Date: December 2, 2017

From: Peter Baumgartner, Dennis Bilinsky, Grant Koroll, Edward t. Kozak, Jude McMurry, Paul M. Thompson, Tjalle T. Vandergraaf, Alfred G. Wikjord

To: Candida Cianci, Environmental Assessment Specialist
Canadian Nuclear Safety Commission

By email: cnsc.ea-ee.ccsn@canada.ca

Subject line: Comments to draft WR-1 Disposal EIS

CEAA Reference number: 80124

Comments:

Dear Ms. Cianci,

Please find attached our collective comments to:

Environmental Impact Statement
In Situ Decommissioning of WR-1 at the Whiteshell Laboratories Site
Pinawa, Manitoba,
Rev. 1.

Best regards,

Peter Baumgartner, P.Eng.Ret.

2017 December 02

Ms. Candida Cianci
Environmental Assessment Specialist
Canadian Nuclear Safety Commission
P.O. Box 1046 Station B
280 Slater Street
Ottawa ON K1P 5S9

RE: Comments to Environmental Impact Statement In Situ Decommissioning of WR-1 at the Whiteshell Laboratories Site Pinawa, Manitoba, Rev. 1 (Golder et al. 2017)

Dear Ms. Cianci:

The proposed *in situ* disposal of WR-1 does not meet CNL's strategic requirement to "contain radioactive contamination such that risk to the public and environment is kept ALARA" (Section 3.4.2 – Golder et al. 2017)." This is supported by CNL's statements in Section 2.5 of the EIS dealing with Alternative Means for Carrying Out the Project (e.g., 2.5.2.1.2 (last sentence), 2.5.2.2 (4th paragraph, last sentence), 2.5.4.2 (2nd paragraph) and 2.6.2 (3rd paragraph)).

Definition and Quantification of the Hazard

The Introduction of the EIS (Golder et al. 2017) identifies the scope and overview of the project for *in situ* disposal of the WR-1 reactor but is completely remiss in defining and quantifying the hazard up front, the hazard being the fundamental basis of the whole exercise. This does not occur until the section on Glaciation in Chapter 10 where the current radiological inventory is obscurely provided in Columns 1 and 2 of Table 10.5.1-1.

Nowhere within the document is there a figure or table documenting the decay of the identified key long-lived ILW radionuclides over time (i.e., the rate at which the hazard naturally diminishes) as originally identified in our first set of comments (Baumgartner et al. 2016 Jul 03). Figure 1 provides such an illustration showing the relationships over time before any consideration of loss of radionuclides by groundwater leaching. It also highlights the radionuclide inventory at the estimated cessation of the next glaciation, 140,000 years from now, regardless of where the radionuclides may have been redistributed or dispersed. This creates a strong visual image for the reader and provides a comparative reference timeline in discussing further arguments, such as the relative insignificance of ±50,000 years to the 140,000 year intraglacial estimate. The beginning of the next glaciation is set here at 50,000 years ±40,000 years assuming a nominal glacial duration of 90,000 years as suggested in Chapter 10.

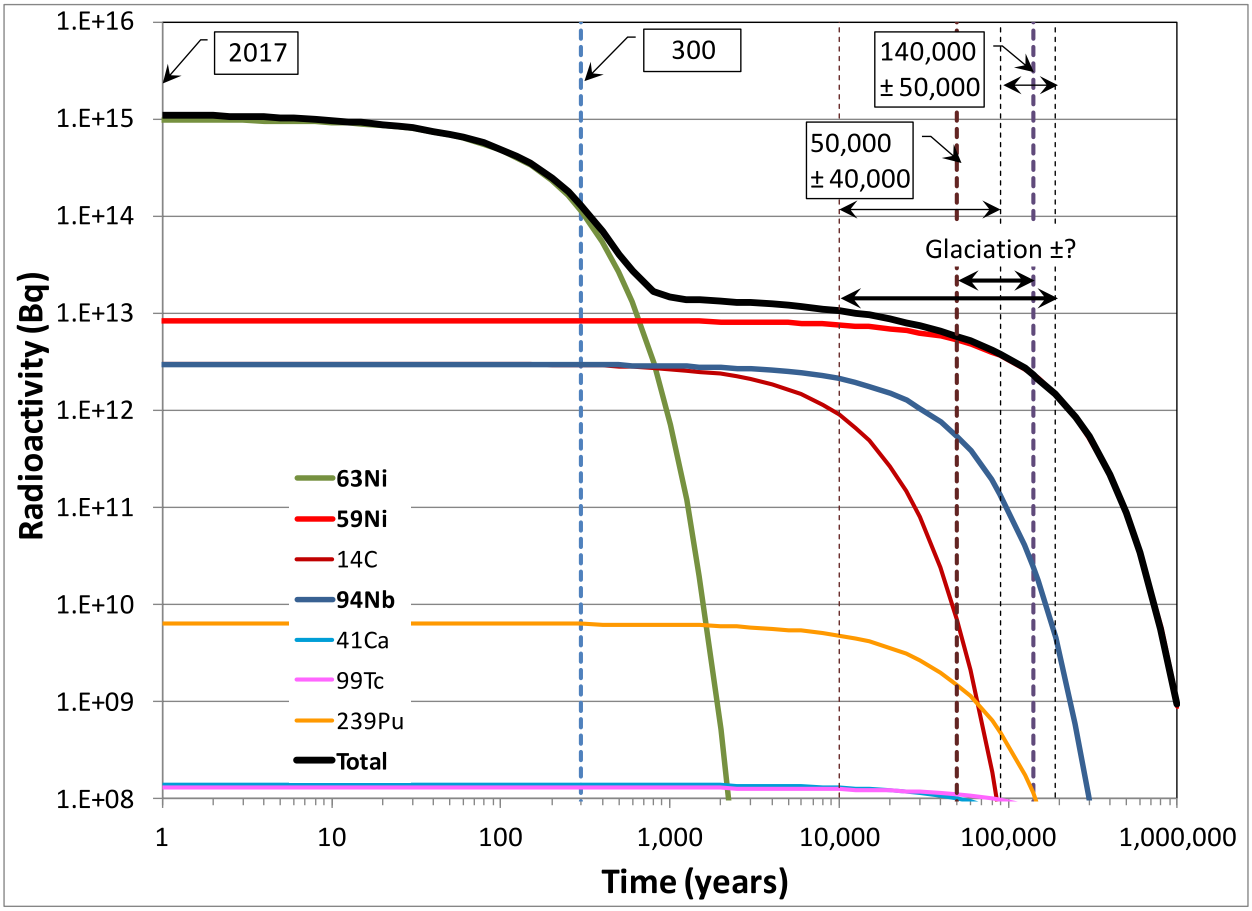

Figure 1: Radionuclide Inventory with Decay for WR-1 (note: limited to key long-lived radionuclides exceeding 1×10^8 Bq). Note: Estimates for the Glaciation Period from 50,000 years to 140,000 years with possible error bands are provided.

