone meal (MBM), blood products, and various other products unfit for humans that were historically fed to domestic livestock. During the crisis, the price of bovine meat and bone meal (MBM) dropped from $280/tonne in May 2003 to $40/tonne in October 2003 (Beltranena 2003). MBM has since rebounded to over $80/tonne domestically and the export market to China remains open to RMBM\textsuperscript{11} imports however, the massive fluctuations and uncertainty in MBM prices put pressure on the rendering industry to shift pricing strategies.

For meat processors, this resulted in the conversion of what was once a revenue stream (fees paid from renderers by weight for inedible by-products) into a growing and increasingly uncertain economic burden (Personal Communication with abattoir that wishes to remain anonymous). Ultimately all costs were passed on down to livestock farmers, from having to feed growing populations of cattle to lower prices paid per head at slaughter, necessitating government assistance totaling over $2b to keep the Canadian Cattle Industry from going belly up (AAFC 2004).

Japan and most other Asian markets still remain closed to any and all Canadian beef products and only as recently as October had Japan recommenced negotiations with the U.S. to resume their imports of U.S beef. Since Japan had accounted for 37 percent of the total value of U.S beef exports (Dreyfuss 2004) it is of utmost importance to the U.S cattle industry to appease Japanese ministers of the safety of their product. These factors combined provide impetus for the U.S and Canada to develop harmonized regulations.

1.2.2 Impact on BC

Revenues for the cattle industry in BC at the end of the 3\textsuperscript{rd} quarter 2004 were at the lowest level since 1978 (BCStats 2004). 2004 second quarter receipts for cattle sales in BC dropped 23.9% over the same period in 2003 and third quarter receipts dropped 2.7% over 2003 (BCStats 2003; BCStats 2004). The reason for the lower decline in third quarter 2004 in comparison to second

\textsuperscript{11} See terms and abbreviations
quarter is because third quarter receipts in 2003 (the quarter closing after the border closure) had already dropped 85.9%, from $51.5 million to $7.3 million as BC Cattlemen could not export any live cattle to the U.S. (BCStats 2003).

Overall the farm receipts were 10.1% lower in the third quarter than the same period in 2003. And farm receipts in 2003 were already down 7.1% from 2002 (BCStats 2003; BCStats 2004). It should also be noted that in addition to these BSE related economic shocks, third quarter receipts from sales of most other livestock products were lower than in 2003 with receipts from chickens (-49.0%), turkeys (-26.0%) and eggs (-40.1%) drastically lowered due to the Avian Flu Crises (BCStats 2004).

In order to assist the struggling cattle industry, the provincial and federal government are providing assistance to producers as they continue to experience very low prices for culled animals, combined with high feed costs. Cattle producers under the cull program can receive up to $320 per head (60% from the federal govt. and 40% from the province) for 8% of their beef herd and 16% of their dairy herd.

In addition, the provincial government has established a set aside program for calves, offering $176 per calf set-aside until Oct 1, 2005 and $200 set aside until Jan 1, 2006. (Information Bulletin, Ministry of Agriculture Food and Fisheries, Producers given choice on calf program set-aside date) The goal of this program is to help reduce pressures on slaughter capacity as well as to hold inventory until market prices improve (BCMAFF 2004).

Federal and provincial compensation certainly provides much needed relief assistance, but farmers are still very much struggling.
1.3 BSE Related Regulations

1.3.1 Canadian Regulations

In 1997, Canada prohibited the feeding of MBM protein from ruminants (cattle, sheep, goats, bison, elk or deer) to other ruminants. It wasn’t until August 2003 that SRM was removed from the human food chain (e.g. from mechanically separated meat) however it is still permitted as feed material for pigs, poultry, fish and all other non-ruminants. (Canada 2004).

While current Canadian regulations prohibit the feeding of bovine MBM (including SRM) to ruminants, rendered MBM (including SRM) from bovines, downers (non-ambulatory animals) and pre-slaughter mortalities are still allowed in the animal feed chain, to non-ruminant farmed animals such as pigs and poultry. Reciprocally pigs, horses, and poultry proteins are still fed to cattle. Please see Table 3 at the end of this Chapter for a comparison of current and proposed feed bans in Canada and the EU.

The rendered fats of ruminants are still fed back to all farmed animals, including ruminants. While the practice of using ruminant tallow for feed will most probably be allowed to continue, proposed restrictions may soon require that they be less than 0.15% insoluble impurities (termed "protein-free tallow") as is the current case in the EU (CFIA 2004).

Currently, the main elements of the Canadian feed ban regulations are as follows:

- Ruminant to ruminant protein feed ban since 1997
- Milk, gelatin and blood products from all species are allowed to all species
- Manufacturers, users, vendors and feeders of animal proteins and feeds to have procedures in place to demonstrate that:
  - The segregation of animal proteins is maintained and cross-contamination of ruminant feeds with prohibited proteins is prevented
  - Labels of products comprising or containing prohibited proteins carry warning about not feeding them to ruminants

It will be very difficult to monitor on-farm compliance

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12 It will be very difficult to monitor on-farm compliance
Records of distribution for proteins and feeds are kept to facilitate tracing through the animal feed and animal production chain. (CFIA 2004)

While these measures have helped to reduce the risk BSE contamination, they are still less stringent than protective regulations currently in place in Europe or Japan (where every single cattle that goes to slaughter is tested post-mortem for BSE) as discussed in detail in this section and section 3.1.2.

Post-mortem rapid tests (BioRad), immunohistochemistry tests (IHC), and western blotting methods using tissues from the brainstem are believed to be the most effective at detecting the BSE prion. According to the Senior Staff Veterinarian of the U.S Department of Agriculture - Animal and Plant Health Inspection Service (APHIS), the false negative rate for rapid tests of apparently normal adults in the cattle population could be 92%, and >99% in cattle less than 24 months of age (Ferguson, 2004). For this reason, testing measures in Canada and the U.S have been focused on animals showing visible signs of neurological dysfunction, such as inambulatories referred to as "downers".

Reports from Japan, where every animal for slaughter is tested, show that the false positive rate for the Bio-Rad TeSeE ELISA test is 1 in 30,000. When this happens, the test is known to be "inconclusive" and requires further testing from either IHC or western blotting to truly identify whether the sample is positive or negative (Government of Alberta, 2004). Once it goes through the additional tests, the potential for false-positive drops to 1 in 100,000.

Data from federally and provincially inspected plants showed that 3.2 million head of cattle were slaughtered in Canada in 2002 (StatsCan, 2003). USDA figures show that approximately .44% - .85% of the 45 million cattle slaughtered in the US are downers, and .99% are high risk.

According to these statistics, the number of downer cattle slaughtered in federally or provincially inspected plants in Canada could be 13,816 - 26,350 animals and the number of high risk could be ~32,000. It should be noted that in BC, there are 43 registered slaughter plants and 69 non-registered plants\textsuperscript{13} (BCMAFF 2004) so there could be a significant number of downers or diseased cattle that are not accounted for both in the province and across Canada.

\textsuperscript{13} Non-registered do not have on-site inspectors to examine animals prior to slaughter, or offal and other materials after slaughter.
Canada tested 23,549 animals in 2003 targeting those from the highest risk group. This highest risk group is defined by the CFIA to include:

- "cattle with clinical signs consistent with BSE (for example, behavioral change including excitability and anxiousness, and emaciation)
- cattle over 30 months of age from the 4-D categories
- animals found dead (dead stock)
- animals that are non-ambulatory (downers)
- animals presented for emergency slaughter (distressed or dying)
- animals sent to slaughter and found to be sick at the ante-mortem inspection (diseased)"

(CFIA, BSE Enhanced Surveillance Program website, 2004)

The release this September of the updated European Geographical BSE Risk assessment (GBR) for seven nations, including Canada and the U.S., placed Canada (and the U.S) in a higher risk category than previously, moving from a Category II risk ("unlikely but excluded") to a Category III risk ("likely but not confirmed or confirmed at a lower level") (EFSA 2004). The GBR examines BSE stability based on four primary factors: feeding, rendering, SRM removal, and surveillance. The reasons for Canada being placed in stated include:

- The feeding of non-ruminant MBM to cattle remains legal as well as feeding of ruminant MBM to non-ruminant animals. This makes control of the feed ban very difficult because laboratory differentiation between ruminant and non-ruminant MBM is difficult if not impossible.
- SRM and fallen stock (downers and mortalities) are still included in animal feed.
- Rendering industry is operating with processes not known to reduce infectivity for meat and bone meal (less than 120C/3bars pressure/20 minutes and tallow is permitted to have over 0.15% insoluble proteins)
- Current surveillance in Canada is deemed to be improving, however still considered passive. (EFSA 2004)
Due to international, as well as domestic market pressures, the CFIA announced on July 9, 2004 that it planned to introduce new animal feed restrictions and increase monitoring (surveillance) controls to provide a greater level of security to the livestock and meat processing sector for the prevention of BSE. These regulations were to largely be drawn in accordance with USDA regulations, for the reasons described above.

The Enhanced Regulatory Framework that was put in the Gazette on December 10th would amend four Canadian Regulations; the Health of Animals Regulations as well as the Freed Regulations 1983, the Fertilizers Regulations and the Meat Inspection Regulations 1990 to coordinate regulatory control measures. Such changes would bring Canada closer in line with the European Animal By-Products Regulations No 1774/2002. The most significant changes to Canadian Feed Regulations would:

- Prohibit the use of proteins derived from SRM in any animal food, including pet food;
- Require the removal and separation of SRM at slaughter or in post-processing facilities;\(^1\)
- Require dedicated equipment for the processing of downers and dead stock
- Specify the manner and conditions of disposal or alternative use for SRM, and down and dead stock cattle. (CFIA 2004)

The complete extended list of these proposed elements are provided in the appendix. These measures alone would significantly reduce the risk of BSE transmission, primarily as a result of the removal of SRM from the feed chain, however in addition to these proposed elements are "Consequential Regulatory Enhancement Elements" and "Additional Elements" which could create additional minimum requirements:

- For the rendering process (namely treating all animal wastes at 133 C at 3 bars of pressure for 20 minutes)
- Additional regulatory controls for fish meal
- A "protein free tallow" requirement as described above
- Mandatory recall procedures

\(^1\) Currently SRM are mixed with other wastes and are not allowed in ruminant feed. They are still allowed as feedstock for non-ruminant feeds.
• A complete listing of ingredients for livestock feeds
• Prohibiting the use of proteins derived from downer and dead stock from animal food (including pet food)
• Prohibiting proteins from cattle SRM in fertilizers
• And banning blood products from mammals (excepting swine and horses\textsuperscript{15}) to be fed to ruminants. (CFIA 2004)

It is also worth noting that it has been proposed to prohibit the use of animals “such as those killed along roadsides and other rights of way, research animals, zoo animals and others from being collected and processed into livestock feed ingredients.” (CFIA 2004)

Lead member of the CFIA BSE Working Group in Canada, Sergio Tolusso, said that it was still unclear as to which of these proposed enhancements will be adopted in the new regulations, or when the regulations will fully take effect (Tolusso 2004). If harmonization with the U.S. takes longer than expected or is unachieved, there appears to be sentiments among the industry that the date these regulations take effect will be postponed further. This has not been confirmed by the CFIA.

It will be helpful to look at the European regulations to explore measures they have taken to eradicate the risk of BSE and other Transmissible Spongiform Encephalopathies.

1.3.2 European Regulations

The European Union has witnessed far more cases of BSE than Canada. The first outbreak was experienced in 1986 the UK and by 2001 there were nearly 180,000 verified cases of BSE in the UK alone (USDA 2001). These cattle were destroyed, initially largely through burial or burned in heaping piles of carcasses doused with fuel but in recent years alternative methods have been discovered, refined, and approved by the European Commission (EU 2002; EU 2003).

A Scientific Steering Committee (SSC) was granted the authority to examine and make recommendations related to BSE for protecting the public health, livestock, and the environment to inform regulations to monitor and control all aspects of the farming, feeding, processing,

\textsuperscript{15} Presumably swine and horse blood would not contain or be in contact with any SRM materials
storing, transporting, and disposing of wastes throughout the livestock and processing sectors. Predominately as a result of opinions presented by the various scientific committee panels, the EU drafted numerous regulations and amendments beginning in 1989 leading to the most comprehensive Regulation No. 999/2001 followed by 1774/2002, also known as the Animal By-Product (ABP Regulation) in October 2002.

Since 2002, a number of amendments have been made, but 1774/2002 continues to serve as the most current legislative framework for the eradication of BSE/TSE within the EU and "sets out clear rules on what must and may be done with the excluded animal materials, imposing strict identification and traceability system requiring certain products such as meat and bone meal and fats destined for destruction to be permanently marked to avoid possible fraud and risk of diversion of unauthorized products into food and feed." (EUROPA 2004)

The ABP distinguishes all animal by-products into three main categories, 1, 2 & 3 as follows:

Category 1
- All body parts, including hides and skins of animals suspected of being infected by a TSE or in which the presence of a TSE has been officially confirmed including animals killed in the context of eradication measures
- Pet animals, zoo animals, circus animals, experimental animals
- Wild animals when suspected of being infected with diseases communicable to humans and animals (e.g. rabies)
- Specified risk material and whole bodies of dead animals containing SRM
- Wastewater and residues from Category 1 processing plants where SRM is removed
- Catering waste from transport operating internationally (e.g. airlines)

Category 1 must not enter the food supply and must be disposed of directly by incineration or co-incineration, or after method 1-5 treatment prior to incineration burial or landfill. Please see the table below for descriptions of these methods.

