Algonquin Eco-Watch
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March 6, 2017

Deep Geologic Repository Project
Canadian Environmental Assessment Agency
160 Elgin Street, 22nd Floor,
Ottawa ON
K1A 0H3

Attn: Project Manager

Re: A Review Report for the Algonquin Eco Watch Group Regarding the Proposed Bruce-Huron DGR Site
Reference Number: 17520

Dear Sir/Madame:

With regard to the Ontario Power Generation ("OPG") response to the request from the Minister of the Environment and Climate Change (the "Minister") for detailed examples of possible alternate sites for a Deep Geologic Repository ("DGR") for low and intermediate waste, Algonquin Eco Watch ("AEW") wishes to comment as follows:

1. We feel that by only referring to 2 "generic" possible sites, i.e. sedimentary and crystalline, OPG misinterpreted the Minister's intent, which presumably meant finite examples in both generic types, so that comparisons within each type could be made, ultimately arriving at the best all-round site in the southern portion of the province. We are not sure why OPG adopted this interpretation and are further surprised that the Minister's office did not instruct OPG accordingly.

2. Even though this search is a quest for a suitable site for low and intermediate nuclear waste disposal, it should be noted that while highly radioactive waste **must not** be stored in low and intermediate waste disposal sites, low and intermediate waste **may** be stored in highly radioactive storage sites. Therefore, one could assume that sites in northern Ontario, e.g. Manitouwadge, White River and Ignace, presently at an advanced level of investigation for highly radioactive waste disposal, could well have been considered and detailed in the OPG response since the Minister does not appear to have differentiated between the three forms of waste storage. AEW questions which criteria must be met to fulfill the requirements for a "low and intermediate" storage facility as against the requirements for a "highly radioactive" storage facility. Are there cumulative similarities and differences? In other words, can 100 low grade mops equal 1 high grade fuel rod? Moreover, the OPG response appears to be particularly tailored toward the "benefits" of

sedimentary rock in the vicinity of Bruce Nuclear, while generally discounting the sedimentary rock in other parts of southern Ontario.

3. Following are excerpts from a report by Greg Stott, PhD, PGeo of Stott Geoconsulting Ltd., dated February 24, 2017, which was commissioned by Algonquin Eco-Watch for this study.

> The following is a brief review of the Bruce-Huron site for a proposed Deep Geological Repository (DGR) for medium to low-level nuclear waste disposal. It is to advise the Algonquin Eco-Watch group ["AEW"] in their submission of queries regarding some issues of concern, long-term planning of research, insufficient data, any apparent errors in available reports in the public domain, plus concerns of uncertainty or lack of clarity in the publicly available data, or how the data was integrated into the decision-making. Not all of these elements are addressed below. It is recognized that at present, all publicly available technical geological assessment reports are Preliminary Phase 1 reports and that further investigations require select deep boreholes to be drilled to conduct various technical research on the stratigraphy and structures at depth and characteristics that may affect the groundwater and groundwater wells that penetrate the bedrock. Consequently, this research endeavour is a rather long, involved process to evaluate the suitability of the Bruce area.
>
> Issues of particular interest to briefly discuss here include:
>
> - Groundwater integrity and protection;
> - Ground disturbance, both seismic and long-term postglacial uplift;
> - How the Deep Geological Repository would affect the groundwater or be affected by potential ground disturbance.
>
> <u>Owing to the concern regarding the obscure response regarding Alternative Locations by OPG (December 28, 2016) to the Information Request by the Minister of the Environment and Climate Change, examples are provided below of possible locations in each of granitic and sedimentary terrains in Ontario.</u>
>
> Each of these issues is discussed separately below with comments on and reference to the available technical reports where relevant. Much of this report directs AEW and the Canadian Nuclear Safety Commission ("CNSC") to specific technical reports and their map figures to illustrate points being made and issues to consider.

GROUNDWATER

- A key consideration is that the sedimentary units of Ordovician age (older than 444 million years), within which it has been proposed to put the DGR, are very deep and within carbonate beds and associated shales that might serve to host a deep repository. Research appears to be ongoing, with emphasis on a borehole drilling program to ascertain the rock characteristics to great depth. AEW may wish to submit further queries on this research plan, laid out in a Nuclear Waste Management Organization ("NWMO") draft document intended for discussion with local communities: https://www.nwmo.ca/~/media/Site/Files/PDFs/2016/07/11/10/37/Borehole Drilling Sedimentary english June 29.ashx?la=en.

