Review of Potential Public Health, Groundwater Resource, Financial and Other Impacts of the Proposed Crane Mountain Landfill

February 3, 1997

Prepared by
Brian Gallaugher, B.A., B.E.S.
Gallaugher Associates
and
G. Fred Lee, PhD, PE, DEE
G. Fred Lee and Associates

for

River Road Concerned Citizens Committee
and
River Road Action Team
Saint John, New Brunswick

EXECUTIVE SUMMARY

Dr. G. Fred Lee, an internationally known expert in groundwater pollution resulting from landfills and Brian Gallaugher, a Toronto planner who specializes in landfill issues have been hired by the River Road Concerned Citizens Committee (RRCCC) and the River Road Action Team (RRAT) to review issues relating to the proposed Crane Mountain Landfill. They examined the proposal with a view to its ability to protect the environment and safeguard the rights of those living within the sphere of influence of the landfill. They looked for deficiencies in the information presented or proposed facility that would make it difficult for Saint John area decision makers to implement the most efficient and appropriate waste management system possible.

The Fundy Region Solid Waste Commission (FRSWC) proposes to build a so-called "dry-tomb" landfill at Crane Mountain, with a low-permeability cover layer and a single composite bottom liner (plastic sheet over compacted clay and/or soil). The liners are designed to minimize the production of and contain toxic leachate so that it can be properly treated. There is no question that both cover and bottom liners will eventually fail.

The contaminating lifespan of a landfill of this type is hundreds, if not thousands, of years. After the landfill has begun to leak, groundwaters flowing past the landfill will become polluted and some neighbouring residents will eventually be unable to use groundwater for domestic purposes. Plant and animal life may also be affected. There are approximately 1,000 homes and businesses in the area of the landfill.

The monitoring systems proposed by the FRSWC to detect leaks will have a low probability of being effective, due to the location of the landfill on a recharge area and

fractured bedrock and the ability of leachate plumes to bypass monitoring wells. The only effective way to know when the leaking leachate will impact neighbouring groundwater users is to regularly and perpetually monitor all water-producing (production) wells in the area. At the first sign of pollution steps must be taken to control and remediate the groundwater pollution, even if water quality standards are met. Leachate contains toxic and carcinogenic chemicals, many of which are not tested for in water quality evaluation programs.

Of particular concern is a possible hydraulic connection between the Crane Mountain site and the Spruce Lake system, which feeds the Saint John municipal water supply. The ability of polluted groundwater to enter this system through fractured bedrock and the potential strength of the leachate needs additional study.

Once polluted by municipal solid waste leachate, groundwater resources can never be cleaned up sufficiently to permit human use. Measures must be taken to control and remediate the pollution. Pumping and treatment of polluted groundwater through purge wells must continue indefinitely. It may eventually be necessary to exhume all waste in the landfill if this is the only effective means available to stop the pollution.

The 5-year Capital and Operating Budget submitted on Jan. 17, 1997) by the FRSWC to area municipal Councils is seriously deficient in the level of information provided and assumptions made. It predicts a loss on landfill operations in the fifth year under both of its tonnage scenarios (115,000 and 85,000 tonnes per year). The financial resources required to build and operate an environmentally safe landfill, including indefinite post-closure costs for a worst-case scenario over many hundreds of years, are not included. These will have a significant impact on both capital and operating costs. The potential for massive long-term liabilities at the time of groundwater pollution has not been considered.

It is recommended that the budget be thoroughly reworked to give a more accurate picture of the true cost of landfilling. This will allow decision-makers to make rational choices about the most efficient waste management system for the Fundy region.

The recycling component needs more attention to its potential revenues and costs. Current figures act as a disincentive to divert waste from the landfill.

A suggested method of resolving differences of opinion among experts is also proposed. One of Dr. Lee's papers dealing with many of the landfill construction, operation and post-closure issues touched on in this report is also available upon request to the authors or the RRCCC.

INTRODUCTION

The River Road Concerned Citizens Committee (RRCCC) and the River Road Action Team (RRAT) community groups have engaged the consulting firms of Gallaugher Associates and G. Fred Lee and Associates to conduct a review of the proposed Crane

Mountain Landfill. We were provided by RRCCC with the "Environmental Impact Statement - Regional Landfill at Crane Mountain or Paddy's Hill Sites" (Dec. 21, 1994) and some related reports, documentation, correspondence and other relevant material.

Credentials

Dr. Lee holds a Ph.D., was a university professor teaching graduate level environmental engineering and is a professional engineer in the State of Texas. Since he retired from university teaching and research in 1989 and became a full-time consultant he has been active with many governmental agencies such as water utilities, municipalities and others in helping to evaluate the potential for an existing or proposed landfill to cause pollution of groundwaters. His work has included serving as an advisor to public groups in Ontario and the City of Winnipeg on landfill siting and development issues.

Brian Gallaugher holds a Bachelor of Environmental Studies from the University of Waterloo, Ontario. His consulting practice has focused on landfill siting and operational issues from the perspective of both proponents and residents who may be impacted. Significant projects have included work with groups in Kirkland Lake, Ontario, Sarnia, Ontario and communities surrounding Metropolitan Toronto.