Table 1, adapted from Table 10.5.1-1 in the EIS, also provides the current (column 3) and future radionuclide inventories following 140,000-years of decay (column 4) plus the remaining radionuclides following groundwater leaching (column 5). CNL acknowledges that grouting with cementatious materials will be relatively ineffective in preventing groundwater flow through the WR-1 structure. The comparison of decay vs. leaching in the EIS suggests that it is desirable to wash out virtually all (i.e., >99.99%) of the remaining radionuclides from the WR-1 structure and to disperse the radionuclides within the environment before they are excised or exhumed in mass by glaciation. Clearly, this loss of containment is akin to the internationally banned practice of ocean dumping of radioactive waste (i.e., “the solution to pollution is dilution”).

The proponent assumes that the remaining radionuclides would be either widely distributed or sorbed on downstream geological materials prior to return of the intraglacial period. Then little or no radionuclides would remain at the exhumed WR-1 site for future human contact as in the comparison to the fraction of the CNSC Unconditional Clearance Level in Table 10.5.1-1. This argument cannot be substantiated and must be rejected.

Table 1: Radioactivity as a Function of Decay and Leaching

Radionuclide	Half-life (a)	Total Activity in WR-1 in 2017 (Bq)	Total Activity after 140,000 years of Decay (Bq)	Activity within Remains after 140,000 years of Leaching (Bq)
C-14	5.74E+03	2.99E+12	1.35E+05	7.17E-01
Ca-41	1.03E+05	1.40E+08	5.46E+07	2.12E-10
Cl-36	3.01E+05	4.20E+03	3.04E+03	8.22E-11
Nb-94	**2.03E+04**	**3.00E+12**	**2.49E+10**	**1.59E+05**
Ni-59	**7.60E+04**	**8.30E+12**	**2.32E+12**	**1.95E+07**
Ni-63	**9.60E+01**	**9.81E+14**	**0.0E+00**	**0.0E+00**
Tc-99	2.11E+05	1.30E+08	8.21E+07	4.95E+02
I-129	1.57E+07	2.80E+05	2.78E+05	1.56E+00
Np-237	2.14E+06	6.70E+06	6.40E+06	4.03E+01
Pu-239	2.41E+04	6.36E+09	1.14E+08	7.13E+02
U-235	7.03E+08	1.60E+06	1.60E+06	1.14E+01
U-238	4.47E+09	1.22E+07	1.22E+07	7.63E+01
U-234	2.46E+05	1.22E+07	8.22E+06	2.93E+01
Totals		**9.96E+14**	**2.34E+12**	**1.97E+07**

Radionuclide Leaching

Before discussing these misrepresentations of the pre- and post-glaciation status, we need to define two terms for the mechanism of the release of the radionuclides that are subsequently transported: the "surficial" radionuclides and the "congruent-release" radionuclides. The surficial radionuclides are those that are deposited on the surface of an object (e.g., contaminants such as particles associated with fuel failures entrained within the coolant system) and are readily accessible to the groundwater for transport. The congruent-release radionuclides are those that are an integral part of an object matrix (e.g., neutron activation products such as Ni-59 created within the alloyed stainless steel reactor vessel) and, unless released preferentially, require dissolution or corrosion of the host matrix to enable their release for subsequent transport. In Table 1, the congruent-release radionuclides are essentially limited to Nb-94, Ni-59 and Ni-63 found in the alloyed fuel-channel and stainless-steel materials and only can be released by corrosion. The bulk of the remaining radionuclides in Table 1 are found in the surface deposits of the reactor vessel, internal components and piping and are essentially "instantaneously" available for release.

As can be seen in Figure 1 and Table 1, the radionuclide inventory is dominated by the two nickel congruent-release radionuclides, Ni-59 and Ni-63, in the stainless-steel alloys of the reactor vessel and components. Stainless steel was chosen for the reactor components due to its high corrosion resistance in water, particularly in chloride-free environments. The virtual total dissolution of the congruent-release radionuclides are estimated in Table 2 (derived from Table 4-3 in Bishop 2017). The solute transport model used the Full Corrosion (2-way) values which is based on the simultaneous attack on both sides (inside and outside surfaces) of the reactor components (e.g., Calandria Vessel - 63,500 years and stainless-steel Fuel Channel - 17,800 years) (Bishop 2017). This simultaneous attack on both sides of all of the components seems to be highly conservative and unrealistic because it results in the maximum possible rate of radionuclide release into the geosphere without any consideration of glaciation effects.

Table 2: Reactor Component Corrosion Rates and Times for Full Corrosion

Step and Reactor Component (number is the step in the corrosion attack sequence)	**Material**	**Thickness (mm)**	**Corrosion Rate (mm/yr)**	**Full Corrosion (2-way) (yr)**	**Full Corrosion (1-way) (yr)**	**Full Corrosion (1-way sequence) (yr)**
1&5. Thermal Shields	C-steel	127	1.00E-04	6.35E+05	1.27E+06	4.95E+05
4. Calandria Vessel	SS	12.7	1.00E-04	6.35E+04	1.27E+05	2.79E+05
3&4. Calandria Tubes	Al	3.556	1.00E-04	1.78E+04	3.56E+04	1.52E+05/ 1.88E+05
2. Fuel Channels	Zr-Nb Alloy	3.556	1.00E-05	1.78E+05	3.56E+05	3.12E+05
2. Fuel Channels	Ozhennite	3.556	1.00E-05	1.78E+05	3.56E+05	3.12E+05
2. Fuel Channels	SS	3.556	1.00E-04	1.78E+04	3.56E+04	1.17E+05
1. PHT Pipe (8” Sch. 40)	SS	8.13	1.00E-04	4.07E+04	8.13E+04	8.13E+04

CNL plans to fill all the voids of the WR-1 system with grout and to seal all penetrations to prevent/reduce groundwater ingress and to provide long-term structural support. WR-1 (Figure 2) is compartmentalized as itemized in Table 2 to specifically separate and control the flow of gases and liquids within the reactor system. This sealing prevents the simultaneous corrosion of all reactor component surfaces regardless of grouting. The incorrect consequence of the proponent’s unrealistic 2-way corrosion process is that few to no radionuclides remain within the WR-1 structures at the time of the next intraglacial period (i.e., 140,000 years of leaching in column 5 of Table 1).

