



## **Oral Presentation**

### **Submission from Eugene Bourgeois and Anna Tilman**

In the Matter of

#### **Bruce Power Inc. – Bruce A and B Nuclear Generating Station**

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Request for a ten-year renewal of its Nuclear Power Reactor Operating Licence for the Bruce A and B Nuclear Generating Station

**Commission Public Hearing – Part 2**

**May 28-31, 2018**

## **Exposé oral**

### **Mémoire d’Eugene Bourgeois et Anna Tilman**

À l’égard de

#### **Bruce Power Inc. - Centrale nucléaire de Bruce A et Bruce B**

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Demande de renouvellement, pour une période de dix ans, de son permis d’exploitation d’un réacteur nucléaire de puissance à la centrale nucléaire de Bruce A et Bruce B

**Audience publique de la Commission – Partie 2**

**28-31 mai 2018**



**Submission to the Canadian Nuclear Safety Commission (CNSC)**

with respect to

**Bruce Power's Request for a ten-year Renewal of its Nuclear Operating Licence  
for the Bruce A and B Nuclear Generating Station**

**April 16, 2018**

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## EXECUTIVE SUMMARY

This submission provides comments on Bruce Power's relicensing application to continue operating the eight nuclear units at Bruce A and B for a 10-year period. These facilities are located at the Bruce Power Nuclear Generating Station (BNGS) in Tiverton Ontario, on the shores of Lake Huron.

The focus of this submission is health and safety and the well-being of the local community located in the vicinity of the BNGS, including that of the workforce (nuclear energy workers and contract workers). We are particularly concerned that there is not at present any scientifically valid means of determining what the long-term effects, if any, on public health in general are.

In our 2015 submission we proposed that a community health study is urgently needed for Inverhuron residents (refer to Appendix for a summary of a proposed community health study).<sup>1</sup> The urgency of this study is even greater now and in this submission we will focus on the failure of the CNSC to fulfill its mandated duties to both Canadian people as well as Inverhuron residents. The Emergency Plan Bruce Power has proposed along with the Municipality of Kincardine's implementing plan will fail to protect the most vulnerable citizens from suffering the greatest harm possible if or when a nuclear emergency (such as a Loss of Coolant Accident) were to occur and a steam release from the vacuum building was necessary.

Our analysis of the Emergency Plan, along with the proposed Evacuation Time Estimates prepared by KLD and Associates for Bruce Power shows these are deeply flawed and point to the need both of building safe shelter for these residents as well as to understand the state of health of the Inverhuron population.

This leads to our first two recommendations:

- Safe shelter adequate to house the resident population of Inverhuron must be built
- A study of the state of health must be undertaken in order to ensure that the safe shelter will provide for the care and safety of this vulnerable population, as identified by the 2017 Provincial Nuclear Emergency Plan (PNERP).

Thus, we are once again proposing for a community health study which we hope will assist us to acquire the baseline database that will allow us to examine potential health effects in the community that may have resulted from the long-term operations at the Bruce Power Nuclear Generating Station. We have identified a variety of distinct communities in this study, including workers at the facility, both contract and nuclear energy workers, each of which presents a separate challenge for the industry if it wants to make the simple claim: *Bruce Power's operations are safe and have not caused ill-effects in the communities within which it operates.*

A major component of our submission regarding Bruce Power's current licence proposal for 2018-2028 is related to safety and the degree to which "safety culture" is actually practiced by Bruce Power and the CNSC. To this end we have undertaken an analysis of Bruce Power operations including topics on releases of radioactive substances to air and water, the condition of aging component parts, in particular Pressure Tubes, cumulative effects, in particular, health

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<sup>1</sup> E-doc-#-4696700-CMD-H2.110 Submission from Eugene Bourgeois and Anna Tilman

and safety issues, a review of reportable events to the CNSC, and an overview of refurbishment experience to date.

Many of these units have operated for more than 30 years now, even with the number of lengthy shutdowns that have occurred. Yet the CNSC and Bruce Power have argued that six of these 8 units (Units 3-8) be allowed for far longer than originally planned. James Sconack, in a presentation to business stakeholders in late January, described the reactors as in many ways similar to an old car. Parts break down and parts need to be replaced on a routine and regular basis. As a retired farmer very familiar with operating old machinery and equipment, fixing one part invariably leads to the failure of others parts. And this is what we report finding in our analysis of Bruce Power's operations and its equipment.

We would argue that these units are past their prime and question these plans to refurbish them, especially in light of the many issues that have developed during the past refurbishment of Units 1 and 2 of Bruce A. These have been very costly (well over estimated budget), run into several delays and have been highly dangerous to a community of workers and perhaps to the public-at-large, and come with no guarantee that the life of a reactor could be extended safely by twenty-five to thirty years.