Area of Investigation

We have confined our remarks to an analysis of current knowledge and practice and the potential environmental and public health impacts of

- the ability of municipal solid waste landfills to pollute groundwater,
- the ability of operators to detect and monitor groundwater pollution and
- the ability of operators to correct or remediate groundwater pollution.

We have also examined some aspects of the economics of the proposed landfill and its potential impact on the economy and municipal finance of the City of Saint John and surrounding areas including

- effect of tonnages on tipping fees and taxes,
- potential costs for long-term care, potential remediation, worst-case scenarios,
- costs of the proposed Max Recycling Facility and
- inadequacies of the 1997 FRSWC Capital and Operating budget currently before Council.

We make recommendations on further studies that must be conducted before final decisions are taken, to ensure that all parties have the information required to ensure the Saint John region

- enjoys the most efficient municipal solid waste management system possible,
- safeguards the environment and
- protects the rights of the neighbours of any proposed landfill.

We have confined our remarks to the Crane Mountain Landfill site and have not engaged in any comparison with other potential sites. We have also not dealt significantly with methods of managing municipal solid waste other than landfilling. River Road Concerned Citizens Committee and River Road Action Team have paid for the preparation of this overview. The expert opinions contained in it are the work of the authors alone. RRCCC and RRAT have exercised no control over its content.

POLLUTION OF GROUNDWATER

Potential for Landfill to Leak

Consultants for the Fundy Region Solid Waste Commission (FRSWC) have proposed what appears to be a "dry-tomb" landfill type, in which the wastes are deposited cell by cell, each cell as it is completed being covered by a top layer of compacted material complete with a drainage layer. The fill area is underlain by a plastic liner on top of a compacted layer of soil and/or clay.

The purpose of the top liner is to minimize the amount of water entering the landfill, thereby minimizing the production of leachate, which is the contaminated fluid produced from water percolating through the municipal solid waste (MSW). In principle, the leachate is contained by the bottom layers, pumped out by a leachate removal system, stored and pretreated on site and then transported by truck or pipeline to a sewage treatment plant for final disposition.

Liners and Leaks

While it is possible, with careful construction, to construct a landfill liner system of the type proposed that will have low leakage rates at the time of construction, over time the plastic sheeting liner will deteriorate in its ability to collect leachate and it will allow significant passage of leachate through the liner into the underlying groundwater system, polluting the groundwater and rendering it unsuitable for domestic purposes.

All "dry tomb" type landfills, whether for hazardous wastes and residues or municipal solid waste, should be designed with a minimum of double-composite liners with a leak detection system between the two composite liners. This leak detection system should be a high permeability layer of sand or other media that is not subject to significant clogging by leachate-induced biological growths. It should be understood that the lower composite liner is not a containment liner but is part of the upper composite liner leak detection system, i.e. a full landfill area pan lysimeter. This is the approach which was adopted by the state of Michigan in its Rule 641 governing landfilling of municipal solid wastes.

The key protection of groundwater quality in a double-composite lined landfill, where the lower composite liner's function is primarily that of a leak detection system for the upper composite liner, is the ability to take appropriate action when leachate is found in the leak detection system between the two composite liners. When leachate is found there that could result in groundwater pollution if the second composite liner were not present, it

has to be assumed that the upper composite liner has failed. At that time, if the landfill owner/operator cannot stop the leachate from entering the leak detection system below the upper composite liner, then there is no alternative but to remove the wastes from the landfill since it is only a matter of time until there will be failure of the second composite liner and pollution of any groundwaters associated with the hydrogeologic system in which the landfill is located.

Contaminating Lifespan of the Landfill

One of the terms and conditions imposed by the Minister of the Environment requires that the

"landfill cells and leachate holding ponds shall be designed and constructed in a manner to ensure the reliability and effectiveness of the soil portion of the liner of not less than 25 years." (Crane Mountain EIA Approval Conditions - NBDOE Press Release - Sept. 11, 1996).

Twenty-five years is wholly inadequate to protect the groundwater resources and health and well-being of those surrounding the landfill site. The landfill proponent may justify this extremely short time period by arguing that any leakage will be detected and corrected by monitoring, or that the period of time in which the landfill may produce toxic leachate is not longer than 25 years or by pointing out contingency measures that can be taken to protect the water supplies of the neighbours. It is inappropriate to rely upon any of these, as explained in following sections.

Even at the end of 100 years there will be a significant threat to groundwater and surface water quality from leaking leachate. It is likely that the contaminating lifespan of this landfill will be several hundred to a thousand years or more. Belevi and Baccini (1989) have developed a model that predicts that conventional sanitary landfills in Switzerland will be threats to groundwater quality through the leaching of lead that is normally present in municipal solid waste for over 2,000 years. It must also be remembered that small amounts of MSW leachate have high potentials to pollute large amounts of groundwater, impairing their use for domestic and other water supply purposes. This stems from the presence in municipal solid waste of amounts of hazardous materials included by householders and businesses, some of which may not be considered conventionally hazardous but which can, when mixed with groundwater through leachate leakage, render the groundwater unfit for use.

From a conservative and protective perspective, it should be assumed, unless it can be convincingly demonstrated otherwise, that the contaminating lifespan of the proposed Crane Mountain Landfill will be at least several hundred years, and likely, a thousand years or more.