---

<table>
<thead>
<tr>
<th>Method 1</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. If the particle size of the animal by-products to be processed is more than 50 mm, the animal by-products must be reduced in size using appropriate equipment, set so that the particle size after reduction is no greater than 50 mm. The effectiveness of the equipment must be checked daily and its condition recorded. If checks disclose the existence of particles larger than 50 mm, the process must be stopped and repairs made before the process is resumed.</td>
<td></td>
</tr>
<tr>
<td><strong>Time, temperature and pressure</strong></td>
<td></td>
</tr>
<tr>
<td>2. After reduction the animal by-products must be heated to a core temperature of more than 133 °C for at least 20 minutes without interruption at a pressure (absolute) of at least 3 bars produced by saturated steam; the heat treatment may be applied as the sole process or as a pre- or post-process sterilisation phase.</td>
<td></td>
</tr>
<tr>
<td>3. The processing may be carried out in batch or continuous systems.</td>
<td></td>
</tr>
<tr>
<td>Method 2</td>
<td>Reduction</td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>1. If the particle size of the animal by-products to be processed is more than 150 mm, the animal by-products must be reduced in size using appropriate equipment, set so that the particle size after reduction is no greater than 150 mm. The effectiveness of the equipment must be checked daily and its condition recorded. If checks disclose the existence of particles larger than 150 mm, the process must be stopped and repairs made before the process is resumed.</td>
<td></td>
</tr>
<tr>
<td><strong>Time, temperature and pressure</strong></td>
<td></td>
</tr>
<tr>
<td>2. After reduction the animal by-products must be heated to a core temperature greater than 100 °C for at least 125 minutes, a core temperature greater than 110 °C for at least 120 minutes and a core temperature greater that 120 °C for at least 50 minutes.</td>
<td></td>
</tr>
<tr>
<td>3. The processing must be carried out in a batch system.</td>
<td></td>
</tr>
<tr>
<td>4. The animal by-products must be cooked in such a manner that the time-temperature requirements are achieved at the same time.</td>
<td></td>
</tr>
</tbody>
</table>
**Method 3**

**Reduction**

1. If the particle size of the animal by-products to be processed is more than 30 mm, the animal by-products must be reduced in size using appropriate equipment, set so that the particle size after reduction is no greater than 30 mm. The effectiveness of the equipment must be checked daily and its condition recorded. If checks disclose the existence of particles larger than 30 mm, the process must be stopped and repairs made before the process is resumed.

**Time, temperature and pressure**

2. After reduction the animal by-products must be heated to a core temperature greater than 100 °C for at least 95 minutes, a core temperature greater than 110 °C for at least 55 minutes and a core temperature greater that 120 °C for at least 13 minutes.

3. The processing may be carried out in batch or continuous systems.

4. The animal by-products may be cooked in such a manner that the time-temperature requirements are achieved at the same time.

---

**Method 4**

**Reduction**

1. If the particle size of the animal by-products to be processed is more than 30 mm, the animal by-products must be reduced in size using appropriate equipment, set so that the particle size after reduction is no greater than 30 mm. The effectiveness of the equipment must be checked daily and its condition recorded. If checks disclose the existence of particles larger than 30 mm, the process must be stopped and repairs made before the process is resumed.

**Time, temperature and pressure**

2. After reduction the animal by-products must be placed in a vessel with added fat and heated to a core temperature greater than 100 °C for at least 16 minutes, a core temperature greater than 110 °C for at least 13 minutes, a core temperature greater that 120 °C for at least eight minutes and a core temperature greater that 130 °C for at least three minutes.

3. The processing may be carried out in batch or continuous systems.

4. The animal by-products may be cooked in such a manner that the time-temperature requirements are achieved at the same time.
### Method 5

**Reduction**

1. If the particle size of the animal by-products to be processed is more than 20 mm, the animal by-products must be reduced in size using appropriate equipment, set so that the particle size after reduction is no greater than 20 mm. The effectiveness of the equipment must be checked daily and its condition recorded. If checks disclose the existence of particles larger than 20 mm, the process must be stopped and repairs made before the process is resumed.

**Time, temperature and pressure**

2. After reduction the animal by-products must be heated until they coagulate and then pressed so that fat and water are removed from the proteinaceous material. The proteinaceous material must then be heated to a core temperature greater than 80 °C for at least 120 minutes and a core temperature greater than 100 °C for at least 60 minutes.

3. The processing may be carried out in batch or continuous systems.

4. The animal by-products may be cooked in such a manner that the time-temperature requirements are achieved at the same time.

---

**Category 2**

- Manure and digestive tract content
- All animal materials collected when treating waste water from slaughterhouses other than those handling SRM
- Products of animal origin containing residues of veterinary drugs and other contaminants
- Animals and parts of animals, other than those in Cat.1 that die before slaughter for human consumption, including animals killed to eradicate an epizootic disease

Category 2 materials are to be disposed of as Category 1 materials, or can additionally be rendered into fat derivatives for use in fertilizers, soil improvers or other technical uses other than cosmetics, pharmaceuticals and medical devices. Proteinaceous material can also be transformed in a biogas plant along with manure, in a composting plant, buried or landfilled.
Category 3

- Parts of slaughtered animals fit for human consumption but not intended for human consumption for commercial reasons
- Parts rejected as unfit for human consumption but not affected by any signs of communicable disease derived from carcasses fit for human consumption
- Hides and skins, hooves and horns, pig bristles and feathers originating from animals slaughtered in a slaughterhouse fit for human consumption or those deemed free from communicable diseases; Blood from animals, other than ruminants, fit for human consumption, Former foodstuffs of animal origin, other than catering waste but not intended for human consumption for commercial reasons, Raw milk Fish or sea animals, that are not mammals,

Category 3 materials can be incinerated, rendered, transformed in a technical plant, used as raw material in pet food, transformed in a biogas or composting plant or landfilled. Fishmeal can now also be fed to livestock in certain instances.

Accepted practices and methods for all aspects of dealing with these three categories are laid out in exhaustive, but clear, detail in articles and annexes throughout the ABP regulation. Additionally, surveillance is quite thorough, requiring all bovines over 30 months of age intended for human slaughter in addition to animals showing outward signs of BSE and all bovines over 24 months of age showing any form of illness to be tested by one of the five approved rapid BSE tests.

1.4 Summary

The first two cases of indigenous BSE in Canada have had tremendous impacts on the Canadian economy. The actual risks to human and animal health are difficult to calculate, and in the absence of certainty, over 30 nations have closed their borders to exports of Canada’s number one agricultural commodity since May 2003. Due to the very low incidence, or confirmed incidence for both BSE and vCJD in Canada, health concerns have been far overshadowed by economics.

In the absence of scientific certainty, it appears the best route to pursue would be precautionary. Regulations have been proposed to increase protection for human and animal health, the
environment, and to aid the Canadian economy. The newly proposed regulations can move towards accomplishing these goals, however they are going to have consequential impacts on the beef sector including the farming, processing, rendering and feed industries, as well as create additional challenges for regulatory monitoring and control.

The protective measures that the EU has in place are more comprehensive in comparison to that existing in Canada (and the U.S.) and clearly were used as a basis for the proposed regulatory changes in the Canadian Gazette on December 10, 2004. Exactly what regulatory measures will be adopted by Canada and the U.S. remains unclear, but it is most probable regulations will prohibit the use of SRM materials in any animal feed and this change is likely to come into effect in harmonization.

Even with these new regulations in place, there still remain a number of important points to consider. Firstly, the European definition of SRM and that of Canada differs considerably, by inclusion of bovine animals aged over 12 months rather than 30 months; and in addition includes the spleen of caprine (sheep) or ovine (goat) animals of all ages.

A major distinction in the current EU regulations and even the most stringent of the proposed Canadian regulations is the total ban of any intra-species (other than fish) -recycling of any protein, including all MBM and blood products. This full intra-species ban was introduced as a control measure to prevent the inappropriate or inadvertent feeding of any mammalian protein that may harbor prion infectivity to ruminants. Both compliance and cross-contamination were deemed to be significant hurdles for reducing this risk until the ban was introduced. Please see Table 2 below for a comparison of EU and Canada’s existing and proposed feed regulations.

Surveillance measures in Canada are still “passive”. Surveillance and testing of Canadian mortalities and downers should be increased substantially in order to prove the low incidence of BSE in Canada. As can be seen in the chart below, Canada is still only testing a small number of cattle in comparison to its 16.8 million head cattle herd.
Canada detected one cow with BSE out of the 23,539 tested in 2004, on December 29, 2004. From these statistics, it can be discerned that the number of BSE cases in Canada is low. It should be noted however, that an infective dose of BSE has now been determined to be as little as 1 milligram of tissue. It is thus reasonable to infer based on this and recent evidence showing a high prevalence of feed violations, that there could be BSE cattle in the existing Canadian herd, yet to be found and confirmed, as was the conclusion of the European Geographical BSE Risk Assessment (European Food Safety Authority, 2004).

In closing, it is beyond the scope of this paper and the limits of science as of yet to discern which hypotheses are truly correct regarding the cause of BSE or vCJD. The objective of this chapter is to establish BSE in the Canadian context and compare related regulations with those in the EU. The following chapters examine the volume of risk materials in BC and the Lower Mainland-SW and explore disposal options for SRM and other ruminant materials that are precautionary and economically feasible.

This statement was written prior to the discoveries on December 29th and January 11th.
<table>
<thead>
<tr>
<th>Feed Material</th>
<th>To</th>
<th>EU</th>
<th>Canada</th>
<th>Proposed December 10, 2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ruminant MBM</td>
<td>Ruminant</td>
<td>Prohibited</td>
<td>Prohibited Since 1997</td>
<td>Prohibit</td>
</tr>
<tr>
<td>Ruminant MBM</td>
<td>Non-R</td>
<td>Prohibited</td>
<td>Allowed</td>
<td>Allow</td>
</tr>
<tr>
<td>Non-R MBM</td>
<td>Ruminant</td>
<td>Prohibited</td>
<td>Allowed</td>
<td>Allow</td>
</tr>
<tr>
<td>Non-R MBM (Intra-species recycling)</td>
<td>Non-R</td>
<td>Prohibited</td>
<td>Allowed</td>
<td>Allow</td>
</tr>
<tr>
<td>SRM MBM</td>
<td>Ruminant</td>
<td>Prohibited 1990</td>
<td>Prohibited 1997</td>
<td>Prohibit</td>
</tr>
<tr>
<td>SRM MBM</td>
<td>Non-Ruminant</td>
<td>Prohibited</td>
<td>Allowed</td>
<td>Prohibit</td>
</tr>
<tr>
<td>Ruminant Blood</td>
<td>Ruminant</td>
<td>Prohibited</td>
<td>Allowed</td>
<td>Allow</td>
</tr>
<tr>
<td>Ruminant Blood</td>
<td>Non-R</td>
<td>Prohibited</td>
<td>Allowed</td>
<td>Allow</td>
</tr>
<tr>
<td>Non-R Blood</td>
<td>Ruminant</td>
<td>Prohibited</td>
<td>Allowed</td>
<td>Allow</td>
</tr>
<tr>
<td>Non-R Blood</td>
<td>Non-R</td>
<td>Prohibited</td>
<td>Allowed</td>
<td>Allow</td>
</tr>
<tr>
<td>Non-R Blood</td>
<td>Farmed Fish</td>
<td>Allowed</td>
<td>Allowed</td>
<td>Allow</td>
</tr>
<tr>
<td>Fish Protein</td>
<td>Ruminant</td>
<td>Prohibited</td>
<td>Allowed</td>
<td>Allow but controlled</td>
</tr>
<tr>
<td>Fish Protein</td>
<td>Non-R</td>
<td>Allowed</td>
<td>Allowed</td>
<td>Allow</td>
</tr>
<tr>
<td>Non-R Hydrolysed Protein &amp; Ruminant HP from Hide/Skin</td>
<td>Ruminant</td>
<td>Prohibited</td>
<td>Allow</td>
<td>Allow</td>
</tr>
<tr>
<td>Non-R Hydrolysed Protein &amp; Ruminant HP from Hide/Skin</td>
<td>Non-R</td>
<td>Allowed</td>
<td>Allowed</td>
<td>?</td>
</tr>
<tr>
<td>Ruminant &amp; Non-R Dicalcium &amp; Tricalcium Phosphate</td>
<td>Ruminant</td>
<td>Prohibited</td>
<td>Allowed</td>
<td>?</td>
</tr>
<tr>
<td>Ruminant &amp; Non-R Dicalcium &amp; Tricalcium Phosphate</td>
<td>Non-R</td>
<td>Allowed</td>
<td>Allowed</td>
<td>Allow</td>
</tr>
<tr>
<td>Milk, milk-based products &amp; colostrum</td>
<td>Ruminant &amp; Non-R</td>
<td>Allowed</td>
<td>Allowed</td>
<td>Allow</td>
</tr>
<tr>
<td>Feed Material</td>
<td>EU</td>
<td>Canada</td>
<td>Proposed Canadian</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------</td>
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<td></td>
</tr>
<tr>
<td>Egg and egg products</td>
<td>Ruminant &amp; Non-R</td>
<td>Allowed</td>
<td>Allowed</td>
<td></td>
</tr>
<tr>
<td>Gelatine derived from Non-R</td>
<td>Ruminant</td>
<td>Allowed</td>
<td>Allowed</td>
<td></td>
</tr>
<tr>
<td>Catering Waste Edible residual material (ERM)</td>
<td>Ruminant</td>
<td>Prohibited</td>
<td>Prohibited - but allowed on case by case</td>
<td></td>
</tr>
<tr>
<td>Catering Waste</td>
<td>Non-R</td>
<td>Prohibited</td>
<td>Allowed</td>
<td></td>
</tr>
<tr>
<td>Downers/Morts MBM</td>
<td>Ruminant</td>
<td>Prohibited</td>
<td>Prohibited</td>
<td></td>
</tr>
<tr>
<td>Downers/Morts MBM</td>
<td>Non-R</td>
<td>Prohibited</td>
<td>Prohibited</td>
<td></td>
</tr>
<tr>
<td>Downers/Morts MBM</td>
<td>Pet Food</td>
<td>Prohibited</td>
<td>Prohibited</td>
<td></td>
</tr>
<tr>
<td>Ruminant Fats and Tallow</td>
<td>Ruminants</td>
<td>Allowed (0.15% Insoluble)</td>
<td>Allowed</td>
<td></td>
</tr>
<tr>
<td>Ruminant Fats and Tallow</td>
<td>Non-R</td>
<td>Allowed (0.15% Insoluble)</td>
<td>Allowed</td>
<td></td>
</tr>
<tr>
<td>Non-R Fats and Tallow</td>
<td>Ruminants</td>
<td>Allowed (0.15% Insoluble)</td>
<td>Allowed</td>
<td></td>
</tr>
<tr>
<td>Non-R Fats and Tallow</td>
<td>Non-R</td>
<td>Allowed (0.15% Insoluble)</td>
<td>Allowed</td>
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</tr>
</tbody>
</table>

2.0 SRM Resource Assessment

As Chapter 3 will demonstrate, a number of energy recovery technologies exist that may serve as disposal methods for SRM and other ruminant special waste materials. The goal of this chapter is to discern the existing volume of Specified Risk Materials in the Lower Mainland – Southwest geographic region of B.C. and the energy potential for these materials. It is primarily focused on cattle and dairy production, slaughter, and dead stock populations, as well as sheep populations. British Columbia is an extremely productive agricultural province.