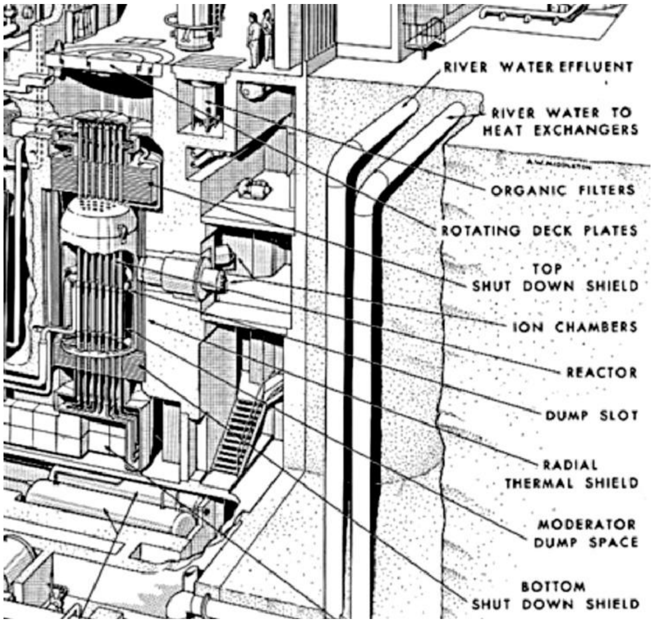

Figure 2: Nested Reactor Components (thermal shields, calandria vessel, calandria tubes and fuel channels) (Golder et al. 2017)

Corrosive attack can only begin from the outside of the outer-most components of the reactor system, namely the thermal shield and primary heat transport (PHT) pipes (e.g., 8" Sch 40), identified as Step 1 in Table 2 and as shown in Figure 3. All the remaining components of the system are effectively sealed from the groundwater environment by these two metallic barriers. This one-way attack effectively doubles the time to breach through and fully corrode these two components, as shown as Full Corrosion (1-way) in Table 2. Note also that the greater thickness of the Thermal Shields increases their time for breaching and full corrosion (e.g., 1,270,000 years) as compared to the PHT pipes (e.g., 81,300 years) (Sequence Year 81,300) by a factor of ~15 (Full Corrosion (1-way) in Table 2).

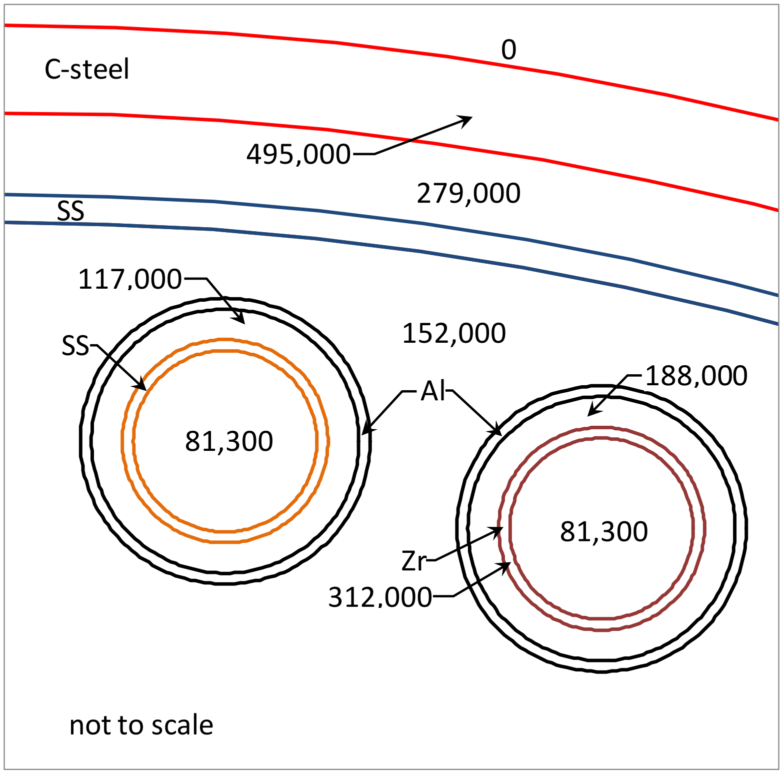

Figure 3: Sequence of Nested Corrosion as shown in years. Note: C-steel is Carbon Steel of Thermal Shield, SS is stainless steel of Calandria Vessel and some Fuel Channels, Al is aluminum of Calandria Tubes and Zr is zirconium-niobium and Ozhennite of remaining Fuel Channels). Note: Derived from Figure 3-8 (Barrios and Minenkov 2015).

The next Step (2) is the one-way penetration of the Fuel Channels as accessed internally from the PHT pipes. The one-way corrosion rate through the stainless-steel (SS) Fuel Channels is an order of magnitude faster (e.g., 35,600 years) than through the two zirconium-alloy Fuel Channels (e.g., 356,000 years) (Full Corrosion (1-way) in Table 2). After the SS Fuel Channels are breached (Sequence Year 117,000), their surrounding aluminum (Al) Calandria Tubes are attacked (Step 3) from the inside surfaces which take the same amount of time to breach (e.g., 35,600 years) (Sequence Year 152,000).

At this point (Step 4), both the inner surface of the Calandria Vessel and the outer surfaces of the Al Calandria Tubes surrounding the zirconium-alloy Fuel Channels come under corrosive attack.

The one-way corrosion of the Calandria Vessel takes 127,000 years to complete (Sequence Year 279,000) (Table 2). The one-way corrosion of the Al Calandria Tubes takes 35,600 years (Sequence Year 188,000). Meanwhile, the corrosion of the zirconium-alloy Fuel Channels becomes a two-way process, shortening the time for corrosion completion (Sequence Year 312,000).

With the breaching of the Calandria Vessel (Sequence Year 279,000), the corrosion of the Thermal Shield becomes a two-way process, shortening the time for completion (Sequence Year 495,000). Note that the high-pH (alkaline) environment of the cementatious materials (concretes and grouts) is not considered in any known analyses by CNL or their contractors and should significantly reduce the corrosion rates. Nor is the supply rate of corrosion reactants considered in any analyses.

Consideration must also be given to which surface is contaminated with surficial radionuclides and to which congruent-release radionuclides are being released by each metallic component of the nested sequence. Similarly, all the process pipes and tanks are radioactively contaminated on their inside surfaces, not on their outer surfaces, and the time for their breach must be considered in assessing conservatism in design and analysis.