- The bathythermetry of Lake Huron has been documented in detail. For the location of the Southampton Basin referred to below, see: https://www.ngdc.noaa.gov/mgg/image/images/huronmax.pdf. The maximum depth of the southern half of Lake Huron, west of the Bruce Nuclear Site is approximately 100 metres along narrow trenches but the northern half of the lake, west of the Bruce Peninsula and north of the Bruce-Huron area, contains two deeper, broader basins with local depths below the lake level that appear to exceed 200 metres. More detailed Canadian hydrographic surveys of Southampton Basin closest to the Bruce Peninsula would clarify this. It is unclear but worthy of attention as to whether this nearby basinal "gouge" into the Paleozoic stratigraphy limits placing the DGR further east since the Ordovician sedimentary rock layers become shallower and thereby less deep below the Southampton Basin, which lies 120 km north of the Bruce-Huron area.

- The groundwater wells are evidently restricted to within 275 metres below the ground surface. How fracture systems and faults may affect the recharge and discharge of groundwater (if at all) and how the DGR affects the dynamics of this system deep within the Ordovician rocks remain to be researched.

GROUND DISTURBANCE

- Thermal and mechanical influence of the repository on the ground surface has been modeled mathematically for crystalline (granitic) rock with a set of assumptions and material properties of the used fuel (Nuclear Waste Management Organization ("NWMO") -TR-2016-15). Also,

assuming the DGR is completely filled with used fuel rods that are already 30 years old, it was calculated that there would be "a general slow uplift of the ground surface due to thermal expansion over an area larger than the repository footprint, with a maximum uplift of about 28 cm occurring above the centre of the repository in about 3400 years." (abstract of above publicly available reference). It would be wise to inquire whether a similar study has been publicly available for a sedimentary rock host of a DGR, comparable to the Bruce-Huron setting. **[Note: See attached email of Feb. 24-17.]**

- Postglacial uplift has been determined to range from negligible for southwestern Ontario to slightly negative relative to the isostatic rebound documented around Hudson Bay.

- Seismicity is very low near Lake Huron owing to the very stable nature of the Michigan Basin, a large, roughly circular basin of Paleozoic sedimentary formations that dip toward the centre of the basin in Michigan, west of Lake Huron (see Figure 5 in Armstrong and Carter, 2010, or Figure 3.1 (geological features map) and 3.3 (cross section) of 117083E, accompanying report accessed as 117057E, Phase 1 Geoscience Desktop Preliminary Assessment – Geofirma, September, 2015 for NWMO). Negligible seismicity for this region is documented by the Geological Survey of Canada as illustrated at: http://www.earthquakescanada.nrcn.gc.ca/zones/eastern-en.php.

- The region close to Lake Huron is somewhat unique in that it shows both negligible postglacial uplift and a comparatively quiet record of seismicity (Sella et al., 2007); although the seismic data, are based on a short, documented history of instrumental seismology (Swafford and Stein, 2007) the relative absence of seismicity records is consistent with the location of the Bruce Site within a large sedimentary basin.

- Calcite veins as in-fills of fractures can serve as a proxy for determining the age of the fractures. Uranium-Lead geochronology of secondary calcite by D.W. Davis (2013) and (Davis 2016), shows that calcite (calcium carbonate), which forms a common seal along fractures as veins and vugs (small cavity infillings) in carbonate sedimentary rocks, has revealed a complex history of fluid mobility ranging in age from the Paleozoic age of the host rocks to the Pleistocene in rocks

down to approximately 180 metres depth (Upper Silurian, 423 to 416 Ma (million years) old below ground surface. Calcite veins in deep Ordovician carbonate sedimentary rocks are generally thinner (up to mm-scale widths) than surface veins. A few samples from the Ordovician rocks give an imprecise age of fracture formation and vein in-filling of 445 million years, with a precision of +/- 45 Ma, which is close to the Ordovician depositional age of the rock. In general, results from the surface to approximately 180 metres depth show evidence of multiple generations of calcite infilling fractures ranging in age from 100 to 0 Ma. The results thus far, in this leading-edge research at the University of Toronto, suggest that one could map a spatial pattern of well-sealed, old fractures and zones of more complex fracture ages. This has implications for testing the relative crustal stability of this region. Initial results suggest that the deeper, Ordovician rocks, where the DGR is proposed, have been stable for over 400 million years; however, further tests are needed on drill core from the deep boreholes proposed.

- There is insufficient data at depth to fully assess any ground disturbance by a DGR, but this is a comparatively stable crustal region removed from significant postglacial uplift and seismic events. There is some uncertainty about the limited exploration evidence of oil and gas in the Ordovician sedimentary rocks at great depth. See also report 117057E Phase 1 Geoscience Desktop report on Central Huron (Sept. 2015), wherein the Executive Summary notes “While the Municipality of Central Huron appears to contain large areas with favourable geoscientific characteristics, there are inherent uncertainties that would need to be addressed during subsequent stages of the site evaluation process. The assumption of transferability of geoscientific characteristics and understanding based on regional data and data from the Bruce nuclear site to the Municipality of Central Huron would need to be confirmed.”