Total farm cash receipts reached $2.2 billion in 2002 and the livestock sector, including cattle, hogs, poultry, eggs, dairy, honey, fur and game-farm animals accounted for 51 percent of these receipts (BCMAFF 2004). Of this, cattle and calve farming and slaughter totaled nearly $318 Million (9.4% above the 5-year 1997-2002 average) (BCMAFF 2004). Dairy receipts were higher at $368 million in 2002 (8.6% above the 1997-2002 average.) Together cattle and dairy products accounted for over 31% of total farm receipts in BC, totaling over $686 million in 2002.

This assessment is concerned with the following regional districts within the Lower Mainland - Southwest Region (highlighted with numbers in the maps below): Fraser Valley (9); Greater Vancouver (15); Sunshine Coast (29) and; Squamish-Lillooet (31).
2.1 Cattle, Calves and other Ruminants

According to the most recent data collected by the BC Ministry of Agriculture, Food and Fisheries, the total cattle population in BC on the 1st of January 2004 was 808,851, (BCMAFF 2004) this is over 15% higher than the inventory of Jan 1 2003 (StatsCan 2001). Populations in the Lower Mainland – Southwest Region were 125,109, 15.5% of BC’s total. Of this population, the herd is broken down into roughly 19 % beef and 81 % dairy, with 17,529 and 74,797 not including calves less than 1 year.

Figure 5 BC Cattle Populations (BCMAFF 2004)

Figure 6 Herd Inventory in LM-SW (BCMAFF 2004)
As mentioned in Chapter 1, the cattle and calve populations for the whole of Canada was 6.0% higher July 2003 over July 2002. This is three to four times the average growth rate (1.0% and 2.6%) between same periods 2000 – 2002 suggesting that the leap within months of the export ban can be directly attributed to the closure of the U.S border to Canadian exports.

Data from the Supply Disposition Balance Sheets provided by the Agriculture Division of Stats Canada in combination with BC MAFF data support the assertion that cattle populations continued to increase as a result of the border closure to live exports. This would only be common sense, as international exports from BC increased from 70,600 in 2000 to 91,700 in 2001 to 136,800 in 2002 (StatsCan 2003). International exports were continuing to grow in 2003 until they were completely banned after May 20, 2003.

Cattle and calve populations show a birth trend of approximately 51.4% based on cattle & calve inventories on January 1, 2000 through 2003, followed by 5.7 – 7.8% based on inventories on July 1 for the same years. In other words, the cattle population in BC on January 1, 2000 was recorded to be 650,000 head and during the first 6 months of 2000 334,300 new calves were born (51.4% of existing herd); the cattle population on July 1, 2000 was recorded to be 805,000 head and during the last 6 months of 2000, 46,200 calves were born (6%). From Jan1 2000 to Jan 1 2003, inventories grew from 650,000 to 655,000 to 670,000 to 700,000 respectively, and then jumped to 808,000 in Jan 2004. Recent communication with a statistician at CanFax research
services, clarified that Jan 1 2004 cattle & calve populations were recently readjusted to 740,000 and that Jan 1 2005 populations actually declined to 710,000. (CanFax, 2005) The decline in numbers is primarily due to increased inter-provincial exports of calves to Alberta for processing, as the beef herd has actually increased approximately 5% (as did Alberta's beef herd). Due to the dairy quotas, dairy herds are kept fairly stable.

2.1.1 Slaughter

Slaughter for BC in 2003 was recorded to be 79,700 head (BCMAFF 2004). This is up nearly 30,000 head from the numbers registered for slaughter in 2000, 2001 & 2002 (StatsCan 2001; StatsCan 2003) and can be attributed to the lack of access to international export markets increasing the need for domestic slaughter and government assisted culls. According to the BC Cull Animal Program, 60% of cull animals in BC were sent to the U.S. for slaughter, helping to explain the dramatic increase in provincial slaughter. The Lower Mainland-Southwest region accounted for 40.3% of slaughter that took place in BC at 32,240 head (a weekly average of 620 animals per week).

![Annual BC Cattle Slaughter 2000-2003](image)

**Figure 8 — Annual BC Cattle Slaughter 2000-2003** (StatsCan 2003)

BC Slaughter figures ranged from 2.4% - 2.8% of total provincial supply until the closure of the border to live exports, after which it is indicated by BCMAFF figures, that slaughter increased to 3.2% - 4.1% of the growing total supply. Private communications with private abattoirs and the occurrence of government support for OTM culls support this trend.

As mentioned in Chapter 1, boned meat makes up only 40% of the live carcass weight (LCW) of cattle. Depending on the age of the animal, inedible wastes from slaughter can be as high as 250-
300kg. Table 6 is a breakdown of the weight of an UTM and OTM cattle weighing 373 kg and 430 kg respectively.

<table>
<thead>
<tr>
<th>Table 6: Products and by-products from the slaughter of UTM 373kg and OTM 430 kg beef cattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of LCW</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>Live carcass weight (LCW)</td>
</tr>
<tr>
<td>Boned Meat</td>
</tr>
<tr>
<td>Inedible material for rendering (bones, fat, head, condemned offal etc.)</td>
</tr>
<tr>
<td>Hide</td>
</tr>
<tr>
<td>Edible offal (tongue, liver, heart, kidneys, plucks, etc.)</td>
</tr>
<tr>
<td>Blood</td>
</tr>
<tr>
<td>Miscellaneous (paunch, manure, shrinkage, blood loss etc.)</td>
</tr>
</tbody>
</table>

Adapted using percentages from (Agriculture 2004)

The cattle slaughter numbers in the six registered facilities in the Lower Mainland was recorded to be 18,755 head from animals under 30 months (UTM) and 13,485 animals over 30 months (OTM). Based on industry estimates of 13kg and 40kg of SRM materials per UTM & OTM it is estimated that 2003 generated 244 tonnes and 539 tonnes of SRM respectively. These volumes do not include the balance of remaining inedible portions of the ruminant material.

Figure 9 - Number of UTM/OTM slaughtered in 2003

Figure 10 Tonnes of SRM Material by UTM/OTM

18 LCW - Live Carcass Weight; UTM & OTM - Under/Over Thirty Months of Age
These additional materials are referred to as "drop" by BC MAFF and would be included as special waste material in the event that a full ruminant protein ban was put in effect. If these non-SRM materials were included, the volumes of slaughter wastes prohibited from feed increases to 4,201 tonnes and 3,479 tonnes for UTM and OTM respectively. This amounts to 7,680 tonnes of special waste material from slaughter activities in the LM-SW.

It should be noted that BC MAFF estimates include the hide of the cattle, which most probably would not be counted as special waste material, even in the event of a full ruminant protein ban. Accounting for this, the volumes of waste would therefore be 3,711 tonnes for UTM and 3,043 for OTM, for a total of 6,754 tonnes of bovine special wastes annually in the Lower Mainland – Southwest region in BC from slaughterhouse activities.

Currently, rendering is the primary method of disposal of slaughterhouse wastes in LM-SW, accounting for nearly 77% of current disposal in BC. The remaining methods for slaughterhouse waste disposal include wildlife, composting, burial, pet food. Landfill is prohibited in the LM-SW.

![LM-SW SRM & Drop w/o Hide (in Tonnes)](image)

**Figure 11 Annual Volume of SRM & Drop Materials by UTM/OTM in LM-SW in Tonnes**
2.1.2 Cattle Mortalities (Dead Stock) and Condemnations

BC MAFF estimated on-farm mortalities in BC to total 9,959 tonnes and was recorded according to type of animal type by tonnage. According to the herd distribution of mortalities recorded by BC MAFF, this data was extrapolated to show roughly 26,183 animals provincial wide, with 7,228 less than 12 months of age and 18,956 over 12 months of age by definition, estimated at 250kg and 430kg respectively.

| Table 7 Estimated # of Animals and Tonnes of Mortality Waste in BC and LM-SW by Herd |
|---------------------------------|---------------------------------|
|                                 | BC*                             |
|                                 | Tonnes | # Animals (est.) |
| Dairy Calf.                     | 480    | 1,930            |
| Beef Calf                       | 1325   | 5,300            |
| Dairy Cow, bull & heifer        | 3,925  | 9,135            |
| Beef Cow, bull & heifer         | 3,700  | 8,625            |
| Beef Heifer & Steer             | 515    | 1,190            |
| Totals                          | 9,945  | 26,180           |
| LM-SW*                          |        |                  |
| Tonnes                          |        |
| # Animals (est.)                |        |
| 55                              | 220    |
| 150                             | 604    |
| 2,690                           | 6,261  |
| 130                             | 300    |
| 45                              | 100    |
| 3,070                           | 7,485  |
| * All figures +/- 5%            |

Of the estimated 7,485 mortalities in the Lower Mainland, 6480 (86.6%) were dairy and 1004 (13.4%) were beef cattle. This appears to reflect the trend for higher mortality rates in the dairy herd population (typically 4.5% vs. 1.5%) as well as reflects the higher distribution of dairy cattle to beef cattle in the lower mainland (81.0% and 19.0%).

It is important to note however that the volume of dead stock calculations show roughly only half the number of deaths and condemnations indicated in the Stats Canada Inventory, which averaged 50,000 cattle for 2000, 2001, and 2002. In addition, the higher numbers of cattle on farms in BC for 2003 (& 2004) would rather suggest a higher number of on-farm mortalities. The number of mortalities indicated by the BC MAFF assessment thus either 1) does not include condemnations, which according to StatsCan data, would include an additional 24,000 cattle & calves; 2) the numbers of mortalities reported by producers were underestimated or 3) reflects inaccuracies in Stats Canada data.

If we are to assume that Stats Canada data is correct, it may be that the volume of materials in BC unfit for human consumption, and thus potentially included in the SRM or full ruminant feed ban
is actually much higher than previously thought. Using data from 2000-2002, the volume of SRM from these 24,000 unaccounted for cattle or calves would be an additional 6,500 to 11,180 tonnes if the entire animal were condemned (e.g. for diseases other than or including BSE) in addition to the 31,000 tonnes of SRM material estimated by BCMAFF.

As no data is available specific to the Lower Mainland regarding condemnations, it is not possible to say with confidence how much of these additional cattle & calve mortalities or condemnations would take place within the region. A rough estimate based on the herd distribution (15.5% of total cattle & calves in LM), could mean an additional 1,008 (UTM) -1,733 (OTM) tonnes of this special waste material in the LM (~3700 animals)

Currently, cattle wastes are disposed of by six methods in the province: 1) Wildlife (i.e. left above ground in the environment), 2) composting, 3) burial, 4) landfill, 5) rendering, and 6) pet food. Of these methods, wildlife (42.2%), burial (24.7%), and rendering (29.4%) are used to handle the majority (96%) of the 9,959 tonnes of provincial mortality wastes (BCMAFF 2004). In the LM-SW, rendering is the disposal method for 62.7% of the recorded 3,070 tonnes of mortality wastes and presumably similar for condemnations.

In closing, it is estimated that there is 6,755 tonnes from slaughter, 3,070 tonnes from mortalities and an additional 1,375 tonnes from condemnations for a total of 11,200 tonnes bovine SRM material in the LM-SW region. Assuming 50% moisture content, 30% meat and bone meal, and 20% fats, the estimated volumes are provided in Table 8 below:

<table>
<thead>
<tr>
<th>Table 8 - Estimated Volume of SRM in LM-SW in Tonnes*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Moisture</td>
</tr>
<tr>
<td>MBM</td>
</tr>
<tr>
<td>Tallow</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

* All figures +/- 5%
2.1.3. *Sheep and Lamb*

BC MAFF estimated that in 2002, there were 70,000 sheep and lamb in British Columbia, down from 83,307 sheep recorded in 2001. Specific provincial data available from the Statistics Canada 2001 census reported that 19.3% of all sheep and lambs were located in the Lower Mainland – Southwest area. The following diagrams extrapolate regional distribution based on the information provided in the 2001 census. The turnover rate for the herd is roughly once per year, as BCMAFF recorded that 77,100 sheep were slaughtered in the province in 2002. A regional breakdown for slaughter was not found.

Figure 12 BC Sheep & Lamb Populations

Figure 13 Sheep & Lamb Inventory in LM-SW

Figure 14 Distribution in LM-SW

(StatsCan 2001; StatsCan 2003; BCMAFF 2004)
2.2 Waste Classification

2.2.1 SRM / Special Wastes

Proposed changes to the regulations will classify SRM as a special waste material that is to be handled differently than other conventional agricultural waste materials. Changes will require that SRM be disposed of in a manner that prevents them from entering the human and animal feed chain, but it will not be made mandatory that prion material be deactivated or destroyed (BCMAFF 2004).

The regulatory changes will mandate that exacting records are kept concerning all SRM and carcasses of dead or condemned cattle prior to slaughter for seven years. Other significant changes to the regulations will require that:

1) Abattoirs stain SRM with an indelible marker;
2) SRM be collected in special bins (marked in both English and French);
3) SRM be conveyed in specialized equipment; and that
4) Renderers stain materials with a marker or tracer if they are prohibited from being fed to ruminants in a manner distinguishable from markers or tracers for SRM.

It is still unresolved as to whether rendering plants must have dedicated manufacturing lines to prevent the mixing or contamination of material that is not prohibited from being fed to ruminants or if SRM will be allowed to be transported in the same vehicle as non-SRM. The CFIA has also stated that they do not view it necessary to impose a new dedication requirement for feed milling, distribution and on-farm manufacturing for use of animal feeds. It would seem counter-intuitive if these risk protection measures were not put in place.

