Comments on Characteristics of Proposed Thorhild Landfill with Respect to Providing Reliable Protection of Public Health & Environmental Quality for as Long as the Wastes Remain a Threat

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Presented below are comments on characteristics of proposed Thorhild Landfill with respect to its ability to provide reliable protection of public health & environmental quality for as long as the wastes remain a threat. These comments were prepared on behalf of the Concerned Citizens of Thorhild County Society, Alberta, Canada and were submitted to the Society as a series of reports on individual documents. Those individual reports are provided as a collection in this document. The individual reports, in the order in which they appear in this document, are:

Pages 38-42
Lee, G. F., and Jones-Lee, A., "Comments on CH2MHILL, 'Subsurface Landfill Gas Monitoring Program-Greenfield Site in the County of Thorhild (Updated 2010),' Final Report Prepared for Waste Management of Canada Corp., March 16, 2010," Report of G. Fred Lee & Associates, El Macero, CA, USA, 5 pp, August (2012)

Pages 43-44
Lee, G. F., and Jones-Lee, A., "Comments on AECOM, 'Thorhild Landfill – Field Investigations,' Letter Dated February 21, 2012 (AECOM, 2012a)," Report of G. Fred Lee & Associates, El Macero, CA, USA, 2 pp, July 1 (2012)

Pages 45-50
Lee, G. F., and Jones-Lee, A., "Comments on 'Waste Management of Canada Corporation Proposed Thorhild Landfill Design Report for Waste Footprint Configuration and Containment Systems,' dated March 2010, prepared by Adelantar Consulting," Report of G. Fred Lee & Associates, El Macero, CA, USA, 6 pp, March 15 (2012)

Pages 51-52
Lee, G. F., and Jones-Lee, A., "Comments on 'Proposed Thorhild Landfill End Use Plan' Prepared by EDA for WM," Report of G. Fred Lee & Associates, El Macero, CA, USA, 2 pp, August (2012)

Page 53
Lee, G. F., and Jones-Lee, A., "Comments on Geographic Dynamics Corp (GDC), 'Technical Wetland Compensation Report for the Proposed WMCC Thorhild Landfill,' GDC, Edmonton, Alberta, March 8, 2010, Report of G. Fred Lee & Associates, El Macero, CA, USA, 1 p, August (2012)

Pages 54-60
Lee, G. F., and Jones-Lee, A., "Comments on 'Waste Management of Canada Corporation Proposed Thorhild Landfill Closure and Post-closure Cost Estimate,' dated March 2010, prepared by Adelantar Consulting," Report of G. Fred Lee & Associates, El Macero, CA, USA, 7 pp, August (2012)

Pages 61-62
Lee, G. F., and Jones-Lee, A., "Comments on Alberta Environmental Protection 'Action Leakage Rate Guidelines,'" Report of G. Fred Lee & Associates, El Macero, CA, USA, 2 pp, October (2012)

Pages 63-65
Summary of Dr. G. Fred Lee Professional Publication Record, 3 pp, June 15 (2012).

Comments on the Province of Alberta Finance and Administration Division Regulatory Approvals Centre Approval of the Thorhild Class II Municipal/Industrial Landfill EPEA Application No. 001-236328

Submitted to
Alberta Environmental Appeals Board.
On behalf of The Concerned Citizens of Thorhild County Society

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March 5, 2012

On September 22, 2011 the Province of Alberta Finance and Administration Division Regulatory Approvals Centre approved the Thorhild Class II Municipal/Industrial Landfill EPEA Application No. 001-236328. The Concerned Citizens of Thorhild County Society, Abee, Alberta, Canada has filed an appeal of that approval. The Concerned Citizens of Thorhild County Society has also requested that we (Drs. G. Fred Lee and Anne Jones-Lee) review the technical content of the approved application and render an assessment of the ability of the proposed landfill to provide the citizens of Thorhild County with public health, groundwater and surface water quality protection from releases from the landfill for a long as the wastes that are proposed to be deposited will be a threat.

Request for Technical Review of Potential Impacts of Proposed Thorhild Landfill as Approved: Background

In connection with our review, Betty Kolewaski, Chair of The Concerned Citizens of Thorhild County Society provided CDs of the administrative record that was filed by Alberta Environment in its review and approval of the proposed Thorhild Landfill and by Waste Management of Canada (WM) in its application for approval of the proposed landfill. The comments provided herein are based on our review of that administrative record and our expertise and more than 40 years of experience in reviewing potential impacts of municipal solid waste (MSW) landfills in the USA, Canada, and several other countries on public health and environmental quality. In addition to our conduct of university-based research on landfill liners and landfill impacts, on-going review of the professional literature, and review of more than 80 landfills for their existing or potential impacts on public health and the environment, we have developed about 100 professional papers and reports on the results of our investigations of impacts of MSW landfills. Many of those papers and reports are available as downloadable files from our website, www.gfredlee.com, in the "Landfills Groundwater Section" at http://www.gfredlee.com/plandfil2.htm. Additional information on our qualifications to present this review of information provided in the Alberta Environment Approval of the Waste Management of Canada application for the Thorhild Class II Municipal/Industrial Landfill is appended to these comments.

In 2009 we conducted a detailed review of the WP application for development of the Thorhild Landfill that was filed with Thorhild County; our review included a site visit, examination of the WM application, and review of the hydrogeology/hydrology of the area of the proposed landfill as reported in:

> WorleyParsons, "Hydrogeological Review of Proposed Landfill Facility, Thorhild County, NW 18 & 19-61-20 W4M," Report submitted to the Concerned Citizens of Thorhild County, Alberta, Canada, April 23 (2009).
> http://www.gfredlee.com/Landfills/worleyparsons_thorhild.pdf

We developed a report on our findings and presented testimony at a Thorhild County Board hearing on potential impacts of the proposed landfill. Our report and PowerPoint slides covering our findings are available as:

> Lee, G. F., "Summary of Comments on Waste Management's Thorhild Landfill Re-Zoning Application Binder," PowerPoint Slide Presentation to Thorhild County Council, Alberta, CAN, April 24 (2009).
> http://www.gfredlee.com/Landfills/Thorhild-Powerpoint.pdf
>
> Lee, G. F., "Comments on Waste Management's Thorhild Landfill Re-Zoning Application Binder Dated February 2009," Report to Concerned Citizens of Thorhild County, Alberta, CAN, submitted by G. Fred Lee & Associates, El Macero, CA, April 24 (2009). http://www.gfredlee.com/Landfills/CommentsWMThorhildLF.pdf

The Thorhild Landfill proposal that WM filed with and approved by Alberta Environment is essentially the same as that which had been filed by WM in its application to Thorhild County. With few exceptions the comments we made on technical deficiencies in the proposed siting, design, operation, closure, and postclosure care, cited above, are applicable to the Thorhild Landfill application filed with Alberta Environment.

During our 2009 review of the WM proposed Thorhild Landfill we reviewed the Alberta Environment Landfill Standards and found that those regulations were badly out-of-date with respect to incorporating the current state of the professional literature on the ability of landfill liners to protect groundwater from pollution by landfill leachate for as long as the wastes in an MSW landfill will be a threat to generate leachate that can pollute groundwater. Subsequent to our review of the proposed Thorhild Landfill we became aware that the Province of Alberta Environment Alberta was preparing updated landfilling regulations. On our own initiative without support we prepared the following comments on the draft regulations:

> Lee, G. F., and Jones-Lee, A., "Comments on Environment Alberta's 'Consultation Draft' of 'Standards for Landfills in Alberta," Report of G. Fred Lee & Associates, El Macero, CA, Submitted to Environment Alberta, Edmonton, Alberta, Canada, September (2009). http://www.gfredlee.com/Landfills/EnvAlbertaDraftLF.pdf

These comments were prepared to assist Alberta Environment in becoming familiar with the current professional literature on landfill containment and monitoring systems to prevent releases of hazardous and deleterious chemicals that are a threat to public health, groundwater resources and the environment for as long as the wastes in a current "dry tomb" type landfill will be a threat.

Over the past two decades we have develop a well-referenced overview of potential public health and environmental quality concerns associated with lined ("dry tomb") landfills of the type being permitted in the US and elsewhere. That review discusses issues of proposed siting, design, closure, and postclosure care (monitoring and maintenance) to provide protection of public health and environmental quality, and is periodically updated as new information on these issues emerges. The current version of this "Flawed Technology" review is available as:

> Lee, G. F., and Jones-Lee, A., "Flawed Technology of Subtitle D Landfilling of Municipal Solid Waste," Report of G. Fred Lee & Associates, El Macero, CA, December (2004). Updated July (2011).
> http://www.gfredlee.com/Landfills/SubtitleDFlawedTechnPap.pdf

It contains comments on public health/environmental quality protection aspects of technical elements of the Alberta Environment proposed revised landfill regulations, including the following excerpt:

"Comments on Environment Alberta July 1, 2009 Draft Standards for Landfills.
The Canadian Province of Alberta proposed to update its landfilling regulations. Lee and Jones-Lee (2009f) commented on the deficiencies in the proposed regulations as follows.

- *25 year Post-closure period is grossly inadequate to protect public health, groundwater and surface water quality and the interests of those in the sphere of influence of the landfill.*
- *Leachate composition not reliable to determine duration of post-closure period for landfill monitoring and maintenance. Draft regulations should specify that the postclosure period for landfill shall be for as long as the waste in the landfill can potentially generate leachate that can pollute groundwater or surface waters.*
- *Clay liners and natural clay deposits specified in draft regulations not protective of groundwater quality for as long as the wastes in the landfill can generate leachate. The specified clay deposits and packed clay liners only delay when groundwater pollution occurs, they do not prevent it.*
- *Groundwater monitoring wells spaced up to 200 metres apart at the compliance boundary will have a low probability of detecting leachate polluted groundwater when it first reaches the compliance boundary. Should use double composite liner with leak detection layer between the composite liners. When leachate found in the leak detection layer the landfill cover needs to be improved to stop leachate from entering the leak detection layer.*
- *30 metres of buffer land between the landfill waste footprint and adjacent property lines is grossly inadequate to prevent trespass of waste derived materials and landfill gas including odors on to adjacent properties. This highly limited amount of buffer land will be a health threat to those who own/use adjacent and nearby properties. At least a mile (several kilometers) of buffer land should exist between where the wastes are deposited and adjacent property lines.*
- *Landfill gas subsurface migration should recognize that subsurface landfill gas migration can be a significant cause of groundwater pollution including up groundwater flow direction from the landfill.*
- *Surface water quality monitoring should continue for as long as the wastes in the landfill can generate leachate when contacted by water to detect when seeps (breakout) leachate occurs from the sides of the above the ground surface of the landfill.*

- *The end of the Post-Closure Period report shall contain the detailed results of the studies that were conducted to show that the wastes in the landfill no longer have the potential to generate leachate when contacted by water.*

In February 2010 Alberta released its updated landfilling regulation where essentially none of the deficiencies listed above have been addressed. It is disappointing that a governmental agency in a developed country would propose such obviously deficient updated landfill regulation."

The Flawed Technology review provides detailed information, with citations to the professional literature, on the need to consider and implement appropriate landfill siting, design, operation, closure, and postclosure care specifications in developing new or expanded MSW landfills.

Alberta Landfill Standards

The current Alberta Landfilling regulations are available on the Internet as "Standards for Landfills in Alberta" (Standards) dated February 2010 at:
http://environment.gov.ab.ca/info/library/7316.pdf.

The Foreword for those Standards states:
"Alberta Environment is updating its waste management regulatory requirements. It is anticipated that the new regulatory requirements will be in place for all landfills by 2011."

The Standards state on page iv:
"Application of the Standards for Landfills
The Alberta Standards for Landfills (Standards) outline the ***minimum*** *requirements for development, operation, monitoring, closure and post-closure of Class I, Class II, and Class III landfills. The Standards are intended to provide public assurance regarding the protection of groundwater and surface water, and the appropriate management of nuisances associated with landfill development."* [emphasis added]

Proper Interpretation of Alberta's Minimum Landfill Standards

By establishing the minimum landfill standards the standards should not be interpreted to mean that landfills that only meet the specified minimum standards will be protective of groundwater resources and public health at all locations. Indeed, specification of minimum design that may be allowed at some site where there is natural protection of groundwater quality acknowledges that additional elements/specifications for design and postclosure care of a landfill will be needed to provide protection of public health and groundwater quality at some locations. If Alberta Environment had intended to imply that the specified minimum standards would be protective at all locations it would not have specified the February 2010 Landfill Standards as "minimum" but rather simply as the requirements applicable to all landfills independent of the characteristics of the landfill location.

Requirements for Public Health and Environmental Protection in Alberta

The "Environmental Protection and Enhancement Act, Revised Statutes of Alberta 2000, Chapter E-12 Current as of November 1, 2010" http://www.qp.alberta.ca/documents/Acts/E12.pdf sets forth the overall requirements for environmental protection in the Province of Alberta. Those requirements, which are applicable to landfills, include the following definitions and provisions:

"Definitions

p. 9 *(b) "adverse effect" means impairment of or damage to the environment, human health or safety or property;*

p.10 *(l) "conservation" means, except in sections 22 to 24, the planning, management and implementation of an activity with the objective of protecting the essential physical, chemical and biological characteristics of the environment against degradation;*

p.11 *(t) "environment" means the components of the earth and includes*
(i) air, land and water,
(ii) all layers of the atmosphere,
(iii) all organic and inorganic matter and living organisms, and
(iv) the interacting natural systems that include components referred to in subclauses (i) to (iii);

p.11 *(y) "groundwater" means all water under the surface of the ground;*

p.21-22
2 The purpose of this Act is to support and promote the protection, enhancement and wise use of the environment while recognizing the following:
(a) the protection of the environment is essential to the integrity of ecosystems and human health and to the well-being of society;
(b) the need for Alberta's economic growth and prosperity in an environmentally responsible manner and the need to integrate environmental protection and economic decisions in the earliest stages of planning;
(c) the principle of sustainable development, which ensures that the use of resources and the environment today does not impair prospects for their use by future generations;
(d) the importance of preventing and mitigating the environmental impact of development and of government policies, programs and decisions;
(e) the need for Government leadership in areas of environmental research, technology and protection standards;
(f) the shared responsibility of all Alberta citizens for ensuring the protection, enhancement and wise use of the environment through individual actions;
(g) the opportunities made available through this Act for citizens to provide advice on decisions affecting the environment;
(h) the responsibility to work co-operatively with governments of other jurisdictions to prevent and minimize transboundary environmental impacts;
(i) the responsibility of polluters to pay for the costs of their actions;
(j) the important role of comprehensive and responsive action in administering this Act.

The *Water Act http://environment.alberta.ca/02206.html*
"Alberta has significantly updated its water legislation, to better manage and protect its water and to streamline water-related administrative processes.

Key features of the Water Act:

- *Protect existing water licences in good standing*
- *Protect existing traditional agricultural uses of water through a grandfather clause*
- *Recognize the priority of household water use as a statutory right*
- *Ensure sustainability of Alberta's water by requiring a provincial water management planning framework*
- *Allow for water management plans to be developed to address local and regional issues*
- *Recognize the importance of protecting Alberta's rivers, streams, lakes and wetlands, by requiring that a strategy for the aquatic environment be developed as part of the provincial water management planning framework*

It is clear from the foregoing provisions of the Environmental Protection and Enhancement Act and Water Act that one of the primary goals of these Acts is to protect the water resources of the Province. Thus, while a proposed landfill such as the WM Thorhild Landfill that is proposed to be located at a highly unsuitable site without reliable natural protection of groundwater quality may meet existing minimum landfill standards, such a landfill **does not meet** the goals of the Environmental Protection and Enhancement Act and Water Act

As discussed in our 2009 comments on the WM application for the Thorhild Landfill cited above "*With respect to protecting agricultural water supplies The **County of Thorhild No. 7** Regional Groundwater Assessment Developed for Canadian Agriculture and Agri-Food Canada Prepared for Thorhild County July 1998 – stated,*
1 PROJECT OVERVIEW "Water is the lifeblood of the earth." - Anonymous
"How a county takes care of one of its most precious resources - groundwater - reflects the future wealth and health of its people. Good environmental practices are not an accident. They must include genuine foresight with knowledgeable planning. Implementation of strong practices not only commits to a better quality of life for future generations, but creates a solid base for increased economic activity. This report, even though it is preliminary in nature, is the first step in fulfilling a commitment by the County toward the management of the groundwater resource, which is a key component of the well-being of the County, and is a guide for future groundwater-related projects"

That statement reflects the importance of protecting the quality of the County's groundwater from pollution for current and future generations. The rezoning of the area of the proposed WM Thorhild Landfill will be strongly contrary to protecting the groundwater resources of the County. The WM proposed Thorhild Landfill is a significant threat to pollute the agricultural water supply for agricultural interests in the vicinity of the proposed landfill."

Alberta Environment Review of the Potential Impacts of Thorhild Landfill

One of the most important issues facing landfill regulatory agencies, such as Alberta Environment, is that landfill development companies seek to provide the minimum investment in landfill design that will result in approval of the project. As discussed in the above-referenced 2009 review of the WM-proposed landfill that was submitted to Thorhild County, and herein, WorleyParsons, **the Thorhild site is an unsuitable location for a minimum design landfill**. The unsuitability of that site for providing natural protection of the water resources of the Province, should cause Alberta Environment to critically examine the characteristics of the proposed landfill offered, to ensure protection of the environment as long as the wastes in the landfill pose a threat. The mechanical comparison of the provisions and characteristics proposed for the Thorhild Landfill with the minimum Landfill Standards, as set forth in the February 2010 Standards, as has been done in the review and approval of the proposed landfill by Alberta Environment, **is inadequate to assess, much less ensure, protection of water resources and environmental quality**. Because of the inadequacy of the review of the protective nature of the landfill relative to the characteristics of the proposed site, the Alberta Environment Appeal Board should overturn the approval of the proposed Thorhild Landfill site that was issued by the Alberta Environment.