Reliability of Top Liners

The FRSWC proposes to cover the landfill with a low permeability cover that will reduce the amount of water entering the landfill, thereby reducing the leachate produced. It is inappropriate to assume that the design characteristics of the top cover will remain constant as designed over the hundreds to thousand or more years that this landfill could be a threat to public health, groundwater resources and the environment. It is inevitable that cracks, vegetation and structural instability will create significant gaps in the cover that, once concealed by the drainage, topsoil and vegetative layers, will be difficult to visually inspect and repair.

The increased water that will likely enter the landfill through the cover and become leachate, beyond the amount projected when the cover is installed, should be evaluated with respect to how it would impact the many components of leachate management, especially the impact on capacity of the sewage treatment plant that will treat the leachate. Rather than allowing leachate generation in the landfill to be controlled by unplanned changes in the permeability of the cover due to cracks that develop, the FRSWC may find that installing a leak detectable cover would be a significant asset in reducing the amount of leachate produced. This type of cover would also, however, increase the capital cost of the landfill and significantly increase the cost of operation in perpetuity of the leak detection system and cover maintenance and repair.

ABILITY TO DETECT AND MONITOR GROUNDWATER POLLUTION

Monitoring Leachate Movement in Fractured Rock

One of the issues that must be addressed in connection with assessing the hazard that the proposed Crane Mountain Landfill represents to groundwater quality is the ability of any groundwater monitoring system to detect pollution of groundwaters by landfill leachate, before widespread pollution occurs. While the FRSWC has designed a groundwater monitoring system that proposes to detect leachate-polluted groundwaters when the landfill liner system fails, it should be required to conduct an evaluation of the reliability of such a monitoring system.

It has been known since 1990, with the publication of Dr. John Cherry's work (Cherry 1990) on the reliability of groundwater monitoring systems of the type that are proposed for use at the Crane Mountain Landfill, that these monitoring systems have a low probability of detecting landfill liner leaks before widespread groundwater pollution occurs. Dr. Lee and Dr. Jones-Lee published a summary of this work (Lee and Jones-Lee, 1994) in a national environmental journal. Narrow plumes of leachate polluted groundwater can exist which travel between even closely spaced monitoring wells, thereby allowing the fact of leachate release to go undetected for long periods of time.

It is well known that groundwater monitoring in fractured rock is virtually impossible to carry out reliably. The basic problem is that the flow in rocks of the type near the Crane Mountain site will occur through fractures. This means that monitoring wells spaced even a few feet apart may not be able to detect leachate transport through the bedrock unless they happen to intercept the fracture(s) that are principally responsible for leachate

transport. Haitjema, in "Ground Water Hydraulics Considerations Regarding Landfills," Water Res. Bull. 27(5):791-796 (1991) characterizes monitoring groundwaters for leachate leakage in fractured rock systems near landfills:

'Monitoring wells in the regional aquifer [consisting of fractured rock] *are unreliable detectors of local leaks in a landfill.*

'The design of monitoring well systems in such an environment is a nightmare and usually not more than a blind gamble."

The ability of the landfill operator to effectively monitor the transport of leachate-contaminated groundwater should be demonstrated so that it can be independently reviewed by experts.

Production Well Water Quality Monitoring

An alternative approach to groundwater monitoring using vertical monitoring wells is one in which the landfill operator would commit to monitor production wells within the potential sphere of influence of the polluted groundwater associated with the development of the Crane Mountain Landfill. A production well is defined as any well that is used by a property owner as a water supply source for any purpose. This monitoring program would be designed to detect incipient pollution by leachate-derived constituents before significant harm is done. It would need to be carried out effectively forever where, on a quarterly basis, samples would be taken of all existing and any future developed production wells and analyzed for constituents that would indicate that landfill leachate is being found in the well at low concentrations.

Typical MSW leachate has a characteristic signature (chemical composition) for a group of conservative chemicals that can be used to indicate when leachate first begins to pollute a well. Chemical analysis of the groundwaters can be used to detect when leachate pollution of groundwaters first begins to occur, before significant harm is done to the users of the groundwater. At that point, the use of the groundwater can be terminated provided that an alternative water supply is available to meet the needs of the well owner.

When sufficient data has been collected from the quarterly monitoring of production wells so that small changes in water quality can be reliably detected, the frequency of monitoring could be reduced to semi-annually, and then possibly, annually. However, the development and implementation of this program will require a much more sophisticated approach toward groundwater monitoring than is typically done in monitoring groundwaters for landfill leachate pollution. Such a program should be carried out by experts and should be conducted by a third party independent consultant who would report the results to a citizens advisory committee overseeing the landfill operations and impacts. The funding of this monitoring program should be provided by the landfill operators and will require *ad infinitum* assured funding.

The potential worst-case sphere of influence would be judged by the shortest possible time that leachate-polluted groundwaters could travel from the landfill to the location of the production well. Once the projected worst-case plume could have possibly passed the location of a production well, then the monitoring of that well would be initiated and continued *ad infinitum*.