Another factor that must be considered is the total mass of metal within the confines of the WR-1 structure. The mass of the radioactive stainless steel components of the reactor is between 7.8 Mg (McIlwain 1992) and 18 Mg (Barrios and Minenkov 2015). The balance of carbon steel and stainless steel of the WR-1 system is about 5400 Mg (Barrios and Minenkov 2015). These additional steels will be in active competition or will act as a “getter” for the incoming corrosion reactants, making the proponent’s estimate for total reactor dissolution highly improbable, possibly increasing these corrosion time frames by another order of magnitude or greater. This competition for reactants was not considered in the solute modelling (Bishop 2017).

The EIS needs to illustrate the likely corrosion processes and rates for congruent and surficial radionuclide release taking into account the contacting ground water-flow rates, high-pH chemistry, microbial activity under both oxic and anoxic conditions, glacial permafrost and hindered groundwater replenishment conditions. Note that the EIS acknowledges that glaciation will hinder groundwater flow, not only limiting migration of contaminants from the reactor into the geosphere but concomitantly limiting the supply of corrosive reactants, such as oxygen. For example, the annual flow rate through the backfilled WR-1 structure of 0.167 to 0.193 m^3/day (Bishop 2017) will approach zero during the permafrost and glacial cover periods, possibly leaving diffusion as the primary transport mechanism for reactant and product transport. Only after rupture and exhumation of the WR-1 structure by the glacier can a complete two-way corrosive attack occur on the remaining structures.

The stated release of the nearly total nickel radionuclide inventory within 140,000 years is highly suspect and needs a more valid supporting argument. Most of the Ni-59, as shown in Figure 1, should be available for glacial exhumation of WR-1. Even if the total nickel inventory is released as described in the EIS, the proponents will have to show that the solubilized nickel is not reconcentrated downstream of the WR-1 site through sorption and/or bioaccumulation.

Glacial Exhumation of WR-1

While the EIS recognizes that the excised or exhumed WR-1 will not be structurally intact, the less corroded, abraded and fractured metals nevertheless will tend to be tougher and more malleable than the brittle grouts, concretes and any entrained rock. These metals may result in a much coarser size fraction (e.g., fist-sized or larger) than the cementatious or rock material and will be quite distinguishable by future generations. Once discovered as an unusual curiosity, non-geological material and possibly useful, it is plausible that metal fragments will be actively gathered.

What radiation doses from the long-lived radionuclides (e.g., Ni-59) could post-glacial peoples expect if they resettled near the glacially crushed, displaced and exposed remains of WR-1? The expectation would be that these remains would largely consist of the more malleable stainless steel and other metals of the reactor vessel and its components separated from the brittle grout and concrete shielding (Baumgartner et al. 2016 Oct 28). The inability of the scientific and engineering community to predict the details of the glacial transport mechanism, path and/or re-emergence of WR-1 to the surface obliges the necessity to prevent this transport from occurring in the first place.

A Suggested Approach to Conservatism in the EIS

The complexity and unknowns of continental glaciation and climate change require a conservative approach in assessing the long-term safety of waste disposal. Perhaps a bounding approach can be used where the problem is broken down into two distinct phases and corresponding bounds that are not necessarily sequentially relatable.

For example, the current radionuclide leaching model used in the EIS (Bishop 2017), including the rapid, unhindered corrosion of activated stainless steel, is possibly an unrealistically high impact result during the pre-glaciation phase. Due to the high uncertainty of the corrosion rates and congruent release of radionuclides from the shells of activated reactor components, no attempt should be made to release the WR-1 site from CNSC control by using such highly suspect unconditional clearance calculations.

Instead, the post-glaciation exhumation model should be based on a highly restricted leaching model based on nested shells of reactor components, high-pH chemistry, microbial activity, glacial permafrost, hindered groundwater supply rate, hindered reactant supply and competition (“getters”) by non-activated metals for reactants. Post-glaciation human doses should then be based on contact with these less corroded, partly intact radioactive metals. Alternately, the calculations could ignore any Ni-59 leaching and depend on decay alone. Both approaches would need proper explanation for the public to show that they are bounding extremes and do not necessarily represent an expected reality.

Specific and Detailed Comments to the WR-1 EIS Document

Below, the text in italics is taken from the WR-1 EIS document (Golder et al. 2017) and the text led by the hyphen are our comments.

WR-1 EIS Report Section	Review Comments Preceded by – (hyphen)
1.1 Project Context	*The most significant contributor to the remaining radioactive source term is the reactor core (calandria and fuel channels) which accounts for 99% of the source term.* - What is the source term? What portion of the source term and which radionuclides are attributed to the reactor core, thermal shield, biological shield, primary heat transport system, moderator system and any other contaminated or activated system which may be left behind in the WR-1 ISD structure? - Describe the process used to determine the source term including sampling methods/locations used. *The new proposed approach for WR-1 is In Situ Decommissioning (ISD) which allows CNL to decommission the facility in a safer, compliant manner that reduces interim storage and provides protection of the public and the environment.* - A statement yet to be proven, therefore inappropriate in this section.
1.6.1 Federal Review Process	*The Project is located on Federal lands and is regulated by the CNSC, therefore, it is anticipated that provincial permits, licences or other authorizations are not required.* - Has CNL had discussions with the Province of Manitoba regarding the High Level Radioactive Waste Act? Please describe how this Provincial Act does not apply to the proposed ISD of WR-1 and any assurances or authorizations received from the Province.
2.5.1 Evaluation Approach	*CNL has presented four alternatives for evaluation in the EIS that are deemed technically feasible. All alternatives include appropriate safe work processes and mitigation to reduce worker safety hazards and radiological protection (e.g., temporary shielding and ventilation, personal protection equipment and clothing [PPE&C]) can be put in place to ensure that worker dose limits are not exceeded during decommissioning and waste handling operations.* *The two complete dismantling alternatives require transport of waste containers to an off-site waste storage or disposal facility. Nuclear waste transport containers are designed taking into account foreseeable accidents. The transport containers are designed and tested to withstand conditions associated with fire, impact, wetting, pressure, heat and cold. Therefore, the risk of public exposure*