Duration of Threat of MSW in the Thorhild Landfill

In order to evaluate the protective nature of a proposed landfill it is necessary to understand how long the wastes in an MSW landfill will be a threat to generate landfill leachate and landfill gas. The proposed Thorhild landfill would accept municipal solid wastes that are generated in households and commercial establishments as well as so-called allowed "non-hazardous wastes." There are at least three common misconceptions that obfuscate the proper assessment of the long-term threat posed by MSW landfills. First, because of the euphemistic names assigned, e.g., "municipal waste" and "non-hazardous waste," those wastes, when buried, are benign and do not represent an intrinsic threat to groundwater quality. Second, when MSW first appears "stabilized," i.e., does not show evidence of producing gas, the waste no longer poses a threat. Third, as long as the facility is "covered," "lined," and "monitored" as required by regulations (i.e., in a "dry tomb" landfill), groundwater will be protected. Despite requirements for "maintenance," landfill containment systems are subject to deterioration and breach, and many elements are buried and not amenable to thorough inspection, maintenance, and repair.

These and other misconceptions and their implications for the protection of public health and groundwater quality from MSW management practices are discussed in our "Flawed Technology" review referenced above. In short, municipal solid wastes contain a myriad common, known, unrecognized, regulated, and unregulated constituents/chemicals, which if leached into groundwater, can render the water unsuitable for domestic and other purposes. When water contacts the wastes, components can be leached from the wastes and transported to groundwater.

As discussed in our "Flawed Technology" review, the practice of MSW landfilling has evolved from open dumping usually with burning, to "sanitary landfilling" in which the MSW is covered each day with a few inches of soil, to so-called "dry tomb"-type landfilling in which the MSW is

placed in a lined landfill in an attempt to keep the wastes dry to retard the production and escape of landfill gas and leachate and to collect the leachate and gas that are produced. The protectiveness of a "dry tomb" landfill, such as the approved Thorhild Landfill, relies on keeping moisture out of the wastes; as long as the wastes are kept dry, they will not ferment and will not generate leachate. A "dry tomb" landfill will be protective only as long as the containment system keeps the wastes dry. However, keeping MSW wastes dry in a "dry tomb" landfill does not render the wastes inert/safe or unable to generate leachate or gas that can adversely affect groundwater quality. Once water comes in contact with MSW it will generate leachate and landfill gas that can leave the landfill and enter the surrounding environment. If the wastes have been kept dry for three decades, this leachate and gas production will be delayed by three decades or more. Some of the MSW is deposited in plastic bags that are crushed, but not shredded, prior to deposition, wastes protected from liquid by the plastic will not generate leachate until the plastic bag decomposes, which can be many decades to hundreds of years.

Based on observations at classical sanitary landfills, once contacted by water typical MSW has the potential to generate leachate for many decades to hundreds or thousands of years or more. Landfills sited in areas hydraulically connected to groundwater or surface water pose a threat to those resources for as long as the wastes contain leachable components. Short of fermenting and thoroughly leaching wastes prior to landfilling (as discussed in our "Flawed Technology" review), the key to developing a protective landfill in an area that does not provide for complete natural protection of the groundwaters is proper construction, maintenance, repair, and monitoring of a waste containment system that will keep the wastes dry effectively forever. That will require a landfill liner/leachate collection removal system that will collect all leachate that is generated in the landfill *ad infinitum* for removal and management/treatment to protect the environment. The Alberta landfill minimum design standards do not provide for that level of protection.

As discussed in the "Flawed Technology" review, in theory dry tomb-type landfills can be protective, however the dry tomb landfilling approach allowed by minimum design standards and regulatory agencies in Alberta, the USA, and many other countries, that employ plastic sheeting and compacted clay liners and covers at best only postpone for a relatively short period the development and escape of leachate and landfill gas. For assessing the potential threat posed by a proposed MSW dry tomb landfill, it should be presumed that the wastes in the landfill will be a threat essentially forever, and provisions made for the landfill maintenance and monitoring programs to be carried out for at least a hundred years after closure with anticipated needs beyond that. As documented in the "Flawed Technology" review it is recognized by those who have critically reviewed the properties of MSW in dry tomb landfills that today's dry tomb landfills only postpone releases of leachate and landfill gas and thus at best only postpone adverse impacts on public health, groundwater resources, and the interests of those in the sphere of influence of the landfill which can extend for several miles/kilometers from the landfill. The postponement of landfill leakage that can be achieved by meeting minimum design requirements may extend beyond the period during which landfill owners are responsible for landfill maintenance and for the damage caused by the landfills. This situation leads to justified "Not in My Backyard" (NIMBY) opposition to the siting of MSW landfills.

Inadequate Postclosure Care Period. One of the most important deficiencies in developing "dry tomb"-type landfills is the period of time during which postclosure care (landfill/groundwater monitoring and maintenance) is provided by the landfill developer. The February 2010 Alberta Landfill Standards state on page 31 in "Section 6: Final Landfill Closure and Post-Closure":
"*6.3 Post-Closure*
(a) Post-Closure shall be a minimum period of 25 years following the final landfill closure."

Today's "dry tomb" landfills can generate leachate and landfill gas for many decades to hundreds to a thousand years or more into the future; how long leachate and gas generation is postponed after closure depends on how effectively the wastes are kept dry. Under any maintenance/failure scenario, a 25-year postclosure period can be expected to be grossly inadequate to protect public health and the environment from leachate that will be released from the landfill. It is well-recognized (see the review of the literature presented in our "Flawed Technology" paper) that the postclosure monitoring and maintenance period should continue as long as the wastes in the landfill are a threat to generate leachate and landfill gas. For planning purposes it is reasonable to specify an initial minimum postclosure period of no less than a hundred years with the understanding that that period may need to be extended if the wastes in the landfill can still generate leachate when contacted by water.

In addition to the monitoring and maintenance specified, a critical element is ensuring a reliable funding mechanism for postclosure care. An MSW landfill developed with public funds can be reasonably expected to have a mechanism for providing public funds for postclosure care for as long as needed. However, there is considerable uncertainty surrounding the ability of a private landfill company to ensure the availability of sufficient funding, *ad infinitum*, for reliable, effective postclosure care for as long as the wastes in the landfill will be a threat to pollute the environment. Private landfill companies develop landfills as an income generation activity; covering the costs of postclosure care indefinitely after the landfill ceases to generate income would be expected to consume profits generated during the active life many times over. Given that reality it can be reasonably expected that the local political jurisdiction that approved the permitting of the landfill would eventually have to assume the duty of finding funding for continued post-postclosure care of the landfill in order to protect public health and environmental quality.

The key issue in developing a fully protective MSW landfill in Alberta within the regulatory parameters for siting design and limited postclosure care is a comprehensive investigation of the characteristics of the proposed location of the landfill with respect to the nature and degree of natural protection it offers for the area groundwater and surface waters from leachate-associated hazardous and otherwise detrimental chemicals for as long as the wastes in the landfill will be a threat. The February 2010 Landfill Standards do not require that a site have soil/geological strata characteristics that can be relied upon to prevent the eventual transport of pollutants from the area just outside the landfill to ground or surface waters that will be polluted by the leachate polluted groundwater. Thus just-meeting or even exceeding the allowed siting standards will not compensate for the inadequacies in the allowed landfill designs to provide reliable protection of environmental quality for as long as the wastes in the landfill will be a threat. Furthermore, the February 2010 regulations do not require the provision of adequate landfill-owned buffer lands

between sites of waste deposition and adjacent properties. The February 2010 Alberta Landfill Standards Section 3.1 Landfill Design Plan and Specifications (p 12) only specifies:
"*a minimum 30 metre separation between the waste footprint and the landfill property line;*

i.e., 30 metres between waste deposition areas and adjacent property lines. It is well-recognized that a 30-metre buffer is grossly inadequate for dissipation of releases of landfill gas, odours, and hazardous volatile chemicals on the landfill property; a landfill that just meets that requirement can be expected to adversely impact adjacent and nearby property owners and users.

Inadequate Groundwater Quality Monitoring Well Spacing. The groundwater monitoring programs allowed by the February 2010 Alberta Environment Landfill Standards are inadequate to provide reliable detection of incipient leakage of the landfill liner system that will occur as it inevitably deteriorates. This issue was discussed in our 2009 comments on deficiencies in the proposed revised Alberta Environment Landfill Standards.

The February 2010 revised Landfill Standards states in Section 5: Monitoring, Analysis and Corrective Action (page 23):
"*5.6 Groundwater Monitoring Wells*
(a) The person responsible for a new or laterally expanding landfill shall construct groundwater monitoring wells that are:
(i) no more than 200 metres from the nearest groundwater monitoring well as measured along the compliance boundary;"

Spacing of groundwater monitoring wells at 100 metres apart around the perimeter of a landfill is a highly unreliable approach for detection of the initial leakage of the landfill liner. As discussed in the "Flawed Technology" review, the initial points of failure of the landfill liner will likely produce narrow plumes of leachate-polluted groundwater that can readily pass between groundwater monitoring wells in such an array around a landfill without being detected by the monitoring wells. As a result, offsite groundwaters will be polluted by landfill leachate before it is detected in a groundwater monitoring program of the type set forth/allowed in the February 2010 Alberta Landfill Standards.

Overall Assessment of the Adequacy of Alberta Environment Landfill Standards

Overall it is clear that just meeting, or even greatly exceeding, the Alberta Environment minimum Landfill Standards cannot be relied upon to protect public health of those in the sphere of influence of the landfill, groundwater quality, or the interests of those who own or use properties near the landfill. However, as discussed in the "Flawed Technology" review, landfills for non-recyclable MSW can be developed to provide greater protection by proper siting, providing adequate buffer lands between waste disposal areas and adjacent properties, and by incorporating proper design, operation, closure, and *ad infinitum* maintenance, repair, and monitoring with proper and reliable funding. Adoption of this approach will cause the primary generators of the wastes in urban areas to pay to the true cost of proper management of their MSW, which includes reliable protection of public health and the environment.

Review and Comments on the Waste Management-Proposed Thorhild Landfill Application

Tab 1-6 Part 1 – Approval for the Thorhild Class II Municipal/Industrial Landfill EPEA Application No. 001-236328 issued by the Government of Alberta – Environment on September 22, 2011 ("Tab 1-6 Part 1 document") – documents the approval and presents the "Terms and Conditions Attached to Approval" of the Landfill application. In general those Terms and Conditions are a statement of the Alberta Environment February 2010 Landfill Standards that set forth the minimum standards for developing a Class II Municipal landfill in Alberta. As discussed, nothing in those Standards precludes the incorporation of more protective aspects or elements of a Class II landfill; they set forth the minimum requirements.

In the discussion that follows reference is made to discussions of issues in our "Flawed Technology" review (referenced above) that was developed in large part in the context of the US EPA Subtitle D Landfilling regulations. To aid in understanding the discussion in that review as it pertains to the Thorhild Landfill, pertinent Alberta Environment Landfill Standards definitions provided in the Terms and Conditions Part 1: Definitions, are compared with those of the US EPA Subtitle D Landfilling regulations that are discussed in the Flawed Technology review. Page references are to the pages in the document, "Terms and Conditions Attached to Approval;" "document page" numbers refer to the pagination of the Tab 1-6 Part 1 document.

Section 1.1.2 (page 2) (document page 7)
(l) "compliance boundary" means the location or locations where measurements of groundwater quality for regulatory purposes are taken to assess the landfill's performance;
The Alberta groundwater quality compliance boundary has the same meaning as the US EPA's "Point of Compliance" for groundwater monitoring.

Section 1.1.2 (page 5) (document page 10)
(rr) "post-closure" means:
- *(i) a minimum period of 25 years following the final closure of the landfill;*
- *(ii) the groundwater quality performance standards are met at all points of compliance; and*
- *(iii) the quality and quantity of leachate and landfill gas generated at the landfill meet objectives that, in the opinion of the Director, show the landfill has stabilized;*

The US EPA's minimum postclosure period is 30 years. As discussed in the "Flawed Technology" review, it is recognized that 30 years of postclosure care is grossly inadequate. The State of California recently adopted a 100-year postclosure period as the minimum period during which postclosure care funding must be provided for MSW landfills.

Part 3: Landfill Construction (page 12) (document page 17)
Section 3.1: General
"3.1.8 The Design Plan and Specifications in 3.1.4 for any cell closure shall include, at a minimum, all of the following unless otherwise authorized in writing by the Director:
- *(a) a final clay barrier;*
  - *(i) consisting of at least 0.6 metres of clay, and*
  - *(ii) having a maximum hydraulic conductivity of $1x10^{-7}$ metres/second or less;*

(b) a subsoil layer overlying the clay barrier with a minimum thickness of 0.35 metres;
(c) a topsoil layer overlying the subsoil layer with a minimum thickness of 0.20 metres;"

As discussed in the following paper, a compacted layer of clay with a permeability of $1x10^{-7}$ metres/second (10^{-5} cm/sec) will allow rapid penetration of water.

Workman, J., and Keeble, R., "Design and Construction of Liner Systems," Chapter 5.1 IN: Christensen et al. (eds), Sanitary Landfilling: Process, Technology and Environmental Impact, Academic Press, New York, pp. 301-309 (1989). http://www.gfredlee.com/Landfills/Workman-Keeble.pdf

As discussed in our comments above and in the "Flawed Technology" review, clay layers in landfill covers will develop cracks that can allow large amounts of water to enter the wastes. As cracks develop in the clay layer, water penetration will be even more rapid than anticipated based on design permeability.

A landfill cover that just meets the Alberta Environment minimum standards is far-less effective in preventing entrance of moisture into landfilled wastes than the US EPA Subtitle D landfill cover because the former does not include a plastic sheeting layer that is required by the latter. As discussed in the "Flawed Technology" review a landfill cover that consists of only a clay layer does not provide an effective barrier to the entrance of water into the wastes where it will generate landfill leachate and gas.

Section 3.1: General (page 14) (document page 19)
"3.1.13 The approval holder shall maintain:
(a) the integrity of the landfill liners; and
(b) the integrity of the leachate collection system."

That condition is not in the Alberta Environment February 2010 Landfill Standards but rather was developed by Alberta Environment Finance and Administration Division Regulatory Approvals Centre staff; it does not reflect an understanding of the characteristics of MSW landfills. It is **impossible to achieve that condition because it is not possible to thoroughly inspect and repair a landfill liner buried under wastes**. Also it is **not possible to "maintain the integrity of the leachate collection system;"** such systems are well-known to become plugged and cannot be kept unblocked for as long as the landfilled wastes can generate leachate when contacted by water that enters the landfill through the landfill cover. **The approval of the Thorhild Landfill should be voided because that approval condition cannot be achieved.**

Section 4.3: Waste Acceptance (page 18) (document page 23)
"4.3.1 The approval holder shall not dispose of the following at the landfill:
(a) hazardous waste as defined in the Waste Control regulation (AR 192/1996), as amended;
(b) bulk liquid waste;
(c) domestic wastewater;
(d) explosives;
(e) radioactive waste;

(f) biomedical waste; and
(g) ozone depleting substances.

4.3.2 Except as provided for in 4.3.3, if any waste listed in 4.3.1 is received at the landfill, the approval holder shall remove it within seven days of receipt or such time as directed in writing by the Director.

4.3.3 The approval holder shall remove the following waste listed in 4.3.1 from designated storage areas within 365 days of acceptance:
(a) household hazardous waste; and
(b ozone depleting substances"

In the "Definitions" section of the Alberta Environmental Protection and Enhancement Act Waste Control Regulation 192/1996 referenced in Section 4.3.1 quoted above it is stated (page 5):

"(v) 'hazardous waste' means waste that has one or more of the properties described in Schedule 1, but does not include those wastes listed in Schedule 2;"

Those regulations also provide information on how Alberta defines hazardous wastes that cannot be deposited in a MSW landfill. A review of those regulations reveals that because of the way in which "hazardous waste" is defined, chemicals that can, in fact, pose a significant threat to public health, animal health, and the environment can be legally deposited in an Alberta MSW landfill without their being classified as hazardous waste. The approach that Alberta Environment has taken in defining "hazardous wastes" is similar to that taken by the US EPA. The shortcomings of the US EPA's approach to trying to exclude hazardous chemicals from MSW landfills is discussed in the "Flawed Technology" review. That critique applies also to the Alberta Environmental Protection and Enhancement Act. The Terms and Conditions set forth for the approval of the WM Thorhild Landfill do not, ensure that landfill leachate generated by that landfill will not be a significant threat to public health and the environment.

Pages 19 and 20 (document pages 24 and 25) of the Terms and Conditions state:

"Section 4.4: Nuisance Management

4.4.1 The approval holder shall implement the nuisance control procedures specified in the Operations Plan submitted with the application at a minimum, unless:
(a) otherwise specified in this approval; or
(b) otherwise directed in writing by the Director.

4.4.2 The approval holder shall take all necessary measures to control nuisances within the landfill boundary, including but not limited to:
(a) minimizing the size of the working face;
(b) compacting the waste;
(c) covering waste with soil or other alternative cover material immediately after closing at the end of each day at a minimum;
(d) establishing and maintaining litter controls to minimize the escape of fugitive waste from the landfill boundary;
(e) maintaining recycling storage areas in a clean and orderly manner;
(f) implementing dust control measures; and

(g) retrieving litter that accumulates within the landfill boundary."

Those two terms and conditions explicitly require the control of landfill odours that trespass across property lines and pollute the air on adjacent properties. It has been our experience that MSW landfills that are sited, without at least 1 to 2 kilometers of landfill-owned buffer land between where waste deposition areas and adjacent property lines, will not meet such a requirement to prevent emanation of odours onto adjacent properties. An important issue that should be addressed in the Approval is how this, and other, terms and conditions be enforced and what will be the consequence to the landfill owner if/when offsite odours occur.

Page 26 (document page 31) presents *"Table 4.10-B: Leachate Monitoring and Reporting Requirements."* That table of required monitoring parameters should be expanded to include low-molecular-weight chlorinated VOCs since they are present in MSW leachate and represent a significant threat of penetrating the liner and polluting groundwater with hazardous chemicals.