Bruce Power and the CNSC profess to have a "healthy" safety culture. Our findings indicate that there appears to be, and to have been for an extended period of time, a degraded safety culture, both at Bruce Power and at the CNSC. If an organization is convinced that it has achieved a safe culture, it demonstrates a lack of proper concern for safety. Safety culture is a product of continual striving. There are no final victories in the struggle for safety.<sup>2</sup>

Bruce Power and the CNSC have recommended a 10-year licence period. This lengthy licence period denies the public the scrutiny and transparency that such a project requires, and thus greatly diminishes the public accountability of reactor operators and regulators, which is essential to ensure public safety.

CNSC staff also recommend approval of operating up to a maximum of 300,000 EFPH, contingent on Bruce Power recommending a fracture toughness model for concentrations of  $H_{eq}$  in excess of 120 ppm, while Bruce Power is aiming for 160 ppm. There is no guarantee that such models can provide that level of guarantee.

We recommend that Bruce Power's license to operate these reactors be placed in a cautionary state until the concerns and issues we report are addressed and fully rectified. The mantra of "Leak Before Break" has been repeated so many times at CNSC Hearings that it needs to be considered carefully: leaks are abundant and on-going, ever changing, moving from one component part to another. Hydrogen is unevenly distributed in the moderator water throughout each pressure tube, with very high concentrations near the end cap, a location where "breaks" are most likely.

The public needs to be able review and have input into the whole Bruce Power plan, especially if there are delays and problems, which no doubt will occur. As a result, we recommend that a

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<sup>2</sup> [http://www.nts.gov/news/speeches/rsumwalt/Documents/Sumwalt\\_121007b.pdf](http://www.nts.gov/news/speeches/rsumwalt/Documents/Sumwalt_121007b.pdf) p.17 (with reference to a publication by Professor James Reason, 2000, p. 4)

public session be held within 5 years to review operations at Bruce Power to date to gauge whether this work should proceed or not for other units. Furthermore:

- Bruce Power and the CNSC need to describe how power will be replaced because of delays; and
- It must also be described how cost will be a factor to stop any of the work or not refurbish a unit.

### **How the industry has impacted Inverhuron residents**

As this Commission well knows, there have been numerous incidents, beginning in 1985, that have impacted seriously on our personal health, beginning with the operations of the Bruce Heavy Water Plant and extending to the Fire Training Facility. In addition to these episodes of high concentrations of toxic chemical fumigation, radiological releases from Bruce operations have been persistent and pernicious. Since field testing began, there has never been an instance when unwanted radiological chemicals were not found in abundance in our vegetables, soil and agricultural products, as well as in our urine and that of our flock animals whenever tested.

Both Bruce Power and CNSC persist in using models that will fail to estimate airborne emissions and their concentration correctly. At no point has Bruce Power or CNSC been willing to test the assumptions used in these models to predict events. A clear and simple instance of this presented itself at the DGR Hearings held in 2013 and 2014 when tritium concentrations in our green leafy vegetables were reported to be more than 50 times higher than any other sample measured, including at a location nearest to the source. At these Hearings, I asked both OPG and CNSC whether either would be willing to back-test their model assumptions to determine whether the models each uses for airborne emissions would predict this seriously anomalous situation. Each declined to do so. A strong safety culture would, of course, seek to leave no stone unturned in attempting to account for known data and the root causes of these data. CNSC, however, will not back-test its assumptions, leaving the public exposed to unknown concentrations of dangerous chemicals.

In 2002, our farm was fumigated by Bruce Power during its fire training activity with the result that everyone present was sickened by the event. Over the course of the next 9 months, my staff and I met regularly with Bruce Power personnel to develop a protocol that would allow it to conduct and engage in activities that are necessary to operate the nuclear power station safely and to protect innocent members of the public from high concentrations of toxic chemicals. We did develop just such a protocol and it worked effectively until May, 2008 when Bruce Power unilaterally abrogated this agreement without notice or warning. Predictably, our property was fumigated again, making my wife very ill. When we asked how this had happened, Bruce Power had no explanation because it believed we had an agreement not to operate the fire training facility under these meteorological conditions. Not to be deterred, Bruce Power once again conducted a major burn in June under adverse meteorological conditions, and once again affected my wife's health severely.

Bruce Power's response was to threaten to sue us if we were to talk publicly about having been fumigated by it rather than mitigate operations to ensure that the public will not be harmed by

it. CNSC has supported Bruce Power in this action with the result that, when a meeting was finally convened at the direction of Commissioner Barnes, Ken LaFreniere of CNSC opened it by stating unequivocally that, as far as CNSC is concerned, this matter is closed.

Our air and the food we grow always contain radioactivity, as well as other hazardous by-products of Bruce Power's operations. No health studies of the Inverhuron population have been conducted and there are, then, no scientifically valid grounds to maintain that these are safe conditions. There is evidence of disease and morbidity in our residential community that is consistent with exposure to ionising radiations.

CNSC, even as it is unwilling to review the airborne models it uses to estimate the concentrations here, claims that the concentrations to which we are exposed are safe. This, clearly, is an unscientific statement. It does so without citing or providing any supporting evidence. CNSC has acknowledged that there are no known safe levels of exposure to radionuclides. Nonetheless, without the data that our proposed baseline health study will provide, it states that these concentrations are safe. While CNSC and the Bruce-Grey Medical Office of Health have stated the population base here is too small and limited to conduct a valid epidemiological study, a health survey similar to the one we have proposed will be able to provide valid baseline data from which it can be determined whether Bruce Power operations pose no risk to population health and safety.