There are also substantially lower requirements for dead stock or cattle that are slaughtered on the farm. These include allowing SRM materials to be composted and spread as fertilizer, a method that could pose a risk if such materials are ingested by grazing cattle.
2.2.3 Blood & Milk

The government of Canada has stated that the issue of feeding ruminant blood products to ruminants has been carefully considered, and it will remain as non-prohibited material. It acknowledges that TSE has been spread through blood transfusions, however states that there is to date no clear scientific evidence to demonstrate that the transmission of BSE has occurred via the consumption of blood products in feeds.

Milk has also been demonstrated not to transfer infectivity through various studies, including intracerebral injection to transgenic mice, As such it will still be allowed to all animals.

2.3 Energy Composition

The energy composition of waste materials from the cattle farming and processing industry is important when considering disposal options that involve energy recovery. The following sections explore these biological materials in the context of their value as an energy source.

2.3.1 Proximate Analysis

A proximate analysis is the determination of the percentage of the following in a substance:

- Moisture
- Volatile Matter
- Fixed Carbon
- Ash

Comparisons of the proximate analysis of MBM in relation to other fuels:

<table>
<thead>
<tr>
<th></th>
<th>Moisture (%) wt</th>
<th>Volatile Matter (%) wt</th>
<th>Fixed Carbon (%) wt</th>
<th>Ash (% dry wt)</th>
<th>LHV MJ/kg</th>
<th>HHV MJ/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>MBM(^{19})</td>
<td>8.09</td>
<td>64.5</td>
<td>7.20</td>
<td>28.3</td>
<td>16.2</td>
<td>20.1</td>
</tr>
<tr>
<td>Bituminous Coal(^{20})</td>
<td>2.35</td>
<td>28.3</td>
<td>47.9</td>
<td>18.4</td>
<td>25.3</td>
<td>26.2</td>
</tr>
<tr>
<td>Sewage Sludge(^{21})</td>
<td>5.20</td>
<td>85</td>
<td>20</td>
<td>17.9</td>
<td>15.8</td>
<td></td>
</tr>
<tr>
<td>Diesel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>38.7</td>
<td>44.8</td>
</tr>
<tr>
<td>Natural Gas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>49.4</td>
<td>54.7</td>
</tr>
<tr>
<td>Tallow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>39</td>
<td>40</td>
</tr>
<tr>
<td>Biodiesel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>37.8</td>
<td>40.5</td>
</tr>
</tbody>
</table>

Table 9 Proximate analysis comparing MBM and Other Fuels

\(^{19}\) (Francisco García-Peña 2002)  
\(^{20}\) (Baxter 2004)  
\(^{21}\) (Francisco García-Peña 2002)
3.2 Ultimate Analysis

An ultimate analysis is a quantitative analysis in which percentages of all elements in a substance are determined. For solid fuels, the primary elements that are of greatest interest are:

- Carbon
- Hydrogen
- Nitrogen
- Sulphur
- Oxygen

<table>
<thead>
<tr>
<th>Table 10 Ultimate Analysis of MBM, Bituminous Coal &amp; Sewage Sludge</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Carbon</strong> (% dry wt)</td>
</tr>
<tr>
<td>MBM</td>
</tr>
<tr>
<td>Bituminous Coal</td>
</tr>
<tr>
<td>Sewage Sludge</td>
</tr>
</tbody>
</table>

(Francisco Garcia-Peña 2002)

The proximate and ultimate analyses, as well as the LHV and HHV assessments indicate that MBM is a suitable biomass fuel, although lower in fixed carbon and heating values. Based on the estimated volume of waste materials, the energy value of MBM and tallow is 150 TJ, minus 30TJ of natural gas required to remove moisture equals 120 TJ as follows:

<table>
<thead>
<tr>
<th>Table 11 Estimated Energy Value of SRM in LM-SW *</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tonnes</strong></td>
</tr>
<tr>
<td><strong>Displaced</strong></td>
</tr>
<tr>
<td>Moisture</td>
</tr>
<tr>
<td>MBM</td>
</tr>
<tr>
<td>Tallow</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

* +/- 5%

If these materials were to be converted to power at 100% efficiency, the embodied energy value of these materials is roughly equivalent to 40.3 - 43.0 GWh or 4.6 - 4.9 MW.

---

22 Using 1.55lb steam per lb moisture removed; .064m3 Natural gas/lb moisture; 788,400m3 NG/5,600 t;
23 Using 38MJ/m3 NG ; 20 MJ/KG for dry MBM; and 40 MJ/kg Tallow; MBM displaces 2/3 coal (30MJ/kg) in kiln;
Tallow displace petroleum diesel (38MJ/kg)
24 1.9kg CO2e/m3 NG; 2.07 CO2e/kg coal; 2.75 CO2e/kg petroleum diesel
25 Using 3.6 MJ/kWh
3.0 Disposal Options - Waste Mitigation and Biomass Conversion Technologies

This chapter will provide an overview of disposal options for Specified Risk Materials. These options include: Landfill, Incineration, Cement Production, Thermal Hydrolysis, Composting, and Anaerobic Digestion. In addition, Biodiesel Production and Combined Heat and Power are also explored as options that can be utilized to maximize energy recovery from these materials.

3.1. Land

3.1.1 Landfill

The two primary forms of landfill are Sanitary Landfill (SL) and Municipal Solid Waste (MSW) Landfill, with the primary difference being that a SL uses a clay liner and an MSW landfill uses a synthetic plastic lining (usually made of polyethylene). Trash is buried in a manner to help ensure that it will be isolated from groundwater, animals and birds, will be kept dry and will not be in contact with air. Most landfills are particular about the type of refuse accepted, e.g. organic waste, hazardous waste, recyclables/non-recyclables, and charge tipping fees based on type and volume of waste. Landfills are increasingly establishing onsite composting facilities and landfill gas (methane) to power systems. The basic components of a landfill are:

- Bottom liner system - separates trash and subsequent leachate from groundwater, usually made of polyethylene
- Cells - segmented portions of the landfill where the trash is stored and buried
- Storm water drainage system - collects rain water usually in the form of high and low drainage ditches surrounding the perimeter of the landfill
- Leachate collection system - collects water with contaminating substances (leachate) that has percolated through the landfill. Leachate is stored in a collection pond adjacent to the landfill and eventually discharged to a wastewater treatment centre.
- Methane collection system - collects methane gas that is formed during the breakdown of trash. The methane is either flared (methane has 21x greater GHG effect than CO₂) or, with increasing development, utilized for power generation
- Covering or cap - soil and tarps are used at the end of each day to seal off the top of the landfill. Once a cell reaches capacity, it is covered with layers of soil beneath and above a tarp, and grass and vegetation is grown for aesthetics. (Burns Bog 2004).
Only one landfill in the LM-SW, the Lillooet Landfill, currently has legislative permission through Ministry of Water Land and Air Protection (WLAP) and municipal bylaws to receive slaughter and/or mortality wastes (BCMAFF 2004). Landfilling of raw animal wastes is not perceived to be the safest method of for a number of reasons, most importantly that SRMs can contaminate soil and leachate creating groundwater risk. In addition, depending on location and proximity/access of landfill to wildlife, pets, or humans, there is an increased risk of transmission. Rendering prior to landfilling materials will reduce pathogen infectivity; however it will not deactivate the BSE prion if it exists in the materials being disposed.
Figure 15 Landfill Diagram

- Green Waste (Clippings/Leaves)
- Solid Waste/Demolition/Refuse/Ash
- Catering Waste
- Delivery, Reception, Weighing, Separation
- Garbage
- Recyclables
- Land application on Cells (Dumping, Bulldozing)
- Composting
- Methane Collection, Flaring or Cleaning
- CO₂
- CH₄
- Leachate Collection Pond
- Drainage Ditches
- Power Generator
- Waste Water Treatment Plant
- Waste Water
- Leachate
- Storm Water
- Methane Collection, Flaring or Cleaning
- Delivery, Reception, Weighing, Separation
- Garbage
- Recyclables
- Land application on Cells (Dumping, Bulldozing)
- Composting
- Homogenization (Grinding & Mixing)
- Composting (Aerating/Turning)
- Maturation/Sieving & Product Grading
- Leaching
- End Markets
- Sewage Treatment
- Landfill
- Grit/Contaminants

Adapted using diagram design from (McLanaghan 2002)
3.2 Thermal

3.2.1 Incineration

Incineration is a thermal process by which organic materials are incinerated in a combustion chamber (in the presence of oxygen) and reduced to ash. The process also produces carbon dioxide (CO₂) and various other airborne pollutants (e.g. NOx, SOx, HCL, CO, heavy metals, dioxins). The heat generated from incineration can be used to fuel boilers for steam, hot water, and power (in a combined heat and power system CHP). After incineration, waste volumes can be reduced by up to 90%, however the toxicity of the ash will be more concentrated. Perhaps the most critical component for the success of an incineration facility is public acceptance, as they notoriously struggle with a NIMBY (Not In My Backyard) response from local residents.

There are a number of different incineration technologies available and they are distinguished primarily by the method in which the waste is held or passed into the combustion chamber. These methods include moving grate (forward, backward, rocking, roller), rotary kiln (rotating cylinder), and fluidized bed reactor (particles forced to float in the air with fuel) incineration. Combustion temperatures can vary but usually range from 800°C - 1200°C (Brunner 1983; Brunner 1991; Rand 2000; McLanaghan 2002; Velma I. Grover 2002; Burnaby Tour 2004). All waste incineration technologies should require air pollution control (APC) mechanisms to reduce particulate and gaseous pollutants. This involves cooling of the flue gas, and then passing it either through wet or dry scrubbers (w/ lime slurry) and then particulate filters (fabric or electrostatic precipitators). The type and expense of the APC unit is usually dependant on emission reduction requirements, which are strictly regulated and enforced.

Prior to incineration, it would be useful to render SRM materials to remove moisture content as well as to extract tallow, which will continue to have value as both an input for feed, or as feedstock for biodiesel production

The LM-SW has municipal incineration capacity at the Burnaby Incinerator located in Burnaby, however it will not accept raw or rendered animal wastes, regardless of species, age, or infectivity. (Burnaby 2004)
3.2.2 Cement Production

Cement production facilities can utilize meat & bone meal and various other wastes (e.g. sludge pellets) as a combustion fuel in cement kilns. Cement kilns consist of a rotary kiln in which clinker sintering takes place. The length of the kiln varies from 70 to 200 m with one burner at the hot end of the kiln where combusted fuels reach 2000°C while heating the core temperature of the kiln to 1450°C. At these temperatures the BSE prion and other transmissible agents are believed to be destroyed. The EU is widely pursuing the use of MBM in cement kilns, with over 400,000 tonnes per year of MBM co-incinerated in Europe, primarily in France, Belgium and Germany (Castle Cement 2003). Other primary drivers for this practice include favorable support in the EU for waste derived fuels, as a displacement of coal, and less stringent air emission restrictions put on cement factories in comparison to those for large incineration facilities producing power for electricity.

MBM has a heating value ranging from 16-20 MJ/kg (Francisco Garcia-Pefia 2002; CastleCement). This value is lower than fossil fuels such as coal, oil, & natural gas (20-40 MJ/kg) predominately used in the cement industry however the "negative" cost makes it a desirable fuel for co-incineration. Cement production companies have charged upwards of $300/tonne to accept MBM for use in their operations.

There are three primary processes for producing cement - Wet Process, Dry Process, & Pre-heater/Pre-Calciner Process. Approximately 74% of global cement production uses the Dry Process (often in conjunction with Pre-calciner process) because it is more energy efficient and creates less waste (Ashgrove 2004). When combusting MBM, CO₂, NOx and small amounts of other gases are released while inorganic materials (ash residues) are incorporated in the clinker.

Cement kiln temperatures operate at temperatures believed to effectively destroy prions and cement facilities have successfully demonstrated ability to utilize MBM in their operations. A major hurdle however remains that cement kilns will not accept raw materials. SRM and dead stock must first be rendered if they are to be used as fuel in cement kilns, creating little incentive for renderers to collect or process these materials, unless collection fees are increased to reflect the full costs of disposal, or cement operators compensate renderers for use of this coal-displacing alternative fuel.
3.2.3 Thermal Hydrolysis (TH)

Thermal hydrolysis refers to a process in which biological materials are treated with high-temperature high-pressure steam. The process has been used for pre-treatment of sludge at wastewater treatment plants (WWTP) since the 1940s to assist with dewatering (Kepp 1996). It is highly successful at destroying a wide range of pathogens and there has been renewed interest in using TH as a method for treatment of carcasses, slaughter wastes, meat and bone meal and other food wastes. The TH process blasts steam at the materials under pressure in order to destroy the cell walls of the material, which breaks proteins down into amino acids and peptides (Biorefinex 2004). TH has recently been approved by the EU Scientific Steering Committee as an effective treatment method for Category 2 & Category 3 materials (as it supercedes the 133C/3 bars/30 minutes sterilization requirement) but has not been accepted as a method to treat high infectivity BSE risk materials, as its effectiveness as a prion destruction technique requires further testing.

The process takes place in specialized vessels at high temperatures (150-180°C) at pressure ranging from 3-12 bars for 30 minutes or longer. TH substantially optimizes rate of biogas production when used in conjunction with an anaerobic digester (Kepp 1996; Ødegaard 2004).

