CRANE MOUNTAIN ENHANCEMENT INC.

REPORT OF CONCERNS

REGARDING

CRANE MOUNTAIN SANITARY LANDFILL

To

The Honourable Gilles LePage

New Brunswick Minister of the Environment and Climate Change

23 August, 2025

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Executive Summary

CMEI has been acting as the watchdog for the Crane Mountain landfill since the original design and construction started. Recently, in response to the proposal by FRSC to extend the life of the landfill by adding ninety feet to the height of waste on the pile, CMEI has contracted with experts to review and analyze the areas of landfill construction and hydrogeology and have extensively reviewed documentation on the original design and construction of the landfill.

As a result of our consultation and reviews, CMEI has identified eight items that are of serous environmental concern and has provided detailed explanation of the specific issues and their potential impact. The areas are:

- Landfill Liner
- Construction and Demolition Waste Area
- Testing for PFAS and Microplastics
- Analysis of Bedrock
- Discrepancies in Testing of Monitoring Wells
- Failure to Test Monitoring Wells
- Shortage of Monitoring Wells and Surface Water Stations
- Approval to Operate

The document identifies the background to the landfill and CMEI's involvement and provides an introduction to the remainder of the report. The subsequent sections describe the specific concerns and issues. As a result of this analysis, CMEI has identified nine actions which should be started and implemented quickly to protect the local environment and protect a significant number of residents from potential loss of access to drinking water with a resultant significant loss of the value of their homes.

The recommendations are described more fully in Section 11. Overall, they consist of the following actions:

- stop the landfill life extension/height increase project immediately or as soon as feasible. Continue with filling a newly constructed cell for municipal waste (apparently, cell #9 of 14 has not been started).
- add testing requirements for monitoring wells and leachate to include PFAS, PFOS and microplastics
- initiate stricter processes for testing monitoring wells, including additional oversight and initiating actions to analyse and correct anomalies
- ensure **all** monitoring wells are tested regularly

- perform detailed geological study of the bedrock between the landfill and the downstream community
- install additional monitoring wells downstream of the landfill (this action is dependent on having the geological study completed
- update the Approval to Operate to include these requirements
- install a double liner for all future cells
- install a liner system under the C&D site; this should also be a double liner system

1. BACKGROUND

Crane Mountain Enhancement Inc. (CMEI) was created by renaming the Fundy Future Environmental Benefits Council (FFEBC) who were appointed by the Order in Council 96-849 as one of the conditions imposed by the Minister of Environment for providing approval for the Fundy Region Solid Waste Commission (FRSWC - now the Fundy Region Service Commission, FRSC) to construct and operate a regional sanitary landfill at Crane Mountain. Specifically, the requirement related to the establishment of CMEI stated:

> *"(I) the Fundy Region Solid Waste Commission shall establish a Community Environmental Monitoring Committee where membership, terms of reference and mandate shall be determined in consultation with the Department of the Environment; the Committee shall be established prior to initiating construction of the facility; and the Department of the Environment shall have the authority to review the results of the monitoring programs and make appropriate recommendation".*

The FRSWC established the Fundy Future Environmental Benefits Council (FFEBC – now CMEI) and an agreement was signed between FRSWC and FFEBC with the approval of the Minister of Environment.

The agreement defined the mandate of the FFEBC and included the requirement to report to the Minister of Environment.

The Crane Mountain Solid Waste facility includes two main areas on the site in which waste is disposed: 1) a disposal area for municipal solid waste which is placed in lined landfill cells with leachate collection and management, and 2) an unlined C&D (construction and demolition) disposal area. In this respect the facility is similar to the other regional containment solid waste sites established within the Province of New Brunswick circa 1990s to regionalize and provide for more environmentally robust waste management. However, the Crane Mountain landfill is considered unique among the six provincial regional solid waste landfills in that it is located within a groundwater recharge area, positioning it upgradient and in relatively close proximity to approximately 1000 potable water supply wells.

In the agreement with FRSC, the mandate of CMEI includes among other items, to:

- monitor the Operation of the Facilities;
- ensure that its members are regularly and fully informed concerning the Operation of the Facilities;
- report to the Minister;

- advise the Commission on the views and comments of the council concerning the operation of any element of the Commission's solid waste management system where the operation of such element or elements has a direct impact on the Operation of the Facilities.

It is important to note that the Province identified that one of the primary objectives of CMEI's mandate was to ensure that the necessary efforts and measures are assessed and implemented to protect the groundwater resource on which the community relies to meet their current and future potable water requirements.

The original design for the site was for a lifespan of twenty-five years (Fundy Solid Waste Action Team, 1994), based on an estimate of the amount of waste expected. The actual volume of waste has been approximately half that amount since the landfill started operation. Through programmes such as collection of recyclable materials over the last several years, waste diversion efforts have improved municipal and the amount of waste being added to the main pile is being reduced. This provides a significant extension to the landfill life cycle extending its lifetime to more than double the original planned timeline – this extension provides sufficient time to find alternatives to increasing the height of the landfill, given the dangers introduced by this project.

2. INTRODUCTION TO THIS REPORT

In September 2023, CMEI contracted the engineering company, EXP Services Inc. (EXP – formerly ADI Limited), to perform a detailed review of the Crane Mountain landfill. CMEI has been working with EXP for most of the life of the landfill; they have significant expertise in landfills in New Brunswick and elsewhere and in 2005 (as ADI Group Inc, Engineering Services) they completed an independent external review of the landfill, and have continued since that time to provide periodic support to assist CMEI in their ongoing monitoring and review of various landfill aspects (e.g., construction, monitoring).

As part of their recent work on behalf of CMEI, EXP retained Dr. Kerry Rowe, who is the current Barrington Batchelor Distinguished University Professor in the Faculty of Civil Engineering at Queens University in Kingston, Ontario and is the Canada Research Chair in Geotechnical and Geoenvironmental Engineering. Dr. Rowe has performed extensive globally recognized and peer reviewed research into landfills with a specific focus on liner

systems. CMEI received a report from Dr. Rowe and it is available on the CMEI website at www.cmei.ca.

To implement the monitoring portion of the mandate, CMEI has established a Monitoring Committee, from among the council's Board of Directors. The members of this committee have performed extensive research of various publications and documents, including the original Environmental Impact Assessment (1994) and including reports from EXP and Dr. Rowe.

This document identifies several major issues that the Monitoring Committee has identified with the design, construction, operation and monitoring of the landfill, and the serious potential effects on these issues with the Height Increase project. These are critical to assessing the potential impacts of raising the height of the landfill and thereby extending not only it's active operational life, but also the active leachate generation life after closure. The following sections identify those concerns and provide detailed background in each case.

3. LANDFILL LINER

An engineered containment landfill liner system provides a barrier to contain leachate to prevent contamination of the surrounding environment and to enable collection of the leachate for subsequent treatment. The engineered liner for the Crane Mountain landfill includes a composite clay and geomembrane hydraulic barrier, plus drainage and protection layers, referred to as a single composite liner system.

At the time of the original design of the Crane Mountain landfill, this single composite liner was considered satisfactory for containment of the leachate and was designed to provide a breakthrough timeline of twenty-five years. This breakthrough time, understood to be based on the assumption of advective transport only through the landfill liner, was identified in the New Brunswick Department of Environment and Local Government (NBDELG) Guideline of Landfill Construction document titled April 12,1994 Liner Guidance, which can be found in Appendix A. Item r. on page 3 of this document identifies the 25-year breakthrough. It is important to note that this document is now 31 years old. In the intervening years, there has been much research in this area.