Page 30 (document page 35) of the Terms and Conditions states:
"Section 4.11: Groundwater
4.11.1 The approval holder shall develop a revised proposal for the Groundwater Monitoring Program described in the application for the landfill which shall include, at a minimum, all of the following:
(a) any requirements set out in the Standards for Landfills in Alberta, February 2010, as amended;
(b) groundwater monitoring wells shall be constructed no more than 200 metres from the nearest groundwater monitoring well as measured along the compliance boundary;"

As discussed in the "Flawed Technology" review and as noted above, groundwater monitoring wells spaced 100 metres apart at the point of compliance are unreliable for detecting initial landfill liner leachate leakage; the spacing can be expected to allow the passage of the initial leachate leakage between the monitoring wells without being detected. Such monitoring well spacing will allow leachate-polluted groundwater to trespass onto adjacent properties and pollute domestic and animal water supplies.

Page 36 (document page 41) presents the Terms and Conditions for postclosure in Section 5.2. While postclosure monitoring and landfill maintenance is required for 25 years, that period can be extended. For reasons discussed elsewhere in these comments and in the "Flawed Technology" review, it is imprudent at best to presume that 25 years of postclosure care is sufficient to ensure protection of public health and environmental quality from the wastes buried at the Thorhild landfill. Neither the regulations nor the terms and conditions of approval, address how the determination is made, that a landfill no longer needs to be maintained without compromising public health, environmental quality, or the interests of those within the sphere of influence of the landfill. Section 5.2 should be expanded to include detailed information on the conditions that need to be met in order for postclosure monitoring and maintenance to be stopped after 25 years. That discussion should specify that the landfill owner will be required to fund appropriate postclosure monitoring and maintenance for as long as the wastes in the landfill will be a threat to generate leachate and landfill gas when contacted by water. It should also specify that the postclosure period can be ended only after representative samples of wastes taken from

the landfill demonstrate that the buried wastes no longer produce leachate and/or landfill gas when contacted by water. If such assurances are not incorporated into the Terms and Conditions of approval of the landfill, the approval should specify the source of funds that will be used to monitor and maintain the landfill and to remediate polluted groundwater when the landfill liner system eventually fails.

Overall, the Terms and Conditions set forth in the Alberta Environment approval of the WM-proposed Thorhild Landfill are inadequate to protect public health, groundwater and surface water resources, and the interests of those within the sphere of influence of the landfill for as long as the MSW that is proposed to be deposited in that landfill will be a threat.

Comments on Alberta Environment Review of the Proposed Thorhild Landfill Application

The Tab 1-6 Part 1 document includes a memorandum (document pages 51–55) from T. Ko, E.I.T. with the Government of Alberta Environment, Operations Northern Region, to P. Marriott, District Approvals Manager, Northern Region dated September 22, 2011 regarding "Thorhild Landfill (236328-00-00) Approval." The memorandum presents a summary of the public's Statement of Concerns (SOC) and responses to those SOCs prepared by the Alberta Environment Operations Northern Region staff member T. Ko. That memorandum began:

"Background
Waste Management of Canada Corporation (WM) proposed the construction of a new Class II landfill in the County of Thorhild. The proposed facility will accept an approximate average of 500,000 tonnes of waste per year, over a lifespan of approximately 40 years."

Excerpts from SOCs and the staff responses are presented below, along with our discussion of adequacy and reliability of the responses by the Alberta Environment. At best, the responses given are shallow and naïve; they do not recognize the legitimacy of the concerns or reflect any understanding of the realities and limitations of the landfill siting, design, operation, maintenance, monitoring provisions or conditions, or of the long-term (*ad infinitum*) threat posed by landfill leachate to public health and environmental quality.

One of the most significant deficiencies in the responses of Alberta Environment staff to the public concerns is their failure to appropriately address the impacts of the WM-proposed Thorhild Landfill on public health, groundwater/surface water quality, and the environment for as long as the wastes in the landfill will be a threat. The landfill containment system (liner and cover) will not function as designed indefinitely; even if installation has been flawless, it will deteriorate over time and will not be amenable to rigorous inspection and repair. As the containment system deteriorates, it will allow entrance of increasing amounts of moisture, which will allow generation of leachate and gas, and will allow leakage of leachate and gas. The containment system may be capable of postponing the entrance of sufficient moisture to generate detectable leachate leakage for some time after closure, perhaps decades. It can be anticipated, however, that there will be failure of the landfill containment system that will result in release of hazardous and deleterious chemicals to the environment at some time in the future.

Based on the information provided, the proposed site for this landfill does not provide for natural protection of the onsite and offsite groundwater from pollution by landfill leachate, that will be released as the landfill liner fails to collect all the leachate generated in the landfill. The proposed siting, design, closure, and postclosure care elements of the Thorhild Landfill are essentially the minimum allowed in the February 2010 Alberta Landfill Standards. As discussed above and in the "Flawed Technology" review, a landfill with these characteristics will eventually fail to protect public health, groundwater resources, and the interests of those in the sphere of influence of the landfill. Many of these issues were discussed (referenced above) of the proposed Thorhild Landfill and are reviewed further herein.

With WM's only proposing, and Alberta Environment's requiring, postclosure care (monitoring/maintenance) for only 25 years after closure of the landfill, and given that the wastes in that landfill would be a threat to public health and the environment for hundreds of years or more, the public has the right to know how Alberta Environment will address these issues and fund their remediation after the end of the postclosure period. Future generations will want and need clean water near the landfill forever. Will Alberta Environment, Thorhild County or some other entity provide the postclosure funding for as long as the wastes in this landfill will be a threat? These are issues that Alberta Environment should have addressed in reviewing/ approving this landfill.

Beginning on page 2 of the September 22, 2011 Ko memorandum (document page 52):
"To address Concern #1 – Landfill liners leak
The design of the landfill cells proposed by Waste Management meets the requirements set out in the Standards for Landfills in Alberta, February 2010 (the Standards). The requirement of the Standards for a composite liner is a geo-membrane placed directly on the surface of a liner that is comprised of earthen material with a hydraulic conductivity of less than 1 x 10^{-9} metres per second compacted to a thickness of not less than 0.6 metres, measured perpendicular to the slope, or an alternative design of equivalent performance."
"… The groundwater monitoring system will provide early warning should there be issues with the liner and leachate collection system performance, and the results of the monitoring submitted to AENV for review in the annual report."

The "response" offered by Mr. Ko to the public's concern that all "landfill liners leak" is non-responsive. It merely reiterates design requirements, states that documents must be "signed and stamped," claims unfeasible capabilities of WP to prevent leachate buildup on the liner, and touts unrealistic expectations of the groundwater monitoring system. The response fails to acknowledge, much less address, the justifiable concern of the public whose groundwater can be polluted by leakage of the Thorhild Landfill. The people who depend on the groundwater and associated surface waters that are hydraulically connected to the landfill area as a water supply, want to be certain that their groundwater supply will not be polluted by the proposed landfill. Mr. Ko's response to this concern by citing the minimum design of landfill liners set forth in the February 2010 Landfill Standards does not address the issue. First, and most important, the minimum design for a landfill liner does not ensure that the Thorhild Landfill will not pollute the groundwater in the vicinity of the landfill through landfill liner leakage for as long as the buried wastes represent a threat.

The technically valid response to the public's SOC that "landfill liners leak" should be that since the proposed site for the Thorhild Landfill does not provide for natural protection for as long as the wastes in that proposed dry tomb-type landfill (with a single-composite liner, landfill cover that will allow water to enter the landfilled wastes, groundwater monitoring wells spaced up to 200 metres apart around the landfill and without postclosure assured funding for as long as the wastes in this landfill will be a threat) will be a threat, the proposed landfill **is not approved**.

Based on my undergraduate and graduate degrees in public health and environmental engineering and more than 50 years of professional experience in reviewing the potential impacts of MSW landfills, the approach that Alberta Environment staff took in reviewing the potential public health, water resource and other impacts of the WM proposed Thorhild Landfill, based on a mechanical comparison to Alberta Landfill Standards, is strongly contrary to public health and engineering practice. The Alberta Environmental Appeal Board must reverse the approval of the proposed Thorhild Landfill to protect the public's health, water supply water quality and interests.

The Tab 1-6 Part 1 document (document page 58) presents a letter of transmittal for an application for a Development Permit for the Proposed Thorhild Landfill Project to the Thorhild County dated March 31, 2010; document page 59 presents a March 31, 2010 letter of transmittal of the "WMCC Thorhild Landfill Project Application for Regulatory Authorization March 2010" sent to the Regulatory Approvals Center.

The "WMCC Thorhild Landfill Project Application for Regulatory Authorization March 2010" provides a summary of the characteristics of the proposed landfill. Some of key issues of concern with respect to evaluation of the potential protective nature of the proposed landfill include the following:
In Section 11.0 Waste Footprint and Leachate Pond Design and Construction (page 37 – document page 106) it is stated:
"The design report includes lining, capping, leachate collection and construction aspects of the Waste Footprint, and lining and construction aspects of the leachate pond. The key findings in that report may be summarized as follows:

- *the design intent is to meet or exceed the criteria prescribed in the Standards for Landfills, and to be consistent with good industry practices;*
- *the design report of the Waste Footprint describes the following:"*
  - *"lining: the design incorporates a composite lining system comprising compacted clay and an overlying geomembrane"*
  - *"final cover: the design incorporates an earthen cap overlain by subsoil and topsoil placed to support vegetation;"*

The summary of the proposed liner design describes a single composite liner, which is the minimum allowed for this type of liner as set forth on page 13 of the "Standards for Landfills in Alberta dated February 2010 as follows:
"*3.2 Design of a Class II Landfill*
(a) In addition to the requirements in section 3.1, the Landfill Design Plan and Specifications for the construction of a new or laterally expanding Class II Landfill shall include, at a minimum, all of the following:

(i) a liner; and
(ii) a leachate collection system capable of maintaining the maximum acceptable leachate head."

and on page 14 in Section 3.5 Construction:

(d) If the new landfill, laterally expanding landfill or landfill cell is to be constructed with a composite liner, the composite liner shall be constructed with a geomembrane placed directly on the surface of:
(i) a liner that is comprised of earthen material with a hydraulic conductivity of less than 1 x 10^{-9} metres/second compacted to a thickness of not less than 0.6 metres, measured perpendicular to the slope, or
(ii) a liner that is comprised of earthen materials with a hydraulic conductivity greater than 1 x 10^{-9} metres/second compacted to a thickness greater than 0.6 metres that will achieve an equivalent advective performance to 3.5(d)(i), or
(iii) a liner that is comprised of a geosynthetic clay liner and earthen material compacted to a thickness of not less than 0.6 metres, measured perpendicular to the slope, that will achieve a combined equivalent advective performance to 3.5(d)(i).

These specifications for a composite liner are the same as the single composite liner discussed in the "Flawed Technology" review. As discussed there, it is well-known that at best such a landfill liner design only postpones the passage of landfill leachate out of the landfill to pollute the underlying groundwater. A number of states in the USA will not allow the development of a MSW landfill with such a liner design because it will not be protective of groundwater quality.

The County of Thorhild "Development Permit for a Class II Private Landfill and Wetland Restoration" submitted by Waste Management of Canada, March 2010, states (Tab 94-96 page 16591):
"The following development is approved:
Class II landfill with double synthetic liner with leak detection plus clay liner together with Wetland Construction and Peatland Restoration"

The design of the "double synthetic liner with leak detection plus clay liner" is not provided. From the description given, however, the design is not a true double-composite liner of the type discussed in the "Flawed Technology" review. As discussed in the "Flawed Technology" review, a synthetic liner that does not have a clay backing that is in intimate contact with the plastic sheeting liner can leak at a very high rate. Further, the landfill can produce leachate for very long period of time, well-beyond the 25-year postclosure period; the County has not discussed who will be monitoring the leak detection system after the end of the required postclosure period and what will be done when leachate is found in the leak detection layer. These are key elements that significantly affect the effectiveness of a double-composite liner system for as long as the wastes in the landfill will be a threat to generate leachate.

The SOC response's claim regarding groundwater monitoring: "*The groundwater monitoring system will provide early warning should there be issues with the liner and leachate collection system performance, and the results of the monitoring submitted to AENV for review in the annual report."* is technically invalid and reflects a lack of understanding of the nature of leachate leakage and groundwater monitoring. The system proposed and accepted for the Thorhild Landfill – with monitoring wells spaced at the 200-metre maximum allowed by the

Landfill Standards or as specified by the Thorhild County in its permit of 100 metres apart– is grossly inadequate to detect the initial failure of the liner system to contain leachate. As discussed the "Flawed Technology" review summarized above, the initial leakage of the single-composite liner will produce finger-like plumes with limited lateral dimension that can readily pass undetected between the monitoring wells. The monitoring wells will only sample groundwater at about 1 foot on each side of the well. With monitoring wells spaced up to 100 metres apart there is a very large distance between wells where leachate-polluted groundwater can pass without be detected. It is well-recognized that such a monitoring approach is unreliable for detecting leachate-polluted groundwater before it trespasses onto adjacent property.

Page 3 September 22, 2011 Ko memorandum (document page 53) states:
"To address Concern # 2 – Impact to groundwater supply
The landfill has been sited on lands which were deemed suitable for the development of a landfill in accordance with the Standards. Areas of geologic uncertainty require further investigation by Waste Management and the design of the landfill will have to be altered if the investigation reveals conditions which are not consistent with the application prior to construction. The landfill cell design submitted in the application meet the requirements of the Standards. Waste Management is required to actively manage their leachate."

Again, the "response" is non-responsive to the expressed concern. In response to the concern about the impacts of the landfill on groundwater supply, Mr. Ko simply repeated elements of the "Standards" and acknowledged inadequate existing information on the suitability of the site for protection of groundwater quality from this landfill.

To assume, as the response did, that the proposed site is suitable for an MSW landfill on the basis that it meets the minimum landfill siting standards, reflects a lack of understanding of the landfill functioning, the nature of geologic systems, and how the minimum location standards should be evaluated in light of a particular landfill application for the protection of environmental quality. A proper engineering evaluation of the suitability of a location for a minimum-design MSW landfill with only a single-composite liner of the type that WM proposes to construct at the Thorhild location, would involve determination of whether the location provides natural protection of groundwater quality when the landfill liner eventually fails to collect all leachate and allows some of it to pass through the liner into the underlying groundwater system. As discussed in our evaluation of the hydrogeology of the proposed location of the Thorhild Landfill, the groundwater system under that proposed landfill does not provide natural protection that would prevent leachate-polluted groundwater that develops under the landfill from polluting the groundwaters of the area, including those groundwaters under adjacent and nearby properties. While as discussed in our comments and the comments of WorleyParsons, "Hydrogeological Review of Proposed Landfill Facility, Thorhild County, NW 18 & 19-61-20 W4M" referenced above – and, indeed, acknowledged in the "response" to the SOC – there is need for further investigation of the site. If properly conducted, further investigation by WM of the location will confirm that the site is highly unsuitable for the proposed landfill with the proposed design and other characteristics because of the characteristics of the groundwater system under and near the site.

Page 3 September 22, 2011 Ko memorandum (document page 53) states:

"To address Concern# 3 -Impact to surface water
The landfill has been designed with leachate management systems and run-off control system. As part of the run-off control system, the storm-water management ponds have been designed as controlled release facilities. The ponds must be manually pumped into the drainage paths, and the water must be tested prior to release."

To address Concern# 4 -Impact to aquatic life
The landfill site has been designed with a run-off control system. The storm-water ponds have been designed to be manual release only. Releases may not occur prior to testing of the water and may only discharge if the water meets the criteria in the Surface Water Quality Guidelines for Use in Alberta. It has been determined that the landfill will not have an impact on Waskatenau Creek, which is considered to be a Class C fish bearing watercourse having moderate to low fisheries value."

Once again, Mr. Ko's "responses" do not address the issues raised in the concerns, they merely state elements of the landfill design. They do not address the fact that leachate-polluted groundwater that will inevitably and undeniably occur under this proposed landfill, will transport waste-associated chemicals to surface waters where it can be adverse to aquatic life. They also fail to address the inevitable occurrence after the postclosure period of landfill leachate seeps through the above-ground surface of the landfill and its runoff into surface waters, or the responsibility for monitoring runoff for as long as the wastes in landfill can produce leachate.

Page 3 September 22, 2011 Ko memorandum (document page 53) states:
"To address Concern # 7 – Increased Vectors and Nuisances
Waste Management is required to operate the landfill in accordance with their operations plan. The operations plan includes management of vectors and nuisances through practices such as fencing, use of daily covers, wind screens, litter retrieval, odour suppressants, dust suppression, bird deterrents, etc. The use of these best management practices will help reduce vectors and nuisances."
and
"To address Concern# 8 – Air Pollution
"Waste Management will implement a landfill gas collection and flaring system once it is feasible. The practices set out in the Operations Plan will help reduce dust and odours. The issue of vehicle pollution is not in the Director's jurisdiction. There are no other known emission sources expected at the landfill."

Again, Mr. Ko does not address the concerns in his responses. Further, it appears that Mr. Ko has failed to read and/or reliably report on the Terms and Conditions that Alberta Environment has imposed on this landfill for the control of nuisances such as offsite odours. As discussed above, "Section 4.4: Nuisance Management" of the Terms and Conditions states (page 20) (document page 25) state:

"4.4.2 The approval holder shall take all necessary measures to control nuisances within the landfill boundary".

Any offsite odours at the adjacent property line will be a violation of that condition. It is not a matter of practices set forth to "help reduce dust and odours" indicated by Mr. Ko; the issue

is achieving effective control odours, so that they do not trespass onto adjacent property, as set forth in the Terms and Conditions, and what the public's recourse and the consequences will be to Waste Management for failing to meet that condition.

Page 4 September 22, 2011 Ko memorandum (document page 54) states:
"*To address Concern# 10 – Site is Unsuitable*
The landfill has been sited on lands which were deemed suitable for the development of a landfill in accordance with the Standards. Areas of geologic uncertainty require further investigation by Waste Management and the design of the landfill will have to be altered if the investigation reveals conditions which are not consistent with the application prior to construction."

Again Mr. Ko has failed to address the issue, but rather has responded by claiming that it has been "deemed suitable" while at the same time acknowledging that the site has been inadequately investigated. His response does not reflect proper analysis or understanding of the characteristics of the proposed Thorhild Landfill location, or the ability of the WM-proposed landfill containment system design, to meet the overall requirements of Alberta's Environmental Protection and Enhancement and the Water Act, cited above to protect public health and the environment, from adverse impacts of projects, such as landfills. There is no time limitation on those requirements, i.e., environmental protection must be afforded forever. A claim that the minimum Landfill Standards as set forth in the February 2010 standards ensure protection, defies the basic principles of public health and environmental protection.