A significant advantage of thermal hydrolysis is that it can process a variety of waste streams including manure, urine, blood, milk, protein meals, and agricultural residues in addition to cattle wastes, thus increasing revenue-generating opportunities. It also supercedes EU sterilization requirements, however it has not yet been proven to fully deactivate the TSE prion, and thus not yet accepted in the EU as a method to dispose of Category 1 materials. Further testing for its efficacy in destroying prions is reported to be taking place this year (BCMAFF 2004).
Figure 17 Incineration Diagram

- Slaughter Wastes/Downers/Morts
- Farm Wastes
- MSW

  - Delivery, Reception
  - Homogenization (Mixing)
  - Combustion/Incineration
    - Hot gases
    - Boiler
      - Hot gases
      - Heat (Hot water/Steam)
    - APC (air pollution control)
  - Power
  - End Use
  - Air
  - Landfill
  - Turbine (if CHP)
  - Heat (Hot water/Steam)
  - Boiler
  - Hot gases
  - APC (air pollution control)
  - Power
  - End Use
  - Air
  - Landfill

Figure 18 Cement Production Diagram

- Raw Animal
- Rendering
- Conventional Fuels
- MBM (Waste Derived Fuels)
- Dry Cement Kiln
  - Exhaust gases
  - Cement Inputs (Limestone, Shale, Sand)
- Clinker
- Cement Inputs (Gypsum, Fly Ash)
- Grinding Mill
  - Cement Kiln Dust (CKD)
  - Portland Cement
- Portland Cement
- Landfill
- End Markets
Figure 19 Anaerobic Digestion Diagram

Slaughter Wastes → Farm Wastes → Organic Wastes

Delivery, Reception, & Storage

Homogenization (Mixing)

Anaerobic Digestion

Biogas → CHP

CHP

Dewatering → Digestate w/suspended

Aeration & Maturation → Compost

End Markets

Sewage Treatment

Landfill

Thermal Hydrolysis

Slaughter Wastes → Farm Wastes → Organic Wastes

Delivery, Reception, Storage

Shredded Wastes

Pulping Tank

High Pressure High Temperature Steam

Heat → Cooled Hydrolyzed Waste

Digestate w/suspended → Anaerobic Digestion

Boiler

CHP

Dewatering → Digestate Cake

Aeration & Maturation → Compost

End Markets

Sewage Treatment

Landfill

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3.3 Biological

3.3.1 Composting

Composting is a controlled aerobic process by which organic materials are degraded in the presence of oxygen to stabilize and sanitize materials such as night soil, sludge, animal manures, agricultural residues and municipal refuse. The microbial (bacteria, fungi, bugs) and temperature activities result in a material that can be utilized as a nutrient rich soil conditioner, fertilizer, landfill material, or fish feed for use in aquaculture. The process also produces carbon dioxide (CO₂), Ammonia (NH₃ which later becomes nitrate), and heat.

The process takes place in specialized pits or piles in basic on-site farm applications or in centralized commercial applications, through "windrow" or "in-vessel" composters. All go through both mesophilic (~35°C) and thermophilic (~55°C) temperatures. Rates of stabilization and pathogen inactivation are primarily dependant on composition, moisture content, mixing procedure, temperature, aeration methods, and pH balances (Polprasert 1996; McLanaghan 2002). Clear guidelines for composting methods and uses have been established by Agriculture and Agri-Food Canada (AAFC) under the Fertilizers Act and Regulation. Canadian compost is classified and distinguished by maturity, foreign matter content, trace elements, and pathogens.

Composting SRM materials does not reach temperatures proven to have any effect on prion deactivation, however it has been suggested that microbial activity could show promise in this area. Until composting has been proven to deactivate the prion, the finished fertilizer product should not be permitted on agricultural or pastureland. An end use suggested for composted SRM materials has been to fill abandoned mines, however it does not appear that this would be economically viable, nor could it guarantee that high-risk materials would not come into contact with rodents or other animals.

3.3.2 Anaerobic Digestion (AD)

Anaerobic Digestion is a biological process by which organic materials are degraded in the absence of oxygen to produce a combustible gas, methane (CH₄). The process also produces carbon dioxide (CO₂) and small quantities of H₂S. The methane energy product, CH₄, is often called “biogas” and can be ignited to fuel boilers for power, or compressed and used in transport
applications similar to compressed natural gas (CNG), or sold into the natural gas grid. In addition to the biogas, a liquid digestate is also produced containing nutrients that can be used as a fertilizer “as is” or after dewatering and aeration of the solid cake.

The process takes place in specialized vessels and can be operated under mesophilic (~35°C) or thermophilic (~55°C) temperatures. Rates of biogas production are primarily dependant on composition, moisture content and age of substrates (total solids/volatile solids), mixing procedure, temperature, digester volume, and pH balances (Stuckey 1986; Wheatley; Polprasert 1996; Velma I. Grover 2002).

A number of different AD technologies exist, ranging from very basic systems used in developing countries such as Fixed Dome Digesters (China), Floating Cover Digesters (India) to Anaerobic Baffled Reactors (ABR), Plug Flows, Anaerobic Filters, and Upflow Anaerobic Sludge Blankets (UASB) used in commercial applications (Stuckey 1986).

Following high-temperature pre-processing technology such as thermal hydrolysis, anaerobic digestion can serve to recover the energy value embodied in the waste materials. Anaerobic digestion will also decrease the volume of raw materials, ranging from 50-70% (Polprasert 1996) however some proponents claim this can be reduced by as much as 95% (BCMAFF 2004). Anaerobic digestion has not been proven to deactivate the TSE prion, however new research is suggesting that microbial activity may achieve significant reductions in infectivity.

3.4 Additional Energy Recovery Options

3.4.1 Biodiesel

Biodiesel production can only be considered as an additional energy recovery option for rendered tallow from SRM. Biodiesel cannot be evaluated as a stand alone solution for risk materials, as it does not satisfy any of the disposal criteria for the MBM portion. It is still worthwhile to explore biodiesel as a potential option for the tallow portion of the risk materials, as it provides an outlet for these materials other than in feed and displaces petroleum diesel as a transportation fuel.

Animal fats can be processed into a biofuel alternative for petroleum diesel known as "biodiesel". Biodiesel can be used as a substitute or in blends with petroleum diesel and requires no engine modifications. It is manufactured through a process called transesterification where vegetable
oils, greases and animal fats (lipids) are broken apart through a thermal-chemical reaction and separated into methyl-esters (biodiesel), glycerin and small volumes of salt fertilizer. The transesterification process has been in existence for decades and in fact, Rudolf Diesel, inventor of the diesel engine, initially designed the diesel engine to run on peanut oil. With rising petroleum costs and climate change concerns, there has been tremendous growth in biodiesel production, especially in Europe where production has gone from virtually zero litres in 1990 to over 1.5 billion litres per year in 2004. Production in Canada is still in the nascent stage, however there is growing support to encourage biodiesel production as it fulfills a variety of federal, provincial and municipal mandates.

The transesterification process takes place in specialized vessels at moderate temperatures (35-70°C) at ambient or low pressure. The chemical inputs used for the process are usually either sodium or potassium hydroxide (NaOH or KOH) and an alcohol, usually methanol (CH₃OH). Depending on the free fatty acid (FFA) content of the feedstock, an additional acid esterification step using sulphuric acid (H₂SO₄) can be used to help increase yields of biodiesel by converting FFAs (4-25%) to methyl esters prior to transesterification (Van Gerpen 2001). It is important to note that animal fats must first be rendered and filtered prior to conversion to biodiesel.

Pharmaceutical grade refined glycerin is a relatively high value by-product commodity, however market access is limited and increased biodiesel production has lead to declining values of glycerin due to market saturation. Depending on the acid catalyst used, a fertilizer salt by-product also results from the reaction.

A number of biodiesel production technologies exist however they do not vary considerably with regards to process. Key factors for biodiesel production are the quality and FFA content of the feedstock & the efficiency of the production equipment to ensure high yields of biodiesel. Ideally all oils, fats and greases are converted to biodiesel during the thermal-chemical processes leaving little to zero production wastes, with the exception of glycerin (which has value as a commodity for technical uses.)

<table>
<thead>
<tr>
<th>870 kg Lipids (low FFA)</th>
<th>120 kg Methanol</th>
<th>10 kg Base Catalyst =</th>
<th>860 kg Biodiesel</th>
<th>40 kg Recovered Alcohol</th>
<th>90 kg Glycerin</th>
<th>10 kg Fertilizer</th>
</tr>
</thead>
</table>

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The substantial environmental benefits of biodiesel are widely known and documented, including reductions in greenhouse gas emissions as well as cancer-causing particulate matter. Biodiesel can offer up to a 78% reduction in net life cycle CO2 emissions, 100% reduction in sulfates, 43% in CO emissions, and 80% reduction in cancer-causing particulate matter (poly cyclic aromatic hydrocarbons (PAH)) from combustion. Additionally, biodiesel non-toxic and biodegradable (a pure blend of biodiesel biodegrades in water 85% within 28 days) (Tyson 2001; NBB 2003). These characteristics of reduced emissions, non-toxicity and biodegradability has significant implications for land and air quality, fragile aquatic ecosystems, and the public health of communities within them.

A number of key studies have demonstrated that there is an extremely low risk tallow with insoluble materials under .15% and even more so once reacted with chemicals, temperature and pressures used for acid esterification and base transesterification reduce TSE infectivity a number of order of magnitude less than the sporadic incidence of CJD (Appel 2001; Cummins 2002).

3.4.1 Combined Heat & Power (CHP)

A CHP plant is an installation where there is simultaneous generation of usable heat and power (usually electricity) in a single process. The term CHP is synonymous with 'cogeneration' but in some instance can provide 'tri-generation' (cooling). The basic elements of a CHP plant comprise of a prime mover such as an engine or combustion turbine to drive an electric generator, heat exchanger and heat recovery equipment. Efficiency gains from CHP are high, increasing energy efficiency from 40% to over 80% in most instances and these gains substantially reduce emissions through the combined process. The thermal energy can be in the form of hot water, steam, or hot air and can be used for a variety of purposes including industrial processes, community heating and space heating. Advanced technology CHP units now include dehumidification and absorption chilling technologies for air-cooling as well (USCHPA 2004).

There are a number of different CHP technologies available and they are distinguished primarily by the type of prime-mover (w/varying fuel sources) and heat recovery equipment. CHP units can utilize a variety of fuels, such as natural gas, diesel, biogas and/or biomass. Combustion gas turbines basically involve three main sections:
• "The compressor, which draws air into the engine, pressurizes it, and feeds it to the combustion chamber;

• The combustion system, typically made up of a ring of fuel injectors that inject a steady stream of fuel (e.g., natural gas) into the combustion chamber where it mixes with the air. The mixture is burned at temperatures of more than 2000 degrees. The combustion produces a high temperature, high pressure gas stream that enters and expands through the turbine section;

• The turbine is an array of alternate stationary and rotating aerofoil-section blades. As hot combustion gas expands through the turbine, it spins the rotating blades. The rotating blades perform a dual function: they drive the compressor to draw more pressurized air into the combustion section, and they spin a generator to produce electricity." (USDOE 2004)

CHP technologies are categorized as follows: engines (reciprocating, internal combustion); turbines (back pressure steam turbine, condensing turbine, combined cycle gas turbine); micro turbines (<1MW); and fuel cells and most usually, costs of technologies per installed kW increase in the order listed (Nyboer 2002; USCHPA 2004; USEPA 2004). Overall efficiency ranges from 60-92% and thermal quality differs based on technology selected, ranging from low (reciprocating engine) to high (all turbines and fuel cells). Heat to Power ratios range from .33-14.0:1, and can be modified based on technology and end-use demand, but for most steam processes operated in the range of 2:1 (RDC 2004).

CHP in itself is not a disposal option, but rather a means to increase both operational and economic efficiencies for disposal options that involve energy recovery. As such it is explored only to provide insight into its potential applicability in conjunction with other options.
Biodiesel

Rendered Animal Fats → Greases → Vegetable Oils

- Sulphuric Acid/acid esterification
- Transesterification/mixer settler unit
- Crude BioD, Crude Glycerin

- Methyl esters, methanol, glycerine, small quantities of catalyst & soap
- Glycerin, small quantities of catalyst & soap

- Methanol recovery
- Washing/refining
- Methanol recovery
- Fertilizer
- Biodie
- Glycerin
- Waste
- Sewage treatment
- End markets

CHP

Boiler (Steam) → Natural gas → Biogas → Biogas → Diesel

- Turbine, engine, fuel cell (Prime mover/electricity generator)
- Condenser/heat exchanger
- Hot gases/steam
- Desiccant dehumidifier
- Absorption chiller (heat recovery unit)
- Cool air
- Heat (hot water/steam)

- Electricity
- Hot water/steam/exhaust gas
- End use
The diagram below illustrates the potential disposal option pathways under proposed regulations:

Figure 23 - Potential Disposal Option Pathways
4.0 Analyses and Assessment of Disposal Options

This chapter will analyze and assess the disposal options according to a set of criteria that were chosen to help instruct the feasibility of each option within the existing local realities. The suitability of a particular disposal option must strike a balance among the criteria, with the effectiveness to minimize TSE transmission being by far the most critical factor.

4.1 Criteria Selection

The primary factors to be considered with respect to the various disposal options were decided in consultation with the thesis committee. It was thus established that the disposal methods should be evaluated according to the following criteria:

1. Effectiveness to Minimize TSE Transmission
2. Permitted or Allowed in Lower Mainland – South West Region
3. Industry Acceptance
4. Environmental Impact
5. Public Acceptance
6. Energy Recovery

Using the information from the preceding chapters, in addition to the Capital Expenses, Operating & Maintenance Costs and Planning to Commission Timescales Summary in Table 10 below, and the SWOT analyses in Tables 11-18 provided below, each of these six criterion were then gauged as to whether they provided low capability/low probability; moderate capability/moderate probability; or strong capability/high probability of success with respect to a particular disposal option. The weights were given 1 for low, 2 for moderate, 3 for high, and 4 for very high and then added to achieve a final score to help inform a decision on which of these options should be pursued in the Lower Mainland – Southwest Region.