Due to the extension of the lifespan of the landfill as identified in Section 1. Background, CMEI is concerned that twenty-five years minimum breakthrough is no longer sufficient to protect the surrounding environment and specifically, the 1000 private wells downstream

of the landfill. This concern is further justified in light of the significant advances in understanding of containment liner systems, including aspects such as contaminant transport processes, the significant limitations of a single composite liner design and the new chemicals e.g. micro plastics and PFAS. For example, in Dr. Rowe's study for CMEI, he has noted that:

(i) "All landfill liners leak" and references several published studies including Giroud and Bonaparte 1989a, b; Giroud 2016; Rowe 1998, 2005, 2012, 2018, 2020; Beck 2015. (The full list of references can be found in Appendix B)
(ii) The actual leakage is likely to be substantially more than originally considered using historical design assumptions, due to holes in wrinkles (as specified in Rowe 1998, 2012, 2020) and due to desiccation of the interface between the geomembrane and compacted clay liner (Rowe 2018).
(iii) The lack of a well-documented construction quality process that involved documentation of the time of day that the liner was covered and any particular actions that were taken to minimize wrinkles, sun exposure, trampolining, or any other adverse conditions affecting liner integrity during construction.

Dr. Rowe identifies three primary factors affecting the effectiveness of this composite liner:
(a) the area of wrinkle with holes,
(b) the hydraulic conductivity of the clay, and
(c) the interface transmissivity between the geomembrane and compacted clay.

Dr. Rowe has also identified problems with:
(a) the lack of a well-documented construction quality process,
(b) the service life of the geosynthetic components of the liner system,
(c) the potential for desiccation of the clay liner below the geomembrane, and
(d) the absence of knowledge of PFAS, a more recent emerging contaminant of concern, or consideration of its potential environmental impact

As a result of his work on liner systems, Dr. Rowe recommends the use of a double liner system and Quarterly testing for PFAS in Leachate. There is currently no testing for PFAS.

Regarding the dated liner design used in the Crane Mountain landfill's original, current and presumably future cells Dr. Rowe summarizes his collective concerns in the statement: "**What was approved about 25 years ago and is being done now is no longer appropriate. As facts change, so must the design.**"

For the complete report by Dr. Rowe refer to CMEI's website: www.cmei.ca.

In 2005, ADI Limited (now EXP) completed an independent external review of the Crane Mountain Landfill. This review was requested by CMEI in response to a 1994 Environmental Impact Assessment Registration (NB EIA #1025) to increase the height of the landfill. The review recommended (among several others) that a double liner be used in the construction of future cells (see Appendix B). Since its initial review, this recommendation was communicated clearly by CMEI to FRSC and was repeated in an update to the EXP review completed in 2009. This recommendation (see Appendix B) was rejected by FRSC and this rejection has never been justified. The research by Dr. Rowe points to significant threats of leakage into the bedrock under the liner and CMEI has major concerns regarding the integrity of the liner under the existing cells, especially if the liner will be stressed with increased height and weight. The failure by FRSC to adopt the significantly more robust double composite liner design is particularly problematic given that the Crane Mountain landfill is located in a much more sensitive hydrogeological setting than other engineered landfills constructed in the Province of New Brunswick that changed to a double liner design and construction very early in their mandate. The continued use by FRSC of a single liner is further inexplicable in that the NBDELG landfill construction guidelines as early as 1988 stated that their primary objective was to *"…insure that all sanitary landfill facilities are designed and constructed to meet state-of-the art environmental standards"*. As stated elsewhere in this brief and clearly demonstrated and stated in Dr. Rowe's review, the continued use of a single liner in a site setting such as the Crane Mountain landfill falls significantly short of this NBDELG objective. To add even more waste on top of an already deficient design cannot be justified in light of the current understanding of containment liners and state-of-the art landfill construction practice.

Dr. Rowe also examines the effects on the liner of extending the life of the landfill by adding `height to the top of the landfill. He identifies significant concerns with this extension including an exponential increase in the time span of post-closure monitoring requirements.

One of the significant concerns of the height increase, follows from the issue with the twenty-five-year breakthrough timeline – as the landfill life extends further beyond this timeline, the plan for the height increase is to peel the top cover off each successive cell to add more waste on top. With the cover removed, the original liner will again be exposed to new leachate production as rainfall filters through the existing waste pile and the new waste on the top. By the time the last of the existing cells is exposed, the age of the liner will be well in excess of twenty-five years. Indeed, if the last cell to be exposed is Cell #1, the liner could be forty years old or more. This issue was completely ignored in the EIA Registration document for the life extension project.

4. CONSTRUCTION AND DEMOLITION AREA

The Construction and Demolition (C & D) area is separate from the main waste pile. Because the area is away from the waste pile, there is no liner that was designed or constructed under the site.

Over the last several years, there is significant literature that suggests certain compounds of significant concern regarding potable groundwater quality (e.g., PFAS, microplastics) can be even more elevated in C&D leachate than in MSW waste leachate; these compounds in leachate can significantly exceed Health Canada Guidelines for Canadian Drinking Water Quality.

The fact that the C & D site is unlined and has no leachate collection but relies solely on infiltration and natural attenuation to mitigate groundwater impacts, suggests this aspect of the facility warrants further rigorous and comprehensive environmental assessment. The natural flow of groundwater from the landfill area is either into the local streams and from there into the Wolastoq (St. John) River and into the Bay of Fundy, into the deeper groundwater flow system that supplies the approximately 1000 downgradient potable water supply wells, or both. This document includes Section 6. Analysis of Bedrock, which suggests that the leakage of leachate from the C & D site poses a significant threat to the 1000 private wells downstream of the landfill.

As identified in Section 1. Background, the lifespan of the landfill is now significantly longer than originally designed. This suggests that, whereas in the original landfill design there was only limited concern for contaminants from C & D waste, the concerns should now be two-fold, based on the expected lifespan of the landfill and on the developing understanding of the significant health effects and risks dangers of microplastics and PFAS in drinking water.

Currently there is no requirement in the Approval to Operate for any liner under the C & D site. CMEI recommends that this requirement should be added to that document as soon as possible and immediate action be taken to rectify the lack of a liner. Further, in light of the increasing concern with C&D disposal site leachates, the nature and quantity of C&D waste disposed at the site warrants significant clarification.

By extending the life of the landfill, by adding height to the main municipal waste pile, the issue with a lack of liner under the C & D waste pile extends this problem for the longer lifespan.