WR-1 EIS Report Section	Review Comments Preceded by – (hyphen)
	during transport is extremely low. *2.5.2.1.2 Overall, complete removal of the facility is considered the safest long term option with respect to the public near the WL site, compared to an ISD alternatives.* *2.5.2.2 Compared to an ISD alternative, the complete removal options also eliminate the potential risk associated with groundwater leaching through the WR-1 ISD structure that could migrate to surface water and then adversely affect human health and the ecological the health of terrestrial and aquatic ecosystems.* *2.5.4.2 and 2.6.2* The preferred ISD *alternative represents the highest risk to the environment at the WL site during the post-closure phase because the majority of radioactive materials will still be present onsite, unlike the other alternatives where the radioactive materials are either completely or partially removed.* - The EIS later documents that the preferred ISD alternative impacts the groundwater surrounding the WR-1 site in Tables 6.4.2-8 and 6.4.2-13. - The ISD groundwater will not meet drinking water standards / guidelines during the period of institutional control and for thousands of years into the future. Contaminants of concern are Cadmium, HB-40 (the WR-1 organic terphenyl reactor coolant), Lead, Xylene, Carbon-14 and Tritium. - Polonium-210, a particularly lethal radionuclide when ingested, does not exceed but approaches approximately 50% of the drinking water guideline. This is disconcerting given the uncertainty associated with the accuracy and representativeness of the groundwater loadings. - The approach used by the proposed ISD of WR-1 is contrary to ALARA for the WR-1 environment and nearby public.
2.6.3-1 Summary Table of Estimated Project Costs	- CNL proposes a 100 year post disposal monitoring program for the WR-1 ISD. The estimated cost of this entire 100 year monitoring is surprising low at $7M and is likely insufficient for a very confident or robust monitoring, reporting and review program. Escalation should be also considered over this length of time. - In the Whiteshell Decommissioning Comprehensive Study Report (CSR) (AECL 2001) the period of institutional control is estimated at 200 years for the complete removal of WR-1. - For the ISD scenarios as opposed to the "complete removal" scenarios, CNL's grant in lieu (GIL) of taxes to the LGD of Pinawa are likely to be higher for longer times because fewer lands would meet release criteria over the period of institutional control (estimated at 300 years).

WR-1 EIS Report Section	Review Comments Preceded by – (hyphen)
3.4.2 Strategic Requirements	*The Project must also meet the following strategic requirements; contain radioactive contamination such that risk to the public and environment is kept ALARA;* - This strategic requirement is not met. The groundwater near the proposed WR-1 ISD structure will not meet drinking water standards / guidelines during the period of institutional control, nor for thousands of years into the future.
3.5.1.1.2 Sealing Building Penetrations	*While the exterior walls of the below grade portion of the WR-1 facility are intact, there are several locations where penetrations exist to allow mechanical and electrical services to enter the building. As part of closure activities, any perforations in the foundation will be filled and sealed, and any system components (e.g., piping or conduits) that exist within 1 m of the foundation wall and floor, or equivalent barrier, will be removed to ensure no voids are present adjacent to the foundation. The penetrations will be sealed with an engineered plug to ensure the outer wall of the below grade portion of WR-1 is a continuous and uninterrupted barrier to mitigate releases to the environment.* - After exiting the WR-1 ISD structure, any potentially contaminated groundwater is free to enter a nearby buried service connector, such as the 24-inch diameter process water line which provides a direct 500-m path to the pump house located next to the Winnipeg River. Such direct pathways circumvent the proponent's calculated mean advective groundwater travel times to the Winnipeg River, which were estimated to be on the order of 100 years (per Section 6.3.2.6.2).
3.5.1.1.5 Targeted Remediation	*Some hazardous materials (such as PCB containing light ballasts or removable lead shielding) may be remediated, to reduce the levels of contaminated materials within the building prior to ISD. This effort will be limited to materials that are easily accessed, and present a relatively low hazard to workers to remove. This will help to further reduce the levels of hazardous materials left within the structure for encapsulation during ISD, and keep exposures to workers, the public and the environment ALARA.* - The document does not identify any dedicated commitment to remove hazardous materials such as *asbestos, PCB's etc.* - The proponent appears to advocate encapsulation of radiological and non-radiological hazardous materials within the proposed ISD structure to the maximum extent possible in this section and other sections of the EIS. - The proposed ISD groundwater will not meet drinking water standards / guidelines during the period of institutional control and for thousands of years into the future, therefore does not meet the principle of ALARA for the environment or WL site public.

WR-1 EIS Report Section	**Review Comments Preceded by – (hyphen)**
3.5.1.2 Grouting of Below Grade Structures and Systems	*Multiple grout formulations may be necessary to achieve complete filling of the below grade structure, but all formulations will adhere to the same minimum requirements to ensure the final end state performs as expected.* - Additional evidence is required to gain confidence in the proposed grout designs and formulations. - What is the “final end state expectation”?
3.5.3.1 Radiological Wastes	*Radioactive wastes such as personal protective equipment are not planned for encapsulation and will be managed in the WMA or transported off-site (e.g., CNL’s Chalk River Laboratories in Ontario).* - Good to know something that should not be encapsulated within the WR-1 ISD structure will not be encapsulated.
3.5.3.2 Hazardous Non-Radiological Wastes	*Targeted removal of hazardous substances remaining within the WR-1 Building will generate small quantities of non-radiological hazardous wastes. Hazardous wastes will be managed in accordance with CNL’s waste management practices (CNL 2017b,c) and Environmental Protection Program (CNL 2017d), and will meet all Federal, Provincial and Municipal requirements. The wastes will be shipped off-site to an appropriate hazardous waste facility, or encapsulated in the same manner as radiological wastes where it is demonstrated safe to do so.* - Please clarify what is encapsulated in the WR-1 ISD structure and what is not.
3.5.4 End-State and Post-Closure Activities	*The final end-state for WR-1 will be a multilayered ISD structure that applies a Defense-in-Depth strategy through the use of numerous barriers (Figure 3.5.4-1). The primary pathway for release of contamination from the system is by groundwater that has infiltrated into the sub-surface structure, picked up contamination, and then carried it out of the sub-surface structure to the groundwater. Each layer of the WR-1 ISD structure provides an additional measure to prevent and mitigate the release of contaminants to protect the Public and the Environment. The layers of defence against contaminant release include reactor system components, grout, internal walls, outer foundation walls, the local geosphere, an engineered cover, and active environmental monitoring. Combined, they form a rigorous system of barriers to provide long term safety to the Public and the Environment.* - Considering the WL site groundwater will not meet drinking water standards / guidelines during the period of institutional control and for thousands of years into the future; the purported Defense-in-Depth strategy lacks any significant merit.