Bruce Power's application for relicensing seeks approval for any number of uncertain conditions, most of which will be unforeseeable because the conditions under which these reactors will operate have never before been observed. Both Bruce Power and CNSC have had years to conduct the appropriate surveys and to collect the necessary baseline data to demonstrate that these operations are safe. Nonetheless, neither has seen fit to do so.

Without this baseline data, it is impossible and improbable to make a claim that these facilities have operated safely and will in the future operate safely. We demonstrate in this analysis known safety failures on the part of both Bruce Power and CNSC since the last relicensing hearing. Neither is prepared to acknowledge unsafe and harmful conditions sometimes even after innocent individuals have been unnecessarily exposed. Worst of all, neither has seen fit to follow the medical history of these exposed workers over the course of time it would take for disease to develop. This degraded safety culture does not warrant our good faith and, until a robust and detailed plan to collect this baseline data for our various communities has been put in place, Bruce Power should have its license to operate the Bruce nuclear site placed in a cautionary state.

## **INTRODUCTORY COMMENTS**

### **Overview of the Bruce Nuclear Generating Station Site**

The Bruce Nuclear Generating Station (BNGS), located on Saugeen Ojibway Nation (SON) traditional territory by the shores of Lake Huron, is currently the world's largest nuclear facility complex. The site houses two nuclear operating stations, Bruce A and Bruce B, each comprised of four nuclear reactors; the Western Waste Management Facility (WWMF), an interim storage facility for low and intermediate radioactive wastes (L & ILW) produced from 20 nuclear reactors in Ontario; an incinerator for reducing the volume of LLW; an on-site landfill; and a used fuel dry storage facility for its eight operating reactors.

Also on site is the Douglas Point nuclear reactor, Canada's first commercial nuclear reactor, which operated from 1968-84 and is now slated for decommissioning; two Heavy Water Production plants (currently decommissioned); water supply and processing facilities; and administrative and support buildings.

In addition to these operations, Ontario Power Generation (OPG) has proposed siting a deep geological repository (DGR) for storing all the low and intermediate level radioactive waste produced by Ontario's nuclear power reactors at the Bruce site adjacent to the existing WWMF.

Nuclear facilities have been operating on this site since the late 1960s, beginning with the Douglas Point reactor. The four reactor units of Bruce A began operations in the late 1970s and Bruce B's 4 reactors started up in the mid-1980s. Other than lengthy periods when reactor units of Bruce A were taken out of service, overall, the Bruce A and B units have been operating for over thirty years.<sup>3</sup>

### **Bruce Power's Licence Request**

In May 2015, the CNSC renewed Bruce Power's operating licences as a single licence for both stations, from June 1, 2015 to May 31, 2020 and authorized Bruce A and B Units 1 to 8 to operate up to a maximum of 247,000 Equivalent Full-Power Hours (EFPH).<sup>4</sup>

In December 2015, Bruce Power entered into a long-term power supply agreement with the province of Ontario to provide reliable baseload electricity to 2064. Subsequently, it applied to the CNSC for the renewal of its Operating Licence for Stations A and B for a 10-year period, from September 1, 2018 to August 31, 2028, during which it plans to undertake a massive life-extension project.

The scope of the life-extension activities under this agreement includes Major Component Replacement (MCR), also referred to as refurbishment, of six of its reactors, Units 3 and 4 at Bruce A and Units 5 through 8 at Bruce B, and Asset Management Work (AMW), i.e., maintenance activities for these reactors. The refurbishment of Units 1 and 2 at Bruce A was completed in 2012.