5. TESTING FOR PFAS AND MICROPLASTICS

- **Lack of testing of Leachate and Monitoring wells for PFAS (a contaminant now restricted at the federal level)**. The expert consulted by EXP, Dr. Kerry Rowe, has identified in his report, that a serious chemical contaminant commonly present in the leachates of landfills (and also by Health Canada, *Reports and Publications*, *Environmental Contaminants* *Please Reference the Government of Canada, Health-Canada website:* *https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/water-quality/guidelines-canadian-drinking-water-quality-summary-table.html#t2* (*refer to Poly and Per-Flouroalkyl Substances (PFAS) in the table*), is not being analyzed or characterized in the monitoring data of the Crane Mountain Landfill leachate and Monitoring Wells. Dr. Rowe's studies have shown that landfills are a large concentration (expected average landfills range are 1500 parts per million, ppm) of Poly or Per-Fluoro-Alkyl substances (PFAs), Perfluoro Octane Sulfonates (PFOS) and microplastics, and these chemicals are ever-present in the leachate. In Dr. Rowe's studies(*Dr Kerry Rowe RKRI report, RKRI Memo Expansion Issues, Crane Mountain Landfill Capacity Augmentation and Life Extension, 2024-12-09 available on the CMEI website*). The studies have also identified that the leachate containing these chemicals also cause breakdown or chemical attack of the synthetic geomembrane liner, its related components (e.g., geotextile, geonet) and the clay liner. A breakthrough of the leachate to the groundwater would cause a serious chemical contamination to the groundwater and subsequently would pose a significant risk to the well water supply to approximately 1000 domestic wells located downstream in the discharge area from the landfill site. The US EPA has set an extremely low maximum allowable concentration of these contaminants in drinking water standards (*Reference the US EPA website:* *https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations*, *for the table on US EPA Drinking Water Standards, as defined in the National Primary Drinking Water Regulations – NPDWR, 2025*), due to their health effects and ability to accumulate in an organism. Accumulation in an organism is not solely through ingestion, but also through absorption. As stated in the Environmental Impact Assessment Registration #1617, June 21, 2023 (cite EIA Registration #1617, Pg. 8) "*the project would add capacity for an additional 2.4 million cubic meter tonnes, essentially doubling the existing capacity of the Landfill*." The doubling of the landfill waste will have the effect of doubling the PFAS and microplastic concentration in leachate and

will extend the presence (or production) of these contaminants for hundreds of years.

- **Health Canada has recently established limits on concentrations of PFAS.** The US EPA has already set a drinking water standard guideline restriction for the chemical identified as PFAs, or also known as, the Forever Chemical, because the chemical does not readily break down into less harmful compounds. World-wide recognition of this contaminant has identified its health effects and realized the seriousness of it making its way into the drinking water stream. Similarly noted for its toxicity and carcinogenic effects, there is another chemical compound labelled PFOS, used for fire retardants in everything from clothing to furniture and building materials. Studies have determined that PFOS and PFAs are cumulative in an organism and cause health effects such as cancers of the liver and kidneys, and reduced growth in fetuses, infants and juveniles. Due to the bioaccumulation of PFAs, the EPA has recognized that the maximum allowable concentration of this contaminant in drinking water is very low (9 ng/L). Guidelines for Canadian Drinking Water Quality have only recently caught up to the US EPA. Therefore, it is negligent for the Landfill operating authority to ignore analysis of the leachate and groundwater samples for these contaminants, knowing their serious health effects on people and aquatic life, and that guidelines will be requiring the Crane Mountain Landfill to monitor them. Other chemical analysis parameters on leachate samples indicate a strong possibility that the contaminants of concern are present.

- **Leachate removed from site is not tested prior to transport to Lancaster Wastewater Treatment Facility (LWTF).** Due to the disfunction of the Crane Mountain Landfill Operation to fulfill its obligation to pretreat leachate prior to release, (*reference: Crane Mountain EIA Approval Conditions 1995, Pg.1, Item 6*) all leachate is trucked offsite (commonly twice daily in a full-size tanker transport trailer, ~30,000 liters per load) to the City of Saint John's Lancaster Wastewater Treatment facility (LWTF). According to the Crane Mountain Annual Environment Reports (*reference: Environmental Monitoring Program, 2008 & 2009, Crane Mountain Landfill, Monitoring Report (January to June 2008) (Final Report) and Annual Report 2009*), there are no separate samples and analysis for the truckloads of Leachate. There is, however, sampling and analysis of the leachate pond on a routine basis. In other environmental monitoring requirements for different waste stream generators, a cumulative and composite sample would be generated representing a periodic sample for analysis. For example, a titer, or a sample size determined from the ratio of the truck volume to the total volume discharged in a defined period, such as a week, from a trailer load sample would be added to a

composite sample retained for a 1- or 2-week composite sample submitted for analysis).

- **LWTF is primarily a sedimentation process.** Sewage Lagoons typically rely on an oxidation (aeration and bioreaction) and settling process for treatment of sewage prior to release to the environment. The process is dependent on a bacterial breakdown of sewage solids and pathogens where an abundance of oxygen in the treatment pond facilitates this action. The broken-down solids are settled out (sedimentation) and the clear liquid (supernatant) above the settling pond flows out and is usually disinfected using chlorine or hypochlorite addition. As wonderful as this process can be to help reduce our human waste footprint on the environment, it is not the suitable type of treatment necessary to remove PFAS, PFOS and microplastic contaminants. Researchers globally have looked for methods to remove these chemical contaminants from drinking water sources. To date, most methods discovered are costly and restrictive, relying on high heat and Ion Exchange filtration treatment, none of which has been suitable with sewage treatment.
- **PFAS, PFOS and microplastics *are* not subject to sedimentation and remain suspended in water.** As the sewage treatment method is not effective to remove these chemical contaminants, they remain in solution and carry through to the effluent, or, as discovered in the State of Maine, USA, it bio-accumulates in the lagoon sludge (settled material solids). In error, several American states, including the state of Maine allowed the use of sewage treatment sludge to be used as farming fertilizer (*Most recent information https:kffhealthnews.org/news/article/pfas-forever-chemicals-tainted-water-maine/*). Now PFAs have been detected in the food chain (vegetables and livestock which fed on fertilized fields of hay).

Impact

PFAS and microplastics are draining into The Bay of Fundy via the Saints Rest Marsh Estuary, therefore *causing* off-site impacts which have never been considered in landfill design, operations and monitoring. The Environmental Impact Assessments for the original Landfill and the Landfill Height Extension Project did not include the Lancaster Wastewater Treatment Facility or the Bay of Fundy aquatic life as a projected impact. The leachate treatment failure of the Crane Mountain Landfill treatment facility (Xenon water treatment plant) very early in the life of the landfill has added an unplanned consequence to the Landfill impacts. With the Landfill Extension Project, the reliance on the Lancaster Wastewater Treatment Facility is far greater, and will continue to be a repository of PFAs

and microplastics. Just as it is being learned from American and Quebec Landfills with PFAS contamination with agricultural food streams (https://www.theguardian.com/environment/2025/jan/14/pfas-sewage-fertilizer and https://www.cbc.ca/news/canada/montreal/quebec-pfas-forever-chemicals-management-plan-1.7486757) , our local aquatic food chain is therefore now further at serious risk (bioaccumulation in shell fish and sea fish) as a result of changes to the landfill's leachate management operations.

6. ANALYSIS OF BEDROCK

The possible travel paths for the leachate that will escape from Crane Mountain are of primary concern to the residents of Martinon and Morna that are down stream from the landfill. There are approximately 1,000 houses and buildings in the effected area whose residents rely on water from individual wells.

The initial EIA performed by Gemtec/Neil and Gunter/Fiander-Good Associates Ltd. in 1994 discusses the geology but does not make any conclusions as to the probability of leachate leaking from the facility and estimates for the time it would take for contaminants to reach the impacted communities. There is very minimal field work (seismic, bore holes, ground penetrating radar, etc.) done in the area of concern between the landfill and the impacted communities.

The EIA was reviewed by hydrogeologists employed by the Department of Environment. In a January 26,1994 internal memo the hydrogeologists in the department stated:

> "*On the basis of the site situation and of the specific hydrogeological information presented in the report, the Department's hydrogeologists have unanimously expressed concern regarding the potential danger to groundwater supplies.*"

In a subsequent memo on October 12,1994 the hydrogeologists conclude (the risky site is the Crane Mountain site and the alternative site was Paddy's Hill).