3.5.4.1.1 Reactor Core and Bioshield Components	*The overwhelming majority (~97%) of the remaining contamination in WR-1 is located within the piping and tanks that make up the reactor systems (primarily in the calandria and fuel channels). The contamination is both on the internal surfaces (surficial contamination) as well as embedded in the material itself (activated components).* - Is it 97% or 99% as per Section 1.1, 10.5 and 10.5.1? 2% more ILW can make a difference. *Breakdown of the reactor system components is expected to occur gradually over thousands of years.* - Please provide supporting evidence of anticipated corrosion rates.
3.5.4.1.2 Grout	*The grout will slowly degrade over time, allowing water movement to increase as it degrades, though this is expected to occur over thousands of years, and not at all once.* *Section 6.4.2.7 Prediction Confidence and Uncertainty discusses how the cover, grout, and foundation were assumed to degrade at rates comparable to other projects (i.e., Savannah River), which increased groundwater flow through time, resulting in total failure (degradation) of grout by year 10,000.* - Please provide evidence supporting the long-life expectations of the numerous grout formulations to be used. - Considering that no credit is given for the grout to retain the radionuclides, what is the rational to use grout instead of unconsolidated material such as sand that could be removed if situations change?
3.5.4.1.3 Internal Walls	*Internal building walls and floors provide an additional barrier between sections of grout. While penetrations exist in these interior walls (to allow services to pass between rooms), they are mostly sealed for operational purposes such as fire-stopping.* - What types of fire stopping materials are used within WR-1 and how appropriate/compatible are they as a sealing materials in the future flooded environment?
3.5.4.1.5 Local Geosphere	*The soil conditions at WR-1 provide an additional barrier to release of contamination into the environment. The local soils are primarily clay based, and provide a natural barrier to groundwater movement. The soils provide a final barrier to groundwater movement, reducing the groundwater speed to ~5m per year, and also chemically sorb contaminants to further reduce their concentrations in any surface water emissions.* - WR-1 site is located about 500 m from the Winnipeg River, so mean advective groundwater travel times are on the order of only 100 years (per Section *6.3.2.6.2).* - This is a limited barrier to the leaching of long-lived groundwater

	contaminants.
3.5.4.1.6 Engineered Cover	*The cover will degrade with time, much like the rest of the sub-surface structure.* - The engineered cover has a design life of 300 years. Is the sub-surface structure (ie: the final engineered barrier or concrete surround) expected to have a similar 300 year life expectancy or is it 10,000 years based upon discussions in Section 6.4.2.7 Prediction Confidence and Uncertainty?
3.5.4.1.7 Post-Closure Monitoring	*The final barrier is post-closure environmental monitoring of the groundwater surrounding WR-1. Groundwater monitoring provides verification that the decommissioned WR-1, and the barriers to release, are performing their function as expected. Monitoring also provides an early warning system in the event that something unexpected has occurred, and provides the data necessary to make decisions about mitigating actions required, if at all.* - A limited monitoring program is not a "barrier" considering that the proposed ISD plan is for WL site groundwater not to meet drinking water standards / guidelines during the period of institutional control and for thousands of years into the future.
3.5.4.2 Post-Closure Activities	*Future use of the WL site will depend on the ability of AECL to release parts of the site for unrestricted use upon completion of the Project.* - Unrestricted use of all of the WL site lands was the original CSR commitment, other than for the Low Level Waste (LLW) trenches in the Waste Management Area (WMA) and the on-site landfill locations. *CNL is developing the WL Closure Land-use and End-state Plan, along with appropriate criteria for site remediation and clean-up activities. The Plan defines the post-closure end-states, the post-closure land-use classifications and allocation, and the physical release criteria that must be met at the site closure. These end-state definitions, land-use classification and allocation, and physical release criteria are applicable to all project decommissioning activities being carried out under the WL Closure Project. Following completion of the work, the lands, including any remaining infrastructure, will enter long-term care and maintenance in accordance with the Institutional Control requirements.* - Based upon above statements, one can assume that more lands may be contaminated for longer periods of time. If so, details of impacted lands should be provided. *As the proponent of the project, CNL will be responsible for implementing and managing the proposed follow-up monitoring program.* - Is it appropriate for the proponent to provide monitoring data to the regulator or if this is blurring of responsibilities?? *The responsible owner of the site (the Government of Canada through AECL), will be responsible for the provision of funds for the follow-up monitoring*

	program. - The ISD monitoring cost estimate is likely insufficient for a very confident or robust monitoring, reporting and review program. Escalation should be also considered over the time frames involved. - GIL of taxes to the LGD of Pinawa are likely to be higher for longer for ISD scenarios because less of the site land would meet release criteria. *In general, affected areas will be remediated to meet the WL preliminary soil cleanup and the non-radiological and radiological clearance and release criteria in accordance with the target end state of the associated land-use category.* - Unrestricted use of WL site lands was the original CSR commitment, other than for the LLW trenches in the WMA and on site landfill locations. - CNL should provide clarification of impacted lands in an open and transparent manner.
3.5.5 Human Resource Requirements and Expenditures	*The size of the workforce after 2021 is anticipated to decrease to zero by 2024. A large workforce is not required during Institutional Control.* - With a workforce of zero, who conducts and maintains the integrity of a robust monitoring program and associated reporting etc.?
6.3.2.5.2.3 Primary Pathways	*The Project is expected to have the following primary pathway effects on groundwater quality that are carried forward to the residual effects analysis: Release of solutes into the groundwater as the grout and reactor components gradually deteriorate over time.* - The WR-1 ISD groundwater will not meet drinking water standards / guidelines during the period of institutional control and for thousands of years into the future.
Tables 6.4.2-8 and 6.4.2-13.	- Rather than just stating the year in which maximum groundwater concentrations are achieved, information should be presented on the total duration in which a radionuclide or non-radionuclide exceeds a drinking water guideline / standard.
6.4.2.7 Prediction Confidence and Uncertainty	*Last paragraph states: Assuming an area source, the estimated dilution could be in the order of 283,000:1 if the plume rises 1 cm from the bottom and 1,400,000:1 if the plume rises 5 cm from the bottom. In either case, the available dilution is sufficient to render the plume indistinguishable from ambient river water*. - In other words, containment (ALARA) is out of question. Pollution by dilution is the proposed solution. - Similar dilution philosophy is displayed in Section 10.5.1, Comparison with Unconditional Clearance Levels, where Table 10.5.1-1 presents the calculated