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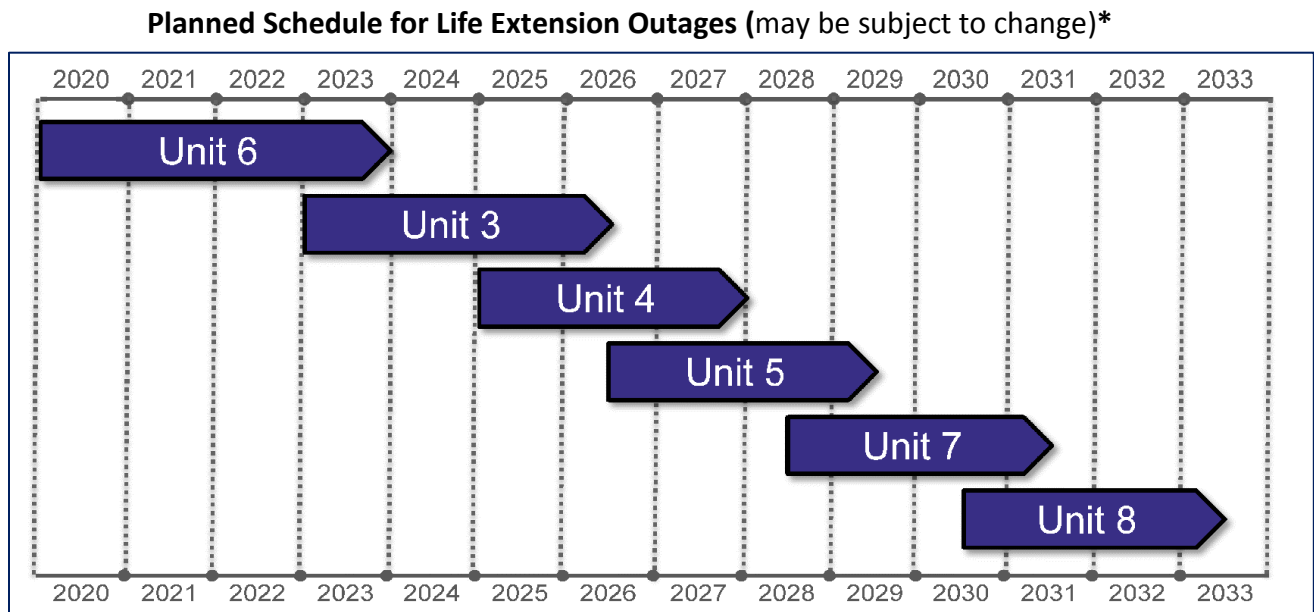
<sup>3</sup> Units 1 and 2 of Bruce A were taken out of service in 1997 and 1995 for 15-17 years respectively. Units 3 and 4 of Bruce A were laid up for 5-6 years (from 1998-2004 and 1998-2003) respectively.

<sup>4</sup> Performance review document p. 18-19; Document NK29-PLAN-09700-001 Major Component Replacement Project Execution Plan, p. 5

The projects under MCR include the replacement of major reactor components, which would include steam generators, feeders, pressure tubes and calandria tubes. Additional work would include the installation and removal of unit isolation bulkheads, and supporting work which would include defueling, dewatering and refueling. This work would be done under an MCR outage for each unit.

AMW activities include ongoing repair and maintenance necessary to extend the lives of key components of the units awaiting refurbishment and would be carried out during routine maintenance outages.

The MCR work is to commence in 2020, starting with Unit 6, and continue to at least 2033. The following chart illustrates the proposed planned schedule for this work.



\*Performance Review of Bruce A and Bruce B p. B19, Figure 3

As indicated in the chart, MCR outages are scheduled to take approximately three to four years for each unit, consecutively. Bruce Power expects that the duration of outages would be shortened given the lessons (or experience) learned from each previous outage.

A core aspect of the AMW project is an ongoing evaluation of the operational health of plant equipment in order to allow Bruce Power to schedule work needed prior to any degradation or failure that could impact safe, reliable operation. Accordingly, this evaluation is intended to allow Bruce Power to optimize the schedule and cost by not replacing components sooner than necessary.

Bruce Power has estimated the cost of the MCR project at \$8 billion (2014 dollars), while AMW would cost an additional \$5 billion through 2053. Between 2016 and 2020, Bruce Power will be investing \$2.3 billion in both MCR and AMW activities.

## **Commentary on Bruce Power's Life Extension Project**

The refurbishment of 6 reactor units, sequentially, within a very short timeframe, is a massive, extremely complex, and potentially dangerous undertaking. It requires highly trained workers, many of whom will likely be contract workers, to carry out intricate and very dangerous tasks. Given the proposed schedule, there will be virtually no pause in this work planned.

The proposed timeline of 3-4 years to refurbish each unit is not only overly optimistic, it is unrealistic. Past experience with refurbishing CANDUs (e.g., Pickering, Bruce Units 1 and 2, and Lepreau) has already borne this out.

In addition to the precarious nature of some of the work involved, the units that are kept operating while awaiting their eventual shutdown for refurbishment will be operating for many more hours exceeding their current EFPH limit, risking the integrity of pressure tubes, the most critical component of a reactor.

Several factors could cause delays in the proposed schedule. While some of these factors could be anticipated, other factors, such as weather conditions, equipment failures, labour shortage, and accidents, are unpredictable and could result in a shutdown for long periods.

While Bruce Power acknowledges that the proposed schedule is subject to change, and thus is anticipating delays, its plans do not reflect or capture the potential adverse consequences of an impractical and unworkable schedule on workers, communities, and the province as a whole.

In reviewing the documents by both the CNSC and Bruce Power, we note a level of optimism that may be misguided. Experience to date, coupled with the nature and intricacy of work that needs to be done, leads us to question many facets of this life-extension project. For example:

- Does Bruce Power's licence application address any of the problems that could develop in this work and the very real potential for delays and cost overruns?
- Why has Bruce Power produced such a tight schedule, when to all intent and purposes, it is unrealistic?
- Are health and safety issues for workers and the surrounding communities, especially exposure to radiation as well as all non-radioactive pollutants, taken into account and given the attention needed to prevent additional adverse effects, beyond what would be considered as routine, but not necessarily benign, operational effects?
- Are emergency measures well in place to handle the impacts of accidents, whether localized at the workplace or that require full-scale evacuation?
- What plans are in place to ensure that there is sufficient replacement power in the case of protracted delays?
- While the CNSC may require "hold points" for restarting a reactor after refurbishment, what level of scrutiny or updates would be available to the public?
- At what point would a decision be made to not proceed with refurbishing a unit?

