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30 March 2015

Golder Associates Ltd.
32 Steacie Drive,
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Attention: Mr. Paul Smolkin, P.Eng.

Dear Mr. Smolkin:

Re: Review of geology, hydrogeology, and geotechnical reports related to the Capital Region Resource Recover Centre investigations by Dr. Ken Howard.

As requested, I have reviewed:

1. Technical Support Document #1 – Comparative evaluation of alternative sites: Capital Region Resource Recover Centre (dated February 2013)
2. Volume III - Geology, hydrogeology, and geotechnical reports related to the Capital Region Resource Recover Centre (dated December 2014)
3. (Draft) Review comments by Dr. Ken Howard with respect to Items 1 & 2 above (dated 10 February 2015)
4. The Golder response to Dr. Howard's comments (Draft provided 20 March 2015)

This letter report summarizes my professional opinion regarding Dr. Howard's comments and the Golder Response to those comments based on my reading of Items #1 and #2 above and my professional experience related to the review of geology, hydrogeology, and geotechnical reports, modelling, and landfill design related to many landfill projects over the last approximately 30 years together with my experience from my involvement with the development of landfill regulations and guidelines (including Ont. Reg. 232/98). My review was restricted to those sections of Items 1 & 2 relevant to Dr. Howard's comments. I did not review other sections of the documents (including those dealing with geotechnical issues such as stability or settlement that are within my area of expertise) and while I reviewed the general methods adopted for flow and transport modelling, I did not perform any independent or detailed check of the calculations or selection of parameters except where explicitly indicated.

Thus my review was restricted to what was required to respond to Dr Howard's specific comments and the Golder response to those specific comments.

1. **Dr. Howards Comment #1 re Technical Support Document #1- Comparative Analysis of Alternative Sites Section TSD#I-B (Geology, Hydrogeology and Geotechnical Component), and Section TSD#l-H (Design and Operations Component).**

In my opinion, it would be possible to engineer both sites to meet the requirements of Ont. Reg. 232/98. However to do so would require a much higher level of reliance on engineering for North Russell Road Site than for the Boundary Road Site. Based on the assessment criterion "Which site is preferred for protection of groundwater?" the evidence (e.g., as summarized in Tables 2.1-8 (pp. 31-32) and Table 2.2-7 (pp. 52-53) of Support Document #1) indicates that Boundary Road Site is preferable.

Given a choice of alternative sites, it is my experience (dating back to the Consolidated Hearings Board's decision, and reasons for that decision, with respect to the Halton landfill) that a geological setting in which the landfill is located in a clay (or clay till; even with the presence of sand/silt lenses/seams) is considered preferable to one where the landfill will be placed directly in/on fractured rock, notwithstanding the potential to mitigate impact with engineered systems in both cases.

Based on the information provided in Support Document #1, I agree with Golder that the Boundary Road Site offers considerably greater confidence for the long-term monitoring of potential impacts from the proposed landfill given the generally better understanding of migration pathways in the overburden material at the Boundary Road Site than would be possible in the fractured rock at the North Russell Road Site. While the bedrock at both sites appears to be fractured, the thick clay deposit at the Boundary Road Site would provide significant natural on-site natural attenuation in the event of an unexpected escape of contaminant beyond the engineered system. There is negligible similar potential for natural attention at the North Russell Road Site.

In my opinion, the Golder evaluation is based on sound and scientific based criteria. No amount of additional investigation or modelling is likely to alter the fact that fractured rock invariably has uncertainly with respect to the degree of fracturing and is difficult to monitor for contaminant transport if there is outward flow away from the engineered facility (i.e., no significant hydraulic containment) and hence reliance must be placed on the engineered system for both contaminant control and monitoring. Given the choice (as is the case here), it is considered preferable to locate a landfill in geologic setting that offers natural containment and attenuation over and above that provided by an engineered system alone.