- More research arising from borehole and other studies is evidently needed. You can inquire from NWMO directly as to the nature of the continued research (e.g., similar to the above report NWMO-TR-2016-15) on this matter. Similarly, you can also inquire about the investigation of potential karsts at depth (see for example, the karst mapping of southern Ontario in Figure 3.5, accompanying the report 117057E Phase 1 Geoscience Desktop report on Central Huron (Sept. 2015). Most karsts lie within the shallower carbonate rocks and more prominently occur east of the Bruce-Huron area. Search for the

map broadsheet at http://www.geologyontario.mndm.on.ca/ included with report Karst of Southern Ontario and Manitoulin Island, GRS005, by F.R. Brunton and J.E.P. Dodge, 2008.

EXAMPLES OF ALTERNATIVE LOCATIONS

Granitic rocks, notably in the older Archean (older than 2.5 billion years) crust that dominates the entire northwest Ontario region, north of Sudbury, most prominently occur as large plutons and older, gneissic rocks. Plutons are large bodies of relatively homogeneous composition and many are shown to have been emplaced very late in the history of the Archean in Ontario. Consequently, where they are relatively distant from major faults, they can display fewer fractures and faults than granitic rocks elsewhere. But, just as in southwestern Ontario, where the sedimentary rocks are generally inaccessible except by drilling deep boreholes, the granitic rocks need to be mapped by geologists to document the distribution and structural character of any faults, fractures and joints, the latter of which may commonly arise from the cooling of granitic magma at great depth before they were subsequently exposed by uplift and erosion. But much of the various phases of mapping across the Precambrian Shield can be conducted on the surface before selecting suitable proposed repository areas where borehole drilling could be recommended; in both cases, Archean granitic and Paleozoic sedimentary strata (older than 359 million years in southwestern Ontario).

1. Several communities across northern Ontario had expressed an interest in hosting a DGR and have been kept informed of the progress on field-based research directed by NWMO. The geological studies have been the basis for winnowing down the remaining suitable areas near a few northern communities.

2. Crystalline rock (granitic) areas of interest mainly lie in north-central and northwestern Ontario. Significant transportation costs involving security, safety and distance would be incurred since the nuclear power generating stations and stored nuclear waste materials are all located in Southern Ontario. Nevertheless, one example of a crystalline rock area, currently being investigated, lies near Ignace, west of Thunder Bay. This area is seismically quiet with minimal to negligible postglacial uplift. A set of granitic plutons have been mapped and potentially suitable repository areas within these plutons have been outlined. These are currently under discussion with the local people in the Ignace Area before any borehole drilling proceeds. There needs to be a general agreement locally for the

research to continue to the next stage. See: https://www.nwmo.ca/en/Site-selection/Steps-in-the-Process/Step-3-Preliminary-Assessments-of-Suitability/Step-3-Phase-2--Field-Studies-and-Engagement/Borehole-Drilling-and-Testing and https://nwmo.ca/~/media/Site/Files PDFs/2016/07/08/13/00/BoreholeDrilling Ignace english June21.ashx?la=en and NWMO map of potentially suitable areas for initial borehole drilling studies near Ignace: https://www.nwmo.ca/~/media/Site/Files/PDFs/2016/12/01/12/14/Ignace InitialBorehole Map web EN.ashx?la=en

3. Other granitic (crystalline) areas currently under geological investigation include Manitouwadge and White River. Technical reports on the geological investigations near Ignace through the initial Phases are available through www.nwmo.ca.

4. Paleozoic sedimentary areas as potential repository sites are largely limited in southern and southeastern Ontario owing to the limited thickness of the sedimentary units and the presence of a seismically active fault zone along the Ottawa River region and St Lawrence River. These sedimentary beds are generally flat to shallowly dipping across most of southern and eastern Ontario, and moderately dipping in the Michigan Basin, as we see east of Lake Huron. There is considerable difficulty in suggesting an alternative sedimentary host for a DGR than the Bruce-Huron area because of the decreasing thickness of sedimentary rock eastwards towards the Niagara Escarpment, the greater presence of oil and gas fields to the south, from Sarnia to Lake Erie, the increased, though modest, seismic activity recorded close to Lake Erie, and the greater evidence of faults east and south of the Bruce-Huron region within the Bruce Megablock illustrated in Figure 3.4b accompanying the 117055Eand 117057E reports by Geofirma, 2014 and 2015 for NWMO. Consequently, the Bruce-Huron region, hemmed in by geologically less favourable regions, is ideally***** the best test region owing to the lack of or minimal postglacial uplift and the relative absence of the above negative features.