Our submission addresses many of these issues.

# EMERGENCY PLANNING

## Overview

Lax oversight by both CNSC staff and Commissioners of Bruce Power operations significantly downplays the seriousness of radiological emissions to the health and safety of local residents and the environment. By maintaining the pretext that radionuclides do not bio-accumulate in living tissue, CNSC allows Bruce Power to describe the adverse health effects as if each exposure is a one-off affair and as if annual exposures do not accumulate, both in the environment and in living tissue. For example, tritium that was released by operations at the Bruce site in the 1960s still has residual activity and the ability to cause harm when taken in by the cells of living organisms. Some of that tritium would be organically bound (OBT). In fact we have provided evidence with the tree-ring analysis from 1990 that demonstrates this to be the case. Exposures in our human population increase annually and add to earlier exposures.

Bruce Power provides evidence of a wide array of radionuclides that it releases to the environment by water and air annually. Due to our local meteorology, these gases and particles are most likely to remain below the escarpment and circulate continuously. In the case of tritium, it will take approximately 123 years (10 half-lives) for the activity to be reduced by a factor of a thousand from the time that it was released.

CNSC staff and Commissioners extol the industry for keeping its emissions low, even below background. We know that background levels are not benign and Health Canada warns us on its website to wear sunscreen whenever we are exposed to solar radiation. However, we have no sunscreen available to us to prevent harm from radioactivity that has taken up residence in our cells themselves. These will, in some cases, produce disease, even death. Because the exposure periods generally take such a long time to cause their effects, it can be difficult to demonstrate cause and effect. This is particularly true when CNSC staff and Commissioners do not acknowledge the need for a population health study of Inverhuron residents. This would provide both the residents and the scientific community with a baseline database against which future disease can be assessed. Nowhere is this more evident than in the case of emergency planning for a nuclear accident.

## Bruce Power's Emergency Plan

In the event of an emergency that requires residents in the Contiguous Zone to evacuate, these residents will be directed to evacuate to the Davidson Center on Russell St. in Kincardine. Bruce Power's emergency plan for Inverhuron, in contrast, will be to encourage shelter-in-place rather than for the immediate evacuation of Inverhuron permanent and seasonal transient residents. This is so because all of Inverhuron, with the exception of Inverhuron Provincial Park, has been arbitrarily placed in what was called the Primary Zone (now called the Detailed Planning Zone in the revised Provincial Nuclear Emergency Response Plan) instead of being placed in the Contiguous Zone (now called the Automatic Action Zone). The first line of defence for residents in the Primary Zone, such as those in Tiverton, is to seek safety in shelter.

This presumes that there is safe shelter available to these residents.

CNSC staff has not determined whether this in fact is the case.



Even such a simple exercise as walking around the hamlet of Inverhuron would confirm that most of the summer cottage residences, 19<sup>th</sup> century cottages that are ideal for summer resort homes, are neither airtight nor adequately shielded. The current plan permits Bruce Power to contend that these residences will provide adequate shelter when it is known they will not. As a result, the entire hamlet community who resides in these summer homes will become exposed to the maximum concentrations possible when an accident, such as a Loss of Coolant Accident, occurs and steam pressure builds up such that it must be released to atmosphere.

In response to our questions concerning the maximum dose Inverhuron residents might experience when steam is released from the vacuum building, Bruce Power says that they could be exposed to as much as 250 mSv whole body dose. This is far higher than the 100 mSv this same email confirms as the lowest acute dose known to cause cancer, according to its Table 3 provided in the email.

Are CNSC staff or Commissioners concerned about this matter? This does not seem to be so. Neither chastises Bruce Power for failing to make certain to safeguard these residents from harm in a nuclear emergency. Neither ensures that Bruce Power makes certain that there is appropriate safe shelter for these residents until they can be evacuated safely. Instead, these residents, innocent in every way, are being allowed to be exposed to whatever radionuclides, among other toxic chemicals, are contained in the steam under pressure.

How likely is it that an accident of this sort will happen? We don't know because Bruce Power, with CNSC's tacit concurrence, will not allow residents to review documents that detail the precarious condition of the facilities themselves. But we do know that various units are losing large quantities of moderator water to collection sumps and that neither CNSC staff nor Bruce Power staff know how or why this is occurring. We also know that:

- Pressure tubes as they age are stretching and sagging. Some tubes may now be operating near to or beyond their current anticipated replacement date. When (or if) this licence extension is granted as proposed, the pressure tubes will continue to operate for much longer periods before being replaced.
- Unit 4 was shut down on March 4, 2018 due to the failure of the Primary Heat Transport Seals, an event that had also occurred in Unit 3, August 2017.

It is not a question as to whether such events and accidents are likely, but of the consequences of such incidents and even more serious ones that that could ensue as a result.