Possible Pollution of Spruce Lake System

One of the key issues that needs to be addressed by the FRSWC is an evaluation of plausible worst-case conditions where leachate-contaminated groundwaters that arise at the edge of the landfill travel beyond the local aquifer through rock fractures to neighbouring aquifers and watersheds. Of special concern is the Spruce Lake system, source of some of the City's domestic water supply.

In making these estimates, the best information available on the highest permeability that could occur in the fractured rock geology should be used. Of particular concern is the rate of transport of groundwater that may be occurring along fractures to lakes which feed the City's water supply. How fast is this groundwater moving along the fractures and from what distance is it derived?

It is Dr. Lee's experience that normally groundwaters do not move more than a few feet per day. This experience, however, is based on sand and gravel aquifer systems. What is known about the fastest possible rate of transport of polluted groundwaters in the groundwater systems? Is it more than a few feet per day? Or is it on the order of 10 to 100 feet per year? The FRSWC should investigate this issue and provide this information to City Council and the public.

If there are significant gaps in information needed to fairly reliably make an estimate of plausible worst-case transport of leachate-polluted groundwaters hydraulically connected to the Spruce Lake system then these information gaps should be defined. A program should be developed to obtain the necessary information before the final decision to proceed is taken. This is critical to protect the public health of the residents of the City of Saint John as well as the proposed landfill's more immediate neighbours.

ABILITY TO REMEDIATE POLLUTED GROUNDWATER

Permanence of Groundwater Pollution

It should be understood that it will not be possible to remediate off-site MSW leachate-polluted groundwaters so that wells that pump such waters can ever again be considered safe for domestic and some other uses. Landfill leachate contains a wide variety of hazardous and deleterious chemicals at high concentrations that could cause a water supply well to have to be abandoned. The US EPA in 1988 concluded, as part of promulgation of its municipal landfilling regulations, that any water supply well that is polluted to any extent with municipal landfill leachate must be abandoned and a new well constructed as an alternative water supply source. This is a justified conclusion that

should be applicable to Crane Mountain Site derived leachate-polluted groundwaters. The fact that the Crane Mountain Landfill is located in an aquifer recharge area over a fractured rock system intensifies the possibility that production wells will be affected by polluted groundwaters, resulting in the inability of local residents to use groundwater for domestic purposes.

Leachate-polluted groundwater could contain a variety of highly hazardous chemicals that can cause cancer in people who use this water as a water supply. In addition, leachate contains chemicals which, while in themselves are not hazardous from a public health perspective, can be significantly adverse to those who use this water for domestic and other purposes. Total salts (TDS), hardness and alkalinity occur in leachate at high concentrations and do cause increased corrosion and scaling (coating) of plumbing, hot water heaters and other fixtures, appliances and equipment, which shortens their lives and increases energy consumption.

Dr. Jones-Lee and Dr. Lee have provided a detailed discussion of these issues as they apply to domestic water supplies in a paper entitled, "Groundwater Pollution by Municipal Landfills: Leachate Composition, Detection and Water Quality Significance," Proceedings of Sardinia '93 IV International Landfill Symposium, Sardinia, Italy, pp. 1093-1103, October (1993). A copy of this paper has been provided to RRCCC and may be obtained from the authors if required.

Downgradient Groundwater Pollution Contingencies

As proposed now, groundwater pollution by the Crane Mountain Landfill is inevitable and it is highly unlikely that this pollution will be detected before widespread pollution occurs. The groundwater monitoring program of production wells can, if reliably implemented, to some degree protect the public health of those impacted by the leachate. This will only be effective provided that there are no hazardous constituents in the leachate polluted groundwater derived from the landfill that could represent a health threat in concentrations below our current ability to monitor for conventional and exotic. Hazardous chemicals are now being found in MSW that have not been previously reported.

It will be essential that the FRSWC have well-developed contingency plans in place to remediate polluted groundwaters to the maximum extent possible and, most importantly, to stop further spread of polluted groundwaters off-site from the Crane Mountain Landfill property when groundwater pollution is detected. These plans should be developed now so they can be reviewed for their adequacy with respect to implementability, reliability and especially funding.

At the time that the operators find off-site leachate-polluted groundwaters, they will have to begin an effective on-site groundwater remediation program to stop further off-site groundwater pollution. This program may have to include exhumation (removal or "mining") of the wastes from the Crane Mountain Landfill if the on-site remediation programs cannot stop off-site pollution of the groundwaters.

Adequate funding for groundwater remedial activities, including the mining of wastes from this landfill, should be available for both the off-site and on-site polluted groundwater remediation programs. This funding should be established in a dedicated trust fund derived from disposal fees that will be of sufficient magnitude to address all plausible, worst-case failure scenarios and groundwater remediation needs. The planning for the use of these funds should make them available *ad infinitum*. If at some time, hundreds to a thousand or more years from now, it is found that no groundwater pollution has occurred and the landfill and associated leachate-polluted groundwaters are no longer a threat to off-site groundwater quality, then these funds could be returned to the community for other uses.