   NOTE: The forgoing may, at least, partially explain why OPG did not include specific examples of suitable alternate sedimentary sites. *** AEW would replace the word "ideally" with the phrase "appears to be". It seems that much work needs yet to be accomplished before the Bruce site could be considered to be the "ideal" test region.**

What continues to be researched, largely from borehole studies, including downhole geophysics, are the structural integrity of the sedimentary layers at depth, the presence of fractures and faults if any, and potential impact on groundwater and groundwater wells.

OTHER CONSIDERATIONS TO QUERY

- What are the future plans for continued geological assessment of the Bruce-Huron Site beyond the borehole drilling? What are the later Phases in the site investigation?

- How far east, away from Lake Huron, can one propose a site location that is comparable geologically and yet at a safe distance from karst in rock formations, potential seismicity, etc., and yet still remain within sufficiently deep, Ordovician formations?

- The initial borehole drilling and its accompanying research is currently under discussion; see https://www.nwmo.ca/~/media/Site/Files/PDFs/2016/07/11/10/37/BoreholeDrilling_Sedimentary_english_June29.ashx?la=en This brief public report (released July, 2016) by NWMO provides a general summary of borehole research plans for discussion with local communities. It provides a brief summary of the kinds of proposed geological and geophysical research to be conducted with the rock drill core and the boreholes.

- Major fault systems are currently interpreted to be limited in the Bruce-Huron area compared to areas further east and south (Figure 3.4 accompanying report 17057E and discussion therein. However, testing this is part of the borehole investigations. What potential role might any fault play on the migration of groundwater?

- How secure is the infilling of deep boreholes to prevent very long-term contamination of groundwater?

(Excerpted from “A Review Report for the Algonquin Eco Watch Group Regarding the Proposed Bruce-Huron DGR Site”, Greg Stott, PhD, PGeo, Stott Geoconsulting Ltd., February 24, 2017. Suggested “follow-ups” for AEW have been included herein, for which time has not been available.)

SUMMARY AND DISCUSSION:

1. Acceptable alternative options in sedimentary rock located within southern Ontario do not seem to be available, at least according to OPG. To the best of my knowledge, no one has as yet described in detail a "perfect" waste containment facility, placed in a "perfect" surrounding environment. Such a description would at least provide a set of circumstances against which to measure possible sites across Ontario.

2. To date, there has been no truly acceptable/operational DGR developed anywhere in the world for highly radioactive waste. (Rodney C. Ewing, et al., "Geological Disposal of Nuclear Waste: a Primer" (2016) 12:4, Elements at p. 233 – copy attached to this submission).

3. In this instance, any form of mitigation, by definition implies a faulted system that cannot guarantee total protection for all life forms into the long-term future, i.e. hundreds of thousands of years.

4. While nuclear energy may well be the most efficient form of energy generation, unfortunately it leaves a destructive trail into history. At the present time there is no form of energy generation that can be truly considered to be "green". Whereas wind turbines and solar generation are likely the closest to "green", they require wind and sunlight respectively and presently offer no storage capacity. Water turbine generation is mistakenly considered by many to be "green" and the most energy efficient, but requires the storage and manipulation of river water in reservoirs, which not only generates harmful gasses, e.g. Methylmercury, but can seriously interfere with the life stages of important fish species such as lake trout *(Salvelinus namaycush)*, in addition to many species of reptiles and amphibians.

5. It becomes fairly obvious to Algonquin Eco Watch that, as yet there is no total solution to this dilemma world-wide, leaving much theoretical and physical work to be accomplished. Reading through this material objectively, one is given the distinct impression that we are racing headlong toward a solution – any solution - that will bring closure to this persistent problem. There are some tenuously promising avenues to further explore, but so far no conclusive results. Unfortunately, there is no "quick fix" to this, and we must accept the fact that if we are to continue to develop nuclear power responsibly, we must also accept the huge research and development expenses associated with waste containment. This problem supersedes politics and threatens the very existence of life on earth. The "least worst" solution will just not be good enough.

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ACKNOWLEDGEMENTS:

Algonquin Eco Watch wishes to sincerely thank Dr. Greg Stott of <email address removed> and Mr. Graham Andrews of SMM Law Professional Corporation for their valuable contributions with regard to geological and legal input respectively, to this submission.

Submitted via email, March 6th, 2017.

(Hard copy signed and mailed March 6th, 2017)

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(On behalf of) Algonquin Eco Watch.
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