26 Primarily with regards to cost of disposal
27 Primarily with regards to NIMBY concerns
4.1.1 Capital, O&M Expenditures, Planning to Commission Timescales

Capital expenditure estimates ranged from $1 million to $100 million. Timescales ranged for planning ranged 4-48 months, design to commission ranged from 4-60 months. The contents of Table 10 outline these factors.
<table>
<thead>
<tr>
<th>Process</th>
<th>Capital Expenses</th>
<th>O&amp;M Expenses / Cost per tonne</th>
<th>Planning Time Scale</th>
<th>Time to Commission</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Landfill</strong></td>
<td>Not applicable</td>
<td>Tipping Fees $60-120 per tonne</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>McLanaghan, BCMAFF, Burns Bog Tour</td>
</tr>
<tr>
<td><strong>Incineration</strong></td>
<td>$30-$40M for 50ktpa</td>
<td>$65-$150 per tonne $400-$800 tonne @ Swan Hill</td>
<td>24-48 months</td>
<td>24-96 months</td>
<td>McLanaghan, Brunner, Rand, BCMAFF, Burnaby Tour</td>
</tr>
<tr>
<td><strong>Cement Production</strong></td>
<td>$1.3-$1.5 Million for dedicated system to handle MBM (~5,000 tpa)</td>
<td>~$50-70 per tonne (still awaiting O&amp;M data from tech providers)</td>
<td>4-12 months</td>
<td>4-6 months</td>
<td>CastleCement, BCMAFF</td>
</tr>
<tr>
<td><strong>Thermal Hydrolysis w/AD</strong></td>
<td>$5-12M for 25 ktpa</td>
<td>~$20-$40 per tonne</td>
<td>4-12 months</td>
<td>16-60 months</td>
<td>McLanaghan, Polprasset, Stuckey, Wheatley, BCMAFF</td>
</tr>
<tr>
<td><strong>Anaerobic Digestion</strong></td>
<td>~$5-8M for 10ktpa facility – ~$7-10M for 20ktpa. Smaller farm systems have been designed for under 1M.</td>
<td>~$20-$40 per tonne</td>
<td>4-12 months</td>
<td>16-60 months</td>
<td>McLanaghan, Polprasset, Stuckey, Wheatley, BCMAFF</td>
</tr>
<tr>
<td><strong>Aerobic Digestion (Composting)</strong></td>
<td>Windrow ~$1.0-2.5M for 20ktpa facility or ~$3.0-4.5M for 50ktpa or ~$1,000/t for 20t/a small on-farm In-vessel ~$1.3-10.0M for 20ktpa facility ~$5.0-20M for 50ktpa.</td>
<td>Windrow ~$20-$35 per tonne In-Vessel ~$25-$60 per tonne</td>
<td>9-48 months</td>
<td>16-60 months</td>
<td>McLanaghan, Polprasset, Grover</td>
</tr>
<tr>
<td></td>
<td>Capital Expenses</td>
<td>O&amp;M Expenses/ Cost per tonne</td>
<td>Planning Time Scale</td>
<td>Time to Commission</td>
<td>Sources</td>
</tr>
<tr>
<td>---</td>
<td>-----------------</td>
<td>------------------------------</td>
<td>---------------------</td>
<td>--------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>Biofuel</td>
<td>~$1-$5 M for 3-15 million /lpa</td>
<td>~$350-$500 per tonne of oil, fat, or grease</td>
<td>~ 4-12 months</td>
<td>~ 8-24 months</td>
<td>NBB, van Gerpen</td>
</tr>
<tr>
<td>CHP</td>
<td>~$350-$1800 installed cost per kW for most technologies e.g. 5 MW_e system @ $1200/kW = $6,000,000 (Fuel cells cost significantly more ~ $2500-$5000/kW)</td>
<td>Variable O&amp;M ~$.006-$0.025 per kWh_e e.g. 5 MW_e system* @ .015/kWh = ~$550,000/yr</td>
<td>12-24 months</td>
<td>24 - 60 months</td>
<td>Nyober, RDI, USDOE, USCHPA, USEPA</td>
</tr>
</tbody>
</table>
### 4.1.2 SWOT Analyses

The contents of the SWOT analyses in Tables 14-21 are primarily summaries of information and discussions in the preceding chapters plus additional aspects.

**Table 14 Landfill SWOT Analysis**

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>• No matter what type of waste management option is utilized by a municipality, landfilling is inevitable (e.g. MSW incineration ash will be landfilled)²⁸</td>
<td>• It is difficult to keep out birds and rodents²⁹</td>
</tr>
<tr>
<td>• Biological/special wastes are prohibited at most landfills and all except one in the LM-SW³⁰</td>
<td>• Depending on type of waste &amp; distance from landfill, transport and tipping fees can be expensive</td>
</tr>
<tr>
<td>• Depending on type of waste &amp; distance from landfill, transport and tipping fees can be expensive</td>
<td>• <strong>Will not deactivate TSE prion</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Technologies that can minimize waste volumes will reduce costs associated with landfill disposal (e.g. rendering, anaerobic digestion)</td>
<td>• SRMs can contaminate soil and leachate creating groundwater risk³¹</td>
</tr>
<tr>
<td>• Volatile Organic Compounds (VOCs) eventually pass through lining³²</td>
<td>• More thorough sterilization could be required prior to landfilled, increasing disposal costs (133°C/3bars/20 minutes)</td>
</tr>
<tr>
<td>• More thorough sterilization could be required prior to landfilled, increasing disposal costs (133°C/3bars/20 minutes)</td>
<td>• Pathogens can spread through improper handling</td>
</tr>
</tbody>
</table>

**Table 15 Incineration SWOT Analysis**

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Is a proven technology</td>
<td>• Capital/O&amp;M is expensive</td>
</tr>
<tr>
<td>• Can process a variety of waste streams (e.g. MBM, fats, MSW, Ag residues)</td>
<td>• May require pre-processing of slaughter wastes to reduce particle size</td>
</tr>
<tr>
<td>• Material volume (ash) to landfill is significantly reduced³³</td>
<td>• Air pollution/odor concerns</td>
</tr>
<tr>
<td>• Destroys all pathogens (although prion can even survive incineration)</td>
<td>• Will require additional fuel inputs</td>
</tr>
<tr>
<td>• MBM has a comparable heating value to coal and other fuels³⁴</td>
<td>• If high pressure steam is utilized, highly trained steam operator(s) must be onsite at all times³⁵</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Biological waste stream inputs could be considered biomass and eligible for GHG reduction credits/funding</td>
<td>• NIMBY objections</td>
</tr>
</tbody>
</table>

²⁸ (Burnaby Incinerator Tour, 2004)
²⁹ (Burns Bog Tour, 2004)
³⁰ (BCMAFF 2004)
³¹ (Bridgeman CB, 2000)
³² (Ashcroft Ranch Meeting, 2004)
³⁴ (Francisco García-Peña, 2002)
³⁵ (Burnaby Incinerator 2004)
### Table 16 Cement Production SWOT Analysis

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Cement kiln temperatures operate at temperatures believed to effectively destroy prions</td>
<td>- Cement kilns will not accept raw materials, they must first be rendered</td>
</tr>
<tr>
<td>- Organic materials fully combusted, inorganic materials incorporated in clinker</td>
<td>- Canada does not have similar incineration capacity as Europe, and thus Canadian cement companies could have greater pricing control</td>
</tr>
<tr>
<td>- Cement facilities have successfully demonstrated ability to utilize MBM in their operations</td>
<td>- The high nitrogen content in MBM could require measures to reduce Nox during production</td>
</tr>
<tr>
<td>- Co-incineration is an acceptable method for disposal of Category 1 materials</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Lafarge operates in Canada and has expressed interest in utilizing MBM in operations</td>
<td>- Kilns in EU currently using waste from animals fit for human consumption or SRM from animals less than 30 months</td>
</tr>
<tr>
<td>- Waste derived fuels may be eligible for GHG reduction credits as fossil fuel substitute</td>
<td>- Cement operators could be unwilling to accept materials of high BSE risk or confirmed BSE</td>
</tr>
<tr>
<td>- May be able to use MBM in up to 50% blend with conventional combustion fuels</td>
<td></td>
</tr>
</tbody>
</table>

### Table 17 Thermal Hydrolysis SWOT Analysis

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Can process a variety of waste streams including manure, urine, protein meals, ag residues</td>
<td>- Technology still not commercially proven for treatment of Category 1 animal by-products</td>
</tr>
<tr>
<td>- Produces both energy and soil stabilizer</td>
<td>- Not yet proven to fully deactivate TSE prion</td>
</tr>
<tr>
<td>- Odor control</td>
<td></td>
</tr>
<tr>
<td>- Process is completed quickly (residence time in reactor under 6 hours)</td>
<td></td>
</tr>
<tr>
<td>- Increases biogas yields and reduces retention period</td>
<td></td>
</tr>
<tr>
<td>- Supersedes EU sterilization requirements (133°C/3bars/20 minutes)</td>
<td></td>
</tr>
</tbody>
</table>

---

36 (BCMAFF 2004)  
37 (Castle Cement, 2003)  
39 (BCMAFF 2004)  
40 (EU 1774/2002)  
41 Ibid.  
42 (Castle Cement 2003)  
43 Ibid  
44 (Kepp 1996)  
45 (Biorefinex 2004)  
46 (EU, 2003)
<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Short time scale/average difficulty from planning to design to operation</td>
<td>• SRMs would contaminate output and liquor may not be permitted for land application</td>
</tr>
<tr>
<td>• Would be permitted by CFIA as treatment of BSE risk materials</td>
<td>• Not yet confirmed as effective treatment for Category 1 materials 47</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Wastestream inputs could be considered biomass and eligible for GHG reduction credits/funding</td>
<td>• SRMs would contaminate digestate and could not be permitted for land application</td>
</tr>
<tr>
<td>• Short time scale/average difficulty from planning to design to operation</td>
<td>• Legislation similar to EU currently prevents all Category 1 materials from being utilized in biogas plants 55</td>
</tr>
<tr>
<td>• Energy from system can be used on site or exported</td>
<td>• Sterilization may be required prior to AD increasing costs (133°C/3bars/20 minutes)56</td>
</tr>
<tr>
<td></td>
<td>• Purchase agreement with utility may be required to make economically feasible</td>
</tr>
<tr>
<td></td>
<td>• Pathogens can spread through improper handling or improper design 57</td>
</tr>
</tbody>
</table>

| Table 18 Anaerobic Digestion SWOT Analysis                                      |
|--------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Is a proven technology both on farm and commercial scale 48</td>
<td>• Sensitive to feedstock modifications and temperature fluctuations 53</td>
</tr>
<tr>
<td>• Can process a variety of waste streams including manure, urine, blood, milk, protein meals, Ag residues, wastewater 49</td>
<td>• Appropriate carbon to nitrogen ratio and pH balance must be maintained</td>
</tr>
<tr>
<td>• Capital/O&amp;M expenses are low to moderate</td>
<td>• Disinfectants used during initial processing or transport may cause contamination of compost by-product 54</td>
</tr>
<tr>
<td>• Produces both energy and fertilizer</td>
<td>• May require pre-processing of slaughter wastes to slurry</td>
</tr>
<tr>
<td>• Requires no additional material and energy inputs to operate 50</td>
<td>• Has not been proven to deactivate TSE prion</td>
</tr>
<tr>
<td>• Flies and pests are minimized / odor control</td>
<td></td>
</tr>
<tr>
<td>• Full process is completed quickly (−6-10 weeks) compared to decades if landfilled 51</td>
<td></td>
</tr>
<tr>
<td>• 100% of nutrients end up in digestate (N,P,K) 52</td>
<td></td>
</tr>
</tbody>
</table>

47 (EU, 2003)  
48 (Wheatley, 1990); (Polprasert, 1996); (McLanaghan, 2002); (Stuckey, 1986)  
49 Ibid  
50 Ibid  
51 Ibid  
52 Ibid  
53 Ibid  
54 (McLanaghan, 2002)  
55 (EU, 2002)  
56 (EU, 2002)  
57 (Wheatley, 1990); (Polprasert, 1996); (McLanaghan, 2002); (Stuckey, 1986)
### Table 19: Composting SWOT Analysis

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Is a proven technology both on farm and commercial scale</td>
<td>• Sensitive to feedstock modifications and temperature fluctuations</td>
</tr>
<tr>
<td>• Can process a variety of waste streams including night soil, sludge,</td>
<td>• Appropriate carbon to nitrogen ratio, pH balance, temperature (&lt;65°C), aeration, moisture content (50-70%) must</td>
</tr>
<tr>
<td>animal manures, agricultural residues and municipal refuse</td>
<td>constantly be maintained</td>
</tr>
<tr>
<td>• Capital/O&amp;M expenses are low to moderate</td>
<td>• Disinfectants used during initial processing or transport may cause contamination of organic materials</td>
</tr>
<tr>
<td>• Produces both nutrient rich end product and low-grade heat</td>
<td>• End product has low value ($20-$60/t)</td>
</tr>
<tr>
<td>• Requires very little energy input to operate (aeration blower/mixer)</td>
<td>• Open windrow may need large area of land</td>
</tr>
<tr>
<td>• Flies and pests are minimized / odor control</td>
<td>• Curing/Storing stage required for nitrification to occur for product to be suitable for land application (1-3 months)</td>
</tr>
<tr>
<td>• Under suitable conditions, AC is completed quickly (~3-20 days) / some</td>
<td>• May require shredding of materials to allow for efficient aeration</td>
</tr>
<tr>
<td>reactors can compost in 24 hours.</td>
<td>• Will not deactivate TSE prion</td>
</tr>
<tr>
<td>• Composted material provides inorganic nutrients suitable for crop uptake (e.g. NO\textsubscript{3} &amp; PO\textsubscript{4})</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Short time scale/average difficulty from planning to design to operation</td>
<td>• SRMs would contaminate materials and would not be permitted for land application</td>
</tr>
<tr>
<td>• Simple technology readily available</td>
<td>• Strict standards for composting processes &amp; quality currently in place, could become more rigorous (e.g. requiring closed reactors)</td>
</tr>
<tr>
<td>• Composting recognized by municipal, provincial and federal governments</td>
<td>• Legislation similar to EU would prevent Category 1 wastes from being composted or applied to soil</td>
</tr>
<tr>
<td>as a vital waste mitigation strategy</td>
<td>• Pathogens can spread through improper handling, maintenance or improper design</td>
</tr>
<tr>
<td>• No chimney stack, minimal aesthetic impact, low noise, low odor</td>
<td>• Collection methods can be costly</td>
</tr>
</tbody>
</table>

---

58 (Polprasert, 1996); (McLanaghan, 2002);  
59 Ibid  
60 Ibid  
61 Ibid  
62 Ibid  
63 (McLanaghan, 2002); (BCMAFF 2004)  
64 Ibid  
65 (EU, 2002)
### Additional Energy Recovery Options