In judging whether off-site groundwater pollution occurs, it will be important that no allowance be made for degradation of existing groundwaters by leachate-derived constituents up to a certain percentage of drinking water quality standards, as is permitted in some jurisdictions. This encroachment upon standards ignores the potential threat that the unregulated organics present in MSW leachate represent to the health and welfare of those who use such waters polluted to this level. There are about 60,000 chemicals in use which could be a part of landfill leachate; water quality standards consider only a few hundred. For the purposes of developing the Crane Mountain Landfill, the need for remediation of polluted groundwaters should be based on finding any MSW leachate-derived constituents in off-site groundwaters.

Remediation Of Polluted Groundwater Potentially Entering Spruce Lake System

Because of the potential for a hydraulic connection with the Spruce Lake system, consideration should also be given to estimating the amount of attenuation that may occur based on dilution/dispersion in the fractured rock system for groundwater transport from the landfill to the Spruce Lake system. It is important not to assume any adsorption, biological transformations and chemical reactions as part of this attenuation since they are likely to be small in this kind of system for some of the constituents in the landfill leachate that could be adverse to public health interests. For these types of chemicals, the only mechanism for decreasing the concentration of leachate-derived pollutants with travel distance that should be assumed to be of importance is dilution/dispersion.

If it can be reliably concluded that, during potential transport from the landfill to the Spruce Lake system, sufficient dilution of the landfill leachate would occur to reduce concentrations below any existing levels, then the likelihood of the landfill being adverse to City domestic water supplies would be small. Typical leachate concentrations of hazardous and deleterious chemicals should be assumed to occur in leachate at the landfill. Further, it should be assumed that a critical concentration of 0.01 μg/L is appropriate for the unregulated organics that are present in MSW leachate.

The lack of a hydraulic connection to the Spruce Lake water supply system or the expected dilution in leachate transport to Spruce Lake does not, however, eliminate concern for the quality of groundwaters on properties adjacent to and nearby the proposed landfill.

COSTS

5-YEAR BUDGET

The FRSWC has forecast, in its 1997 Capital and Operating Budgets, (dated January 17, 1997) tipping fees of $47.00 per tonne based on 115,000 tonnes of waste being received per year. If only 85,000 tonnes (approximately 75% of 115,000 tonnes) per year are received, the tipping fees will be $57.00 per tonne. (An additional $1.00 per tonne will be levied to fund recreational site development in all cases). In both cases, the landfill will suffer a deficit of between $295,000 and $410,000 in its fifth year of operation, even taking into account previous surpluses.

The developers of this budget have assumed that if only 75% of their projected waste is received (i.e. 85,000 tonnes) their costs of operation will also fall by 75% from the 115,000 tonne scenario. This assumption is suspect. Administration and General Expenditure costs for the items listed in the budget document are particularly resistant to reduction, regardless of tonnage. If Administration and General expenditure charges were to remain constant at the 115,000 tonne level, but tonnage received was only 85,000 tonnes per year, operations would start showing a deficit in the third year and would have grown to a loss of $654,000 by year five.

More explanation of the rationale behind a reduction in Administration and General Costs proportionate to tonnage received is required and revisions to the 5-year budget should be made as required. Projections should also extend beyond the 5-year point to show long-term trends.

In addition, annual contributions to the perpetual care fund have also been reduced by 75% at 85,000 tonnes per year level. The wisdom of this policy should be questioned, especially in light of the "worst-case scenario" situation discussed below.

Additional Costs

We have discussed several additional studies which should be undertaken by the FRSWC before final approval is given, to ensure the public health and well-being of those living within the sphere of influence of the proposed landfill, including, potentially, most of the residents of the City of Saint John. Among them are:

- calculation of the ability of the landfill operator to reliably predict the transport of leachate,
- speed of transport through fractured rock potentially hydraulically connected to the Spruce Lake system, and
- expected concentration of leachate, especially in rock fractures.

Several additional safety measures have also been proposed. The FRSWC may wish to consider the

- installation of a leak-detectable cover and double composite bottom liner,
- the provision of funds for perpetual monitoring of production wells to reliably detect leachate leakage, and
- the provision of reserve funds to provide for exhumation or mining of the landfill and/or perpetual pumping and treatment of polluted groundwater and/or perpetual supply of potable water to affected residents should no other method be found effective in mitigating groundwater pollution.

It is also possible that the quantity, composition and concentration of leachate delivered to the sewage treatment plant will overload its capacity or cause damage to its normal functioning thereby causing surface water pollution. Such a situation could develop in the future as the amount of leachate increases due to the degradation of the landfill cover and the nature of waste deposited in landfills changes due to diversion programs. In this case, the treatment plant operators may refuse to accept the leachate for treatment, necessitating the provision of separate treatment facilities elsewhere or alterations to the existing plant. This situation could be accentuated in view of the importance of the fishery to the Saint John area. The cost of providing these facilities would be significant.

These costs have not been included in the proposed budget. They should be estimated by the FRSWC and the budget revised to reflect them. The effect may be to increase the deficits already predicted in the budget. It will not be sufficient to simply increase tipping fees to cover any unexpected mitigation or remediation costs as they arise. Some of these costs may not become apparent until the landfill has been closed. As well, in order to make rational choices in the planning of the waste management system, all potential costs must be identified in the planning stages.