> "Conclusion
>
> Relatively much less effort was apparently expended on the Paddy's Hill site than on Crane Mountain, even after our identification of major potential problems with the latter site..... Existing domestic wells in Lorneville would not be affected by even a catastrophic release of contaminant at the proposed site. I find it remarkable that so much effort has been expended on a risky site when there is easily available and apparently low-risk site that is reasonably economical and probably has

significantly greater potential for future expansion. I believe the way forward here to a solution of Saint John's waste problem is very clear."

From the information in this document. it is very clear that the Environment department ignored its own experts and pushed the approvals through despite the risk.

A subsequent report was prepared by engineers at FRACFLOW CONSULTANTs INC in September, 1997 entitled "*Review of Environmental Impact Statement, Regional landfill at Crane Mountain*". In this document it is stated:

> "*The proposed Crane Mountain landfill has been sited in the worst possible location within the drainage basin, namely in the main recharge area for the drainage basin. Furthermore, it is underlain by intensely fractured rocks whose hydraulic conductivities have been poorly characterized. In a large measure, the acceptance of the site, including part of the risk assessment, has been based on the results of numerical flow and transport modelling. We find that this numerical modeling is deficient and incomplete in a number of areas …*"

There is a significant lack of complete analysis of the fracturing of the bedrock which in turn creates a knowledge gap regarding the potential paths of leakage into the groundwater.

Gemtec, in their 2006 report on the Bedrock Hydrogeology concluded that an engineering group should:

> "*Carry out a more detailed bedrock-mapping program in the area down gradient of the landfill. The mapping should focus on surface outcrops and include fracture orientation, trace length, aperture and spacing. The information will aid in better assessing groundwater flow directions and velocities.*"

EXP did a review brief, in December 2024, where EXP addressed the deficiencies in the assessment of the ongoing analysis of the hydrogeology since 2006. EXP had developed a more recent groundwater model referenced by Gemtec in their ongoing analysis of the site hydrogeology and the recent plan by FRSC to increase quantity and height of waste. However, regarding Gemtec's use of this work EXP stated that:

> "*Other significant deficiencies of the submission include reliance on the EXP numerical modeling study; EXP was not consulted and has reservations concerning the use of the model to justify the proposed increase in waste loading on the liner and with the watershed. The numerical model and conceptual model on which it was based are subject to several simplifying assumptions and limitations, for which the recommendations for additional field assessment have not been implemented*

or completed. The EXP study is not, as stated by Gemtec, a "comprehensive" numerical model and does not address the NBELG requirement for detailed hydrogeological assessment, particularly for a proposed significant modification to the facility inherent in the planned significant increase in waste quantity and height."

The external reviews by experts in the field of hydrogeology. demonstrate the inadequate assessment of the hydrogeological conditions in this area of highly fractured bedrock. Opinions from three different professional groups including the Department of Environment themselves, do not support the conclusions being reached by Crane Mountain and its consulting firm.

There is an attempt to hide behind the monitoring wells as protection for those who are on wells downstream of the landfill. These wells may or may not detect discharges from Crane Mountain as the identified highly fractured bedrock could provide paths that would completely miss the wells that have been drilled (see Sections 8 and 9 below).

Gemtec performed a desk top study for their EIA related to the height increase at Crane Mountain. They performed no further studies or field investigations on the fractured geological conditions at the site or between the site and the adjacent communities which are downstream of the Crane Mountain landfill. As stated above, the creators of the model that Gemtec quotes as "comprehensive" have stated that it is not adequate for this purpose. Crane Mountain and their consultant Gemtec are basing their EIA on an incomplete model with a lack of adequate seismic, bore hole, GPR, and field investigation. This invalidates the EIA and puts the downstream communities at significant risk.

7. DISCREPANCIES IN TESTING OF MONITORING WELLS

- **Discrepancies in the test results of the monitoring wells that are not properly explained and with no potential remediation provided;** In the Compliance Monitoring Program, July to September 2023, Crane Mountain Landfill, Saint John, New Brunswick, (GEMTEC Project: 4662.09 – R58), Section 3.2, "Groundwater Results" it is stated with regards to analysis "*For ammonia, mercury, vanadium and cobalt it was not possible to determine whether the concentrations exceeded applicable guidelines, as their respective laboratory method detection limits exceeded the guideline concentrations. Historically, these detection limits have been greater than their applicable guidelines with the exception of mercury*."

The report did not provide an alternate analysis technique nor was a laboratory with adequate analysis technique employed. It was stated in Section 4.0 "Conclusions and Recommendations" "*For future sampling events it is recommended to discuss with the laboratory the possibility of lower detection limits for ammonia, vanadium, cobalt and mercury in surface water and groundwater to allow for comparison to the applicable guidelines*."

As per common industry practice, if a contracted laboratory cannot meet expected analysis limits, then it is the end of a contract with that laboratory and a new laboratory is contracted that is capable. Furthermore, Gemtec is not the responsible hiring party of the lab and is not in any position to provide such statements. As stated in Section 1.0 "Introduction", a disclaimer stated by the engineering firm regarding the laboratory: "*GEMTEC was not involved in the selection of the analytical laboratory.*"

- Annual Monitoring Report identifies some anomalies, e.g:
    - **"Concentrations of [analytes] manganese exceeded" the Canadian Drinking Water Quality Guidelines for Drinking Water (CDWQ).** In the Monitoring Report for January to June 2008 (Final Report) as required by the Environmental Monitoring Program and Approval to Operate 2015**?** Section 2.2.1 Monitoring Wells states the aluminum concentration in samples obtained from monitoring wells… exceeded the guideline of 100 ug/l, and, same stated for the analytes arsenic, iron, and manganese. These exceedances were explained as "*consistent with historical levels*" or "*are aesthetic Objectives and do not indicate a health hazard*."

      The CDWQ Guidelines classifies manganese as an aesthetic objective but also states manganese is a health hazard, especially for breastfeeding infants.

    - **"A new maximum" concentration , or "greater than their applicable guidelines", or "historic highs" for concentrations.** In the Environmental Monitoring Program Fourth Quarter and Annual Report 2023, Crane Mountain Landfill, Saint John, New Brunswick, (GEMTEC Project: 4662.09 – R59), Section 4.4.1, "Groundwater Results", in reporting about concentrations of zinc in Monitoring Well MW31S (shallow) provided results that were a "new high" compared to Atlantic RBCA Ecological Guideline (>10m from surface water) limit of 70 ug/L. There is no further discussion of remediating this "new high" result such as resample or more analysis of related parameters. To re-

iterate here; the Atlantic RBCA (Risk Based Corrective Action) Ecological Guideline was not a guideline standard agreed upon in the Conditions for Approval, it appears Gemtec decided to choose the guidelines to their own desire. The Atlantic RBCA Guideline is to be referenced for remediation of sites impacted by petroleum hydrocarbons and other contaminants (https://atlanticrbca.com)

- **"Turbidity exceeded the [Canadian Drinking Water Guidelines] at 28 monitoring well locations".** In the Environmental Monitoring Program Fourth Quarter and Annual Report 2023, Crane Mountain Landfill, Saint John, New Brunswick, (GEMTEC Project: 4662.09 – R59), Section 4.4.1, "Groundwater Results", it was stated "Elevated turbidity exceeding the GCDWQ Aesthetic Objective (AO) of 1.0 NTU was observed at 28 monitoring wells". It only explained the high result as being "consistent with historical data." And "sampling techniques" may have caused the result by rapid removal of water. There were no re-sampling results offered and no discussion if the sampling person's qualification provided sufficient training to not cause this problem.