Not one refurbishment project in Canada has been completed on schedule. CNSC staff and Commissioners seem to trust that schedules will be met in an orderly way and that nothing will go wrong at the reactors themselves in the interim. It does so knowing that, even given the very limited oversight that we in the public have been allowed to review, alarm bells over the safety of the resident population should be going off. And what is CNSC staff's conclusion? No thorough investigation, such as a Type 1 inspection, of operations is required. Instead, the CNSC refers to Type II inspections, which have been criticized and identified as not being thorough or adequate by the Office of the Auditor General.

How do we know that Inverhuron residents will be harmed by being forced to shelter-in-place? A simple review of the implementing plan is all that is required. If a retired sheep farmer can identify these flaws, one would hope that the professionals in CNSC offices would have been able to do so too.

## **The Implementing Plan**

Under the Provincial Nuclear Emergency Response Plan (PNERP), the Municipality of Kincardine is responsible for providing the implementing plan with Bruce Power's involvement. The Contiguous Zone is the region that must be evacuated at the first notice of a nuclear emergency at the Bruce site. This zone is arbitrarily constructed around a 3 km boundary on the south end of the Bruce site but includes the entire Scott Point community north of the site. Only Inverhuron Park campers to the south will be notified to evacuate immediately. However, even this 3 km zone is not strictly followed because our property is within 3 km but has nonetheless been placed in the Primary Zone by the implementing plan instead of in the Contiguous Zone, which would be both logical and appropriate given the reasoning used.

The entire region below the escarpment shares approximately the same geography and meteorology. The Advisory Group responsible for reviewing responses to the Ministry's Discussion Paper of the PNERP (2009) last year agreed that the implementing plan should not blindly follow arbitrary distances in determining the boundaries of a zone. Rather, it ought to include consideration of the local meteorology and geography in determining these boundaries. By this standard, all of Inverhuron below the escarpment would be evacuated at the first notice of an emergency and its residents would be informed immediately.

Bruce Power is not open as to whether or not it agrees with this recommendation by the Advisory Group. When questioned about this, it provided this email response:

As noted in our previous response, this is an area of jurisdiction under the control of the OFMEM. Bruce Power's Emergency planning team only looks at on-site response, although we do provide information and assistance to the Province and Municipalities for the development of their Emergency Plans. It is our understanding that the OFMEM is currently studying the possibility of including all of Inverhuron in the Automatic Action Zone. Bruce Power supports this review and will support the Province and Municipality, as required, for any changes required to the Municipal and Provincial Emergency Plans for the Bruce site based on the outcome of this review.

Why isn't this part of the emergency plan? According to Frank Merkt, the coordinator responsible for the municipality's plan, it would be too difficult to identify each and every one of the residents, as it must do if Inverhuron were part of the Contiguous Zone.

Those in the Contiguous Zone will be immediately evacuated when a major nuclear accident has been declared. South of Bruce Power, there are only two roads to the east and none south. When Inverhuron Park campers are advised to evacuate, they will do so with their trucks and trailers. This will immediately fill the two access roads leading east away from the plant.

## How Long Will It Take To Evacuate To The Davidson Centre?

Bruce Power hired KLD Engineering in 2016 to conduct an analysis of evacuation time estimates. KLD estimates the size of the population to be evacuated and the time it will take that group to reach safety, presumably at the evacuation centre, the Davidson Centre in Kincardine, although it only specifies this destination once in reference to Amish evacuees. However, the Municipal implementing plan identifies it as the evacuation centre.

On page ES-2, it states: “Table 7-1 and Table 7-2 document the ETE for the 90th and 100th percentiles. These ETE range from 50 minutes to 2:00 (hr:min) at the 90th percentile and 3:15 to 3:55 at the 100th percentile.” Later, on page 7-3, it states:

Figure 7-4 shows that the BPS [Bruce Power Station] is clear of congestion at 1 hour and 15 minutes after the ATE [Announcement to Evacuate]. Tie Rd and Albert Rd are still congested. Hwy 21 and Bruce County Road 1 are both still congested southbound. Congestion on Hwy 21 southbound has intensified with queuing from the PZ boundary to just outside Tiverton, and from Concession Rd 4 to Concession Rd 6.

KLD makes assumptions about the resident and transient population to make this assessment. Its analysis is based on both on Canadian census data as well as on a telephone survey it conducted in February of 2016 when it says on page 1-6: “A random sample telephone survey of households within the PZ was conducted in February, 2016 to gather information needed for the evacuation study.” Earlier, on page 1-1, it confirms that:

Bruce Power:

- Attended project kickoff meeting to discuss methodology and data needs.
- Reviewed and approved all project assumptions.
- Reviewed and approved telephone survey instrument and sampling plan.
- Provided employment data for BPS, including outages.

