

If we are going to move forward with such a project we need to get it right from the start, and it does need public support, which I don't think it has. I have concerns over the heat emitted from the waste and its effects on the buffer in the nearer term. I have problems with potential corrosion of the copper coating. Both of these are key to the barrier system. The third part of this system is the geosphere which will contain the repository. Again, it is the heat that is the problem. The rise in temperature in the surrounding rock will cause stresses in the host rock, over the long term, from heat expansion which will cause fracturing, stress cracks and possibly seismic events caused by faulting in the repository tunnels and surrounding rock that will facilitate migration of radionuclides. The heat from the waste may also serve to drive contaminated groundwater towards the environment above. Are there mitigation measures in place to counteract this kind of activity in a timely and effective way?

Further the transportation of the waste to the project site is, without a doubt, the riskiest part of the whole project. A risk analysis would prove this out. I read somewhere that it was expected that 'only' 1 in 1000 containers would leak - is this accurate? To omit this from the project description is a grievous error and will not earn any points from the public, especially those along the route who are at greatest risk to exposure from thousands of loads passing by, stopping, vehicles following behind loads - 5 millisieverts, sabotage, accidents with possible long term release to the environment - that's a 40 millisievert event, negative effect on property values, and so on. In fact, if the transport casks were built thick enough to totally block gamma radiation, they would have to rebuild the entire road network from the reactors to the project site because of their extreme weight - that is not part of the Project description. Nor is there any kind of compensation mentioned for these people whose only crime is to be down the road from the people who wanted the project because it would improve 'their' local economy. This is not to mention that if there was a significant transport incident, the public outcry might close down the projects operations - would this not impact the whole project and is worthy of discussion with the public. And what about the insurance that would be needed - does the nuclear liability act cover that?

Another omission is venting from the underground shafts and the infrastructure on sight involved in activities. No mention whatsoever is mentioned about the risks of these emissions. It might be radon at the time of venting but it is 7.5 times heavier than air, and won't go far when the weather is calm at the project site. While most of the radon daughters are very short lived, Pb210 and Po210 (Polonium) stick around quite a bit longer and are responsible for a lot of cancers, particularly those who smoke tobacco, whose large leaves trap the falling radon. Lichens in the forest, which extract nutrients from the air, would be good indicators to sample as well as wild life that might feed on them - the best samples for this task are urine samples, not tissue samples or stools. What exactly are the details of your monitoring program?

Back in 1997 I presented at the Seaborn Commission about their concept for dealing with nuclear waste. I also attended information meetings in Prince Albert considering NWMO's interest in considering a site in Saskatchewan. It was interesting that NWMO suddenly decided, when they were considering the Creighton area, to withdraw its interest in Saskatchewan, stating that there were no suitable sites. I have looked at NWMO's Initial Project Description in Ontario, submitted Jan 5, and have a number of concerns. A major one is there is not nearly enough information here for the public to make any kind of informed decision. If a knowledgeable scientific expert were to review the project description they would be forced to say they are also unable to make a decision based on the information presented. There is absolutely no detail on anything!!

The Seaborn Report is an interesting read and whose recommendations resulted in the NWMO and what its mandate should include. Since then, the body of scientific knowledge of what should be considered in developing such a project has moved forward. The Panel stated, among other things, that the concept should have broad public support and should be safe from both a technical and social perspective and be selected after a comparison with risks, costs and benefits of other options. I feel that the Project description gets failing remarks on the technical and social aspects as well as with comparison with the alternatives. One option only seems to

be considered and the details on this are sketchy. For sure, there is no rush to move forward with the project because the nuclear industry fully intends to move forward with creating more nuclear waste which will mean a steady supply that will be required to be under institutional control for quite some time. In fact, the longer the waste has to cool, both in terms of temperature and radioactive decay, the less the risks in early stages of the project and in transport. And, more research is required.

The Seaborn Panel stated that "In total, spent fuel contains roughly 350 different nuclides, about 200 of which are radioactive. Its level of activity per unit mass declines to that of natural uranium and its associated radioactive decay products after about one million years. The methods of ensuring the continuity of institutional controls are not considered very reliable beyond a few hundred years, a permanent disposal method that does not rely on such controls for its long-term safety is preferable to storage."

Further the Panel stated, "First, some components of high-level nuclear wastes will pose a serious hazard to human health and the environment for hundreds of thousands of years. [NOTE: THE TIME FRAMES JUST MENTIONED, IN THE LAST TWO PARAGRAPHS, DO NOT MATCH UP WITH THE TIME FRAMES GIVEN IN THE PROJECT DESCRIPTION.] Hence, more so than for most human activity, we have to think of potential repercussions far into the future. This leads us to take a very cautious approach to any decisions on safety flowing from judgments made now. Society must be confident that human institutions will have the knowledge and capacity to manage a risky situation and to change direction to deal with things that might go wrong.