As is documented in our comments on the hydrogeology of the area under the proposed landfill, as well as in the comments of WorleyParsons cited above, the proposed landfill site does not provide for natural protection of groundwater and surface water quality, but rather will allow leachate-polluted groundwater to trespass to adjacent properties. Since the WM-proposed design of the Thorhild Landfill will not prevent leachate from passing through the liner, the site is not suitable for this landfill. A proper analysis of the characteristics of the site relative to the proposed landfill design will show that the proposed landfill should not be approved for development.

Page 4 September 22, 2011 Ko memorandum (document page 54) states:
"*To address Concern# 12 – Waste Acceptance Procedures are Inadequate*
The waste acceptance procedures are included as part of the operations plan. Special wastes must be handled in accordance with any guidelines available for that material (ie. sulphur, asbestos, etc.). Landfill can only accept materials which are non-hazardous. Landfill operators are trained to detect and remove unacceptable material from the landfill cell, as is common practice at all landfills in the province."

Yet again, this "response" is non-responsive; to the concern of the inadequacy of the procedures, Mr. Ko simply replies that the procedures are included in the plan, and expresses a lack of understanding of the classifications of materials and the ability of landfill operators to "detect and remove" all unacceptable material.

The setting of the Terms and Conditions of the approval of the WM Thorhild Landfill does not prevent the development or leakage of leachate that will pose a significant threat to public health and the environment. The prohibition of acceptance of what are classified as "hazardous wastes" is not the same as prohibition of acceptance of "hazardous chemicals;" it is astounding that Mr. Ko's response does not recognize that difference. The Terms and Conditions allow acceptance at and deposition in the Thorhild Landfill of what are known to be hazardous chemicals and materials that are typically present in MSW waste streams. Furthermore, the Alberta Environmental Protection and Enhancement Act does not address, much less preclude from disposal, the large number of unregulated but nonetheless hazardous and potentially hazardous chemicals and materials that are also routinely present in MSW waste streams. Even flawless execution of "training", by landfill operators, will not result in the exclusion of hazardous chemicals and materials that are legally allowed into the landfill. Mr. Ko has provided highly unreliable information in his response to the SOC raised by the public concerning the types of wastes that can be accepted in the Thorhild Landfill, that will cause the leachate and gas generated in that landfill to be hazardous to public health and the environment.

Page 4 September 22, 2011 Ko memorandum (document page 54) states:
"*To address Concern# 16 – Health Effects*
The proposed landfill design meets the requirements of the Standards and an operations plan was submitted as part of the application. The landfill liner system will prevent groundwater contamination, the run off control system will prevent surface water contamination, while the operations plan will prevent the increase in vectors and nuisances. Direct impacts to health are unlikely to occur from this facility."

Mr. Ko's assessment that meeting the minimum Landfill Standards will be protective and ensure public health protection, while wishful thinking, is naïve and grossly misleading. The specification of standards, as Alberta Environment has done, as "minimum standards" indicates an acknowledgement that **those standards should not be interpreted to be protective under any or all conditions or locations.** While elements of those standards may afford protection with some designs and at some locations, meeting the minimum standards does not afford protection of public health and environmental quality, from wastes buried at the proposed Thorhild Landfill at the proposed location. Mr. Ko's statement, "*The landfill liner system will prevent groundwater contamination,*" reflects a lack of familiarity with the literature on landfill liner design. These issues are discussed in detail in the "Flawed Technology" review. A reliable review of the long-term impacts of the proposed Thorhild Landfill would reveal that, there is a significant potential for the proposed landfill to adversely affect environmental quality and the public health and welfare of those who use the offsite groundwaters that have been polluted by landfill leachate.

Page 4 September 22, 2011 Ko memorandum (document page 54) states:
"To address Concern# 17 – Length of Post Closure
Waste Management will be required to monitor the landfill for a minimum of 25 years after final closure. In addition, the landfill must demonstrate that the landfill has stabilized and all groundwater quality performance standards are met before the post closure period is

considered over. The closure requirements are set out in the Standards, and Waste Management's closure plans are to be submitted to the Director 180 days prior to the ceasing of operations for authorization. In addition, Waste Management is required to maintain financial security on the site. The initial amount is $8.6M, however, this amount is to be re-evaluated on an annual basis and varied accordingly.

The public is clearly justified in raising concern about the duration of postclosure that will be required of the proposed Thorhild Landfill; the "response" offered neither addressed that concern nor reflected an understanding of the nature of landfills and the long-term threat that they can pose. The 25-yr minimum postclosure care period prescribed by the Alberta Environment Landfill Standards and applied to the proposed Thorhild Landfill, is an infinitesimal portion of the period during which wastes in that landfill could pose a threat to public health and environmental quality.

If constructed as proposed, the landfill will be active for about 40 years. At the end of the active life, WM would begin postclosure for those areas of the landfill that had not been previously closed. This means that in approximately 65 years, there could be need to find funds to continue postclosure monitoring, maintenance, and remediation of polluted groundwater. Since WM will have derived no income from the landfill during the 25 years after landfill closure, it will likely be very difficult to get WM to continue to fund postclosure activities that continue to be needed to protect public health and environmental quality. It is even appropriate to inquire as to what guarantees exist that WM will still be in business at that time. Private garbage companies like WM are amassing very large financial obligations for postclosure care of all the landfills they are operating. As discussed in the "Flawed Technology" review, some financial news agencies (Barons) are predicting that garbage companies will all have to go bankrupt because of the massive liability that they are incurring; this concern will be exacerbated if the postclosure periods for their landfills are extended for as long as the wastes in the landfill are a threat. The public has the right to know how Alberta Environment will be able to secure the funds needed to continue postclosure care and groundwater remediation, once the landfill company is relieved of responsibility. Mr. Ko (Alberta Environment) should have addressed this issue in his response to the public's statement of concern about long-term funding, rather than simply repeating the minimum requirements specified in the Alberta Landfill standards.

The Flawed Technology review presents statements made by individuals knowledgeable on this issue expressing concern about the limited minimum postclosure period of 30 years in the US; certainly the shorter minimum included in Alberta standards is grossly inadequate. As indicated by Skinner, current Executive Director of Solid Waste Association of North America (SWANA) on pg.16 of the July/August 2001 MSW Management Journal, *"The problem with the dry-tomb approach to landfill design is that it leaves the waste in an active state for a very long period of time. If in the future there is a breach in the cap or a break in the liner and liquids enter the landfill, degradation would start and leachate and gas would be generated. Therefore, dry-tomb landfills need to be monitored and maintained for very long periods of time (some say perpetually), and someone needs to be responsible for*

stepping in and taking corrective action when a problem is detected. The federal Subtitle D rules require only 30 years of post-closure monitoring by the landfill operator, however, and do not require the operator to set aside funds for future corrective action. Given the many difficulties of ensuring and funding perpetual care by the landfill operator, the responsibility of responding to long-term problems at dry-tomb landfills will fall on future generations, and the funding requirements could quite likely fall on state and local governments."

Hickman (1992, 1995, 1997) former executive director of SWANA and Hickman and Lanier (1998), in a series of articles ("Financial Assurance-Will the Check Bounce?", "Ticking Time Bombs?", "No Guarantee," "A Broken Promise Reversing 35 Years of Progress"), have discussed inadequacies in approaches for postclosure funding allowed in the USA, under US EPA Subtitle D regulations. The "Flawed Technology" review quotes several other statements by officials in governmental agencies, including the US Congress General Accountability Office, on the inadequate requirements for assured postclosure funding for Subtitle D landfills. While these problems have been well-understood for more than two decades, the US Congress and the US EPA have still not corrected this very significant deficiency in Subtitle D landfilling requirements.

Hickman, L., "Financial Assurance-Will the Check Bounce?" Municipal Solid Waste News, March (1992).

Hickman, L., "Ticking Time Bombs?" Municipal Solid Waste News, Solid Waste Association of North America, March (1995).

Hickman, L., "No Guarantee," Waste News 2(35):1 (1997).
http://www.gfredlee.com/plandfil2.htm#postclosure

Hickman, H. Lanier, Jr., "A Broken Promise Reversing 35 Years of Progress," MSW Management, 8(4) :78 July/August (1998).
http://www.gfredlee.com/plandfil2.htm#postclosure

In our writings on this issue, we suggest that one way to address the "post-postclosure" care funding dilemma, is to elevate the price of waste management so that those who generate the garbage, pay to true and complete cost of managing the wastes to protect public health and welfare and environmental quality, for as long as the wastes in the landfill will be a threat. The fees collected for waste management should be sufficient to fund a dedicated trust of sufficient magnitude, that it could address all plausible worst-case failures of the landfill for as long as the wastes in the landfill will be a threat.

The County of Thorhild "Development Permit for a Class II Private Landfill and Wetland Restoration" submitted by Waste Management of Canada, March 2010, states (Tab 94-96 page 16595 states,

"30. The closure plan submitted as part of the development permit application shall be modified so that it is for a period of a minimum of 25 years or until it can be demonstrated by an

independent third party, to the satisfaction of the County, that the landfill no longer has the potential to generate leachate, whichever period is longer."

Mr. Ko offered the following hollow assurance with regard to meeting the need for postclosure beyond the minimum 25 years: "*In addition, the landfill must demonstrate that the landfill has stabilized and all groundwater quality performance standards are met before the post closure period is considered over."* Neither the landfilling regulations and the Terms and Conditions nor Mr. Ko's (Government of Alberta) responses to SOCs raised by the public address how Alberta Environment will determine that the landfill has demonstrated "*that the landfill has stabilized and all groundwater quality performance standards are met"* and hence *"the post closure period is considered over."* The Thorhild County permit requirements quoted above also do not specify how the end of the minimum 25 year postclosure period is to be determined. Meeting AENV groundwater quality performance standards during the postclosure period does not mean that leachate will not be generated and pollute groundwater at some time in the future; burial in a landfill does not serve to detoxify wastes or render their leachate safe. Even after hundreds of years, wastes in a dry tomb-type landfill can still generate leachate when contacted by water that will pollute groundwater at some time in the future.

As discussed in the "Flawed Technology" review, WM North America staff has tried to convince regulatory agencies, contrary to reason and technical foundation, that if no leachate is being generated after a given postclosure period, a landfill no longer needs postclosure care. As discussed in the "Flawed Technology" review, leachate generation is controlled largely by the integrity of the cover. If no water enters the landfill, no leachate will be generated. However, the wastes do not lose their ability to generate leachate when contacted by waters. Over time the integrity of the cover will deteriorate and water will enter the landfill and can generate leachate; the lower-permeability elements of the cover are buried and not amenable to rigorous inspection and repair. The first evidence of cover failure is the appearance of leachate. The staff of CalRecycle, the California solid waste management agency (formerly called the California Integrated Waste Management Board) has pointed out the unreliability of WM approach for evaluating when postclosure care can be stopped. CalRecycle recently adopted regulations that require an assured postclosure funding period of a minimum of 100 years, subject to extension. That requirement was adopted over the objections of WM and other private garbage companies.

Overall, the proposed Thorhild Landfill should not be allowed to operate without a clear commitment of WM to provide all needed postclosure care with assured funding for as long as the wastes in the landfill will be a threat. This is to be determined by taking samples of the landfilled wastes from the closed landfill and exposing them to water to determine if they can generate leachate and or landfill gas.

As discussed in a subsequent section the $8.6 million financial security will not be sufficient to maintain the cover of the landfill to prevent water from entering the landfill. Funds will be needed to install and maintain a plastic sheeting layer in the cover to be an effective barrier to water entering the wastes.

Overall the Alberta Environment, through Mr. Ko's responses to the public's concerns by simply restating the minimum requirements in Alberta's Landfill Standards, without discussing the significant deficiencies in the minimum standard when applied to a proposed landfill, that is to be located at a site that does not provide natural protection of groundwater quality, with a landfill design with minimum design that will ultimately fail to collect all the leachate that will be generated in the landfill, when water enters the wastes. Alberta Environment has failed to adequately address the public's concerns about the development of the proposed Thorhild Landfill. This is adequate justification for the Alberta Environmental Appeals Board to overturn the approval the proposed Thorhild Landfill. This is in the best interest of the people of Alberta in beginning to establish an approach for developing MSW landfills that will adequately manage the MSW developed in the Province and most important protect public health and the environment from the potential impacts of the landfill.

Comments on

"Joint Report of Administration to County of Thorhild No. 7 Development Authority – Development Permit for a Class II Landfill Submitted on Behalf of Waste Management of Canada, June 14, 2011," (Thorhild County staff report) prepared by Thorhild County staff and Norm Nuttall in response to the Waste Management application for development of its proposed Thorhild Landfill. That document states (Tab 94 page 16510):

"A Class II Landfill is defined in the Land Use Bylaw as:

'Class II Landfill' means a 'Class II Landfill' as defined in the Waste Control Regulation, except for the purposes of this Bylaw, for a bioreactor landfill as defined in this Bylaw, and further excludes the processing of hazardous waste or hazardous recyclables as those terms are defined in the Waste Control Regulation. Without limiting the foregoing, a Class II Landfill may include all, or some of, the following:

- *(a) a Cell or Cells,*
- *(b) site perimeter fencing,*
- *(c) lockable gates for site entrance and exit,*
- *(d) signage,*
- *(e) facilities for vehicle and waste weighing and auditing,*
- *(f) moveable wind screening,*
- *(g) litter-catching fencing,*
- *(h) soil stockpiling,*
- *(i) landscaped berming,*
- *(j) facilities for managing the sound, odour, and appearance of landfill operation,*
- *(k) equipment for waste spreading and compacting, as well as equipment for excavating and placing Cover,*
- *(l) Wheel Wash Facility,*
- *(m) facilities for monitoring and managing Leachate, Landfill gas, groundwater and surface water,*
- *(n) buildings and roads necessary for the operation and maintenance of, or customarily incidental and subordinate to, a Class II Landfill approved, or conditionally approved, by Alberta Environment."*

That report provides information on those characteristics as pertains to the proposed Thorhild Landfill. Comments on some of those issues are presented below. These comments are also applicable to the information presented in "Development Permit for a Class II Private Landfill and Wetland Restoration submitted by Waste Management of Canada, March 2010," dated July 14, 2011, (presented in Tab 94 beginning on tab page 16591), which is the permit issued by Thorhild County to WM for the development of the Thorhild Landfill. Additional information on the issues discussed below is provided in our comments on the AENV approval report, which are part of these comments.

Page 8 of the Thorhild County staff report (Tab 94 page 16515) states:

"*Administration recommends approval of the following use:*

Class II Landfill with a double synthetic liner with leak detection plus a clay liner subject to the following conditions:

General:…

2. The Applicant shall submit plans for the double synthetic liner with details of the leak detection system and clay liner, plus additional operational procedures for the leakage detection

system, prior to commencing construction of the Landfill. These are to be to the satisfaction of the County in accordance with the development permit approval.

3. The Applicant shall submit plans for the double synthetic liner with leak detection system and clay liner and a revised operation plan for leachate monitoring and collection, prior to commencing construction of the Landfill, to the satisfaction of the County in accordance with the development permit approval."

A double synthetic liner with clay liner is not a typical landfill liner system. No information is provided on the design of that combination of liner layers. Both WM and AENV have specified a single-composite liner for the proposed landfill liner. At this time it is not known what landfill liner design would be used at the proposed landfill.

Continuing the listing of "General" aspects of the conditions for the County Administration's recommendation for approval of the Thorhild Landfill, Page 9 of the Thorhild County staff report (Tab 94 page 16516) states:
"6. The Applicant shall provide a letter of credit to the County, on terms acceptable to the County, equal to five hundred thousand ($500,000.00) dollars to ensure compliance with the terms of this development permit and as closure security. The Applicant shall ensure that the letter of credit remains at five hundred thousand ($500,000.00) dollars and shall replenish any funds expended within thirty (30) days of receiving notice from the County that funds are required. The Letter of Credit shall remain in place until the expiration of the post-closure period."

The $500,000.00 compliance closure fund can readily be grossly inadequate to cover the closure of the landfill if WM fails to properly close the landfill. Simply closing a landfill with that funding does not ensure the funding that will be needed to conduct postclosure care and groundwater remediation for as long as the wastes in the landfill will be a threat, which can be hundreds of years.

Page 10 of the Thorhild County staff report (Tab 94 page 16517) states:
"*12.The development shall be modified to provide for adequate down-gradient wells, based on a spacing of not more than one hundred (100) metres between the wells."*

As discussed in our comments on the AENV approval report, groundwater monitoring wells spaced 100 metres apart can readily fail to detect leachate-polluted groundwater before it contaminates offsite groundwater.

Page 11 of the Thorhild County staff report (Tab 94 page 16518) states:
"22. The Closure Plan as submitted as part of the development permit application shall be modified so that it is for a period of a minimum of 25 years, or until it can be demonstrated, to the satisfaction of the County, by the Applicant that the development has stopped generating leachate, whichever period is longer."

As discussed in our comments on the AENV approval report regarding the postclosure period, this proposed approach described is not reliable for ensuring that WM will, in fact, fund

postclosure care, including remediation of the polluted groundwater that will occur at the Thorhild Landfill, over the hundreds of years that the wastes in that landfill will be a threat. As discussed in our comments on this issue, the postclosure funding period should extend for as long as the wastes in the landfill can generate leachate with contacted by water. The protocol for making that evaluation should be specified; the "satisfaction of the County" is an inadequate and unreliable determiner of the point at which the landfill no longer poses a threat.

Beginning on Page 16522 of Tab 94 is a tabulated outline of issues reportedly considered in reviewing the proposed landfill. In the "Issue" category of "Water" under the "Administration Comments" regarding "Hydrogeology" it is stated:
"Information provided is satisfactory to Administration to establish that the development of a landfill with appropriate engineering, as provided, would be acceptable."

That conclusion does not reflect understanding or a proper analysis of the hydrogeology of the area relative to the ability of the location to provide natural protection of groundwater quality for as long as the wastes in the proposed landfill will be a threat. Detailed information on this issue is provided in our comments in other sections of these comments.