2. **Dr. Howard's comments regarding Geology, Hydrogeology and Geotechnical Report and hydrogeological investigation**

I agree with points raised by Golder in their response. In particular, having reviewed the borehole logs for the Boundary Road Site, I do not consider the geology at the CRRRC Site to be complex. On the contrary, with the exception of the fact that the soil is sensitive and highly compressible, I would consider the geology and hydrogeology critical to the design of a landfill and the protection of groundwater to be relatively straightforward and not unusual. In brief, there is a surficial silty sand layer/weathered clay upper layer, a layer of low permeability clay, a relatively shallow sandy silt to silty sand layer (denoted by Golder as the "silty layer") and then thick clay to a glacial till/fractured bedrock aquifer (e.g., Section E-E, Figure 3-14 of Item 2 referenced above). The primary receptors for groundwater impact are the surficial layer adjacent to the landfill and shallow silty layer. This has been recognised and addressed by Golder. The only "unusual" characteristic of the site with respect to many landfills upon which I have worked is the sensitivity and compressibility of the clay. Again this has been recognised by Golder and addressed in their design. They have recognized that the consolidation of the clay will squeeze out pore water from the clay (which can be expected to have elevated chloride and sodium concentrations) as it compresses. This has the potential to impact both the surficial sand/weathered zone and the silty layer however this impact is not due to leachate and would be similar to that which would occur if any structure of similar weight (i.e., causing a similar change in stress in the clay) were constructed over the same area. While this compressibility does require careful consideration in design (especially with respect to the leachate collection system) they have a reasonable conceptual framework for this in their preliminary (EA/EPA level) design and the details can be fine-tuned at the final design stage. It is notable that: (a) the consolidation will likely resist contaminant migration during the period of consolidation while some of the pore water is squeezed upward toward the leachate collection system (thereby reducing the potential for contaminant transport during the period of consolidation), and (b) after consolidation, the hydraulic connectivity of the consolidated clay can be expected to be lower than the current value (i.e., also reducing the potential for contaminant transport).

For the reasons stated above, I consider Golders' greater emphasis on the surficial silty sand/weathered clay, silty layer, and clay than on the glacial till and bedrock to be appropriate given that the surficial silty sand/weathered clay and silty layer are the layers most likely to be affected by the landfill and the clay is a natural liner providing protection to underlying layers from the leachate. Less, but appropriate and sufficient, attention was paid to the glacial till and bedrock materials given that they are separated from the landfill by a substantial thickness of relatively low permeability silty clay. Given the significant

additional investigation of the most important layers noted above that was conducted by Golder (as detailed in Item 2 and summarized in their response), the information available for interpretation of the site is substantially more than the 7 boreholes referred to by Dr. Howard. In particular, I note that the 25 CPT tests to depths of 24.35 to 37.93 m (Appendix B, Item 2) not mentioned by Dr. Howard actually offer very valuable information regarding the consistency of the site with the interpretation of the data from the 7 Boreholes. I found this information extremely helpful in my review of the site data and it should not be ignored.

3. **Dr. Howard's comments regarding 3-D Groundwater Modelling**.

   In my opinion, Golder's modelling was reasonably well documented and Golder have responded in an appropriate manner to the questions/issues raised by Dr. Howard. I personally have no major concerns regarding the 3D modelling in the context of the purpose and use of the modelling.

4. **Dr. Howard's comments regarding: Predictive Simulations, Regulatory Objectives, and Modeling of geological/hydrogeological conditions beneath landfill is based on a modified (post- construction) version of the model**

   I agree with Golder's response to Dr. Howard's comments regarding the questions he raised with respect to these issues**.** In my opinion the flow modelling and contaminant transport modelling was conducted with appropriate models, at a level of detail, and using methods consistent with the EA/EPA level of documentation to be submitted to the Ministry for approval.

   In my opinion, the Conceptual Model is reasonable and appropriate at the level of detail required for a new landfill approval study. While a general understanding of the regional geology is an important part of the process, given the thick low permeability clay the primary focus of attention needs to be on the local region around the site and, in particular, on the surficial silty sand/ weathered clay, silty layer, and clay as previously noted.