	radioactivity remaining after being subjected to groundwater leaching for 140,000 years (Golder et al. 2017).
6.4.2.9 Conclusions	*The predicted maximum radionuclide concentrations in surface water at both the Nearfield and the Farm A Intake on the Winnipeg River are orders of magnitude lower than groundwater concentrations.* - In other words, containment (ALARA) is out of question. Pollution by dilution is the proposed solution.
6.7.1.6.2.1 Methods	*Under: Receptor Selection and Characterization Section* *An On-site Farm was not considered reasonable for the normal evolution scenario during the Institutional Control period. The WL site will be under institutional control for the first 300 years of post-closure, which will physically restrict residential use of the WL site, including any farming activities. However, the establishment of a farm (On-site Farm) was considered following post-Institutional Control once the site is no longer being actively managed. The assumption is made that at some time in the distant future, government failure leads to government controls (e.g., zoning designations, land use restrictions, or orders) becoming ineffective and people will be present on-site and make some use of local resource.* ***The On-site Farm has the same characteristics as Farm A; however, residents obtain water from drinking, irrigation, and bathing from the Winnipeg River directly downstream of the WR-1 groundwater seep into the River.*** - How do you prevent future residents of the on-site farm from using a well within the contaminated groundwater plume as a water source for daily living requirements?
6.7.1.10 Human Health Conclusions	*Although uncertainties in the assessment exist, conservatism has been included in the modelling so that residual effects are not greater than predicted.* - Conservatively, and to eliminate some uncertainty, perhaps an on-site farmer should use a well within the contaminated groundwater plume exclusively as the sole water source in the modelling.
Table 10.5.1-1	- The column entitled Specific Radioactivity in should be renamed Activity Concentration and not be confused by the property of Specific Activity, which is defined as the activity per quantity of atoms of a particular radionuclide.
General Summary Comment	- The proposed WR-1 ISD structure is the not the most suitable option to contain the waste and prevent environmental effects including impacts to water quality and subsequent harm to the public. - If monitoring costs and GIL of taxes were more accurately presented for the proposed ISD of WR-1, the apparent cost advantage of the ISD would be substantially reduced or eliminated.

Conclusion

Three additional concerns need to be addressed, the mistaken assumption by the proponents that the Whiteshell Site is “remote,” the lack of a discussion on retaining knowledge and the basis for institutional controls.

Use of the Term “remote”

The frequent use of the word “remote” is indicative of the mindset of the proponents for the in situ disposal of the WR-1 reactor. To note,

> “Ideally, an air quality monitoring station would be within close proximity of the Project with a similar geographical siting and similar influences; however, the NAPS program focuses on areas that are impacted by local sources and not on *remote un-impacted areas like the WL site* (italics ours)”. (p. 6-37)
>
> “Its [the Winnipeg monitoring station at 65 Ellen Street] siting *is not as remote as the Project*, (italics ours) has little influence from waterbodies, is located within an industrial setting and is not considered to be as representative as the Winnipeg station” (p. 6-37)
>
> “The Project is located in a *fairly remote area*, (italics ours) with very few industrial emission sources that influence the airshed surrounding the Project. (p. 6-38).”
>
> “During the KPI Program, participants noted that they wanted to ensure that their respective communities were able to thrive. Further description of community values shared through the KPI Program included the self-identification as nuclear communities, the high value placed on rural living and proximity and accessibility to *remote wilderness* (WR-1 Decommissioning Project KPI Program 2016) (italics ours).” (p. 6-425)

The term “remote” is relative. The Whiteshell site is as remote from southern Ontario as Southern Ontario is from Ottawa. The implication of the use of the term “remote” is that this site will remain “remote” in terms of “sparsely populated” in contrast to that in southern Ontario for the time period during which the radioactive material poses a hazard to the general public.

Contrast this with the effort spent in time and money (C$1.28 billion) to characterize the historic NORM (naturally occurring radioactive materials) located in Port Hope, southern Ontario, to remediate the town and to dispose of the waste material (Hebert and Case 2016).

There is no assurance that the Whiteshell site will remain as remote as it now. With the increase in population of Winnipeg and demands for recreational areas in its close proximity, it can be anticipated that Winnipeg residents will want to build cottages and summer homes in the Pinawa area and that there will be an increase in human activity. Thus, “remote” may no longer be a proper term to describe the Pinawa, Whiteshell, Lac du Bonnet area.

Note also that the WR-1 site is only ~100 km (~1 hour by car) from the edge of Winnipeg (pop. ~700,000). During the operation of the Whiteshell Laboratories and its former more distant Underground Research Laboratory, about 5% of the labour force commuted daily from Winnipeg, little different from commuting practices in major population centres. This is hardly remote.

The entire Winnipeg River system beginning at and including Lake of the Woods on the Ontario/USA border is an important recreational area. Nominally, the local region's population grows by a factor of three during the summer months due to cottagers, children's camps (e.g., Tim Hortons), anglers and tourists, both Canadian and American. The area downstream of the WL site has a population density no less than that of the rural farming districts in the USA, which is not referred to as "remote". The term "remote" implies very distant, difficult to access and of little importance. This is hardly how the local populace including the indigenous people see themselves or appreciate being treated in such an insulting manner.

Knowledge Retention

It has been recognized for many years now that the information pertaining to any human activity that has an environmental or radiation hazard associated with it be maintained. Simple decay calculations show that, although the current radionuclide inventory will decrease from the current ~10^{15} Bq (27,000 Ci) by two orders of magnitude over the first 3000 years, there will still be nearly 350 Ci left. Leaching of the two most soluble radioisotopes, Cl-36 and I-129, will have no appreciable impact on the radionuclide inventory as these two radioisotopes represent less than 1% of the isotopes present and both have long half lives. The legacy of a proposed in-situ disposal of a fairly large contaminated structure (the WR-1 reactor system) will be much longer than recorded history and history has shown that no reliable records exist that are older than a few millennia. A considerable amount of research has been done to develop markers that will only last millennia but that will contain information that can be deciphered over that space of time (e.g., OECD-NEA 2014). Investigations have shown that warning signs, for example, at the Project Gnome test site in New Mexico, have been used for target practice and that warning signs at other sites have been deliberately defaced (Klein et al. 2016). If a robust system of retaining knowledge cannot be demonstrated, relying on temporary markers to identify a high radiation source at a shallow depth is simply not acceptable. Instead, the WR-1 reactor system needs to be kept in a safe state and under surveillance until such time that it can be removed and disposed off in a properly designed and constructed central repository at considerable depth in a geologically stable formation.

Institutional Controls

CNL's plan for in situ disposal of the WR-1 reactor is based on several key milestones:

- Entombment of the below-grade structures of the reactor and closure of the site by 2024.
- 100 years of active institutional control until 2124.
- A 300-year design life of the engineered cover until 2324.
- 300 years of passive institutional control until 2324.

As the proponent of the in situ disposal strategy, the onus is on CNL to:

1. Provide the underlying rationale and scientific basis for the design life of the engineered structures and the timeframes of the post-closure control periods.
2. Identify the enduring institutions(s) that will be responsible and accountable for protecting human health and the environment during the institutional control periods, and that will undertake remedial measures if they are needed.
3. Verify and validate the data, source terms and computer models which predict that the proposed engineered system will be passively safe during the hazardous lifetime of the wastes beyond 300 years..