Under the "Administration Comments" regarding "Groundwater" also on Page 16522 of Tab 94, it is stated:
"Information provided is satisfactory to Administration to establish that the development of a Landfall with .appropriate engineering, as provided, would be acceptable."

That conclusion also reflects an inadequate and unreliable evaluation of the ability of the proposed landfill to protect groundwater quality for as long as the wastes in the landfill will be a threat. That site does not provide natural protection of groundwater quality, and it is well-known that a containment system of the type proposed will eventually fail to prevent the passage of leachate through the liner.

Under the "Administration Comments" regarding "Groundwater" on Page 16524 of Tab 94, it is stated:
"Groundwater monitoring
Administration is of the opinion that additional down-gradient wells are required to provide adequate coverage for plume detection. As a result, Administration recommends that if an approval is granted, a condition of approval requiring that down-gradient wells be spaced no more than l00m apart should be included."

That Administrative Assessment and recommendation does not reflect a proper or reliable analysis of the ability of proposed groundwater monitoring wells, that can each only sample water within about 1 ft of the well, and spaced as proposed, to detect the initial groundwater leachate plume. The initial plume of groundwater pollution will be expected to be of a few metres' width, and as such will likely pass the monitoring well array undetected.

Overall, the Administration analysis of the ability of the proposed Thorhild Landfill to protect groundwater quality and the welfare and interests of the people of Thorhild County does not

reflect a reliable engineering evaluation of the site and landfill containment system relative to the current professional literature on the issues reviewed.

"Development Permit for a Class II Private Landfill and Wetland Restoration submitted by Waste Management of Canada, March 2010," dated July 14, 2011, (presented in Tab 94 beginning on tab page 16591) is the permit issued by Thorhild County to WM for the development of the Thorhild Landfill. That permit basically restates the issues that were discussed above relative to the Administration review of the proposed landfill. All of the comments provided above are applicable to that permit as well.

Tab 7-25 Part 1 beginning on page 2247 presents "Comments on the Engineering Aspects of Waste Management Inc.'s Application for the Rezoning of Lands to Allow the Construction and Operation of a Class 2 Landfill in the County of Thorhild." It is stated on tab page 2250:
"From the review of the Waste Management Inc. reports it is the writer's opinion that the site can be safely engineered and developed as a Class 2 landfill. Detailed design issues relating to the development of the site as a wet landfill and other detailed engineering issues will be required to be the subject of additional discussions and evaluations. Respectively Submitted, Norm Nuttall M.Sc., P. Eng. April 24, 2009"

In Tab 7 beginning on page 2259 are Mr. Nuttall's comments on the development of a bioreactor landfill at the proposed Thorhild Landfill. WM may attempt to shorten the length of time that the Thorhild Landfill will be a threat to pollute groundwater by instituting a bioreactor approach. Mr. Nutthall, however, failed to note, much less discuss, the significant problems with bioreactor landfills, including the increased potential for groundwater pollution due to the increased water/leachate that will be present in the landfill. We have been involved in evaluating the advantages and problems with bioreactor landfills since the mid 1980's and have published several papers on these issues, including:

Lee, G. F., and Jones-Lee, A., "Comments on the O'Brien ARF SWANA Article, 'The Solid Waste Managers' Guide to the Bioreactor Landfill–A 2009 Update,' MSW Management 20(3):14,16 May (2010),'" Report of G. Fred Lee & Associates, El Macero, CA, Submitted to MSW Management, June (2010).
http://www.gfredlee.com/Landfills/SWANABioreactorCom.pdf

Jones-Lee, A. and Lee, G. F., "Appropriate Use of MSW Leachate Recycling in Municipal Solid Waste Landfilling," Proc. Air & Waste Management Assoc. 93rd annual national meeting Salt Lake City UT paper 00-455 CD ROM Pittsburgh, PA, June (2000).
http://www.gfredlee.com/Landfills/leachatepapsli.pdf

On Tab 7 page 2251 is "April, 2009 Short Biography-- Norm Nuttall, M.Sc, P. Eng." which states:
"Norm has spent over 35 years on solid waste management projects, Included in this experience is:

- *3 years with the City of Edmonton in charge of solid waste engineering and planning;*
- *3 years with BFI Waste Systems as the engineer in charge of 5 Class 2 landfills across Canada, handling about 1.5 million tonnes per year; and*
- *and over 30 years as a solid waste management consultant."*

As discussed above and in other comments on the Thorhild Landfill proposal, the reviews of ability and reliability of the proposed landfill at the proposed location to afford protection of groundwater quality and the welfare and interests of the people of Thorhild County for as long as the buried wastes pose a threat do not reflect a technically solid, disinterested assessment. The proposal, reviews, and permitting do not reflect an understanding of the current professional literature such as presented in our "Flawed Technology" review. It is important to probe the issue of the ability of a landfill consultant who typically works for landfill developers, and especially one who has been a member of WM staff, such as Mr. Nuttall, to provide full and disinterested disclosure of potential problems of a proposed landfill. The difficulties of achieving full and disinterested assessment and disclosure through landfill-company consultants whose future livelihood rests with private and public landfill developers, are well-recognized. Several years ago we were asked by a member of the American Society of Civil Engineers Ethics Committee to present a discussion of this problem. Our discussion of this issue was published as:

Lee, G. F., and Jones-Lee, A., "Practical Environmental Ethics: Is There an Obligation to Tell the Whole Truth?" Published in condensed form as "Environmental Ethics: The Whole Truth," *Civil Engineering*, Forum, 65:6 (1995). http://www.gfredlee.com/Landfills/ethics.htm

This issue is also discussed in:
Lee, G. F., and Jones-Lee, A., "Selection of an Independent Consultant to Review the Potential Impacts of a Proposed Landfill," Report of G. Fred Lee & Associates, El Macero, CA, December (2006). http://www.gfredlee.com/Landfills/SelectIndepConsult.pdf

Comments on
Millennium, EMS Solutions Ltd., "Hydrogeological Technical Report NW=18 & 19-61-20-W4 near Newbrook, Alberta, Prepared for Waste Management of Canada Corp, Millennium EMS Solutions, Ltd, Calgary, Alberta, Canada, March (2010)

Tab 6 part 5 presents the Millennium, EMS Solutions Ltd. "Hydrogeological Technical Report NW=18 & 19-61-20-W4 near Newbrook, Alberta," dated March (2010). The page citations included below refer to the page number in the report as well as the page number within Tab 6 part 5 as "tab document page".

That report states in the Introduction (page 1 – tab document page 777),
"This report contains relevant geological and hydrogeological information to describe the groundwater conditions of the landfill site and area in order to address the technical investigation requirements specific to hydrogeology within the Standards for Landfills in Alberta ('the Standards') (Alberta Environment 2010)."

Section 2.0 Regulatory Requirements presented on pages 1 and 2 (tab document pages 777 and 778) states:
"A technical investigation of potential landfill sites is required under the Standards to characterize the geological, hydrological, hydrogeological and geotechnical settings on regional and local scales."

"*Under the Standards, a new landfill is not to be located where the following conditions exist:*" which is followed by a listing of provisions of the Alberta February 2010 minimum Landfill Standards.

"*This technical report is intended to meet the requirements of the Standards with respect to characterization of the hydrogeology of the proposed landfill development and area*."

According to the provisions of the Alberta Environmental Protection and Enhancement Act, the requirement to provide environmental, water quality, and public health protection is not restricted to a limited time period; protection is to be afforded forever. Any conclusion concerning the suitability of the proposed location of the Thorhild Landfill must be evaluated relative to the ability of the hydrogeology of the area to prevent groundwater pollution at the location of the landfill and offsite, forever. Comparing the hydrological characteristics of the site relative to the minimum landfill standards, as Millennium has done for the proposed Thorhild Landfill, is highly unreliable and inadequate for assessing the potential and reasonably expected long-term public health and groundwater impacts of the landfill.

This report presents the hydrogeology study approach and the data obtained. A key issue that is confirmed by the Millennium investigation is that the location of the proposed landfill is underlain by groundwater that is hydraulically connected to off-site groundwater that is used for domestic and agricultural purposes. In our 2009 comments on the initially proposed Thorhild Landfill that WM presented to Thorhild County we reported that the heterogeneity with sand and silty sand layers/lenses of the proposed site and associated hydrogeology had not been adequately investigated to determine the full magnitude of its unsuitability. The additional data

reported by Millennium confirm the unsuitability of the proposed landfill location. The Millennium report attempts to minimize the significance of on-site and off-site movement of leachate-polluted groundwater that will occur under the proposed landfill by reporting the geometric mean of the hydraulic conductivity but did not present and discuss the most rapid measured rate of migration of leachate-polluted groundwater that could occur at this location based on measurements or an evaluation of potential maximum rates based on a statistical extrapolations of potential extreme rate of migration of the leachate-polluted groundwater. The manner of presentation and limited discussion of the data by Millennium presents a misleading picture of the suitability of the proposed landfill site to the regulatory agencies and the public.

Overall Assessment of the Location of the Proposed Thorhild Landfill

The Millennium study of the proposed site for the WM-proposed Thorhild Landfill clearly demonstrates that this proposed location does not provide natural protection of groundwater quality from leachate-polluted groundwater that will occur over the time that MSW in the proposed landfill will be a threat. Therefore, the Alberta Environmental Appeals Board should overturn the Alberta Environment's approval of the permitting of the landfill.

Comments on:
WorleyParsons Canada, "Hydrogeological and Hydrological Review of Proposed Landfill Facility, Thorhild County, NW 18 & 19-61-20 W4M," Report Submitted to B. Kolewaski, by WorleyParsons, Edmonton, AB, Canada, October 4 (2012)

Comments provided by:
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G. Fred Lee & Associates
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October 5, 2012

WorleyParsons Canada (WP) was asked to review the geologic/hydrogeologic information available on the site for the proposed Thorhild landfill to assess the suitability of the area for a landfill of the type proposed. In conducting its assessment, WP reviewed the information submitted by Waste Management's consultant, Millennium EMS (MEMS 2010), concerning the geologic/hydrologic characteristics of the area in which the proposed Thorhild landfill would be located. WP reported its findings in the following report:

> WorleyParsons Canada, "Hydrogeological and Hydrological Review of Proposed Landfill Facility, Thorhild County, NW 18 & 19-61-20 W4M," Report Submitted to B. Kolewaski, by WorleyParsons Canada, Edmonton, AB, Canada, October 4 (2012)

As stated in that report, WP concluded:
"*the Landfill has been sited on lands that are potentially unsuitable for landfill development, as compared to the requirements set out in the Alberta Environment and Sustainable Resource Development (AENV 2010) Standards for Landfill in Alberta, February 2010 (the Standards). The lands are potentially unsuitable*" for the proposed Thorhild landfill.

This area has been found to have an average hydraulic conductivity that is greater than that allowed by the Alberta Environment Standards for siting a landfill. This area is also not suitable for the proposed landfill because of *"sandy deposits"* that have the potential to allow more rapid transport of landfill leachate that penetrates the landfill liner proposed for the landfill.

WP reported that the site of the proposed landfill has not been adequately characterized in the site studies conducted by Waste Management consultants in its borehole investigation. The boreholes did not characterize the deeper strata above the bedrock that would underlie the proposed landfill.

WP reported:
"*There is considerable uncertainty as to the lateral extent and continuity of inter-till sandy deposits at the proposed Landfill site. Regional geologic study (Shetson 1990) indicates a number of intraglacial meltwater channels (i.e. linear sandy deposits encased in clayey till) in the area, with two adjacent to the southeast boundaries of the proposed landfill, and remarkably, coinciding with the headwaters of Waskatenau Creek.*"

As the landfill liner system proposed for the Waste Management Thorhild landfill inevitably fails, those sandy deposits could be expected to provide conduits by which leachate-polluted groundwater would more rapidly pollute surface waters of area.

WP reported that its review, "*indicates considerable uncertainty with respect to the surface water management plans in terms of:*

- *management of runoff from large storm events;*
- *alteration to the existing surface drainage patterns;*
- *increased risk of flooding due to floodplain alteration;*
- *increased risk of erosion in drainage ditches;*
- *monitoring of surface water quality; and*
- *disruption of surface water – groundwater interactions."*

As discussed in comments we have previously submitted, there is no doubt that during the period over which the wastes in the proposed landfill will be a threat to pollute the environment due to spills, fugitive releases, and breakouts through the above-ground surface sides of the landfill, contaminants associated with wastes deposited in the landfill will pollute surface soils of the area. With stormwater runoff, those pollutants will be transported off-site onto adjacent properties and waterways and will pollute those areas with hazardous and otherwise deleterious chemicals that are a threat to public health and environmental quality.

Overall, the WP review of the Waste Management consultants' studies of the geology and hydrology of the area of the proposed Thorhild Landfill site further demonstrate that the proposed site is not suitable for an MSW landfill. The proposed landfill design, coupled with the unsuitability of the area in which the landfill would be located, will not prevent the eventual pollution of groundwater and surface waters by with chemicals that will be a threat to public health, groundwater resources and the environment, in the area of the landfill. Environment Alberta should not continue to support the permitting of this landfill.

Comments on
CH2MHILL Report, "Subsurface Landfill Gas Monitoring Program – Greenfield Site in the County of Thorhild (Updated 2010)"

Tab 6 Part 10, beginning on tab page 2071, presents the report:
CH2MHILL, "Subsurface Landfill Gas Monitoring Program-Greenfield Site in the County of Thorhild (Updated 2010)," Final Report Prepared for Waste Management of Canada Corp., March 16, 2010.

The Executive Summary on Page ii (tab page 2074) states:
"*The purpose of this report is to provide a subsurface landfill gas monitoring program to meet the requirements as set out in the Section 5.11 of Standards for Landfills in Alberta (AENV, 2010).*"

The "Site Background" section on page 1 (tab page 2076) states:
"*The landfill site is situated in the County of Thorhild approximately 2.5 km southwest of Newbrook within NW Section 18 and all of Section 19 Township 60 Range 20 W4M as shown in Figure 1. The hydrogeological report (2010) indicates that the surficial stratigraphy across the site is glacial till, with a silty sand pocket, overlying low permeable shale and siltstone sequences. The hydraulic conductivity of the saturated glacial till has a geometric average of* $7x10^{-9}$ *m/s.*"

That description of the proposed landfill area is deficient in that it fails to mention the sand and silty sand layers/lenses, and it cites the geometric mean hydraulic conductivity rather than the maximum hydraulic conductivity of the area that was reported by Millennium.

The "Landfill Gas Production" (LFG) section on page 2 (tab page 2077) states:
"*The LFG production estimation was completed using the United States Environmental Protection Agency (USEPA) Landfill Gas Emissions Model (LandGEM, version 3.02). The model is a first-order decay model that has several input parameters to estimate landfill gas emissions. The input parameters used were calculated based on the methodologies provided in Technical Guidance for the Quantification of Specified Gas Emissions from Landfills (AENV, 2008). For this site, the model uses the generation rate constant (k) equal to 0.024/year and the methane generation potential (Lo) of 97.94 kg CH4jtonne for MSW and 79.05 kg CH4/tonne for C&D waste which was calculated and presented in a separated report entitled Evaluation of the Potential for Landfill Gas Generation and Gas Composition of Greenfield Class 2 Landfill-Site in the County of Thorhild (CH2M HILL, updated 2010)*

Using the LandGEM model with the above inputs and forecasted waste generation data and waste type provided by Waste Management of Canada Corp., the gas production curves indicate that the maximum LFG emission is estimated to be approximately 94,662 tonnes/year in year 2051, see Figure 2."

In that section CH2MHILL repeated its 2009 discussion of the use of the LandGEM model to estimate the rate and amount of Thorhild Landfill gas generation, but, again, without evaluating the model's reliability for making those estimates. Our 2009 comments on the original WM

proposal to Thorhild County for approval of the Thorhild Landfill (comments referenced in these comments) discuss why the Alberta Environmental Appeal Board should reverse the decision of Alberta Environment to approve the permitting of the Thorhild Landfill. Our comments addressed issues including the unsuitability of the location for that landfill and the inadequacies in its design to protect public health, water resources, and the environment for as long as the wastes are a threat. As discussed in our 2009 comments, the US EPA LandGEM model is unreliable for predicting landfill gas generation from landfills due to its failure to properly account for the moisture content of the wastes, which is the primary factor that determines the landfill gas generation rate, and for the manner in which landfill gas can be expected to be generated within the landfill. As discussed in our "Flawed Technology" review, the rate of landfill gas generation is directly proportional to the rate at which water penetrates the landfill cover, which is directly related to the permeability of the cover. Predictions of the long-term low-permeability character of a landfill cover are unreliable because they cannot reliably account for the development of cracks in areas of the cover or the rate of deterioration of plastic sheeting in plastic sheeting-covered landfills. Such deterioration of landfill covers will inevitably occur over time but will not be evident by routine visual inspection. Without reliably accounting for that deterioration, it is not possible to predict the longer term rate of landfill gas generation.

Further, as discussed in our "Flawed Technology" review, landfill gas generation also depends on the ability of moisture to interact with the wastes. A considerable amount of the solid waste that is placed in MSW landfills is in plastic bags that are not shredded but only crushed. That plastic material provides some level of shielding of the bagged waste from exposure to moisture that enters the landfill, and thus postpones gas generation from bagged wastes until the plastic bags deteriorate. The rate of plastic bag deterioration in the landfill environment is very slow, likely on the order of decades to hundreds of years, and can be expected to not be uniform throughout the landfill. Thus, the presence of plastic-bagged garbage makes the reliable or meaningful prediction of the occurrence and rate of gas production, over the long-term, impossible. Because of these and other aspects of modeling unreliability, and the failure of the WM/CH2MHILL report to discuss them, the WM/CH2MHILL projections of landfill gas generation for the Thorhild Landfill are highly unreliable with respect to the duration of time that landfill gas can be expected to be generated in the Thorhild Landfill.