- **No explanation is provided for these discrepancies and no remediation suggested.**

Impact. In any case of exceeded acceptable concentrations there is no other discussion of remediation to the results stated. It would be expected practice of due diligence for an Approval holder to resample and verify the exceeded results, as well as performing other analysis to provide further explanation or insight (pH, conductivity, variance in trends that may indicate a contamination). With the Height Extension project doubling the volume-mass of waste, it should be anticipated to take actions for anomalies in results from analysis that require further investigation to mitigate possible leakage effects on groundwater, especially considering the doubled amount of waste will require an extended amount of monitoring (greater than 100 years, per Dr. Kerry Rowe's report).

- "Unknown whether the readings are problematic. Requires improved statistical analysis of recent and long term data to determine if "trends" are present." In the Environmental Monitoring Program 2008, Crane Mountain Landfill, Monitoring Report (January to June 2008) (Final Report), File 658.98 – R02, October 2008, Section 2.2.1, "Monitoring Wells", reporting on sulfate concentration in MW34S, it was stated ""*The cause for the increase in sulfate remains unknown and the trend data at this well location should continue to be monitored*." And similarly, in a preceding discussion on manganese concentrations exceeding the CDWQ Guideline in MW36S, it was stated "*The cause for the increase in manganese and*

cadmium is not known and the trend data at this well location should be closely monitored."

8. FAILURE TO TEST MONITORING WELLS

The Crane Mountain administrators have, as stated previously, tried to calm concerns by pointing to monitoring wells as being the line of defense that would provide early detection. That mitigation, depending on where leachate is discovered, could be very difficult or impossible to implement in a financially viable manner. The alternatives of bringing water from Saint John via new water lines would result in tens of millions of dollars that the city cannot afford given its financial constraints. The land values for the community would take a serious decline (or become un-sellable) and the pollution of the Saint John River would be devastating for aquatic life in the river and would impact recreation (swimming) for those who live in the area.

There are currently a minimal number of landfill monitoring wells and surface water stations between Crane Mountain and the communities of concern. In the Gemtec 2023 report (Compliance Monitoring Program, July to September 2023, Crane Mountain Landfill, Saint John, New Brunswick, December 12, 2023) it is stated that:

> "Samples were not collected in July nor September 2023 from the following monitoring wells: MW39S, MW46U, MW47L/S/U, and MW50U. Monitoring well MW39S has not been sampled since at least 2011, although it remains a sampling requirement on the Approval. MW39S was visited in 2022 and while no damage was observed the monitoring well has been consistently dry. Monitoring wells MW46U and MW50U could not be sampled due to damaged (warped) well casings. In addition, two new monitoring wells were added to the sampling rotation: MW57S and MW57D. These monitoring wells were installed in September 2022, approximately 30 m to the east of MW47L/S/U to replace these wells."

Refer to Appendix C, for diagrams showing the location of the Monitoring Wells identified in this section.

The fact that one well has not been sampled since 2011 (a requirement under their permit to operate) is alarming and shows the lack of concern for a robust sampling program. While MW 47 has been decommissioned, the MW57 has been drilled to replace that well cluster.

The monitoring wells offsite, namely MW46U and MW50U, not being sampled is again alarming. There are not enough wells offsite as it is and having two inoperable is completely unacceptable.

Offsite monitoring wells are those located outside the Crane Mountain facility property and located between Highway7 (main route from Saint John to Fredericton) and the communities whose personal wells may be impacted, namely, Martinon, Morna, Ketepec, and Acamac.

The closure statement provided by Gemtec is particularly alarming given that Crane Mountain defends its position by pointing to a robust monitoring program. The closure statement (provided here for reference) is:

> "This report has been prepared for the sole benefit of our client, Fundy Regional Service Commission. This report may not be relied upon by any other person or entity without the express written consent of GEMTEC Consulting Engineers and Scientists Limited and Fundy Regional Service Commission.
>
> Any use that a third party makes of this report, or any reliance or decisions made based on it, is the responsibility of such third parties. GEMTEC Consulting Engineers and Scientists Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.
>
> GEMTEC Consulting Engineers and Scientists Limited personnel did not observe or oversee the collection of any samples or field measurements. GEMTEC Consulting Engineers and Scientists Limited provides no verification of the accuracy of the results, adherence to standard field sampling procedures, or compliance with field sampling procedures stipulated in the Approval with regard to sampling completed by Saint John Laboratory Services Ltd."

The fact that Gemtec has issued this report and made numerous conclusions and observations yet has never witnessed and approved the sampling methodology is problematic. It is difficult to draw accurate conclusions unless you witness and approve that process. This potentially indicates a lack of thoroughness and technical integrity. Third parties, the communities that could be impacted, do rely on the reports provided by Crane Mountains consultants, and while this language is often provided by professional firms to minimize exposure and liability for the firm, the statement with regards to sampling methodology and field implementation creates issues with the report's observations, statements, and conclusions.

As stated in Section 6 of this submission the above observations again invalidate the EIA expansion submission from Gemtec as submitted for their client Crane Mountain.

9. SHORTAGE OF MONITORING WELLS AND SURFACE WATER STATIONS

The current monitoring system for the Crane Mountain landfill demonstrates an inadequacy in monitoring well placement and density, particularly in the downstream direction where approximately 1,000 private potable wells are situated. This represents a significant gap in the environmental monitoring and protection framework and raises concerns about the ability to detect potential contamination before it reaches residential water supplies. This problem is further exacerbated by the nature of the flow system intended to be adequately monitored, i.e., a complex fractured bedrock aquifer in a potable water setting.

Issues of particular concern include but are not limited to:

- the fact that only three monitoring wells are positioned downstream from the landfill facility;
- they are spaced such that the gaps between them are large;
- and they are vertical wells only which minimizes the potential to intersect discrete fractures within the bedrock.

This limited number of monitoring points is inadequate for effective surveillance of a site with such complex geology and significant potential for environmental impact. The protection of these 1,000 private potable wells must be considered a paramount priority, as they provide essential drinking water to numerous residents in the surrounding communities of Martinon, Morna, Ketepec, and Acamac.

The current monitoring configuration creates several critical vulnerabilities in the environmental protection system. Firstly, as detailed in Section 6 of this report, there is a lack of comprehensive knowledge regarding fractured paths in the bedrock underlying and surrounding the landfill site. This geological uncertainty makes it highly probable that potential leachate leakage could entirely bypass the limited monitoring wells currently in place. The bedrock has been previously identified as “highly fractured” with both horizontal and vertical fracture patterns, yet no significant analysis has been performed to accurately map these potential contamination pathways, if at all possible, unless more monitoring wells are created.

Secondly, there is a complete absence of established groundwater-stream interaction monitoring protocols. This represents a serious deficiency in the monitoring program,

particularly given the importance of understanding how contaminants might travel between groundwater and surface water systems in this hydrogeological complex area. This deficiency necessitates enhanced surface water monitoring at locations where groundwater wells are adjacent to surface water sampling locations to properly understand the exchange dynamics between these interconnected pathways.