Tipping Fees vs. Tonnage

There is a direct relationship between the tipping fees charged and the amount of waste received from any landfill user who has the ability to use other facilities. For example, a substantial hike in tipping fees in the early 90's in Metropolitan Toronto drove away almost all discretionary customers as it became cheaper to transport waste, often hundreds of kilometers, to lower priced landfills, sometimes in the U.S. A subsequent reduction in the tipping fee to near the original levels did not succeed in regaining much of this business.

If tonnages are lower than expected, tipping fees would have to be increased to cover fixed costs, including capital investment. The FRSWC should conduct a study, using a knowledgeable municipal finance or accounting firm, that would examine where the cut-off point is for the diversion of Saint John area waste to other landfills, taking into account neighbouring tipping fees and transportation costs. If the fees contemplated at the Crane Mountain facility are already above this level tonnages may be less than anticipated which would trigger either a further increase in tipping fees, exacerbating the problem, or increase the deficit.

WORST CASE SCENARIO

The FRSWC proposes that numerous mitigation measures be incorporated into the site design and operations. There is no commitment, however, on the part of the FRSWC or any other body that any of the FRSWC's suggested mitigation approach will necessarily be funded and implemented other than the provision of alternate water supplies to neighbours should their wells become polluted by landfill leachate.

Landfill proponents sometimes claim that additional design and operations measures as well as off-site impact management measures can be implemented should the operations monitoring program indicate the need. While this statement is appropriate, there are significant questions about how well they will actually be implemented. No doubt the FRSWC faces a public which is aware of a long history of landfill owners/operators failing to keep commitments on protecting public health, groundwater resources and the interests of those who own or use properties within the sphere of influence. This situation makes the public justifiably skeptical about whether the landfill operator will, in fact, protect their health and interests potentially impacted by the proposed Crane Mountain Landfill.

We are certain that the FRSWC's current staff and management would plan to make the Crane Mountain Landfill a "good neighbor." As this landfill will be a threat for no less than hundreds and possibly a thousand or more years, there can be no assurance that the future landfill operator's staff and management will, in fact, adequately and reliably carry out all needed mitigation measures for as long as this landfill represents a threat. There is need to develop a mechanism to ensure that the plausible worst-case scenario for failure of the landfill containment systems can be adequately and reliably implemented to detect and remediate any problems that occur at any time in the future. This will likely require a dedicated trust fund of sufficient magnitude to address all plausible worst-case scenario problems that could develop at this landfill.

The FRSWC should conduct a plausible worst case scenario evaluation for leachate management and then address how this situation would be detected, remediated, the amount of funds needed to control the problem and the source of the funds that would be needed at any time in the future for the remediation. It will also be important for an independent peer reviewer to conduct an in-depth review of this proposed worst case scenario to be certain that it is reliable and does in fact represent a true worst case situation. Of particular significance would be the potential pollution of the Spruce Lake system supplying the City of Saint John.

Long-term Costs

As is well known, economics is less than a precise science. In order for Saint John Council and other interested parties to reliably evaluate the economic aspects of the proposed Crane Mountain Landfill, it is important that they be provided with reliable economic information. At this time, it appears that the Council may not have received such information. It is impossible to evaluate the reliability of the information provided in the proposed FRSWC 1997 Capital and Operating Budgets since insufficient detail is provided to enable such an evaluation. However, from the authors' experience and

expertise in evaluating the long term cost of landfill post-closure care, it appears that the FRSWC has significantly underestimated the long term costs associated with the development of the Crane Mountain Landfill. Of particular concern is post-closure costs.

As an example, if the contaminating lifespan of the Crane Mountain Landfill is several hundred years to a thousand years, the cost of post-closure care may change drastically.

It is well understood that U.S. landfilling companies are developing massive liabilities associated with landfilling of wastes that will ultimately pollute groundwater for landfills sited in those areas where groundwater pollution is possible. Dr. Jones-Lee and Dr. Lee have published several papers on these issues. They include: "Municipal Landfill Post-Closure Care Funding: The 30-Year Post-Closure Care Myth" Report G. Fred Lee and Associates (1992), "Landfill Post-Closure Care: Can Owners Guarantee the Money Will Be There?" in Solid Waste and Power 7(4):35-39 (1993), "Landfilling of Solid & Hazardous Waste: Facing Long Term Liability" in: Proceedings of the 1994 Federal Environmental Restoration III & Waste Minimization II Conference (1994) and "Overview of Landfill Post Closure Issues" presented at the American Society of Civil Engineers Convention (1995).

As discussed in these articles, it is well known that US waste management companies will not be able to meet the long term liabilities that are accumulating with current methods of solid waste management involving disposal in US landfills that meet current minimum regulatory requirements, requirements which are similar to those being used at the Crane Mountain Landfill. At some time in the future, essentially all of the owners of current landfills will be subject to having to pay for the massive costs associated with groundwater pollution cleanup. There certainly will be significant attempts to collect part of these funds from those who contributed waste to the landfill. While landfill operators may assert that disposing of waste in their landfill will not result in any long term liability for future remediation of polluted groundwaters, there are significant questions about whether such claims are reliable and will, in fact, be valid for as long as the waste in the landfill represent a threat.

RECYCLING FACILITIES

Operating Cost

The budget shows increasing deficits for the MaxRF program. One interpretation that could be placed on this item is that the more recycling is done, the more money is lost. Some municipalities in Ontario are now making an profit on recycling activities, including collection costs (Kitchener, Ontario for example).