#### Table 20: Biodiesel SWOT Analysis

<table>
<thead>
<tr>
<th><strong>Strengths</strong></th>
<th><strong>Weaknesses</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Animal fats can be converted into biodiesel</td>
<td>• Fats must first be rendered to produce biodiesel</td>
</tr>
<tr>
<td>• Technology is proven</td>
<td>• Fats have higher FFA than vegetable oils</td>
</tr>
<tr>
<td>• Prion not found present in biodiesel made from 0.15% insoluble tallow/fuel is combusted to further reduce risk of transmission</td>
<td>• Biodiesel is not yet being produced commercially in western Canada</td>
</tr>
<tr>
<td>• Biodiesel is an environmentally friendly fuel substitute for diesel</td>
<td>• Biodiesel is more costly to produce than petroleum diesel</td>
</tr>
<tr>
<td>• Biodiesel process is considered safe in EU as treatment for category 1 materials</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Opportunities</strong></th>
<th><strong>Threats</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Short time scale/average difficulty from planning to design to operation</td>
<td>• Pathogens can spread from unsafe handling of raw materials</td>
</tr>
<tr>
<td>• All levels of government support biodiesel as an alternative fuel with many GHG and air quality benefits</td>
<td>• Petroleum industry and rendering industry have enormous market power to control inputs and outputs</td>
</tr>
<tr>
<td>• Govt. fleets interested in adopting biodiesel</td>
<td></td>
</tr>
<tr>
<td>• On-road fuel tax abatement in BC for biodiesel</td>
<td></td>
</tr>
</tbody>
</table>

#### Table 21: CHP SWOT Analysis

<table>
<thead>
<tr>
<th><strong>Strengths</strong></th>
<th><strong>Weaknesses</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Is a proven technology</td>
<td>• Increased expense of CHP technologies increases time of capital cost recovery</td>
</tr>
<tr>
<td>• Produces both power and thermal energy</td>
<td>• Depending on technology, local codes may require 24 hour attendance by highly trained personnel</td>
</tr>
<tr>
<td>• Efficiency gains reduce fuel consumption by up to 35% with relative emission reductions</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Opportunities</strong></th>
<th><strong>Threats</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Biological waste stream inputs could be considered biomass and eligible for GHG reduction credits/funding</td>
<td>• Grid interconnection fees can be costly</td>
</tr>
<tr>
<td>• Biogas could be utilized in conjunction with natural gas to power turbines</td>
<td></td>
</tr>
<tr>
<td>• Steam from incineration system can be used to power turbine</td>
<td></td>
</tr>
<tr>
<td>• Thermal energy can be utilized for a variety of onsite uses (e.g. rendering)</td>
<td></td>
</tr>
</tbody>
</table>

---

66 (Appel, 2001); (Cummins, 2002)
67 (NBB, 2003)
68 (EU, 2004)
69 (Cummins, 2002)
70 (Van Gerpen, 2001)
71 (Nyober, 2002); (RDI, 2002); (USDOE, 2004); (USCHPA, 2004); (USEPA, 2004)
72 Ibid
73 Ibid
74 Burnaby Incinerator, 2004
75 Ibid

4.1.3 Summary Assessment of Disposal Options

Table 22 below provides a summary assessment of the impact economic, environmental, social and political factors had on the evaluation for each of the disposal options. When applicable, the options were also paired with other technologies as well as with and without cogeneration.
### Table 22 Criteria Evaluation Summary Table

<table>
<thead>
<tr>
<th>Disposal Options</th>
<th>Effectiveness Minimizing Prion Transmission</th>
<th>Permitted in LM-SW</th>
<th>Ability for Industry to Tolerate Expense</th>
<th>Environmental Impact Minimized</th>
<th>Public Inclined to Accept</th>
<th>Energy Recovery</th>
<th>Score</th>
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<tbody>
<tr>
<td>Landfill</td>
<td>Low</td>
<td>Low</td>
<td>Low/Moderate</td>
<td>Low</td>
<td>Low</td>
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<tr>
<td>Incineration w/out CHP</td>
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<tr>
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<td>High</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
<td>High</td>
<td>16</td>
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<tr>
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<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
<td>12</td>
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<tr>
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<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
<td>11</td>
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<tr>
<td>Therm. Hydrolysis AD w/CHP</td>
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<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
<td>High</td>
<td>13</td>
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<tr>
<td>Composting</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>10</td>
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All of these disposal options have the potential to convert the tallow portion after rendering into biodiesel, refer to page 79 for the discussion of biodiesel as an additional energy recovery method.

**Key:** Low = low capability/low probability (1 pt) | Moderate = some capability/moderate probability (2 pt) | High= good capability/high probability (3pt) Very High=strong capability/very high probability (4pt)
To screen disposal options, only options that were evaluated to have high or very high scores for “transmission risk minimization”, and those with overall scores over 10 were considered to be suitable solutions. This limited the options to the following:

<table>
<thead>
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<th>Table 23 - Screened Options</th>
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<tr>
<td>Option</td>
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<td>For All SRM and/or MBM</td>
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<tr>
<td>For Tallow Only</td>
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<tr>
<td>Biodiesel</td>
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</table>

Landfill w/ rendering

Landfill w/ rendering received a low score for its “Effectiveness to minimize TSE transmission” because it is not recognized to adequately destroy prions. Landfills also attract rodents, birds and other wildlife thereby creating opportunities for transmission. It received a low score for the criterion of “Permitted in the Lower Mainland” because special wastes are prohibited at all but one of the eight registered landfills in the LM-SW (Squamish). It is also questionable as to whether the Ministry of Water, Land, and Air Protection will continue to permit SRM in any landfill in the lower mainland after the recent detection of BSE. Additionally, the UK has prohibited category 1 materials from landfills since 1991, suggesting that there may be reasons to justify such actions.

“Industry’s ability to tolerate expense” was scored as low to moderate, as tipping fees at landfills range from $65-$120/tonne, however this does not include transport costs. Currently, abattoirs are paying $100/tonne to have wastes collected, but tenderers still enjoy a market for their meat and bone meal and tallow. In the absence of this market, collection costs would increase making this option less attractive. It also received a low score for “Environmental impact minimized” due to the potential for soil and groundwater contamination. For this reasons and others, local residents could also reject such activity after learning more about BSE and the risk uncertainty associated with its transmission, as was the case during the Avian Flu Crises, thereby giving it a low score for
“Public inclined to Accept”. Lastly, it received a low score for “Energy recovery”, because the one landfill in the LM-SW mentioned above that is permitted to accept special waste materials does not have energy capture technology.

Incineration

Incineration received a high score for its “Effectiveness to minimize TSE transmission” because it combusted these materials at high temperatures and reduces the volume of materials by over 90%. Remaining ash would be landfilled, however ashen materials will not attract wildlife. There is currently one municipal incinerator operating in the lower mainland, however due to strict emission restrictions in the lower mainland, widespread NIMBY issues regarding commercial incinerators, and the incinerators refusal to accept biological waste materials during the Avian Flu crises, it received a low score for “Permitted in the Lower Mainland”. This disposal option also received a low score for “Industry’s ability to tolerate expense” due to the fact that in the absence of local capacity to incinerate these materials, they would have to be trucked at greater expense to sites where such activity is permissible. Currently, the Swan Hill hazardous waste incinerator in Alberta is charging $500/tonne for hazardous waste disposal, and indicated this could be as high as $800/tonne for SRM. Incineration received a moderate score for “Environmental impact minimized” due to the fact that the licensed incinerator in the Lower Mainland has operated below its emission limits due to its air pollution control (APC) system which includes dry lime acid scrubbers for acid gases such as SOx, NOx, HCl, & HF1, an ammonia injection system recently installed in the combustion chamber to further reduce Nox and fabric filters for reducing particulate matter. Dioxin releases from incineration are regulated and should not be adversely affected from utilization of SRM. It received a low score for “Public inclined to Accept” again due to NIMBY response in light of the uncertainty associated with BSE transmission and public concern for the potential of airborne transmission. While this risk is not fully known, it can be offered anecdotally that the workers at the Burnaby incinerator did not want to handle or accept birds during the Avian Flu crises due to similar fears. Incineration without CHP received a low score for “Energy recovery” however, with CHP, it received a high score.

Incineration with CHP

Other than for “Energy Recovery”, this option was evaluated similarly as above.
Cement Production

Cement production received a very high score for "Effectiveness to minimize TSE transmission" because it reaches high temperatures believed to substantially destroy prions as well as incorporates any left over inorganic materials into the clinker, thereby removing it from the environment where it could be ingested. If the precautionary principle were to be applied, cement kilns provide the most robust disposal option for MBM. The LM-SW currently has existing cement production facilities and increasing interest in waste-derived fuels from biomass suggest that there is a high probability that this option will be "Permitted in the Lower Mainland". Additionally, cement companies have expressed interest in pursuing such activities and have been largely successful in receiving approval in Europe. This option received a moderate score for "Industry’s ability to tolerate expense" due to the fact that a large cement company suggested that it would consider accepting such materials with no tipping fee as long as the capital costs was paid for to enable them to accept them. In the absence of covering capital costs, a cost per tonne fee would be moderate, however materials still would require rendering prior to be accepted. Either way, this provides a negative cost to the collector and processor of these wastes, which would be passed on to both the processor and farmer. "Environmental impact minimized" received a moderate score due to the potential minimize direct contamination of soil and groundwater and that replacing existing fossil fuels with ruminant biomass would actually reduce their air emission profile. However, cement kilns are not currently prepared for the increased nitrogen load of MBM and without appropriate measures to accommodate this, NOx emissions would increase. "Public inclined to accept" received a moderate score due to the fact that the materials would have to first be rendered and that the cement kilns reach temperatures that are believed to adequately destroy the prion, creating few risks for transmission, however there could still be public concerns for airborne emissions. "Energy recovery" received a moderate score since the materials would be utilized as a replacement fuel however they would first require rendering which is a thermally intensive process requiring energy inputs predominately in the form of steam produced via boilers heated by natural gas.

Anaerobic Digestion

Anaerobic digestion received a low score for "Effectiveness to minimize TSE transmission" because it does not reach temperatures believed to destroy prions. There is research being conducted to ascertain how effective the microbial activity may be in deactivating prions, however in the absence of this information, it cannot be deemed effective. Additionally, depending on the disposal method utilized for the disposal of the digestate by-product (e.g. land
application), there would be opportunities for transmission. This option received a moderate score for "Permitted in the Lower Mainland" due to the fact that it would take place in specialized vessels to contain materials and produces very low odours and emissions, while substantially reducing the volume of waste materials. It is yet unclear exactly how much liquid digestate will remain, and there could be issues regarding waste water treatment and disposal.

There is increasing interest in AD as a waste mitigation technology for the agricultural sector and a strong case could be made to WLAP for its approval. "Industry’s ability to tolerate expense" received a moderate score since it has a low cost per tonne operating expense however capital expenses can be substantial. Operating expenses will also be dependant on additional feedstock inputs to digester (for achieving necessary C:N ratios) and their costs are not fully known. Ideally they would be negative cost inputs such as manure. "Environmental impact minimized" received a moderate score for the same reasons mentioned regarding permitting. Its overall environmental impact is highly dependant on the way in which the digestate is disposed of, which could entail dewatering and disposal of cake in a landfill or incinerator. "Public inclined to accept" received a moderate score due to the lack of existing digester capacity in the LM-SW and potential concerns related to how its digestate and waste water would be treated. "Energy recovery" received a moderate score due to uncertainties related to volumes of biogas production. Many biogas installations in Europe and elsewhere provide both heat and power efficiently utilizing manure and MSW, however the utilization of SRM materials is still in its infancy.

**Thermal Hydrolysis w/AD**

Thermal Hydrolysis received a moderate score for "Effectiveness to minimize TSE transmission" because it utilizes temperatures and pressures that are capable of achieving 5-10 log reductions in prion infectivity however it has not yet been approved as an allowable method in the EU for treatment of category 1 materials. Further research is currently being conducted to assess its ability to adequately destroy prions. It received a high score for "Permitted in the Lower Mainland" for similar reasons as anaerobic digestion, that it would take place in specialized vessels to contain materials and produces very low odours and emissions, while substantially reducing the volume of waste materials. "Industry’s ability to tolerate expense", "Environmental impact minimized", "Public inclined to accept", and "Energy recovery" received the same scores as anaerobic digestion for the same reasons except that it should be noted that thermal hydrolysis is more energy intensive than solely anaerobic digestion due to the requirements for high pressure high temperature steam. However the biogas yields are reported to
be higher as a result of the breaking down of cellular walls prior to materials being fed into the anaerobic digester.

**Thermal Hydrolysis w/ AD and CHP**
This option received the same ratings as above for all of the criterion except for "**Energy recovery**", which received a high score due to the increased efficiencies that would be realized utilizing combined heat and power technology.

**Composting**
Composting received a low score for "**Effectiveness to minimize TSE transmission**" because it is not known to destroy prions. It has been suggested that microbial activity during composting may help to damage the BSE prion but this could not be verified. "**Permitted in the Lower Mainland**" received a medium score due to the fact that the CFIA has not taken a definitive stance on the permissibility of composting SRM. The EU has not approved composting as an acceptable treatment method for category 1 risk materials. "**Industry's ability to tolerate expense**", received a high score due to the low capital and O&M expenditures required for this option. Compost made on the farm, from dead stock, would not be permitted to leave the farm and thus would have little economic value. It should also be mentioned that composting of SRM would not necessarily be viable for abattoirs, since the compost made from risk materials would be prohibited from resale. "**Environmental Impact Minimized**" received a low score since, again, composting SRM materials would amplify the volume of risk materials. Additionally, if materials composted with SRM were put on field or pastureland, the potential for soil and groundwater contamination remain. It is widely known that cattle consume fair amounts of soil as they graze, creating the potential for ingestion. Composting received a low score for "**Public Inclined to accept**" as the risk of contaminating soil, groundwater, and perpetuating BSE through a direct transmission pathway such as ingestion could lead to a negative perception for this option. The composting of birds during the Avian Influenza (AI) crisis is justifiable with very good reason since the temperatures reached during composting are capable of destroying the AI virus. Temperatures achieved during composting have not been demonstrated to a significant effect on prions. It also scored low for "**Energy recovery**" since composting does not generate energy.
Additional Energy Recovery Methods

Biodiesel

Biodiesel production received a high score for "Effectiveness to minimize TSE transmission" for a variety of reasons. Firstly, the biodiesel process utilizes a number of screening procedures in order to produce a fuel acceptable for use in engine requirements – insoluble and other impurities in the fuel would not prevent it from meeting fuel quality standards. Secondly, the proteinaceous nature of the TSE agents they tend to remain with cellular residues of MBM during the rendering process. Thirdly, the chemicals and heat used during the biodiesel further reduce risk of infectivity. "Permitted in the Lower Mainland" received a high score as municipalities in the Lower Mainland have been working to develop a biodiesel market and encourage local production through collective purchase agreements and through participation in the federal fleet challenge to increase awareness and use of biodiesel. "Industry's ability to tolerate expense" received a moderate score since tallow has not been prohibited from the animal feed chain, nor will it be, so it maintains a relatively stable market value (FOB Pacific Northwest ~CDN $0.42 - $0.46/litre.) At this price biodiesel would need to be sold for over ~$1.00/Litre, which is slightly higher than conventional diesel, but the gap is closing. Biodiesel's direct impact on the environment in terms of SRM is difficult to assess since it is produced from a byproduct of the rendering process. However it received a moderate score for "Environmental Impact Minimized" due to the many emission benefits biodiesel offers over conventional diesel fuel. It received a high score for "Public Inclined to accept" since there is rapidly growing awareness and support from the public with regards to biofuel. "Energy recovery" received a high score since the biodiesel process produces a fuel from tallow comparable in terms of energy density to petroleum diesel.