Furthermore, as indicated in Section 7 of this report, there are ongoing issues with the monitoring wells that are currently in place. The inability to sample certain wells due to damage, dryness, or other factors further compromises the already insufficient monitoring network. When combined with the geological complexities of the site, these operational deficiencies create an unacceptable level of uncertainty regarding the potential migration of contaminants from the landfill.

The numerical groundwater flow model that was recently developed for this site was based on limited field data and broad assumptions about site conditions. Despite this, there is no evidence that annual monitoring data is being systematically incorporated into this model to refine and improve its predictive capabilities. This represents a missed opportunity to enhance understanding of the site's hydrogeology based on available data. Continuous refinement of the groundwater model would provide valuable insights into potential contaminant migration pathways and could help identify optimal locations for additional monitoring wells.

Given the identified presence of potentially critical contaminants of concern in the leachate, including PFAS and microplastics, the need for a robust monitoring network becomes even more urgent. These contaminants pose long-term environmental and health risks, with documented persistence in the environment and potential for bioaccumulation in organisms, including humans.

In light of these geological and contaminant concerns, the current monitoring well network falls short of what would be considered adequate due diligence for a facility of this nature, particularly one situated upstream of so many residential water supplies that rely on a fractured bedrock aquifer. The limited number of downstream monitoring wells cannot reasonably be expected to provide early warning of potential contamination events, which undermines the fundamental purpose of having a monitoring system in the first place.

10. APPROVAL TO OPERATE

The Approval to Operate for the Crane Mountain landfill demonstrates significant deficiencies and has become increasingly outdated and insufficient to address modern environmental concerns. The original framework and resulting landfill design, developed approximately thirty years ago as part of the original EIA and approval to build and operate, fails to account for numerous critical factors that have emerged in the intervening decades, leaving gaps in environmental protection requirements.

A fundamental issue with the current Approval to Operate is its notable deficiency in specifying comprehensive remediation protocols. As detailed in Sections 6 and 7 of this report, there is a pronounced lack of knowledge regarding fractured paths in the bedrock underlying the landfill site. This geological uncertainty creates a significant risk that leachate leakage could go undetected by the sparse monitoring network. Despite this well-documented vulnerability, the current Approval to Operate does not adequately address this risk nor provide detailed remediation protocols should contamination be detected.

The Approval to Operate has been subject to only minimal updates over the years, failing to incorporate significant advancements in several key areas. Most notably, it does not reflect technological advances in testing methodologies that could provide more accurate and comprehensive monitoring of potential environmental impacts. Modern analytical techniques allow for the detection of contaminants at increasingly lower concentrations, providing earlier warning of potential environmental concerns. However, the current Approval to Operate does not mandate the use of these advanced methodologies and their specific analytes of concern, leaving a critical gap in the monitoring framework.

Furthermore, the Approval to Operate does not address our growing understanding of emerging pollutants such as microplastics , Polyflouro-Orthosulfates (PFOS) and per- and polyfluoroalkyl substances (PFAS), commonly referred to as "*forever chemicals*." These compounds present substantial long-term environmental and health risks, with documented persistence in the environment and potential for bioaccumulation in organisms, including humans. Despite the growing body of scientific evidence regarding the environmental and health impacts of these compounds, and the increasingly stringent regulatory frameworks being established by agencies such as the US EPA, Health Canada and being developed by the Canadian federal Department of Environment, the current Approval to Operate contains no requirements for monitoring or mitigating these critical contaminants of concern. Furthermore, recommendations from ADI (now EXP) from their 2005 independent review have not been fully integrated into the operational requirements.

The current Approval to Operate demonstrates no consideration for significant advances in waste disposal technologies and methodologies that have been developed over the past three decades. Modern landfill design incorporates multiple layers of environmental protection, from enhanced liner systems to comprehensive leachate collection and treatment processes. These technological advances have significantly reduced the environmental footprint of modern waste disposal facilities, and can if implemented properly provide for significant improvement in mitigating potential subsurface impacts. However, the Crane Mountain landfill continues to operate under outdated standards that do not reflect these advancements, potentially exposing the surrounding environment to unnecessary risks; for example, the landfill containment liner is at best representative of the past century's "state-of-the-art" standard and falls far short in meeting what would be considered recent "state-of-the-art" design.

As well, climate change considerations are absent from the current Approval to Operate. The document fails to account for the impact of changing climate conditions on the landfill design and operation. Climate change is projected to alter precipitation patterns, potentially increasing both the frequency and intensity of extreme weather events in New Brunswick. These changes could affect everything from precipitation patterns to groundwater flow to the integrity of containment systems to the composition, amount and temporal generation of leachate.

Another concerning aspect of the current Approval to Operate is the absence of information regarding how landfill operators are establishing a long-term financial reserve to handle the implications once the site is finally closed. This represents a gap in financial planning for the inevitable post-closure monitoring and maintenance that will be required for decades, if not centuries, after the landfill ceases operations. The extensive research by Dr. Kerry Rowe, as detailed in Section 3 of this report, indicates that the contaminating lifespan of this facility may extend to 960 years under current conditions. Without adequate financial provisions, the burden of long-term monitoring and potential remediation could fall to future generations and taxpayers.

The cumulative effect of these deficiencies in the Approval to Operate is a regulatory framework that is inadequate to address the modern environmental challenges posed by this facility, particularly given its proximity to approximately 1,000 residential water supplies. The document requires revision to incorporate modern environmental standards, advanced monitoring requirements, emerging contaminant considerations, and long-term financial planning to ensure adequate protection of human health and the environment.

11. RECOMMENDATIONS

As a result of the above analysis, the CMEI Monitoring Committee is recommending that significant changes are required to the design and operation of the landfill. The issues identified in this document are not trivial and require considerable action as soon as feasible. Some actions can be taken immediately, others will require planning to implement. CMEI has prioritized the recommendations.

- Immediately cease any activities related to increasing the amount of waste disposed in the single composite lined landfill cells beyond the amount that was approved in the original EIA
- PFAS, PFOS and microplastics are known threats to health and strict limits are being placed on their permitted concentrations in drinking water. Testing for these contaminants must be added to the requirements for testing of monitoring wells and leachate.
- Regulations around the processes for testing monitoring wells need to be increased. These includes stricter oversight of the testing process and ensuring that when anomalies in the results are discovered, there is action taken to analyse the results, to identify potential corrective actions and to ensure that suitable corrective actions are taken.
- When defects in monitoring wells are discovered, the defects need to be corrected quickly to ensure that all monitoring wells are tested regularly.
- The fractured bedrock between the landfill and the downstream community needs detailed geological study to determine the most likely paths of any leakage from the landfill. This study should include, but not be limited to seismic analysis, drilling of bore holes, and use of ground penetrating radar.
- Following the geological study identified above, additional monitoring wells need to be installed downstream of the landfill to ensure monitoring can occur of the most likely leakage paths.
- update the Approval to Operate to include these requirements
- The analysis of liner systems needs to be undertaken and a redesign of the liner system performed to, as a minimum, require the installation of a double composite liner for all future municipal solid waste disposal cells.
- A detailed study of the location of the Construction and Demolition site is required and a liner system needs to be installed under the area. Based on the analysis of liner systems identified above, it is most likely that this should also be a double

composite liner system, with the leachate collected and treated in an appropriate manner.

APPENDICES

APPENDIX A LANDFILL LINER DESIGN GUIDELINES

A 1. LINER GUIDANCE

The following shows the NBDELG 1994 Liner Guidance document.