"Figure 2 LFG Production" (tab page 2084) referenced in the passage quoted above, shows projections of landfill gas emission from the proposed Thorhild Landfill for the next 140 years. That presentation is highly unreliable and misleading because it does not reliably represent landfill gas generation in a dry-tomb type landfill as affected by factors including landfill cover maintenance and plastic-bagged garbage. Based on what is known about even well-developed dry-tomb-type landfills, a more realistic representation would show multiple peaks over decades to centuries. The first peak would be associated with the initial gas generation during the period prior to installation of a low-permeability cover, followed by a decline in gas production as the wastes dry. A second peak would begin as the integrity of the cover is breached allowing moisture into the landfill to interact with wastes and generate landfill gas and leachate. When that rise in landfill gas production begins would be a function of the design and initial quality of the cover as well as the rigor of cover maintenance and repair; how high the peak is and how long the peak lasts will depend on when the cover breach is detected and how well it is repaired. Because key low-permeability elements of a cover are buried and not amenable to rigorous

inspection and immediate repair or replacement, if monitoring for landfill gas has been stopped the first evidence of cover failure may be the presence of leachate in a leachate collection system, provided that that system is functioning properly and monitored. If the faults and/or areas of deterioration in the cover are repaired in a manner that prevents further entrance of water into the landfill, the wastes will eventually dry and gas and leachate production will be expected to subside. This cycle of cover breach, gas/leachate generation, cover repair, drying and cessation of gas production will continue until all the fermentable wastes have been fermented, which only occurs with the introduction of moisture. How many cycles occur, and their intervals and severity will depend on long-term landfill maintenance. The better-maintained the landfill is in the decades and centuries after closure, the longer gas production can occur. The deterioration of plastic garbage bags and exposure of their wastes to moisture can be expected to create additional peaks of landfill gas production; the evidence and timing of such peaks depends on how resistant the plastic bags are to degradation. The "output" of simplistic waste fermentation models such as that employed by CH2MHILL for evaluating landfill gas production in the Thorhild Landfill does not account for these realities.

The last paragraph of the "Subsurface Migration of Landfill Gas" section on Page 2 (tab page 2077) states:
"*Subsurface LFG migration potential at the site is considered low because the landfill will incorporate a composite liner system (compacted clay and a geomembrane liner). There is also low hydraulic conductivity (7x10 $^{-9}$ m/s) within the glacial till adjacent to the landfill.*"

That statement is misleading since, as discussed in the "Flawed Technology" review, landfill gas migration through single-composite liners is well-documented. Such migration has led to groundwater pollution by VOCs up-groundwater-gradient at landfills.

The first paragraph of the "Gas Monitoring Methodology" section on Page 2 (tab page 2077) states:
"The possibility of subsurface migration potential of LFG is low even if a liner breach occurs."

As discussed above and in the "Flawed Technology" review, migration of landfill gas components occurs even through liners that have not been otherwise "breached." This occurs as a result of diffusion of gas components through the plastic sheeting. Because of the very long time over which landfill gas generation will be expected to occur at the Thorhild Landfill, the heterogeneous nature of the geological strata that occurs in the vicinity of the landfill, and the limited proposed expanse of WM-owned buffer lands (only 30 metres between wastes deposition areas and adjacent properties), there is a real and significant threat that landfill gas migration will occur and will trespass onto adjacent properties.

The potential for gas that is present or generated in the landfill to penetrate the landfill liner is becoming sufficiently recognized such that some regulatory agencies are requiring that landfill owners maintain leachate collection systems under a vacuum to collect all landfill gas that is present/generated in the landfill. The operation of such a system should be required for as long as the wastes in the landfill have the potential to generate landfill gas when contacted by water. Again, the better the landfill cover functions in keeping out moisture, the longer such a system will have to be operated.

The first paragraph of the "Gas Monitoring System" section on Page 3 (tab page 2078) states: "*Subsurface gas monitoring probes will be installed around the perimeter of the landfill and adjacent to onsite buildings. The horizontal spacing of probes is recommended not to exceed 300 m. The horizontal spacing will be reduced by 50 percent if offsite structures are located within 300 m of the site boundary."*

Gas monitoring probes spaced at 300-m intervals around the perimeter of the landfill can readily miss some of the preferential pathways through which landfill gas can migrate offsite from the Thorhild Landfill. The approach outlined subsequently in the section of adjusting the gas probe spacing if offsite structures are within 300 m of the site boundary reflects a reliance on adjacent properties for dissipation of subsurface gas migration. Such a trespass should not be allowed; owners of adjacent properties should be able to use their property at the property line at any time in the future, independent of the location of a landfill near the property line. Alberta Environment landfill standards that allow use of offsite properties for dissipation of gas do not ensure such protection of offsite properties.

The "Gas Measurement Frequency" section on Page 3 (tab page 2078) states:
"An initial program of monthly monitoring events will be implemented to buildup a database and establish trends regarding the background concentrations during the four seasons. If there are no/low concentrations measured, a semi-annual monitoring program will be implemented thereafter."

The monitoring approach described is not reliable for assessing subsurface gas migration. As discussed above, landfill gas production will be delayed as long as the landfill cover prevents the entrance of significant amounts of water into the wastes. Once the landfill cover properties deteriorate to the point of allowing water to enter the wastes, landfill gas can be generated. The finding of "no/low" concentrations does not mean that the landfill does not have the potential to generate and emit significant landfill gas well into the future as discussed above. Significant landfill gas generation and emission could readily be delayed by many decades to a hundred years or more. The issue of who will be monitoring the gas monitoring probes beyond the end of the limited proposed WM postclosure period has not been addressed.

The "Subsurface Landfill Gas Contingency Plan" section states on Page 4 (tab page 2079):
"Objective
The objective of the Subsurface Landfill Gas Contingency Plan is to prevent LFG from reaching and potentially harming the nearby environment and public. This is considered highly unlikely given the engineering controls (geomembrane and compacted clay liner) and the observed hydrogeology of the site area."

The statement of this "objective" is misleading at best. That Plan does not have the realistic capability to "*prevent LFG from reaching and potentially harming the nearby environment and public"* especially given that there would be only 30 metres of buffer land between waste deposition areas and adjacent property lines. The proposed "engineering controls" and the "hydrology of the site" do not, in fact, render gas migration onto adjacent properties "highly

unlikely." Despite the "objective" of the Gas Contingency Plan, there is a significant potential for subsurface gas migration to occur from the proposed landfill onto adjacent property.

The "Subsurface Landfill Gas Contingency Plan" section also states on Page 4 (tab page 2079): "*Implementation of Contingency Plan*
The contingency plan would be implemented in the event that methane was detected at one or more monitoring locations. Should methane be detected above the maximum allowable LEL, the following actions will be undertaken:
1. Resample the particular well/wells to confirm initial result
2. Phase 1 risk assessment will be implemented if the retesting confirms the initial results"

The approach outlined is naïve and not protective of public health, environmental quality, or the interests of adjacent property owners. Especially given the very limited buffer land provided, any subsurface migration of methane from the landfill, whether or not its concentration exceeds an allowed regulatory value, poses a threat of trespass onto adjacent property of potentially explosive and hazardous VOC gases. If any subsurface gas migration is detected, action must be taken to prevent further releases of landfill gas from the landfill for as long as the wastes in the landfill will be a threat to generate landfill gas when contacted by water.

One of the approaches to control landfill gas releases is to install and maintain a landfill cover to prevent water from entering the deposited wastes for as long as the wastes in the landfill have the potential to generate landfill gas when contacted by water. This approach should be required if the Thorhild Landfill is allowed to be developed.

Comments on
AECOM, "Thorhild Landfill – Field Investigations"
Letter Dated February 21, 2012 (AECOM, 2012a)

Comments by
G. Fred Lee, PhD., PE, BCEE, F.ASCE and Anne Jones-Lee, PhD
G. Fred Lee & Associates
El Macero, CA

July 1, 2012

AECOM (2012a) summarized the findings of a field investigation at the site of the proposed Thorhild Landfill conducted during the week of February 6, 2012 "*in order to assess certain comments made by individuals who have filed appeals with the Environmental Appeals Board.*"

That summary was based on findings discussed in a June 11, 2012 letter report (AECOM, 2012b): AECOM, Letter to D. Ozdoba, Waste Management of Canada, Edmonton, Alberta, Regarding: "Project No. 60250149, Thorhild Landfill – Surface Water Management Addendum," AECOM, Edmonton, AB, June 11 (2012b).

Presented below are our comments on the AECOM (2012a) summary report.

The section entitled, "Discrete Drainage Path," on page 1 states:
"*AECOM understands that allegations have been made of a discrete surface water flow entering the Landfill Lands, flowing through NW18-061-20-4, and then flowing onto adjacent lands to the south. During the recent field investigation, AECOM confirmed that there is no continuously defined drainage path through NW18-061-20-4.*

A flow path through NW 18-061-20-4 is delineated in the Alberta Provincial Digital Base Map Data set, which is classified as "flow-arbitrary-manual". On February 11, 2011 the horizontal alignment of this symbolic flow connection line was checked within NW18-061-20-4. It was determined that the symbolic flow connection line is not a true flow path along most of its path across NW18-061-20-4, except at the transition from NW18-061-20-4 to SW18-061-20-4 (south of the Landfill Lands). No flow channel through NW18-061-20-4 could be located.

The only continuous watercourse or flow channel on the Landfill Lands is the Improved Swale located in the NE19-061-20-4, which was previously documented in AECOM's Surface Water Preliminary Design Report (March 2010)."

The issue seems to be a matter of the definition of a "continuous flow path."

The section entitled, "Run-On," on page 2 states in part:
"*During the field inspection on 8 February 2012, two additional culverts across Range Road 210 were identified. These culverts were not identified in any previous AECOM reports or figures.*"

"*These culverts were not identified during the field work in May 2007 and October 2009, due to*

either an unintentional oversight or because the culvert ends were covered by vegetation."

AECOM (2012a) claims that the two newly identified culverts will not convey water onto the Thorhild project area.

The information presented in the backup report appears to support the conclusion presented in the summary report. However, this situation needs to be re-examined during periods of high runoff from the area.

Comments on
"Waste Management of Canada Corporation Proposed Thorhild Landfill
Design Report for Waste Footprint Configuration and Containment Systems," dated March 2010,
prepared by Adelantar Consulting

Tab 6 Part 7 page 1362 begins the report:
Adelantar Consulting, "Waste Management of Canada Corporation Proposed Thorhild Landfill Design Report for Waste Footprint Configuration and Containment Systems," Adelantar Consulting, Edmonton, Alberta, Canada, March (2010).

Section 1.0 "Introduction" of that report states (page 1, tab page 1366):
"WMCC is currently preparing an application ('the Application') for approval under the Alberta Environmental Protection and Enhancement Act and for a Development Permit from the County of Thorhild ('the County'), and has retained Adelantar Consulting ('Adelantar') to provide engineering design input to the waste footprint configuration and containment aspects of this application document. The current design report document is intended to provide a summary of design for the containment aspects of the landfill in this regard."

Section 2.0 "Regulatory Setting" states (page 2, tab page 1367):
"2.1 Standards for Landfills
The Standards for Landfills in Alberta ("the Standards for Landfills"), Alberta Environment (February, 2010) and the Waste Control Regulation under the Alberta Environmental Protection and Enhancement Act provide the principal regulatory requirements and guidance for the siting, design, construction, closure and monitoring of landfills which accept third party waste in Alberta. The Standards for Landfills outline the minimum requirements for development, operation, monitoring, closure and the post-closure care of landfills in Alberta, and have been taken as the principal source of regulatory guidance in the development of the Project to date in these regards. The Project comprises a Class II landfill and associated works, and as such the applicable requirements for Class II landfills within the Standards for Landfills have been referenced as the principal source of regulatory guidance."

Section 2.0 "Regulatory Setting" states (pages 3–4, tab pages 1368–1369):
"*The Standards for Landfills are intended by Alberta Environment to be read in conjunction with a set of guidelines that have not yet been finalized. These guidelines would provide regulatory intent and guidance for items within the Standards for Landfills. In the absence of these guidelines, the following sources have been referenced to interpret the intent of the Standards for Landfills, where applicable:*

- *standard industry practice for Class II landfills in Alberta; and*
- *Class II landfill approvals issued by Alberta Environment in recent years.*

The approach used by WM/Adelantar Consulting for designing the Thorhild Landfill focuses on standard industry practice for Class II landfills in Alberta, and Class II landfill approvals issued by Alberta Environment in recent years. It fails, however, to incorporate significant advances in the understanding of and experience with the nature of waste components, landfill gas and leachate, and the functionality and long-term integrity of key components of dry-tomb-type landfill and groundwater monitoring systems that have been discussed in the professional

literature over the past decades. That technical literature discusses the evolving and current understanding of deficiencies in the ability of clay liners and single-composite liners to contain landfill waste components and collect landfill leachate for as long as the wastes in a dry-tomb-type landfill can be a threat.

The WM/Adelantar approach also ignores the greater understanding developed concerning the length of time over which MSW can be a threat, especially in a dry-tomb-type landfill. Problems and limitations in the ability of clay and/or plastic-sheeting layers in a landfill cover to keep moisture out of a landfill for as long as the wastes can generate gas and leachate, as well as significant limitations in the responsible reuse of closed landfill areas, are also substantially better-understood and described in the literature than the approach reflects. The inability of conventional groundwater monitoring well arrays – with well-spacing many tens to hundreds of metres apart around the perimeter of a landfill – to reliably detect the initial leachate-pollution plume has been discussed in the literature. Similarly, the imprudence of establishing comparatively short-terms for assured postclosure funding of only 25 to 30 years is now widely understood and discussed in the professional landfill literature.

As discussed in our "Flawed Technology" review of professional landfill literature, many of the limitations in protection provided by a minimum-design landfill are well-understood by many professional engineers who work in the landfill development field. However, few of the knowledgeable professionals in the landfill development/evaluation field openly discuss these deficiencies and limitations as to do so would create a certain impediment to obtaining future contracts with public and private landfill developers. This situation hinders the obtaining of full disclosure of the potential impacts of landfills. Several years ago we were asked by a member of the American Society of Civil Engineers Ethics Committee to present a discussion of this type of problem. We discussed these issues in a number of papers and reports including the following:

> Lee, G. F., and Jones-Lee, A., "Practical Environmental Ethics: Is There an Obligation to Tell the Whole Truth?" Published in condensed form as "Environmental Ethics: The Whole Truth," Civil Engineering, Forum, 65:6 (1995).
> http://www.gfredlee.com/Landfills/ethics.htm
>
> Lee, G. F., and Jones-Lee, A., "Selection of an Independent Consultant to Review the Potential Impacts of a Proposed Landfill," Report of G. Fred Lee & Associates, El Macero, CA, December (2006).
> http://www.gfredlee.com/Landfills/SelectIndepConsult.pdf

The Government of Alberta Environment and Water website
http://environment.alberta.ca/02956.html currently states:
"*Standards for landfills in Alberta*
The "Standards for Landfills" outline the minimum requirements for development, operation, monitoring, closure and post-closure of Class I, Class II, and Class III landfills. The Standards are intended to provide public assurance regarding the protection of groundwater and surface water, and the appropriate management of nuisances associated with landfill development.

The "Guide to the Standards for Landfills in Alberta" is currently being developed to assist landfill owners, operators, engineers, and others with the siting, design, operation, monitoring, closure, and post-closure of landfills in Alberta."

It is our understanding from correspondence between "Gilbert VanNes" General Counsel and Settlement Officer | Environmental Appeals Board (Gilbert.VanNes@gov.ab.ca) and Betty Kolewaski (bkolewaski@shaw.ca) on March 8, 2012 that the AENV has not developed that guidance for implementing the development of landfills in Alberta "*to assist landfill owners, operators, engineers, and others with the siting, design, operation, monitoring, closure, and post-closure of landfills in Alberta.*"
The absence of reliable technical guidance incorporating the current understanding of the limitations of landfill waste containment and management systems, the long-term threats of wastes in dry-tomb-type landfills, and the nature and limitations of minimum design, minimum postclosure period, minimum monitoring well spacing, etc. such as specified in the February 2010 updated Landfill Standards, will facilitate the continued reliance on badly out-of-date information and the development of deficient landfill such as the proposed Thorhild Landfill by Alberta Environment. The absence of such guidance also enables the continued rendering of technically unreliable opinions, such as that offered by Mr. Ko of AENV in his review of the approval of the Thorhild Landfill, that meeting minimum allowed landfill standards protects public health/welfare and environmental quality from landfilled wastes.

Based on this situation the Alberta Environmental Appeals Board should reverse the approval of the WM-proposed Thorhild Landfill issued by Alberta Environment. Many of the deficiencies in the ability of the proposed Thorhild Landfill to protect public health/welfare and environmental quality for as long as the wastes in the landfill would be a threat that we have addressed elsewhere in our comments are summarized in the following comments on the design of the proposed landfill.

Section 3.0 "Existing Site Conditions" states (page 5; tab page 1370):
"3.1.2 Characterization of sub-surface conditions and soil materials,
The sub-surface conditions of the Landfill Lands were investigated by Millennium EMS Solutions Limited ("Millennium") and are summarized in the following two reports:"
The summary information on the Millennium reports does not provide key information that describes why the proposed location for the Thorhild Landfill does not provide for natural protection of public health and groundwater quality for as long as the wastes in the proposed landfill will be a threat. As we discuss in our comments on the Alberta Environment approval report, the proposed location has shallow groundwater that is hydraulically connected to offsite groundwaters that are used by adjacent and nearby property owners. Millennium failed to adequately consider the length of time over which the wastes in the proposed landfill will be a threat to pollute groundwater. The estimated rate of movement of the underlying groundwater is sufficient to enable leachate-pollution of offsite groundwaters. Also as we discussed, some of the hydrogeology assessment approaches used, such as "*re-compacted hydraulic conductivity in the range of $3x10^{-11}$m/s (based on preparing the samples using standard compactive effort at the as-received moisture content and using 100kPa confining pressure)*" are unreliable for making the needed assessments. It is well-known that assessing a re-compacted sample of aquifer materials can readily grossly underestimate the hydraulic conductivity of the aquifer.

Section 4.0 “Design” states (page 8; tab page 1373):
“Section 4.1 Design Intent
The design intent for the configuration and containment system is to meet or exceed the containment criteria prescribed in the Standards for Landfills and to be consistent with industry practices for Class II landfills in Alberta.
The following fundamentals of design have been adopted for the Waste Footprint:

- *compliance with regulatory constraints and provisions;”*

As discussed above, it cannot be assumed that minimum landfill standards will provide protection of public health and environmental quality; to do so ignores the current professional literature concerning the ability of a single-composite liner to collect all leachate that can be generated over the hundreds of years that the wastes in the proposed landfill will be a threat.