Bruce Power’s response to my question as to whether it agrees with the assumptions KLD uses for the transient population is as follows:

Bruce Power supported the Municipality of Kincardine to conduct an Evacuation Time Estimate Study in 2016 conducted by KLD Associates. As noted in the report, the study focused on using 2011 Canada Census Data as the basis with extrapolation out to 2016 with additional information provided through field study, Municipality of Kincardine and Bruce Power to determine numbers of permanent residents and homes, seasonal residents and cottages, transient residents and park campers, motel users, as well as Amish residents, residents in long-term care facilities and transportation requirements for child care facilities.

Transient residents are defined as people who (are not permanent residents or commuting employees) who enter the Primary Zone for specific recreation. Transient resident population information is provided below.

Table E-4. Lodging Facilities and Recreational Areas within the PZ

Response Sector	Distance (km)	Direction	Facility Name	Street Address	Municipality	Category	Transients	Vehicles
<b>KINCARDINE, ONTARIO</b>								
1	3.2	SSE	Inverhuron Provincial Park	19 Jordon Rd.	Inverhuron	Campground	1,580	480
6	6.9	SSE	Pine Tree Leisure Camping	2863 Bruce County Rd 15	Tiverton	Campground	259	222
<i>Campground Subtotal:</i>							<b>1,839</b>	<b>702</b>
6	10.2	S	Somerhill Golf Course	2483 Highway 21, Route 2	Tiverton	Golf	36	18
<i>Golf Subtotal:</i>							<b>36</b>	<b>18</b>
3	7.9	SSE	Tiverton Motel	110 King St.	Tiverton	Lodging	7	7
6	5.0	S	Lime Kiln Cottages	96 Victoria St.	Tiverton	Lodging	36	36
6	8.9	S	The Ark Farm B&B	755 Bruce Rd. 23	Tiverton	Lodging	6	3
<i>Lodging Subtotal:</i>							<b>49</b>	<b>46</b>
1	3.2	SSE	Inverhuron Provincial Park	19 Jordon Rd.	Inverhuron	Park	1,075	276
<i>Park Subtotal:</i>							<b>1,075</b>	<b>276</b>
2	3.6	ESE	Bruce Power Visitors Centre	177 Tie Rd.	Tiverton	Visitors Centre	40	20
<i>Visitors Centre Subtotal:</i>							<b>40</b>	<b>20</b>
<i>Estimated Seasonal Transient Population:</i>							<b>355</b>	<b>108</b>
<b>PZ TOTAL:</b>							<b>3,394</b>	<b>1,170</b>

On page 3-11, KLD adds more about what is identified as the transient population when it says:

The secondary category of transient population is seasonal residents. These people will enter the area during the summer months and may stay considerably longer (several weeks or the entire season) than the average transient staying at a lodging facility. The seasonal population use other lodging facilities such as condominiums, beach houses and summer rentals that otherwise would not be captured with the year-round typical lodging population.

It continues by adding:

The methodology for calculating the seasonal resident population involves using the 2011 census block data. Each block polygon includes data regarding the total number of private dwellings and the total number of private dwellings occupied by “usual residents” (permanent residents). Subtracting the total number of dwellings occupied by usual residents from the number of total private dwellings results in the total number of vacant dwellings. Using this data, an average vacant dwelling percentage of 33% was calculated for the entire PZ.

Next, it models this population on pages 3-11 to 3.12:

It is assumed that seasonal residents will be renting homes near the shoreline. Using only those census blocks that are within 1 km of these waterways, the number of seasonal dwellings was calculated by determining the percentage of vacant dwellings near the shoreline and subtracting out the average vacant dwelling percentage (33%) within the PZ. It was assumed that the majority of seasonal residents will be traveling as a family. Therefore, using the average vehicle occupancy of 3.90 persons provided by the Inverhuron Provincial Park Superintendent, as the average household size for seasonal homes, the seasonal population was estimated. The number of evacuating vehicles per household of 1.19 (adapted from the telephone survey results – see Appendix F, sub-section F.3.2) was used to estimate the number of seasonal transient vehicles.

### **Why Does KLD not Use Actual Data?**

Neither KLD nor Bruce Power have any need to contrive such data. On a biannual basis, the Inverhuron and District Ratepayers Association produces an updated directory of its members. Bruce Power as well as the Municipality of Kincardine are given copies. Thus each has accurate data and there is no need to model this data. Moreover, KLD chose to conduct this telephone survey in February when it must be obvious that there are no summer residents present that would allow for an accurate account of the Inverhuron population.

KLD uses assumptions made by the Ministry of Natural Resources (MNR) about the number of persons per vehicle when these data refer to day-use at the Provincial Park as well as campers and were themselves modelled during the DGR Hearings in an Undertaking by MNR. Before this change in its model, the number of passengers per vehicle was close to 2 as KLD has for permanent residents in the Primary Zone. For the Pine Tree Leisure Camping it uses a far lower ratio of campers to vehicles of 1.167.

Since the park charges a fee on a per vehicle basis, it is clear that those who use the park as day use to be at the beach will travel with as many people in each vehicle as practical. Most campers travel two per vehicle. These vehicles are not cars but large trucks with equally large camper trailers, taking up considerably more space on the roads than cars do.