The overall conclusion from this table is that cement production and incineration received the highest scores for disposal of the MBM, with scores of 16 and 11 respectively. It must be noted that biodiesel production is only an acceptable method of disposal for the tallow portion of the materials, as raw materials must first be rendered to extract and filter tallow. Other technologies such as gasification and pyrolysis need further examination.
5.0 Conclusions and Recommendations

The UK BSE experience demonstrated the dangers of widely disregarded feed bans. Infectious bovine materials, even after the ban on SRM, found its way into pig and poultry feed and then, by cross-contamination, into cattle feed until the full ban on all animal protein from feeds was put in place in 1996.

There are many reasons to support this path although it is completely unlikely that either Canada (or the United States) will regulate such actions. The first reason in support of such a stringent action is the fact that during the UK crises it was falsely assumed that “any cross-contamination of cattle feed in feed mills from pig or poultry feed containing ruminant protein would be on too small a scale to matter” (Bridgeman CB 2000). This was eventually proven erroneous through subsequent experiments demonstrated that a cow could become infected with BSE as a result of eating an amount of infectious tissue as small 1 gram. And more recently, the infective dose has been proven to be as little as 1 milligram.

- Regulations must be enforceable to achieve desired goals.
- The most effective way to reduce the risk of TSE transmission is to remove all mammalian proteins from the feed chain. At the very minimum all ruminant material, including SRM and non-SRM should be removed from the feed chain.
- 1 gram of infectious tissue in feed is enough to infect 1,000 cattle through ingestion.

It was also not at first believed that BSE could cross the species barrier to humans or pigs. Unfortunately, there is a strong linkage between BSE and vCJD and scientists have also proven through a lab experiment that BSE can indeed cross the species barrier to pigs. This is important to recognize as pigs have the closest physiology to humans next to primates.

Initial claims that BSE did not exist in Canada have proven false, and recent evidence of the shocking loopholes in the feed industry should be a major warning signal that the risk mitigation measures put in place to prevent the amplification of BSE through the 1997 ruminant protein to ruminant feed ban may not be as effective as perceived. Even a report submitted in August 2004 to the USDA on behalf of the National Renderers Association to state their opposition to a
regulated removal of SRM from the non-ruminant feed supply states, "the largest risk (though still extremely modest) for potentially infectious material to re-enter the cattle population is through the accidental or intentional mislabeling or contamination of non-prohibited livestock feed or MBM." (Informa Economics, 2004: 18)

- A ruminant-to-ruminant feed ban does not adequately reduce risk. Implementing an SRM ban without full compliance will not adequately reduce risk and full compliance will not be achieved in the absence of economically viable solutions.

- In the absence of a full animal protein ban, dedicated transport and equipment should be required for rendering and feed facilities handling bovine materials.

- Hold rendering and feed companies economically liable to farmers for violations of BSE regulations.

It should be noted that the age of the dairy cow most recently confirmed for BSE was subsequently lowered the following day of discovery from ten years to eight years, which still would have it being born just before the ruminant to ruminant feed ban in 1997. Under the assumption that it was born before the ruminant feed ban (with 100% compliance and zero chance of SRM cross-contamination) there are three primary possibilities:

1) It is a case of sporadic BSE or;
2) It is a case of inherited BSE or most likely;
3) There was exposure to ruminant materials SRM or other ruminant materials prior to the feed ban.

In the very remote possibility that the dairy cow is in fact found to be younger than eight years of age and thus born after the ruminant feed ban, the compliance violations mentioned earlier would be cause for even greater concern.

Until 1996, a report referred to as the Southwood Report was often cited as if it demonstrated scientific certainty, rather than provisional opinion, that any risk to humans from BSE was remote (Bridgeman CB 2000). The Harvard Risk Assessment is used similarly in North America, often quoted as the defacto authority in defence of passive regulations regarding BSE in both Canada
and the United States. The Harvard Risk Assessment was a "probabilistic simulation model" that characterized the consequences of introducing BSE into the U.S that assumes a base case of zero indigenous cases of BSE and the importation of 10 BSE infected cattle into the U.S. It states that the U.S appears resistant to a BSE challenge because the FDA feed ban provides the necessary safeguards to limit exposure of cattle to infected materials. It does also state, however, that the "effectiveness of the feed ban is somewhat uncertain because compliance rates are not precisely known". (Cohen, 2001:97)

A scientific peer review by a team of expert reviewers including European and North American epidemiologists, specialists in ruminant neuropathology, cattle production and processing systems, and risk assessment methods and modeling however identified a number of weaknesses in the Harvard Analysis. The following are various excerpts from the peer review of the Harvard Risk Assessment, presented verbatim:

- "The lack of data on other factors that could have a greater effect on risk, limits the predictive value of the model. The model does not consider the distribution system for feed." (Section 2, p.2)
- "The review and synthesis of the published literature and expert knowledge is somewhat patchy." ... "One is left with the notion that there has been insufficient consultation with researchers in the field, which could have provided an ongoing peer review." (Section 2, p.8)
- "The reviewers had concerns that the importance of some parameters has been overestimated and others underestimated." (Section 3, p. 4)
- "It must be acknowledged that the validity of the model is not fully established." (Section 4, p.5) (RTI 2002)

In closing, it is possible to utilize SRM and inedible ruminant materials to generate heat and power and/or replace fossil fuels while removing or dramatically reducing volumes of infective solids from the environment. Doing so could achieve (and supercede) the goals set forth by the CFIA as well as produce energy from waste biomass. If the precautionary principle were

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74 E.g. during the SRM disposal option meeting held by AAFC and BCMAFF, H.K. from West Coast Reduction and former chairman of the National Renderers Association exclaimed to the room during SRM disposal discussions, "hasn't anyone read the Harvard Risk Assessment?"
applied, co-firing rendered MBM in cement kilns would be the most effective solution for
disposal of bovine inedible materials, including both SRM and non-SRM. By completely
removing SRM and other inedible ruminant materials from the entire food chain, Canada can
demonstrate to North America and the world its dedication to protecting its animal and human
population from non-Sporadic cases of TSE and its ability to lead and innovate in the face of
uncertainty.
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6.0 Bibliography


Belay, E. Ryan A. Maddox, Elizabeth S. Williams, Michael W. Miller, Pierluigi Gambetti, and Lawrence B. Schonberger. (2004) "Chronic Wasting Disease and Potential Transmission
to Humans". Emerging Infectious Diseases, U.S. Centre for Disease Control. 10 (6): 977-984 June 2004


Browning, SR; Mason, GL; Seward, T; et al. (2004). "Transmission of Prions from Mule Deer and Elk with Chronic Wasting Disease to Transgenic Mice Expressing Cervid PrP" Journal of Virology, 78 (23): 13345-13350 Dec 2004


CFIA (2004). "Development of Specific Regulatory Enhancements to Canada's BSE Feed Controls."


Clark, G. (2004). SRM Meeting. SRM Meeting, Delta, BC.


EU (2003). Opinion on Six Alternative Methods for Safe Disposal of Animal By-Products,


Finnsementti. Alternative Fuels in Cement Production. Presentation. 2004


StatsCan (2001). Cattle and Calves by province, Census Agricultural Region (CAR) and Census Division (CD), Statistics Canada.

StatsCan (2001). Sheep and Lamb by province, Census Agricultural Region (CAR) and Census Division (CD), Statistics Canada.


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<td>287.5</td>
<td>187</td>
<td>32.3</td>
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<tr>
<td>Total Cattle &amp; Calves</td>
<td>815.0</td>
<td>670.0</td>
<td>836.5</td>
<td>700.0</td>
<td>13,371.5</td>
<td>808.8</td>
<td>710</td>
<td>127.1</td>
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<tr>
<td>Slaughter (Year End)</td>
<td>50.0</td>
<td>-</td>
<td>50.1</td>
<td>N/A</td>
<td>3,212.2</td>
<td>79.7</td>
<td>N/A</td>
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<tr>
<td>Deadstock (Year End)</td>
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<td>50.1</td>
<td>N/A</td>
<td>488.1</td>
<td>19.9</td>
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<tr>
<td>Deadstock (Tonnes)</td>
<td>244,050</td>
<td>9,959</td>
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<td>3,070</td>
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</table>

<sup>76</sup> StatsCan (2001). Cattle and Calves by province, Census Agricultural Region (CAR) and Census Division (CD), Statistics Canada.
Table 26 Beginning and Ending Recorded and Estimated Inventories for BC January 2000-2005 (Unit = thousands)

<table>
<thead>
<tr>
<th></th>
<th>Jan-00</th>
<th>Jul-00</th>
<th>Jan-01</th>
<th>Jul-01</th>
<th>Jan-02</th>
<th>Jul-02</th>
<th>Jan-03</th>
<th>Jul-03</th>
<th>Jan-04</th>
<th>Jul-04</th>
<th>Jan-05</th>
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<tbody>
<tr>
<td><strong>Beginning Inventory</strong></td>
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<tr>
<td>Calves Born</td>
<td>334.3</td>
<td>46.2</td>
<td>326</td>
<td>63.6</td>
<td>333.6</td>
<td>59.3</td>
<td>352.3</td>
<td>61.0</td>
<td>404.1</td>
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<tr>
<td>Interprovincial Imports</td>
<td>13.2</td>
<td>5.5</td>
<td>25.6</td>
<td>13.8</td>
<td>33</td>
<td>42.6</td>
<td>25.4</td>
<td>17.6</td>
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<tr>
<td>International Imports</td>
<td>3.6</td>
<td>12.3</td>
<td>6.2</td>
<td>7.5</td>
<td>2.4</td>
<td>6.4</td>
<td>6.6</td>
<td>9.5</td>
<td>0</td>
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<tr>
<td><strong>Total Supply (1+2+3+4)</strong></td>
<td>1001.1</td>
<td>869</td>
<td>1012.8</td>
<td>899.9</td>
<td>1039</td>
<td>944.8</td>
<td>1084.3</td>
<td>974.8</td>
<td>1212.9</td>
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<tr>
<td>Slaughter (6 months)</td>
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<td>23.9</td>
<td>24.4</td>
<td>25.6</td>
<td>24.7</td>
<td>25.4</td>
<td>39.9</td>
<td>39.9</td>
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<tr>
<td>Interprovincial Exports</td>
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<td>152</td>
<td>90.6</td>
<td>152</td>
<td>90.6</td>
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<td>50.7</td>
<td>37.5</td>
<td>54.2</td>
<td>82.6</td>
<td>43.1</td>
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</tr>
<tr>
<td>Deaths and condemnations</td>
<td>32.3</td>
<td>13.4</td>
<td>32.1</td>
<td>14.8</td>
<td>33</td>
<td>14.8</td>
<td>34.6</td>
<td>15.4</td>
<td>38.6</td>
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<tr>
<td><strong>Output (6+7+8+9)</strong></td>
<td>196.1</td>
<td>214</td>
<td>197.8</td>
<td>229.9</td>
<td>202.5</td>
<td>244.8</td>
<td>197.5</td>
<td>166.0</td>
<td>186.2</td>
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<tr>
<td><strong>Ending Inventory</strong></td>
<td>805</td>
<td>655</td>
<td>815</td>
<td>670</td>
<td>836.5</td>
<td>700</td>
<td>886.7</td>
<td>808.8</td>
<td>950</td>
<td>710</td>
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</tr>
</tbody>
</table>

*Adjusted Estimates

<p>| | | | | | | | | | | | |</p>
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<tbody>
<tr>
<td>Calves Born % of Inventory</td>
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<td>0.06</td>
<td>0.50</td>
<td>0.08</td>
<td>0.50</td>
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<td>0.50</td>
<td>0.07</td>
<td>0.50</td>
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<tr>
<td>Inter-provincial Imports</td>
<td>0.02</td>
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<td>0.04</td>
<td>0.02</td>
<td>0.05</td>
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<td>0.04</td>
<td>0.02</td>
<td>0.04</td>
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</tr>
<tr>
<td>International Imports</td>
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<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
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<td>0.01</td>
<td>0.01</td>
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</tr>
<tr>
<td>Slaughter % of Supply</td>
<td>0.02</td>
<td>0.03</td>
<td>0.02</td>
<td>0.03</td>
<td>0.02</td>
<td>0.03</td>
<td>0.04</td>
<td>0.04</td>
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</tr>
<tr>
<td>IE % of Supply</td>
<td>0.09</td>
<td>0.18</td>
<td>0.09</td>
<td>0.17</td>
<td>0.09</td>
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<tr>
<td>INTL E</td>
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<td>0.05</td>
<td>0.09</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
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<td></td>
</tr>
<tr>
<td>Deaths and condemnations</td>
<td>0.03</td>
<td>0.01</td>
<td>0.03</td>
<td>0.02</td>
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</tr>
</tbody>
</table>

(StatsCan 2003) Until Jan 2003 *(BCMAFF 2004) for Beginning Inventory Jan 2004

*Adjustments by Stats Can (CanFax 2005)