7

SANITARY LANDFILL LINERS : STANDARDS FOR CONSTRUCTION AND TESTING

April 12, 1994

The construction methods adopted will provide for a high level of environmental protection. The requirements will be described in detail in the project's Environmental Protection Plan which will be an integral part of the contract documents.

TERMS AND CONDITIONS:

1. The Owner in the construction of the sanitary landfill shall follow:

a. Construction practices, designs, specifications and instructions that will adhere to all existing applicable Municipal, Provincial and Federal laws

b. All communications, both written and verbal, received to date from the Department of the Environment through its representatives in the Operations Branch, Solid Waste and Recycling Section; including, but not limited to, the specific instructions itemized in the following terms and conditions.

c. Any changes to these terms and conditions will require prior approval of the Minister of the Environment.

2. In addition to the terms and conditions in number 1 above the following conditions shall be adhered to:

a. The test pad for the recompacted soil liner will be constructed adjacent to the location of the proposed sanitary landfill cell. The soil used to construct the test pad will be of the same type as will be used to construct the cell liner.

b. The size of the test pad will be a length 12 times the width of the roller and a width 6 times the width of the roller.

c. The methods and standards used for the construction and testing of the test pad shall be applied to the construction and testing of the landfill cell liner.

d. For both the test pad and the sanitary landfill cell, the site will be excavated to the elevations designed to maintain a minimum of 1.5 m of in-situ till. As well, the subgrade will be inspected and any granular seams will be over excavated and compacted to a density of 2025 kg/m3 or greater with a modern (built since 1985), self-propelled vibratory padfoot compactor with characteristics approaching: an 84"

New Nouveau Brunswick

1

wide drum, drum module static weight of 6500 kg, drum applied centrifugal force of 250 kilonewton.

e. The subgrade and each lift of fill of the test pad and the sanitary landfill cell will be compacted to a dry density in excess of 2025 kg/m^3. The density must be at least 92% of the modified proctor density and at least 98% of the standard proctor density. The till fill must have a moisture content of between 8 and 15 percent.

f. The lift thickness of the till fill for both the test pad and sanitary landfill cell will be sized to allow full penetration of the lift by the roller pads.

g. For both the test pad and sanitary landfill cell, stone in excess of 100 mm will be removed prior to compaction of each lift.

h. For both the test pad and sanitary landfill cell, prior to beginning the compaction of each lift, three samples of the till fill will be taken for laboratory testing to determine grain size distribution, Atterberg Limits and moisture content.

i. An accurate and correctly calibrated nuclear density gauge will be used to ensure that the minimum field density of 2025 kg/m^3 is achieved.

j. Nuclear Density Gauge Tests will be performed on a 10 metre grid, after compaction of each lift, to confirm the density of the soil.

k. A series of sand cone tests will be performed on each lift to confirm the in situ density results of the nuclear density gauge.

l. Two Air-Entry Permeameter Tests will be performed on each lift to confirm the hydraulic conductivity of the soil.

m. For both the test pad and sanitary landfill cell, all stones in excess of 6mm will be removed from the surface of the final lift prior to compaction with a smooth drum roller.

n. A Double Ring Infiltrometer Test will be performed on the smooth surface of the completed test pad to verify that the required hydraulic conductivity has been achieved for the soil liner.

o. If the Double Ring Infiltrometer Test performed on the smooth surface of the test pad and all of the Nuclear Density Gauge Tests and Air-Entry Permeameter Tests

performed on each lift of the test pad indicates a hydraulic conductivity of less than 1×10^{-7} cm/sec. the sanitary landfill cell liner system will consist of an 80 mil HDPE liner with 600 mm of recompacted till placed over a minimum of 1.5 m of in-situ till. If this is the case, the sanitary landfill cell liner will be constructed in the same manner as the test pad and will be tested as outlined in sections h, j, k and l above to ensure that this hydraulic conductivity is maintained throughout the liner.

p. If the Double Ring Infiltrometer Test performed on the smooth surface of the test pad and all of the Nuclear Density Gauge Tests and Air-Entry Permeameter Tests performed on each lift of the test pad indicates a hydraulic conductivity of less than 2×10^{-7} cm/sec but greater than 1×10^{-7} cm/sec then the sanitary landfill cell liner shall be the same as outlined in section o. above with the exception that the recompacted till liner will be increased to 750 mm. If this is the case, the sanitary landfill cell liner will be constructed in the same manner as the test pad and will be tested as outlined in sections h, j, k and l above to ensure that this hydraulic conductivity is maintained throughout the liner.

q. If the Double Ring Infiltrometer Test performed on the smooth surface of the test pad and all of the Nuclear Density Gauge Tests and Air-Entry Permeameter Tests performed on each lift of the test pad indicates a hydraulic conductivity of greater than 2×10^{-7} cm/sec., bentonite will be rototilled into the top 150 mm of the test pad. Initial application rate will be determined by laboratory testing and confirmed by the use of a test pad. Spreading of the bentonite will be by a mechanical means which will ensure the uniform spreading of the bentonite over the entire surface of the cell (the use of a farm lime spreader may be appropriate). The bentonite shall be rototilled in each direction to ensure uniform mixing. Bentonite addition will be increased until testing with the double ring infiltrometer and air-entry permeameter indicates a hydraulic conductivity of 1 x 10-8 cm/sec. or less. If a bentonite/soil mixture is necessary, the sanitary landfill cell liner will consist of 1.5 m of in-situ till, 450 mm of recompacted till, 150 mm of bentonite/soil mixture and a 80 mil HDPE liner. If this is the case, the sanitary landfill cell liner will be constructed in the same manner as the test pad and will be tested as outlined in sections h, j, k and l above to ensure that the hydraulic conductivity achieved in the test pad is maintained throughout the 450 mm of recompacted liner.

r. Which ever case is indicated by the test pad, the sanitary landfill liner system shall have a leachate break through time of at least 25 years.

s. Regardless of whether the test pad indicates the situation outlined in sections o, p. or q above, all test results from the construction of the test pad must be forwarded

to the Department of the Environment for approval prior to initiating the construction of the sanitary landfill cell liner.

t. The 80 mil HDPE liner will be seamed using equipment to produce a double seam with an enclosed air space (double fusion welding).

u. Each seam shall be air Pressure tested in accordance with "Gundle Quality Assurance Manual For The Installation Of Polyethylene Lining Systems"

v. Samples of the HDPE liner seams shall be pulled at intervals of one sample for every 500 linear feet of weld and subject to a destructive test as prescribed by the manufacturer.

w. For the 80 mil HDPE liner, all other manufacturer's quality assurance procedures shall be adhered to.

x. The Proponent shall engage a third party inspector, agreeable to the Department of the Environment, to ensure the proper installation of the 80 mil HDPE liner. This inspector shall produce a report on the quality control of the liner installation. The report shall contain but not be limited to: the number of tests, test location and whether the result of the test was positive or negative, if the result of the test was negative what was done as a result, etc. This completed Quality Assurance/Quality Control report shall be forwarded to the Department of the Environment no later than three weeks after the completion of the HDPE liner installation.

y. A Quality Control/Quality Assurance report covering the construction of the entire liner system, including all testing performed during construction, will be forwarded to the Department of the Environment no later than three weeks after the completion of the sanitary landfill liner system.

z. Cation exchange capacity field values will be obtained from the site and included in the Quality Control/Quality Assurance report to confirm assumptions made during the calculation of attenuation rates (10meq/100g of soil).

aa. Under the leachate storage pond, the in-situ till shall be compacted as described previously for waste disposal cells (sections c and d above), in addition a lift of re-compacted till, 200 mm minimum with a conductivity of 1×10^{-7} or less shall be placed on the in-situ till and beneath the drainage layer and 80 mil HDPE liner. The in-situ till will be retained at a minimum depth of 1,500 mm.

bb. The Environmental Protection Plan, section 01560 shall be adhered to.

cc. The groundwater monitoring program shall be developed as per the requirements of Department the Environment's hydrogeologists.

dd. The approval for construction of a waste disposal cell shall be issued for each one-year phase and shall be restricted to the portion specified in the contract documents referenced in the approval. Liner design requirements and construction procedures listed in the approval may change for subsequent construction phases following the analysis of field data collected during construction.