Section 4.0 “Design” identifies among the “*fundamentals of design adopted for the Waste Footprint*” the following (page 9; tab page 1374):
“Liner

- *the Waste Footprint is to be designed with a composite lining system comprised of compacted clay and a geomembrane in intimate contact.*

Leachate collection and extraction

- *the system is to be designed to be capable of maintaining leachate within a maximum allowable head above the upper surface of the liner, and to maintain unconfined flow within the collection layer;*
- *a pipe network, which is to be installed within a drainage medium on the base of the cells, is to direct leachate to a series of sumps within the Waste Footprint; and*
- *leachate extraction is to occur around the periphery of the Waste Footprint.*

Final Cover

- *the final cover is to be designed as an earthen cap overlain by sub-soil and topsoil placed to support vegetation.”*

That proposed landfill containment system design of a single-composite liner and compacted soil cover is the minimum designed allowed under the Alberta Environment February 2010 Landfill Standards that that may be protective for a site that affords natural protection of public health and groundwater quality. However, the characteristics of the proposed Thorhild Landfill site do not provide for natural protection; in fact, the site is highly unsuitable for the proposed landfill. As discussed in our comments on the Alberta Environment Approval Report and in professional literature cited and discussed in our “Flawed Technology” review, a single-composite liner and compacted soil cover does not ensure protection of public health and groundwater quality. The Alberta Environmental Appeals Board should reverse Alberta Environment’s approval of the proposed Thorhild Landfill based on the unsuitability of the design for the location proposed for the landfill.

Section 4.3 “Containment System Design”, Subsection 4.3.1 “Liner” states (page 20; tab page 1385):
“Liner performance

The proposed containment system includes a composite liner. Based on formulae developed by Giroud (1998), the hydraulic efficiency of a lining system with the proposed configuration, utilizing conservative assumptions and utilizing a head of 0.3m above the liner would be approximately 99.8%. Calculation details are provided in Appendix C."

That statement is a distortion of the professional literature and well-known assessments of the expected performance of a composite liner over the period of time during which the wastes in the landfill will be a threat. Giroud's statements referenced are well-documented to be unreliable for use in the context presented. The Giroud statement cited above could only apply at the time of construction and only if very high-quality construction were achieved. There is no doubt that the containment properties of a single-composite liner will deteriorate over time and will eventually become highly ineffective in preventing leachate leakage from the landfill and its entrance into the underlying groundwater aquifer system.

Table 1 (page 11, tab page1376) presents information on the location of the proposed landfill relative to Landfill Standards requirements, including the setback of waste deposition from adjacent property lines. While in other reports on the proposed landfill the distance between waste deposition and adjacent property lines was indicated to be the minimum of 30 m, Table 1 states that the minimum setback is to be 50m. That discrepancy notwithstanding, a setback of 30m or 50m is grossly inadequate to prevent releases of landfill gas and leachate from trespassing onto adjacent property owners' lands. The 150m setback from wetlands is also inadequate to prevent adverse impacts on the ecology/water supply of the wetlands.

Section 4.3 "Containment System Design", Subsection 4.3.2 "Leachate Generation" states (page 21; tab page 1386):
"*The quantity of leachate generated within the Waste Footprint has been estimated using the Hydrological Evaluation of Landfill Performance model ("HELP" – US EPA). A summary of the HELP modelling methods and results is provided in Appendix B."*

"The model predicts the following leachate generation rates for the operational and post closure periods of the landfill:

- *initial operational period: average of 92mm per year (which represents approximately 19% of the annual precipitation);*
- *intermediate operational period: average of 70mm per year (which represents 14% of the annual precipitation); and*
- *post-closure period: average of 35mm per year (which represents 7% of the annual precipitation).*

Those calculations of leachate generation are presented as though they had some reliability. A proper engineering analysis would have included a discussion of the fact that the HELP model cannot be used to estimate with any reliability the leachate generation rates over the time during which the wastes in the landfill can generate leachate when contacted by water. It is well-understood in the professional engineering literature that the leachate generation rate is dependent on the rate of entrance of water into the landfilled wastes. The rate at which water will penetrate the landfill cover and enter the wastes cannot be reliably predicted because the

properties of the cover will deteriorate over time, and will be affected by the effectiveness and diligence of cover maintenance for as long as the wastes remain in the landfill.

Overall, the Adelantar Consulting report of the design of the proposed Thorhild Landfill is far from a credible engineering report that provides the regulatory agencies and the public with sound technical information that can be used to evaluate the protective nature of the proposed landfill over the period of time that the wastes in this landfill will be a threat. The Alberta Environmental Appeals Board should reverse the approval of the proposed Thorhild Landfill based on inadequate landfill design.

Comments on
"Proposed Thorhild Landfill End Use Plan" Prepared by EDA for WM

Tab 6 Part 10 Page 2090 begins the report:
EDA Collaborative, Inc., "Proposed Thorhild Landfill End Use Plan," Prepared for Waste Management of Canada Corporation by EDA Collaborative, March 26 (2010).

Page 3 of that report (tab page 2095) states:
"This end use plan has been prepared to comply with the Standards for Landfills in Alberta requirements (for a post closure plan and use of soil during reclamation) as well as the County of Thorhild Bylaw 1120-2009 (measures to mitigate visual impact).

The proposed end use of the site is wildlife habitat and grazing – a land use that is common to the area but has been affected by agricultural activities. The End Use Plan proposes intensive and extensive naturalization of the project area to reclaim the Landfill Lands and Transportation Lands from their past agricultural use and proposed landfill operational disturbances. Naturalization of the Project Area will be in keeping with recommendation noted in the attached Conceptual Overview of Landscape Level Integration of Restored and Reclaimed Areas of the Proposed WMCC Thorhild Landfill (GDC 2010a) and will serve several purposes: to improve ecological diversity, to create wildlife corridors and habitat, and to provide visual screening and enhanced site aesthetics."

In addition to the wildlife grazing, potential future auxiliary uses of the site include a greenhouse and a tree farm. Should they be constructed, their proposed locations would be flanking either sides of the access road. Plant material grown on site could potentially be used in the naturalization of the site."

WM has a history of glamorizing the potential end uses of landfill areas to the public through its television and print ads; end uses are often characterized as park-like with ponds and other public amenities. In this case, the report on the proposed end use of the Thorhild Landfill evokes a bucolic image – wildlife grazing, a useful greenhouse, and a tree farm – in which the landscape has been restored to a condition even better and more "natural" than that which exists presently. The fact is, however, that landfill end uses should not include any feature that may contribute to the compromise of the low-permeability character of the landfill cover; indeed, they should function so as to protect the integrity of the cover for keeping moisture out of the landfilled wastes for as long as the wastes in the closed landfill will be a threat to generate landfill leachate/gas. The proposed greenhouse and tree farm, as well as potential aspects of habitat restoration, could readily adversely impact the ability of the landfill cover to prevent water from entering the wastes. Similarly, the proposed placement of berms and swales must be done so as to prevent the ponding of water on the landfill site.

While "wildlife grazing" is presented in the plan as an admirable and impressively "natural" end use of the Thorhild Landfill area, as discussed in our "Flawed Technology" review that end use is ill-advised. With such an end use, conditions would be made conducive for wildlife to graze lands atop the closed landfill. It would, however, be those very areas that would be the first to be affected by landfill gas emissions included VOC carcinogens in the landfill gas ; grazing animals

would have nose to the ground to receive the most intense exposure to landfill gas components. The concern for the welfare of "wildlife" was not even mentioned in the end use plan, indicating a significantly deficient plan, especially in light of the deficiencies in understanding and proposed management reflected in the landfill documents as discussed in these comments.

Page 4 of the report (tab page 2096) states:
"*Wetlands that are likely to be disturbed as a result of the project will be compensated for by means of a constructed wetland complex south of the main access road on the Transportation Lands."*

As discussed in another section of our comments, the proposed approach for mitigation of the impacted wetlands fails to include mitigation for the alterations in surface and groundwater hydrology caused by construction of the landfill; those alterations in surface and groundwater hydrology will affect the source water supply for the nearby wetlands. The groundwater and surface water hydrology of the nearby wetlands should be sufficiently investigated prior to initiation of landfill construction so that those aspects of the impact of developing the proposed landfill on nearby wetlands are understood and can be reliably and effectively mitigated.

Page 5 of the report (tab page 2097) states:
"The purpose of the second phase of landscape development (see Operation Plan 2, page 9) will be to increase the amount of wildlife habitat and improve wildlife corridor connections. This will be achieved through the reforestation and infill of native plant material predominantly along the improved swale that traverses both the Transportation Lands and the Landfill Lands, as well as the northern portion of the Landfill Lands in General."
If the proposed approach involves development/"improvement" of a swale across the landfilled areas, this would be of concern for the integrity of the landfill cover. There also does not appear to be consideration given to the potential impact of the roots of reforested trees on the integrity of the landfill cover.

Page 5 of the report (tab page 2097) also states:
"In addition, the perimeter cattle fencing will be removed to allow for increased use of the site by wildlife."
It will be important for maintaining the integrity of the landfill cover and the ongoing postclosure operations at the site that access to the site by the public be restricted.

Comments on
Geographic Dynamics Corp (GDC), "Technical Wetland Compensation Report for the Proposed WMCC Thorhild Landfill," GDC, Edmonton, Alberta, March 8 (2010).

Tab 6 Part 9presents the Geographic Dynamics Corp. "Technical Wetland Compensation Report for the Proposed WMCC Thorhild Landfill," dated March 8 (2010) (tab document pages 1846–1865). That report states on page iii:
"*This technical report outlines the compensation plan, including required actions and timelines, for wetlands inside the Project Development Area (PDA) within the Landfill Lands. The amount of wetlands Class II or greater that will potentially be disturbed by the Project is 9.74 ha (7.98 ha of Class II-temporary, and 1.77 ha of Class Ill-seasonal).*"

The report goes on to describe the "restoration" and construction to be undertaken.

Significant issues and concerns were not addressed in those plans. It is well-known that the development of a landfill will significantly adversely impact nearby wetlands that depend on the landfill area lands as a source of a water supply. The construction, operation, and long-term maintenance of such a landfill will alter both the surface and groundwater hydrology of the perturbed area and hence the hydrology of downgradient areas. The Wetland Compensation Report is significantly deficient in that it fails to discuss and provide compensation for the damage that the proposed Thorhild Landfill will cause to existing nearby wetlands due to its alteration of the water supply for the wetlands. The Alberta Environmental Appeals Board should overturn the Alberta Environment approval of the proposed Thorhild landfill.

Also reviewed was a series of documents available online at
http://www.thorhildproject.ca/documents/20110621-WM-Thorhild-CAC-Meeting-Notes.pdf
that included the following:

- "summary meeting notes" from a June 21 (2011) meeting of WM and Community Advisory Committee (CAC) representatives,
- February 18 (2011) memorandum from Millennium EMS Solutions Ltd. in response to a query from Alberta Sustainable Resource Development (SRD) regarding the amount of wetland compensation proposed, and
- Kemball, K., "Amendment to the Wetland Compensation and Restoration Report," Report of Incremental Forest Technologies, Ltd, Edmonton, Alberta, May 13 (2011).

That additional information did not address the deficiency in the Wetlands Compensation Report discussed above.

Comments on
"Waste Management of Canada Corporation Proposed Thorhild Landfill
Closure and Post-closure Cost Estimate," dated March 2010,
prepared by Adelantar Consulting

Tab 6 part 10 page 2176 begins the report:
Adelantar Consulting, "Waste Management of Canada Corporation Proposed Thorhild Landfill Closure and Post-closure Cost Estimate," Adelantar Consulting, Edmonton, Alberta, Canada, March (2010).

Section 1.0 Introduction of that report states on page 1 (tab page 2179):
"*Prior to issuing an Approval under the Alberta Environmental Protection and Enhancement Act, Alberta Environment requires that WMCC to include a closure/post closure cost estimate that would form the basis for the financial security that will be required by AENV prior to operation. WMCC requested assistance from Adelantar Consulting ('Adelantar') in the preparation of a financial security estimate for the initial development at the site ('Cell 1'). This letter outlines the approach adopted in the calculation and the results of the cost estimate (additional details are enclosed as Appendix A)."*

Section 3.0 "Assumptions and Basis of Estimate" states beginning on page 3 (tab page 2181):
"3.1 General
The basis of the closure and post-closure estimate for the Landfill will be taken to be a 'default' on the part of the Approval holder, such that the security would represent the activities and costs associated with instantaneous closure of the Landfill in the event of default by the Approval holder. This approach does not contemplate the revenue opportunities represented by any airspace which was developed but not consumed at the time of default.

The current submission summarizes the methodology and assumptions used to calculate the financial security for the Landfill at a point in time such that:

- *Cell 1 will have been constructed and not capped;*
- *site infrastructure will have been constructed as outlined in the Application; and*
- *control systems will have been established as outlined in the Application.*

The estimate of Landfill closure and post-closure costs presented in this submission is based on the following method assumptions:

- *that a closure plan will be completed prior to closure events taking place;*
- *that leachate and surface water management systems will be in place and operational prior to the commencement of closure;*
- *the excavation slope north of the Cell area will require lining and leachate collection;*
- *that the Landfill would be operated by a third party to achieve minimum slopes for positive drainage, and that the costs of this operation would be covered by waste revenues. As such, no provision has been included for waste grading efforts and/or construction of a drainable top-of waste surface;*
- *that a cap will be constructed in accordance with the draft Approval (i.e. 0.6m clay cap, 0.35m subsoil and 0.20m topsoil) and an appropriate Quality Control and Quality Assurance plan;"*

Overall, based on the assumptions outlined for their estimation, the postclosure care costs for the proposed Thorhild Landfill will be substantially larger than those projected. Further, if the real costs are not covered by WM, the source of the funding (e.g., Alberta Environment/County of Thorhild) should be defined. A discussion of the unreliability of many of the approaches used and assumed for estimating the postclosure costs is provided below. Additional discussion of these and related issues is provided in our "Flawed Technology" review.

As discussed in these comments, the type of landfill cap proposed for this landfill will not keep water out of the landfill for as long as the wastes can, when contacted by water, generate landfill gas and leachate. The cover will develop cracks that will allow water to enter the landfilled wastes. A cap that includes a proper plastic sheeting layer can afford greater protection against the entrance of water but will also be subject to deterioration and breach, and its integrity cannot be rigorously inspected preemptively as it will be buried. That type of cover will need to be replaced periodically during the time that the wastes in the landfill will be a threat to generate leachate. The cost for cover maintenance will be much larger than that projected in the cost estimates presented.

The "method assumptions" continue on page 4 (tab page 2182):

- *"that materials for the construction of the cap will be available without royalty cost from areas close to the Cell (i.e. short haul distance from stockpile or borrow areas to capping areas);*
- *that the cap will be vegetated using native grass species to the largest extent practical;*
- *that an as-built report will be prepared to summarize the results of the capping program, including test results, QA/QC data and seed mix/seed rate quantities;*
- *that during the post-closure period the groundwater, leachate and gas monitoring programs will be consistent with that proposed in the Application. If detailed groundwater monitoring does not detect any contaminants, the parameter suite will likely be reduced to indicator parameters on an annual basis with a detailed parameter suite being completed less frequently. If this is the case, the estimate presented would be conservative;"*

The projected postclosure cost estimates cover only the minimum 25-year postclosure period specified by Alberta Environment and assume that AENV/County of Thorhild will not extend the duration of required postclosure care (monitoring, maintenance, and remediation of groundwater pollution) that WM would have to fund. If AENV adopts a truly more technically reliable and responsible approach for the protection of public health and the environment for as long as the wastes represent a threat, the period of time over which WM will need to fund postclosure care and groundwater remediation will likely be on the order of hundreds of years. Whether or not WM is held responsible for the postclosure for as long as the wastes represent a threat, the true cost of postclosure care to WM and whatever entity must take over should WM fail, will be much larger than projected in WM's estimates. Under no condition could the estimates presented be considered "conservative" as claimed in the estimates.

If AENV and the Thorhild County allow WM to walk away from monitoring, maintenance, and remediation responsibility while the wastes in the Thorhild Landfill are still a threat, Alberta

and/or Thorhild County will need to provide the balance of the true costs of postclosure care/remediation for as long as the wastes in the landfill will be a threat to generate leachate when contacted by water. The party that will be responsible for the balance of the true, long-term costs of postclosure care must be specified.

The "method assumptions" continue on pages 4 and 5 (tab pages 2182 and 2183):

- *"that decommissioning of the surface water and leachate ponds will be undertaken during closure at an estimated lump sum cost to represent earthworks associated with leveling perimeter berms and re-grading to promote positive drainage;*
- *that any decommissioning of structures (e.g. road, weigh-scale) that takes place as part of landfill closure will not represent a net cost, on the basis that the structures are either required during and/or after the post-closure period, or have a value which is at least equivalent to any decommissioning costs;*
- *that disturbed areas beyond the footprint of the Cell include the surface water and leachate ponds, soil stockpile area, roads, and portions of the infrastructure area (it is assumed that these areas will be reclaimed using 0.1m of topsoil and 0.35m of subsoil);*
- *that the Landfill will be maintained for a post-closure period of 25 years (the minimum specified in the Standards for Landfills). This maintenance will include:*
    - *landscaping activities (e.g. weed control, re-seeding if required, assumes no mowing required);*
    - *repair to areas of excessive erosion (if any);*
    - *operation of leachate management systems (including disposal of leachate to an approved off-site facility);*
    - *maintenance of the leachate extraction system;*
    - *maintenance of the surface water management system (including periodic maintenance to the ditches); and*
    - *no additional gas management systems would be required;*
- *no active gas management will be required in the post-closure period;*
- *that leachate will be disposed of at an approved off-site facility and that the volume of leachate generated will decrease significantly following closure of the cell;"*

These postclosure cost projections are grossly inadequate to provide postclosure care in accord with Alberta Environment and Thorhild County requirements to protect public health, and groundwater and surface water quality for as long as the wastes in the proposed Thorhild Landfill will be a threat; projected postclosure care is estimated only for the minimum of 25 years, and does not address the true long-term costs. Many of the above-listed bulleted items for which it is assumed that postclosure funding will not be required, such as landfill gas management, will, in fact, likely require postclosure funding not only during the 25-year minimum postclosure period, but also for the period beyond that minimum extending for as long as the wastes (including the wastes deposited in crushed plastic bags) in the proposed Thorhild Landfill will be a threat to generate landfill gas when contacted by water.