Second, we are very concerned about the number, nature and importance of the scientific uncertainties that are inevitable in such a new field over such a long time frame.

Third, we recognize that the public tends to be concerned less about the probability of extreme events than about their potentially negative consequences and the magnitude, the reversibility and the extent over time of these consequences. For the public, safety is not a matter of probabilities and meeting standards and regulations. It is, rather, the opposite of danger; it is protection from harm.

It is our judgment that the models used are insufficiently developed to demonstrate that the proponent's concept of deep geological disposal can be used as a basis for a site-specific facility. Considerable improvement and updating of the model would be required before there would be enough confidence to proceed.

Clearly, the development of an approach to managing nuclear fuel wastes must be based on sound physical science. While this is necessary, it is not sufficient. The approach must equally be based on sound social science and traditional Aboriginal knowledge. Without these complementary bases, there can be no assurance that public safety issues have been comprehensively identified, nor that they have been adequately addressed in the concept as presented. "

They also stated, " We believe that a system of early detection of failures, inside the vault or close to it, should be built into the defence-in-depth approach. Such monitoring would provide forewarning and trigger appropriate safety action, including retrieval if deemed necessary, if a series of unexpected events were to thwart the passive safety system. Siting is the first stage of implementation of the concept, and the likelihood of abandoning this project gets progressively more remote as new milestones are passed and more money is spent.

The Seaborn Panel also said, "A multitude of concerns was voiced on waste transportation: the state and safety of Canadian highways, particularly northern ones; the potential for accidents and terrorism; the testing and integrity of shipping casks; emergency preparedness;

and the notification and rights of communities along the routes. Speakers often recounted the events in Gorleben, Germany, where a great deal of policing, time and money were needed to clear opponents from the route used to ship reprocessing wastes. Strong worries about transportation led some participants to reject any option other than on-site waste management. " I have more to add about transportation concerns, particularly concerning communities along transportation routes.

They concluded, "After 7 years of public hearings, it is obvious to us that the concept is not acceptable to the majority of citizens and interest groups that have participated. It seems to us that the Canadian public no longer finds it acceptable to be asked to make a decision based on one option only. A choice of one is not a choice. People want to know, at least in some reasonably comparable way, the implications of other options; their risks, costs and net benefits; and the implications if deep geological disposal is rejected. This process does not adequately achieve the AECB's goal of ensuring effective public participation. It also does not give the public confidence that the AECB has placed technical considerations of risk and safety into a societal context."

For me, these comments still hold.

One of the things that was not brought up by the panel was the matter of whether Canadians actually wanted nuclear power. I don't believe there has ever been that discussion or debate in what direction Canadians want to go in. The honeymoon is over, we understand the reality of nuclear. It needs a proper debate with all the alternatives on the table - none of this 30 day comment period stuff. If Canadians decide they want nuclear in the mix then, there is no rush. We are going to have security issues with stored waste for a long time and we can afford to get our waste concept right. If Canadians decide that nuclear power is something they don't want in their energy mix,

then Canadians will be in a much better position to make a decision on how they want to proceed with the waste we already have - take a look at what our knowledge gaps are before moving forward. At present whatever we have is a bunch of models and risk assessments which, while useful, may not give us the answers we need, yet! There may not be a good, socially and technically acceptable solution just because we want one. At the very least, another look at the reactor sites themselves should be considered.

Let's go back to the engineered barrier system. Beyond identifying the elements, there is really no details given about them. The public is supposed to take this sitting down, that everything is good and has been carefully considered and designed. I don't think so!

The bentonite buffer is probably the most important element to isolating the radionuclides. Bentonite is chosen because of its swelling characteristics that should seal the radionuclides in. In a normal application, where higher temperatures would not be expected, this would be quite true. Nuclear waste is radioactively hot, and if confined will continue to create heat for 50,000 years (AECL EIS). In France, the waste is encapsulated in glass which has a melting temperature of 500 °C. A maximum load of 18.6 kW/m³ would result in exceeding 500 °C.