   With respect to Dr. Howard's comment concerning *Regulatory Objectives*, I agree that Golders approach to modelling the impacts on the silty layer (background concentrations of 890 mg/L; Table 12-7) as given in the documentation he reviewed is conservative. In the POLLUTE modelling reported in Item 2 they neglected the background concentration and hence the peak landfill concentration was 1500 mg/L above that in the silty layer in this modelling whereas in realty it was only about (1500-890)= 610 mg/L above the concentration in the silty layer (a 60% overestimate) at its peak. Also they neglected the

fact that for about 25 years after the landfill was built there would be inward flow of water (consolidation water) to the landfill (Figure 12-1 of Item 2) which would provide additional advective resistance to outward diffusion. Even conservatively assuming the landfill reached it full height at 10 years after landfilling commenced (compared with the expected 20 years) then at year 35 (i.e., 25 years after the full height was developed), the concentration of chloride in the landfill is calculated to be less than the 890 mg/L in the silty layer so in fact after this time diffusion will be upward from the glacial till (chloride concentration around 5600 mg/L; Table 13-13) to the silty layer (chloride concentration around 890-930 mg/L; Tables 12-7 & 13-12) to the landfill and the advective flow while the leachate collection system is in operation will actually be increasing the chloride concentration in the leachate due to its remove from the subsoil. Furthermore the calculated value is at the edge of the landfill and hence there is a 125 m buffer to the property boundary (where Reasonable Use Guideline must be met) for attenuation of any chloride (or other contaminants) that might reach the silty layer. Based on these considerations alone, I would expect no chloride impact due to the landfill leachate at the property boundary. However as noted by Golder in their response, they did repeat the calculation considering the background concentration. I checked the POLLUTE calculations for this case with a background concentration and consider their use of POLLUTE in this analysis to be correct for the conditions modelled and appropriate for assessing the impact of the landfill on the concentrations in the silty layer. This analysis predicted no increase in chloride in the silty layer (if anything there is a slight decrease in concentration) below the landfill. Based on this analysis the proposed design is totally compliant with the Reasonable Use Guideline (assuming that there is a reasonable use for that water despite the concentrations being almost 4 times the drinking water objective). Thus in the context of Dr Howard's comment, recognising that groundwater quality in the vicinity of the site is already poor with respect to chloride, the proponents have (especially with the additional analysis I reviewed) demonstrated that the reasonable use guidelines are met in full.

In my opinion the POLLUTE modelling that was conducted (as described in Item 2) is entirely consistent with what is normally done in the analysis of contaminant transport in the context of Ont. Reg. 232/98. I also note that POLLUTE was the model used in developing the generic designs in Ont. Reg. 232/98 (modelling that was conducted under my guidance and subject to my review at the time it was done).

5. Concluding comment

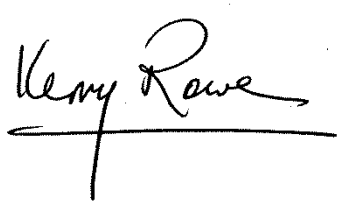
Based on about 30 years' experience directly related to hydrogeological evaluation of proposed landfill sites, the conduct and expert review of flow and contaminant transport modelling, and landfill design as well as the development of landfill regulations and guidelines in several

jurisdictions, I consider that the work undertaken in support of the proposed CRRRC facility at Boundary Road and subject to my review in response to Dr. Howard's comments to be consistent with the level of detail that is reasonable for a landfill in this hydrogeological setting (i.e., where the proposed landfill is underlain by a low permeability silty clay deposit that provides a high degree of natural protection to the groundwater). This hydrogeological setting, combined with the engineered leachate management system which is to be designed consistent with Schedule 1 (100 year service life) and the adoption of reasonable assumptions have resulted in predicted compliance with the Reasonable Use Guideline. Subject to the final detailed design, construction, and operations being consistent with what is proposed in the EA/EPA documents (especially Item 2) reviewed by me, I have a high degree of confidence that the site can be operated in the safe manner predicted.

As recognised by Golder, the surficial silty sand/weathered clay and silty layer are the primary potential receptors for contaminant impact and the detailed design and construction must be such that what is proposed in the EA/EPA is actually constructed. The special characteristic of this site compared to typical landfills is the sensitivity and compressibility of the silty clay. Golder have recognised and accounted for this in the EA/EPA documentation. It is essential that the detailed design and construction take this into careful consideration to avoid either stability problems or problems with the leachate collections system. I note that changes in the drainage gravel that could degrade the system (i.e., the use of unproven materials such as crushed concrete, tire shreds etc.) should not be used as an alternative to the materials envisaged in Ont. Reg. 232/98 Schedule 1 for this site.

Should you have any questions, please send me an e-mail or give me a call (613-484-8837).

Yours sincerely



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