Summary

CNL's proposed in situ disposal of WR-1 does not meet its strategic requirement to "contain radioactive contamination such that risk to the public and environment is kept ALARA". This is an unwitting attempt to trade off the controlled radiological exposure to knowledgeable and accepting decommissioning workers to the unaware and vulnerable future inhabitants, all in the guise of cost savings. "Unwitting" because CNL's staff and contractors have not considered nor illustrated all the relevant factors that affect the rates of radionuclide release over the geological time frame, including the role of cementatious sealing materials, supply of groundwater reactants and the physical interference of continental glaciation. The proponent's assumption of unexpectedly rapid corrosion and release of the radiological materials leaves us with the impression that "dilution is the solution to pollution" even if it is an unrealistic bounding calculation that is not clearly stated.

The EIS does not provide an explanation to the inexperienced reader (i.e., non-technocrat) on how the radionuclides, both the "surficial" and "congruent–release" varieties, are released and transported through all of the downstream pathways. The reader also needs to know how the upstream groundwater supply and contained corrosion reactants play a role in the radionuclide release process. This picture must first be painted in order to show how simplifying assumptions used in the analyses are truly conservative. These points would also have been beneficial to the analysts because they gravely underestimated the long-term post-glacial redistribution of the neutron-activated reactor vessel and its internal components within the environment of returning inhabitants.

Continental glaciation in Manitoba is a valid scenario for Whiteshell, regardless of "successful" near-surface disposal operations in other locations. The pre-glaciation rapid-release model undermines the likely radionuclide inventory for the subsequent post-glaciation exposure of future inhabitants to exhumed reactor materials.

The recommendations by the IAEA (2009) should be followed for the disposal of long-lived ILW in shallow structures within an environment prone to dispersal by continental glaciation.

We also have included many questions and comments pertaining to: details on site groundwater impacts that exceed Canadian Drinking Water Quality (Health Canada 2009); the completeness of all the cost estimates for the listed options, especially for unrealistically low long-term monitoring costs and Grants-in-Lieu of taxes for more impacted lands, over a longer period of institutional control, if any are implemented; and the basis for institutional controls.

If you and your colleagues have any questions on our comments, please feel free to contact me and I will confer with my co-contributors, below.

Sincerely yours,

<Signature Redacted>

Peter Baumgartner, BSc, MSc, P.Eng.(ret.)
P.O. Box 399
Pinawa, MB R0E 1L0

<Signature Redacted>

Dennis Bilinsky, BSc, P.Eng.(ret.)
Pinawa, MB

<Signature Redacted>

Edward T. Kozak, BSc, Hydrogeology (ret.)
Pinawa, MB

<Signature Redacted>

Paul M. Thompson, BSc, P.Eng. (ret.)
Pinawa, MB

<Signature Redacted>

Alfred G. Wikjord, PhD, Material Science (ret.)
Pinawa, MB

<Signature Redacted>

Grant Koroll, MSc, Physical Chemistry (ret.)
Pinawa, MB

<Signature Redacted>

Jude McMurry, PhD, Geochemistry (ret.)
San Antonio, TX, USA

<Signature Redacted>

Tjalle T. Vandergraaf, PhD, Chemistry, FCIC (ret.)
Pinawa, MB

References

AECL (Atomic Energy of Canada Limited). 2001. Whiteshell Laboratories Decommissioning Project: Comprehensive Study Report Vol. 1: Main Report (Rev.2). AECL Report WLDP-03702-041-000 Rev. 2.

Barrios, J.C. and I. Minenkov. 2015. Whiteshell Laboratories Detailed Decommissioning Plan: Volume 6 – Whiteshell Reactor #1 Building 100. Detailed Decommissioning Plan WLDP-26400-DDP-001 Rev. 3. Canadian Nuclear Laboratories.

Baumgartner, P., Bilinsky, D., Koroll, G., Kozak, E.T., McMurry, J., Vandergraaf, T.T. and Wikjord, A.G. 2016 Jul 03. Comments to "In Situ Decommissioning of the Whiteshell Reactor #1 Project (WR-1)" Letter to C. Cianci, Canadian Nuclear Safety Commission.

Baumgartner, P., Bilinsky, D., Koroll, G., Kozak, E.T., McMurry, J., Vandergraaf, T.T. and Wikjord, A.G. 2016 Oct 28. Comments to "In Situ Decommissioning of the Whiteshell Reactor #1 Project (WR-1)", "Nuclear Power Demonstration Closure Project" and "Near Surface Disposal Facility Project" Letter to N. Frigault, C. Cianci and H. Harpell, Canadian Nuclear Safety Commission.

Bishop, N. (Golder Associates Ltd.). 2017. In situ Decommissioning of WR-1 at the Whiteshell Laboratories Site - WR-1 Groundwater Flow and Solute Transport Modelling. Whiteshell Laboratories Decommissioning Project WLDP-26000-REPT-005 Rev. 0. Canadian Nuclear Laboratories

Golder Associates, EcoMetrix Inc. and InterGroup Consultants. 2017. Environmental Impact Statement – In Situ Decommissioning of WR-1 at the Whiteshell Laboratories Site, Pinawa, Manitoba. Rev. 1. Canadian Nuclear Laboratories WLDP-26000-ENA-001.

Health Canada. 2009. Guidelines for Canadian Drinking Water Quality: Guideline Technical Document – Radiological Parameters. https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidelines-canadian-drinking-water-quality-guideline-technical-document-radiological-parameters.html?page=text

Hebert, C. and G. G. Case. 2016. Port Hope Area Initiative – Community Based Concepts Become Reality. Annual Waste Management Conference (WM2016): Education & Opportunity in Waste Management, Phoenix. AZ, March 6 - 10, 2016, Waste Management Symposia, Inc., Tempe, Arizona.

IAEA (International Atomic Energy Agency). 2009. Disposal Approaches for Long Lived Low and Intermediate Level Radioactive Waste. Vienna.

Klein, T., A. Van Luik and R. Patterson. 2016. As Permanent as Practicable: The Reality of Permanent Markers. Annual Waste Management Conference (WM2016): Education & Opportunity in Waste Management, Phoenix. AZ, March 6 - 10, 2016, Waste Management Symposia, Inc., Tempe, Arizona.

McIlwain, H. 1992. WR-1 Decommissioning: Total Radioactive Inventory of the Remaining Core Components for the WR-1 Reactor. Whiteshell Systems Analysis Branch Technical Note SAB-TN-443 (SAB-002.10). Atomic Energy of Canada Limited.

OECD-NEA (Organisation for Economic Co-operation and Development - Nuclear Energy Agency). 2014. Foundations and Guiding Principles for the Preservation of Records, Knowledge and Memory across Generations: A Focus on the Post-closure Phase of Geological Repositories. A Collective Statement of the NEA Radioactive Waste Management Committee. www.oecd-nea/rwm/rkm.