Bentonite belongs to the smectite class of clays. In most countries, the upper limit of the buffer temperature in a geological repository for nuclear waste is set below 100 °C (the boiling temperature of water) because of possible illitization, when bentonite is exposed to high temperatures for extended periods of time. This smectite-to-illite transformation likely causes the swelling function of the buffer to deteriorate. (illite does not swell). One of the other functions of the buffer is to allow the transfer of heat from the waste to the host rock. The more the clay is saturated with water, the better it is able to conduct heat. The thermal conductivity of bentonite has the greatest effect on the design temperature. The bentonite for the project is to be mixed with 20% host rock, and I am not sure what impact this will have on its properties. Something like graphite could

be added to the buffer to improve its thermal conductivity. If the design temperature of the buffer is increased above 100 °C, waste can be packed closer together and less space is required - a cost saving. However, at the boiling point of water moisture is driven off, its conductivity will be reduced and the clay could shrink up to 20% +/-, depending on its properties. It is critically important that the waste is allowed to cool by conducting heat away from it. The water in the repository is necessary for this. If that heat is not drawn off, the waste will continue to heat up the steel and copper in the canisters holding the waste may begin to be compromised. If the bentonite clay dries up, it becomes an insulator and will conduct significantly less heat - again causing a heat build up. The size of the repository and the spacing of the canisters becomes critical to the temperature design of the repository. If the spacing is too close, there will be uneven heating effects around the canisters. The results are drawn as follows: (a) the initial heat power of HLW canisters is the most important and sensitive parameter for evolution of temperature field; (b) the thermal properties and variations of the host rock, the engineered buffer, and possible gaps between canister and buffer and host rock are the additional key factors governing the heat transformation; (c) the gaps width and the filling by water or air determine the temperature offsets between them. The thermal process and the resultant temperature field are determined by the decay heat emission of the HLW, the initial thermal conditions and the thermal properties of the engineered barrier system (EBS) and host rock, possible gaps in the EBS, and the repository layout, etc. For disposal of HLW in granite formations, the temperature on the canister surface is set to be less than 100 °C in the repository ([Hokmark and Falth, 2003](#), [Kari, 2006](#), [Zhao et al., 2009](#)). The maximum temperature is a criterion dictating the dimension of a repository. The deep repository will basically contain thousands of heat-generating canisters. In order to keep the canister surface temperatures below that limit, the spacing between nearby canisters cannot be arbitrarily small. On the other hand, that spacing must be kept at a minimum value in order to limit the extension of the repository such that it can be accommodated within the given rock volume. This means that it is necessary to derive reliable relations that shall show how the canister surface temperature depends on the canister power, on the thermal resistance between canister, buffer and host rock, on the canister spacing, and on the thermal properties of the

buffer and host rock. Consequently, the studies of thermal conductivity properties and temperature evaluation of repository are necessary for the design of long-term safety of HLW repositories.

The previous studies of EBS concept and performance assessment show that the bentonite thickness between 350 mm and 700 mm has the similar function to retard nuclides transportation under the condition of the canister being destroyed. **As the buffer thickness increases, the container surface maximum temperature increases.** The inner gap between the canister and buffer will probably stay dry for a while due to the high temperature at the canister surface. This will have to be designed for. In contrast, the outer gap between the buffer and rock will be filled with water in a relatively short time due to the connection with the saturated host rock. Initially during installation the outer gap is artificially wetted.

I mentioned that graphite could be added to the buffer to increase its heat conduction properties. On the other hand, the use of high heat conduction backfill will increase the far field host rock peak temperature that can occur several thousand years after closure of the repository. These long term host rock peak temperatures generates thermal-poro-elastic stress and the geomechanical changes to the host rock I discussed earlier. A massive shear activation of a well-connected fracture network in crystalline rock could enhance permeability by several orders of magnitude. Even though the backfill creates some measure of stability, these must be factored in to protect the cannisters. Perhaps the tunnel system will have to remain open and ventilated for decades to manage the thermal environment in the repository. Repository excavation also induces stress redistribution, leading to the formation of an excavation disturbed/damaged zone (EDZ) in the near-field. This zone alters the hydro-mechanical properties of the host rock, influencing repository stability and fluid migration behaviour.