The "method assumptions" continue on pages 5 and 6 (tab pages 2183 and 2184):

- *"that surface water will not be retained following closure of the cell. This assumes that previous monitoring would have determined that the surface water quality was suitable for release. In the event that operational monitoring indicates that surface water run-off would not meet discharge criteria, revisions to the cost estimate may be required;*

- *that routine inspections will be conducted, and the results of these inspections and of environmental monitoring activities will be presented in annual reports; and*
- *that the estimate is to be based on reasonably foreseeable closure and post-closure activities and costs in accordance with items and approach established. No provision has been included for contingency items that are not considered reasonably foreseeable in accordance with routine closure and post-closure of the Landfill."*

A properly developed estimate of postclosure costs would include not only the costs for landfill monitoring and maintenance but also the millions of dollars for groundwater remediation that will eventually be needed as a result of the proposed Thorhild Landfill's location at a site that does not have geological characteristics that provide for public health, groundwater, and environmental protection for as long as the wastes in the proposed landfill will be a threat, as well as a result of the grossly inadequate design for the proposed landfill.

The "method assumptions" continue on pages 6 and 7 (tab pages 2184 and 2185):
"It should be further noted that:
- *costs are presented in 2010 dollars;*
- *no attempt has been made to consider the time value of money (i.e. net present value), and that if required, WMCC's Accounting and Finance Department deal with this aspect of the closure and post-closure obligations in accordance with the company's standard accounting procedures.*

The following sub-sections of this letter summarize the selection of values pertaining to the Landfill and the basis for the selection of each site-specific value.

As discussed in our comments, the HELP model is not reliable for estimating the amount of water that will enter the wastes in the landfill over the period of time that the wastes in the landfill will be a threat to generate landfill gas and leachate.

Section 3.2 "Quantity and cost assumptions" continues on page 7 (tab page 2185):
- *the estimated cost of engineering related to closure and post-closure is assumed to be 15% of the total closure cost (which is a typical estimate for earthwork activities);*
- *the estimated cost of closure and post-closure assumes a contingency of 20% (which is typical for earthworks activities for preliminary cost estimates); and*
- *the mobilization and demobilization of the equipment for the capping earthwork will be 10% of the total closure cost.*

Pages 8 and 9 (tab pages 2186 and 2187) present tables of the estimated costs of components of Thorhild Landfill closure and postclosure.

4.0 Estimated Costs
4.1 Closure costs

Item	Unit	Quantity	Unit Rate	Cost*	Comment
Closure plan	LS	1	$10,000	$ 10,000	Prepare closure plan for the site; cost based on consulting fee estimate
Pond reclamation	LS	1	$ 48,000	$ 48,000	Earthworks associated with decommissioning of leachate and run-off ponds; cost based on estimate for 1 excavator, 1 dozer, and 1 rock truck (assumed total of $600/hr) for 80hrs
Liner	m^2	11,250	$ 30.00	$ 338,000	Includes 0.6m compacted clay liner overlain by a geomembrane and leachate collection layer.
Barrier Layer	m^3	66,000	$ 8.00	$ 528,000	Excavate load haul place spread, and compact 0.6m barrier layer material from on-site source; cost based on recent tender prices
Subsoil Layer	m^3	80,100	$ 3.50	$ 280,000	Excavate load haul place and spread 0.35m from onsite source over Cell area and disturbed areas; cost based on recent tender prices.
Topsoil Layer	m^3	33,900	$ 3.50	$ 119,000	Excavate load haul place and spread 0.2m from onsite source over Cell and 0.1m to cover disturbed areas; cost based on recent tender prices.
Seeding and fertilizer	ha	23	$ 800	$ 18,000	Seeding and fertilizer; cost based on Alberta Infrastructure and Transportation**, Item E607 (Drill seeding)
Barrier Layer Supervision – QA/QC	days	30	$ 1,500	$ 45,000	Supervision during the construction of the barrier layer; cost based on consulting fee estimate
Barrier Layer Lab Testing	LS	1	$ 16,000	$ 16,000	Materials testing for the characterization of the barrier layer material; cost based on consulting fee estimate
Mob/Demob	%	10%		$ 134,000	Approximately 10% of total earthworks cost
Subtotal - Closure				$ 1,536,000	
Engineering				$ 230,000	15% of closure cost
Contingency				$ 353,000	20% of closure cost
Total Estimated Closure Cost				$ 2,100,000	

* Costs are shown in 2010 dollars.
** Unit Price Averages, Provincial 2010 construction prices tendered between July 01, 2009 and Jan. 31, 2010 published by Alberta Infrastructure and Transportation

4.2 Post-closure costs

Item	Cost*	Comment
Groundwater, leachate, and gas monitoring (Field Work)	$ 6,000	Based on 13 groundwater wells, and 2 leachate wells, 2 sampling events/year, at $200/sample (cost estimate per sample provided by WMCC)
Groundwater, and leachate (Analytical)	$ 9,300	Based on 13 groundwater wells, and 2 leachate wells, 2 sampling events/year, at $310/sample (cost estimate per sample provided by WMCC)
Leachate Extraction and Treatment	$ 173,000	Based on annual volume of leachate generated estimated using HELP; cost of disposal ($45/$m^3$) provided by WMCC.
Maintenance (including maintenance of cap, vegetation, monitoring systems)	$ 10,000	Construction cost estimate based on $1000/yr for reseeding and landscape maintenance (includes allowance to reseed 5% of the cap annually and $500 for other (weed control and fertilizer)), 30hrs@$250/hr equipment time for cap repair, ditch and road maintenance, $1000/yr allowance for leachate system maintenance, assumes no mowing
Site inspection and recording	$ 6,000	Cost based on a consulting estimate for 2 annual site visits, 8hrs@$125/hr for the visit + 8hrs@$125/hr follow up
Annual Reporting	$ 12,000	Consulting estimate. Includes reporting costs for groundwater, leachate, and gas monitoring
Subtotal – Annual Post-closure cost	$ 216,000	
Post Closure Period	25 years	Minimum period based on Standards for Landfills
Subtotal – Post-closure cost	$ 5,400,000	
Contingency	$ 1,080,000	20% of Post-Closure Cost
Total Estimated Post-Closure Cost	$ 6,500,000	

* Costs are shown in 2010 dollars

Page 10 (tab page 2188) presents:

"5.0 SUMMARY
The total cost associated with the closure and post-closure for Cell 1, based on the stated assumptions may be summarized as follows:

Total estimated closure cost	*$ 2.1M*
Total estimated post-closure cost	*$ 6.5M*
Total estimated closure and post-closure cost Projects:	*$ 8.6M*

As stated in the introduction quoted above, the WM/Adelantar postclosure cost estimates cover only the initial development of Cell 1; they do not cover the total for the whole landfill.

The individual item costs presented in Tables 4.1 and 4.2, as well as the totals, are highly unreliable; they do not provide an estimate of the true postclosure costs for the Thorhild Landfill.

The Alberta Environmental Appeal Board should reverse the Alberta Environment approval of the proposed Thorhild Landfill based on the highly unreliable approach used by WM to estimate the postclosure costs for this landfill. As discussed in these comments, the cost estimates should consider the true costs of monitoring and maintaining the landfill, as well as groundwater remediation, for as long as the wastes in the proposed landfill will be a threat to generate leachate. If WM is not being required to fund the total postclosure costs until such time as the landfill can be reliably demonstrated to no longer have the ability to generate leachate and gas, Alberta Environment should be required to identify the entity that will provide the balance of postclosure funding, as well as its ability to provide the funding, for as long as the wastes in this proposed landfill will be a threat.

Comments on Alberta Environmental Protection "Action Leakage Rate Guidelines"

Comments Prepared by
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Beginning on page 1088 of Tab 144 is:
Alberta Environmental Protection, "Action Leakage Rate Guidelines," Report prepared by Industrial Waste & Wastewater Branch, Air & Water Approvals Division, Alberta Environmental Protection, May (1996).

Presented below are comments on that document as it pertains to the proposed Thorhild landfill.

The introduction states on page 1089:
"1. Introduction
This guideline has been developed by Alberta Environmental Protection because of the reality that all liners will leak to some extent and because of the resultant history of groundwater contamination at some sites. This guideline focuses on double lined ponds with a primary liner consisting of a geomembrane liner, a secondary liner (normally consisting of a geomembrane liner or a clay liner), and a leak detection/collection system in between the two liners, by ensuring that the liner leakage is minimal and that it is controlled."

While the "Guidelines" discussion is focused on liners used for industrial waste ponds, the above-quoted statement concerning the "reality that all liners will leak" applies also to landfill liners. It is generally agreed that a new, well-constructed plastic sheeting liner will contain about two 1-cm-diameter holes per acre; with poor-quality construction, the number of holes can be much greater. It is also understood that over time, plastic sheeting develops cracks, additional holes, and areas of deterioration, providing additional areas in which increased leakage will occur. The rate of deterioration is highly variable, but increasing deterioration can be expected to occur over the first few decades to hundreds of years of service. There is no question that eventually a landfill liner will fail to serve as an adequate barrier to retard the penetration of leachate through it and the passage of leachate into the underlying groundwater system.

Groundwater monitoring wells are intended to detect the leakage of landfills. According to the regulations, when leachate is detected in a monitoring well, action is supposed to be taken to define the area of polluted groundwater and remediate it, usually by pump and treat methods. However, as discussed in our "Flawed Technology" review cited below, it is unlikely that incipient leakage of landfill leachate will be detected by groundwater monitoring wells placed, as they typically are, hundreds of feet apart. The initial leakage of lined landfills will be characterized by finger-like plumes of leachate-polluted groundwater; the zones of capture of typical monitoring wells are about a foot or so around the well. It can be expected, therefore, that the narrow plumes of incipient leakage will readily pass the line of monitoring wells without being detected by them; this will lead to offsite groundwater pollution before detection. These

and related issues are discussed in our "Flawed Technology" review, which has been recently updated with addition information:

Lee, G. F., and Jones-Lee, A., "Flawed Technology of Subtitle D Landfilling of Municipal Solid Waste," Report of G. Fred Lee & Associates, El Macero, CA, December (2004). Last updated October (2012). http://www.gfredlee.com/Landfills/SubtitleDFlawedTechnPap.pdf

The updated "Flawed Technology" review also includes the following citations to additional information:

Jones-Lee, A., and Lee, G. F., "Expectations of Performance of Subtitle D Landfills: Comments on 'End of Life, Post-Closure Care, and the Sustainable Landfill' by J. Morris," Report of G. Fred Lee & Associates, El Macero, CA, August 2 (2012). http:///www.gfredlee.com/Landfills/Expectations_Perf_SubtitleD.pdf

Editor, MSW Management, "New Landfill Impact Paper with Emphasis on Post Closure Issues and Landfill Development Checklist," Online in Editorial Tab, MSW Management, "The Latest," http://www.mswmanagement.com/MSW/Articles/17258.aspx May 9 (2012). http://www.gfredlee.com/Landfills/MSW_Mgt_EditorBlog.pdf

Lee, G. F., and Jones-Lee, A., "Review of Potential Impacts of Landfills & Associated Postclosure Cost Issues," Report of G. Fred Lee & Associates, El Macero, CA, April (2012). http://www.gfredlee.com/Landfills/Postclosure_Cost_Issues.pdf

Lee, G. F., and Jones-Lee, A., "Checklist of MSW Landfill Groundwater and Environmental Protection Issues," Report of G. Fred Lee & Associates, El Macero, CA, April (2012). http://www.gfredlee.com/Landfills/Checklist_LF_Issues.pdf

Those sources discuss fundamental flaws associated with the development and use of lined landfills such as the proposed Waste Management Thorhild Landfill. Such flaws preclude lined landfills from reliably preventing groundwater pollution by landfill leachate and from providing long-term protection of public health and environmental quality.

Summary of Dr. G. Fred Lee Professional Publication Record
June 15, 2012

I was recently informed that a Waste Management staff member stated at a public meeting in Alberta, Canada that I have not published peer-reviewed papers on landfill issues. That claim was made in an attempt to discredit the technical content of my reports that concluded that the proposed Waste Management, Inc. Thorhild landfill will ultimately fail to protect groundwater and surface water quality from pollution by landfill leachate for as long as the MSW wastes proposed for deposition in that landfill will be a threat to the environment and the public health and welfare of those within the sphere of influence of the proposed landfill. First, it is important to note that that rather than address the technical substance of my findings, Waste Management personnel sidestepped the technical critique and attempted to redirect the focus onto my history of technical publication. Second, in doing so, the Waste Management representative demonstrated the paucity of his familiarity not only with my background and publications, but also with the technical literature in this field.

While my history of technical publication does not change the reality of the significant technical deficiencies of the proposed landfill for protecting public health and environmental quality, it behooves me to set the record straight concerning my publication record. As shown in my resume, I have developed more than 1,184 professional papers and reports on issues and projects in which I have been active over my five-decade-long professional career in the sources, significance, fate, and control of chemical contaminants as they may impact beneficial uses of surface and groundwater quality and public health/welfare. Many of those papers and reports are available as downloadable files from Dr. Jones-Lee's and my website, www.gfredlee.com. Included in that total are 487 papers that have received formal peer review or professional review of technical content; about 50 of those papers that have received such review have been devoted to landfilling issues.

In addition to my formally peer/professionally-reviewed papers, I have authored another 647 reports, of which about 100 have been devoted to issues of landfill impacts and protection of public health/welfare and environmental quality from such impacts. Those reports include reports on findings of research projects I have undertaken; those project reports were extensively peer-reviewed by the funding agencies' staffs and their invited peer-reviewers for the studies. Other reports consisted of comments I submitted to regulatory agencies concerning existing and proposed regulations, comments on which I had solicited technical review by professional colleagues.

Another group of our reports is comprised of extensive discussions of landfill issues; those reports contain discussion of, and references to, the landfill literature including peer-reviewed papers by other professionals on the issues of concern. One report in particular, our so-called "Flawed Technology" review, provides an in-depth review of information and findings from the technical literature and professionals in the field concerning aspects and provisions of the US EPA Subtitle D MSW landfilling regulations relative to their adequacy and reliability for providing true protection of public health/welfare and environmental quality within the sphere of influence of the landfill for as long as the disposed wastes are a threat. That more than 50-page discussion contains about 100 references to the professional literature. As with our "Flawed

Technology," review many of our reviews are of greater length and depth than those typically published in the peer-review journal. Among our overview reports are:

> Lee, G. F., and Jones-Lee, A., "Flawed Technology of Subtitle D Landfilling of Municipal Solid Waste," Report of G. Fred Lee & Associates, El Macero, CA, December (2004). Updated July (2011).
> http://www.gfredlee.com/Landfills/SubtitleDFlawedTechnPap.pdf
>
> Editor, MSW Management, "New Landfill Impact Paper with Emphasis on Post Closure Issues and Landfill Development Checklist," Online in Editorial Tab, MSW Management, "The Latest,"
> http://www.mswmanagement.com/MSW/Articles/17258.aspx May 9 (2012).
> http://www.gfredlee.com/Landfills/MSW_Mgt_EditorBlog.pdf
>
> Lee, G. F., and Jones-Lee, A., "Review of Potential Impacts of Landfills & Associated Postclosure Cost Issues," Report of G. Fred Lee & Associates, El Macero, CA, April (2012). http://www.gfredlee.com/Landfills/Postclosure_Cost_Issues.pdf

In addition to my extensive record of publishing in peer-reviewed publication, I have served as member of the editorial boards of several environmental journals including *Environmental Science and Technology*, *Groundwater*, *Stormwater*, *Remediation*, and *Environmental Toxicology and Chemistry*. As a member of these editorial boards, it was my responsibility to peer-review papers proposed for publication in the journal. Rarely does a month pass in which I am not asked by an editor of a national/international journal to peer-review a proposed paper or report that has been submitted for publication. Recently, at the request of the US EPA, I served on two peer-review panels for research projects proposed for US EPA funding in areas of water quality management.

For two decades I served as an American Chemical Society tour speaker, in which capacity of was invited to address various ACS chapters throughout the US concerning landfills and their potential problems. At the invitations of a variety of professional groups including the National Groundwater Association, American Water Resources Association, several University of California extensions, and the American Society of Civil Engineers, I presented numerous one-day to several-day short-courses on MSW landfilling issues and problems. Those presentations received substantial peer-review.

For about 20 years, I served as Chief Examiner for the American Academy of Environmental Engineers (AAEE) in New Jersey and in California, in which capacity I sat in review of the qualifications of professional civil engineers to attain AAEE-certification as professionals in solid waste management.

While I strongly support having papers and reports properly peer-reviewed prior to publication, I also fully understand that going through a peer-review process does not ensure that published papers on all topics are, in fact, technically strong or reliable. Indeed, in my more than 50 years of work on more than 80 landfills, I have found that some papers that are cited by landfill applicants and their consultants do not provide full disclosure of potential longterm impacts of a proposed landfill. In order to address this well-recognized problem, a member of the Ethics

Committee of the American Society of Civil Engineers asked me to provide a discussion of this issue, which was published as:

> Lee, G. F., and Jones-Lee, A., "Practical Environmental Ethics: Is There an Obligation to Tell the Whole Truth?" Published in condensed form as "Environmental Ethics: The Whole Truth," Civil Engineering, Forum, 65:6 (1995).
> http://www.gfredlee.com/Landfills/ethics.htm

For further information on my professional background, expertise, and experience can be found in my resume and on our website.

It is not surprising that Waste Management would be making disparaging, off-the-cuff – though both untrue and tangential to the issues – statements in an effort to try to discredit my technical review of the proposed Thorhild landfill. Not only do I have a strong and extensive history of peer-reviewed publications on landfill impact issues, but also the technical credibility of my comments on the potential impacts of the Thorhild Landfill on public health and the environment cannot be impugned.