Furthermore, as the recycling program develops and more waste in diverted from the landfill, the tonnages received at the landfill for disposal will be reduced, contributing to the problem of escalating tipping fees and/or deficits discussed above.

Capital Cost

The Capital Costs shown in the budget for the construction of the MaxRF building and associated facilities appear low in relation to costs for similar structures in other parts of the Maritimes. The FRSWC should provide additional detail on what type of facility is to be provided and how the costs were derived.

The combination of predicted deficits in the operation of the recycling portion of the FRSWC's mandate and a possibly inadequate facility may create a disincentive to pursue waste diversion options in the area. If a commitment to the 3R's has been made or a certain level of diversion has been mandated by the province, Council should have more detailed information on the actual costs of implementing a program. The impact of diversion on landfill tipping fees and the overall implications for the operation of the solid waste management system should be presented before any final decisions are taken.

Basically, Saint John Common Council and its neighbouring municipalities are faced with the situation of trying to make a business economic decision on how best to manage the area's garbage over the next 25 or so years without having reliable information on the true costs for the various alternative approaches. It is important that Saint John and associated Councils develop a more reliable assessment of not only initial but long term costs associated with managing the area's solid waste, for developing the Crane Mountain Landfill and for the alternative approaches for MSW management.

CONCLUSIONS AND RECOMMENDATIONS

The proposed Crane Mountain Landfill will have the characteristics of a so-called "dry-tomb" landfill, which is supposed to minimize the production of toxic leachate and contain that leachate for removal and treatment at appropriate facilities. Experience has shown that this type of landfill will produce greater quantities of leachate than predicted and that it will inevitably leak leachate, thereby polluting surrounding groundwater. This groundwater, once polluted, will never again be useful for human domestic purposes. The extent of the pollution will be difficult to identify and determining it is complicated by the fractured rock geology underlying the site. There may be a hydraulic connection to the Spruce Lake system which supplies some of the City of Saint John's water.

When the inevitable leakage is detected, expensive pump and treat and other techniques will be required to stop further spreading of the groundwater and to attempt remediation. It may, in the final analysis, be necessary to remove all the waste from the landfill to stop groundwater pollution.

In spite of the above, it may be possible to safely locate a landfill at Crane Mountain, if the necessary additional studies which are undertaken indicate that the risks involved are minimal and if the landfill operator is prepared to provide the physical plant and financial commitments that will be required to ensure the public health and well being of those within the sphere of influence of the landfill are protected for as long as the wastes are a threat.

An important factor in the decision facing the involved municipal councils is the need for reliable and accurate financial information which reflects the true cost of providing landfill capacity, including perpetual care and any "worst-case" scenario, up to and including the removal of all waste from the landfill.

Deficiencies in Available Documentation/Design

Contaminating Lifespan

The terms and conditions of approval for the Crane Mountain Landfill include a provision that the soil portion of the leachate containment layer have a service life of 25 years. This is grossly insufficient to protect the interests of those within the landfill's sphere of influence. The contaminating lifespan of the landfill will be many hundreds if not thousands of years. Containment systems must be designed with this in mind and with the knowledge that leakage will inevitably occur, requiring control and remediation measures.

Liner Construction

The types of liners proposed for the landfill will be inadequate to minimize leachate production and prevent it from escaping to the groundwater, except in the short-term. To provide any degree of medium-term protection the operators should consider use of a leak-detecting upper layer and a double composite leak-detecting bottom liner. Although these types of liners will also eventually leak, they can be useful in indicating that the landfill is leaking so that control and remediation measures can be undertaken.

Monitoring Systems

The monitoring well system proposed will be unreliable in detecting the presence of leachate polluted groundwater. Monitoring wells have severely limited ability to detect pollution in fractured rock, such a that which underlies the site, and limited ability in consolidated material due to the possibility of contaminated plumes which bypass the wells. To ensure complete reliability of detection, all production wells (those producing water for domestic or other use) should be regularly and perpetually monitored for any sign of leachate pollution, even if below conventional drinking water standards. Leachate contains toxic and potentially carcinogenic chemicals which are not measured in standard drinking water tests. At the first sign of pollution, alternate sources of potable water must be supplied and control and remediation measures implemented.

Due to the possibility that the Spruce Lake system supplying the City of Saint John could be contaminated by leachate-polluted groundwaters traveling through fractured rock, the FRSWC must undertake additional study to determine the highest possible rate of transfer that could occur and the probable amount of dilution/dispersion, if any, thereby allowing a calculation of the risk. If the level of risk was found to be little or none, then this area of concern could be eliminated for now.

Control and Remediation

Financial provisions will be needed for all potential control and remediation requirements identified in the "worst-case" scenario, including the perpetual pumping and treating of polluted groundwater when it is detected, the provision of potable water to residents and others who are unable to use groundwater supplies and the possibility of removing all waste from the landfill. These costs must be estimated before the landfill is constructed to allow a rational discussion of the economic viability of the project and the recovery of the funds from tipping fees as the landfill is filled.