APPENDIX B – REPORT REFERENCES

B 1. REFERENCE DOCUMENTS:

The following is a list of references taken from Dr. Rowe's report for CMEI. For the complete report refer to www.cmei.ca.

Beck, A., A. Available technologies to approach zero leaks. In Proc., of Geosynthetics 2015 Conf. Roseville.CA: Industrial Fabrics Association International.

Giroud, J. P. 2016. Leakage control using geomembrane liners. Soils Rocks 39 (3): 213–235.

Giroud, J. P. and Bonaparte R. Leakage through liners constructed with geomembranes — Part I: Geomembrane liners. Geotext. Geomembr. 1989a, 8 (1): 27–67. https://doi.org/10.1016/0266-1144(89)90009-5.

Giroud, J. P. and Bonaparte, R. Leakage through liners constructed with geomembranes — Part II: Composite liners. Geotext. Geomembr., 1989b, (2): 71–111. https://doi.org/10.1016/0266-1144(89)90022-8

Rowe, R.K. (1998). "Geosynthetics and the minimization of contaminant migration through barrier systems beneath solid waste", Keynote paper, Proceedings of 6th International Conference on Geosynthetics, Atlanta, **1**: 27-103.

Rowe, R.K. Long-term performance of contaminant barrier systems, 45th Rankine Lecture, Geotechnique, 2005, 55 (9): 631-678.

Rowe, R.K Short and long-term leakage through composite liners. The 7th Arthur Casagrande Lecture. 2012. *Can. Geotech. J.* **49**(2):141-169.

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Rowe, R.K. Protecting the environment with geosynthetics - The 53rd Karl Terzaghi Lecture, 2020b, ASCE J Geotech. Geoenviron., 146(9):04020081. 10.1061/(ASCE)GT.1943-5606.0002239

B 2. Extract from Independent External Review of Crane Mountain Landfill, November 2005, by ADI Limited:

Leachate Management

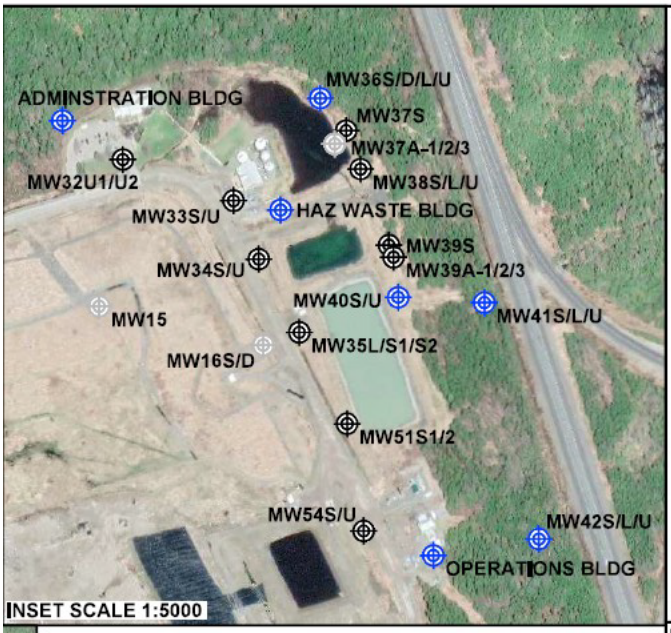
8. Implement a strategy of progressive landfill closure.
9. Reduce the leachate level in the cells or consider double liner in future cells.

I 0. Consider automatically pumping leachate to the Surge Pond, upgrade the liner to a double liner and possibly pre-treat the leachate before discharge.

APPENDIX C - MONITORING WELLS

C 1. LOCATION OF MONITORING WELLS:

For legend and inset see next page



LEGEND

- MONITORING WELL (SURVEYED 2022)
- MONITORING WELL (SURVEYED PRIOR TO 2022)
- MONITORING WELL TO BE DECOMISSIONED (SURVEYED PRIOR TO 2022)
- DECOMMISSIONED OR DESTROYED MONITORING WELL

NOTE: 2020 aerial photo from Google Earth.

2022 SURVEYED MONITORING WELLS

NAME	EASTING	NORTHING	TOP OF PVC ELEV	GROUND ELEV
MW31L	2522249.868	7363523.583	78.964	
MW31S	2522249.932	7363523.582	78.989	
MW31U	2522249.925	7363523.509	78.970	
MW32U1	2522633.364	7363756.288	68.449	67.282
MW32U2	2522634.094	7363757.327	68.146	67.208
MW33S	2522732.091	7363720.662	66.365	65.502
MW33U	2522732.046	7363719.534	66.385	65.548
MW34S	2522755.729	7363668.425	65.733	64.694
MW34U	2522754.532	7363667.435	65.397	64.779
MW35L	2522791.324	7363600.597	64.443	64.041
MW35S1	2522790.649	7363602.101	64.613	64.165
MW35S2	2522789.758	7363603.684	64.788	64.270
MW37S	2522832.440	7363782.136	62.846	61.881
MW38L	2522844.786	7363749.297	63.377	62.440
MW38S	2522845.339	7363747.768	63.509	62.463
MW38U	2522844.761	7363749.322	63.408	62.440
MW39A-1/2/3	2522874.867	7363669.134	61.341	60.847
MW39S	2522870.662	7363679.876	62.711	61.717
MW43S	2522721.996	7362683.403	71.935	71.254
MW43U	2522722.321	7362684.607	71.705	71.159
MW46L	2523395.091	7363118.097	58.678	57.909
MW46U	2523395.853	7363118.659	58.836	57.890
MW51S1	2522832.630	7363522.872		64.359
MW51S2	2522833.273	7363520.579	64.865	64.283
MW52D	2522479.326	7362965.975	77.348	77.348
MW52S	2522482.018	7362967.328	78.239	77.337
MW53D	2522118.717	7362796.402	102.564	101.912
MW54S	2522846.577	7363425.990	65.907	65.018
MW54U	2522848.026	7363424.889	65.779	65.042
MW55S	2522925.559	7363290.242	64.303	63.690
MW56S	2522943.388	7363224.005	68.214	
MW57S	2523210.777	7363862.681	53.064	52.298
MW57D	2523211.932	7363862.940	52.460	52.460

DRAWN BY: AGSD	CHECKED BY: CW
CALCULATIONS BY:	CHECKED BY:

DATE: FEB, 2023

PROJECT: ENVIRONMENTAL MONITORING PROGRAM
CRANE MOUNTAIN LANDFILL

DRAWING: MONITORING WELL LOCATIONS

SCALE: 1:10000

0 200 400 600m

FILE NO.	DRAWING
46620908	FIGURE 1

GEMTEC
CONSULTING ENGINEERS AND SCIENTISTS