This brings us back to the canister that the buffer is trying so hard to protect. The project discussion describes the canister as having a steel shell that can resist pressures that will come to bare and this shell has a copper coating. I couldn't find any other details. The copper coating is vulnerable and if it fails the steel is even more

vulnerable to microbial corrosion, even in an anaerobic environment. MIC (microbial Influenced Corrosion) has been linked to a broad spectrum of microorganisms, both aerobic and anaerobic. Copper is resistant to corrosion in oxygen-free water. However, the presence and colonization of microbial species in ground water in the geological repository may initiate, facilitate and accelerate corrosion of copper under such conditions. A significant increase in the rate of copper corrosion, reaching 9.8 $\mu\text{m}/\text{year}$ (about 1mm/100years), is achieved with the activity of SRB (sulfate-reducing bacteria) in the bentonite environment. The processes of anaerobic fermentation of organic matter, which may be contained in clay minerals, may also play an important role in the process of copper corrosion. Biofilm formation plays an important role in the processes of microbial corrosion of copper. These mechanisms are still not fully understood. It is unclear how thick the copper coating on the canisters from the project description. If it was 3mm, then it would take 300 years for corrosion to penetrate this coating - not much protection for something we have to watch for hundreds of thousands of years.

So, what exactly are the NWMOs design plans and specification for the underground facility!!! There are a lot of factors to consider in the design of the repository and the barrier system and more research needs to be done. And you need to convince the public you know what you are doing. I don't think the step by step approach of progressive licensing is practical in this case. As the costs mount up, there will be pressure to move forward despite problems and unknowns. Put all your cards on the table that you are aware of and outline the gaps that still exist - now!

NWMO was way too close a connection to the interests of the nuclear industries. Politics should have no place in the ultimate decision as to how it is managed - this is far too technical. Who then should be the eventual guardians and managers of the waste that has already been produced to date. I would say that the people who live in the area of the repository, wherever and whatever form that might take. These people should also be the trusted guardians of the land and not motivated by profits and prone to cutting corners. It is their future generations who will be at most risk. They must be the engineers and technicians who design, build, stock and manage the repository in perpetuity. It is not likely that these people have

been the beneficiaries of nuclear power, but they have chosen to be the caregivers of this toxic, long lived, radioactive waste. Waste that can impact muscles, bones, and every part of any organism. They must be given all the knowledge, resources and tools we can give them. Those who have benefitted need to know that they and their future generations are on the hook for this, essentially, forever. We need to man-up to our mistakes.

Other questions that come to mind are:

- is the cost of permanent waste storage factored into cost of nuclear - electrical rates are going up
- how about the cost of rebuilding/maintaining the highway 2/3 trips for 50 years.
- what compensation is available if there is an accident
- given the problems with dealing with nuclear waste and emissions throughout the entire industry, you are going to have to justify how you could possibly call this technology clean.
- when a reactor is shut down for repair /refurbishment, how can you call this reliable energy as it would take out such a large chunk of electrical energy production which must be accommodated somehow?
- Given all the safety concerns and resulting design consideration for nuclear energy, as well as the length of construction, how can it result in climate mitigation in the short term, when significant reduction in emissions is needed?
- if we rush the design of a repository we may well be compromising the wellbeing and level of responsibilities that future generations will have to take on as a result of our decisions now.
- if there is no transparency in regards to deals struck with all parties, how can we be sure the interests of the environment and the Ojibway people are actually being met for the long term?
- will the repository be limited to waste being produced by existing Candu reactors?
- What are the plans for future generations of reactors' waste?
- what is the thermal conductivity of the host rack and will it fit the design?

- if the host rock does fracture from thermal stresses, how is this situation going to be mitigated

- The Porter Report 1978 stated that reprocessing should not be pursued so a central storage system should not be necessary. The establishment of a repository will almost certainly mean that reprocessing will occur at the repository. The expansion of the industry into reactors that will use reprocessed fuels will also mean that large amounts of plutonium will be available to countries involved in reprocessing and will always remain a security risk.

_ there are presently 15 Ukrainian reactors in a war zone and the nuclear industry is promoting SMR's to the world, to countries that can ill afford it and do not have any experience with the technology, and may not be capable of handling the waste. Three mile Island, Cheernobyl, and Fukushima are all examples of avoidable accidents due to human error and mismanagement. This is madness and is creating a massively insecure presence in a far from peaceful world.

STOP!!!

I am not sure of how the privacy/confidentiality rules apply to this submission. Here are some of the literature references I used and which can be removed if they compromise those rules.

https://www.ccnr.org/hlw_fearo_summary.html The Seaborn report © Minister of Public Works and Government Services Canada, 1998 Catalogue No.: EN-106-30/1-1998E ISBN: 0-662-26470-3 ANISHINABEK/IROQUOIS ALLIANCE Joint Declaration [May 2017]

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1994 EIS from AECL Heat continues to be generated by radioactive disintegration. This heat goes into the rock, raising the temperature. After 50,000 years the temperature returns to near normal. This 50,000 year period is the “thermal pulse” – a small blip in time compared with the multi-million-year persistence of radiotoxicity. Gordon Edwards

Bentonite Buffer

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