Cost Budgeting and Forecasts

The 5-year Budget submitted by the FRSWC in January 1997 is seriously deficient in level of detail, appears suspect in its assumptions and does not include estimates for the items which are noted above. All of these deficiencies must be corrected and the budget resubmitted to give decision-makers the ability to judge the viability of the proposed landfill in comparison to other disposal options (neighbouring landfills, incineration, etc.) and other methods of handling municipal solid waste (reduction, recycling, composting). Of particular importance is an analysis of the tipping fee level at which those with the ability to use other facilities or methods of managing waste would do so.

It is also possible that costs associated with the as yet undefined recycling/waste diversion portion of the waste management system are inaccurate. Such inaccuracies could cause Council to fail to implement a recycling and composting scheme which could divert significant amounts of waste from the need to landfill. More attention and detail should be given to this portion of the budget and the waste management system before decisions are taken on the construction of the landfill.

The ability of local sewage treatment plants to effectively handle the leachate produced, both now and in the future should be examined to prevent pollution of surface waters from the discharge of inadequately treated leachate. A future refusal to accept leachate could force the construction of expensive new facilities or alterations to existing plants. These costs should also be estimated and included in the financial forecasts provided to Council.

Alternative Solutions

Once complete and realistic financial information has been presented to the decision-makers on the true cost of landfilling waste at the Crane Mountain site Council should reconsider its options, including those presented to Cabinet at the time it approved the Crane Mountain Environmental Impact Statement. These include

- export of all waste to a neighbouring landfill
- operation of a MaxRF system for the Saint John area with export of residual waste
- operation of a MaxRF system with residual waste landfilled in the region
- landfilling of all waste at a landfill in the region

An option different from that being proposed may emerge as the most economically viable in the long-term.

RESOLUTION OF CONFLICT AMONG EXPERTS

One of the issues associated with the development of landfills is a conflict between technical experts on groundwater pollution issues. Frequently, non-expert public groups involved in landfill issues are faced with the need to determine which expert's presentation of information is most reliable.

This is an issue that has been of concern to Dr. Lee for a number of years. Recently, the American Society of Civil Engineers, *Civil Engineering,* has published a review of this issue developed by Lee and Jones-Lee entitled, "Environmental Ethics: The Whole Truth," *Civil Engineering,* Forum, 65:6 (1995). This article is based on a report that they developed entitled, "Practical Environmental Ethics: Is There an Obligation to Tell the Whole Truth?" Both of these publications will be provided interested parties upon request to the author.

In their discussions of these issues, they have recommended that should a situation develop where disputes occur between experts in a topic area, then the dispute should be resolved by a panel of experts. This panel would require that each of the opposing experts presents the technical basis for their position on an issue in a full peer-review arena where all information in support of an expert's opinion is available for the panel and public review. The panel of experts would then recommend to the public body, responsible for formulating a decision on an issue, the appropriateness of each of the opposing expert's positions on the issue in dispute.

SELECTED BIBLIOGRAPHY

Belevi, H. and Baccini, P., "Water and Element Fluxes from Sanitary Landfills," In: Sanitary Landfilling: Process, Technology and Environmental Impact, Academic Press, San Diego, pp. 391-397 (1989).

Cherry, J. A., "Groundwater Monitoring: Some Deficiencies and Opportunities," In: Hazardous Waste Site Investigations: Towards Better Decisions, B.A. Berven & R.B. Gammage, Eds., Proc. Of 10th ORNL Life Sciences Symposium, Gatlinburg, TN, May 21-24, (1990).

Fundy Region Solid Waste Commission, "1997 Capital and Operating Budgets", (Saint John, NB) Jan. 17, 1997.

Fundy Solid Waste Action Team, "Environmental Impact Statement - Regional Landfill at Crane Mountain or Paddy's Hill Sites", (Saint John, NB) Dec. 21, 1994.

Haitjema, H. M., "Ground Water Hydraulics Considerations Regarding Landfills", *Water Resources Bulletin*, 27-5:791-796 (1991)

Lee, G.F. and Gallaugher, B., "Overview Assessment of the Potential Public Health, Environmental and Groundwater Resource and Other Impacts of the Proposed Adams Mine Site Landfill", Report to the Adams Mine Public Liaison Committee (December, 1995).

Lee, G.F. and Jones-Lee, A., "A Groundwater Protection Strategy for Lined Landfills," *Environmental Science & Technology,* 28:584-5 (1994).

Lee, G.F. and Jones-Lee, A., "Recommended Design, Operation, Closure and Post-Closure Approaches for Municipal Solid Waste and Hazardous Waste Landfills", Report to Greenpeace Mexico, G. Fred Lee and Associates, El Macero, CA (1995).

New Brunswick, Province of, Dept. of the Environment, "Environmental Impact Assessment in New Brunswick", (January 1995).

New Brunswick, Province of, Dept. of the Environment, "Crane Mountain EIA Approval Conditions" In Press Release by Minister of the Environment (September 11, 1996).

Reference as: "Gallaugher, B. and Lee, G.F., 'Review of Potential Public Health, Groundwater Resource, Financial and Other Impacts of the Proposed Crane Mountain Landfill, Saint John, New Brunswick, Canada,' Submitted to Saint John Common Council, February (1997)."