Seasonal residents, however, have different priorities than campers. These are for the most part multi-generational family cottage residences where family members come from far and wide to be together for any numbers of purposes on any number of occasions during the extended summer season. Rather than 3.90 persons per vehicle, many come singly in their own vehicle. A more reasonable assumption would have been to use the Bruce Power employee model for these seasonal residents and to assume that there will generally be between 2 and 10 persons per cottage for the duration of the vacation season. Since many of the cottagers have owned them for multiple generations, the primary cottage residents are often retired people and these folk can stay from April through October.

Would this change the evacuation times that KLD calculates? We don't know this because KLD and Bruce Power prefer models to authentic data, much of which is widely available.

### **What Happens When Evacuees Reach Russell St In Kincardine?**

All evacuees will be instructed to travel to the Davidson Centre, although it is highly likely that those residents who live outside the Primary Zone will evacuate to their homes instead. We do not know whether this will have any impact on evacuation times and attendance at the Davidson Centre because KLD does not address this issue.

KLD maintains in its assumptions that two-lane rural highways ought to be considered in the same way as freeways when it comes to evacuating people and cars from the contiguous and primary zones surrounding Bruce Power. It states on page 4-1:

Rural roads, like freeways, are classified as "uninterrupted flow" facilities. (This is in contrast with urban street systems which have closely spaced signalized intersections and are classified as "interrupted flow" facilities.) As such, traffic flow along rural roads

is subject to the same effects as freeways in the event traffic demand exceeds the nominal capacity, resulting in queuing and lower QDF rates.

This 'freeway', however, terminates abruptly when it enters Kincardine and completely when it reaches Russell St. All evacuees will be instructed to turn right at this juncture and enter a quiet side street that passes through a residential area before reaching the Davidson Centre. Will this interrupt the flow of traffic along the 'freeway' KLD describes? One would certainly think so because vehicles, and particularly trucks with camper trailers, cannot make sharp right-hand turns without slowing down to a stop.

KLD fails to describe this stop-and-go pattern for the 'freeway' and nor does it describe whether this will cause any bottlenecks. It does, however, refer to this type of concern on pages 4-5:

When flow breakdown occurs, queues are formed which discharge at lower flow rates than the maximum capacity prior to observed breakdown. These queue discharge flow (QDF) rates vary from one location to the next and also vary by day of week and time of day based upon local circumstances.

However, judging what any of us has experienced while driving on a freeway, when such a bottleneck occurs, traffic becomes slowed substantially, in some cases, to a standstill. KLD estimates here that traffic would travel at a rate of 1700 cars per hour as it states on page 4-6:

[At the Bruce/Kincardine site] two lane roads comprise the majority of highways within the PZ. The per-lane capacity of a two-lane highway is estimated at 1700 passenger cars per hour (pc/h). This estimate is essentially independent of the directional distribution of traffic volume except that, for extended distances, the two-way capacity will not exceed 3200 pc/h.

It adds one page later: "A conservative estimate of per-lane capacity of 1900 pc/h is adopted for this study for multi-lane highways outside of urban areas, as shown in Appendix K." No reasons are cited for this variance from 1700 passenger cars per hour.

Moreover, it treats all evacuating vehicles as if they were passenger cars when many will be camper trucks with trailers if the emergency occurs during the summer season. It estimates that there are 1580 campers in Inverhuron Provincial Park and that these arrive with 3.19 persons per truck and trailer. Using these criteria, it estimates that there will be 480 vehicles leaving the park during an evacuation emergency.

If KLD had actually surveyed the Inverhuron Park campsite during the summer months, it would be able to verify that most campsites are populated by couples with a minority populated by families with children. The consequence of this is simply that the number of camper trucks and trailers increases substantially. In fact, with 1580 campers and an average of 3.19 passengers per vehicle, this would yield 495.29 vehicles rather than the 480 KLD uses. KLD does not account for this variance in its analysis. If we were to calculate by size, each camper truck and vehicle would be the equivalent of four passenger cars, increasing the number of equivalent vehicles to 1981 vehicles in terms of occupied road space. Would this make a difference? Again, we do not know because KLD counts all of these vehicles as if they were passenger cars.

It does acknowledge that there are thirteen Amish family residences in the Primary Zone and these will be advised to evacuate. On page 8-4 it states:

As discussed in Section 3.1.2, there are 13 Amish families living within Sectors 5 and 6 along Bruce Rd 15 in the BPS PZ. The Amish do not own or operate motor vehicles. They travel in traditional horse-drawn buggies. Based on discussions with Bruce Power and the Municipality of Kincardine, the Amish will evacuate to the nearest Amish community or **the reception centre, the Davidson Centre** [emphasis added]. A single horse-drawn buggy is assumed to have the capacity to transport an entire Amish family and travels at speeds of 8kph to 13kph depending upon weather.

Amish families are extended families and often have more than fifteen people residing in the same extended household. I have never seen as many as five family members in a single horse-drawn buggy. But even if a single horse drawn-buggy did have five family members this would leave 39 horse and buggies travelling the evacuation route along Highway 21 rather than the 13 that KLD estimates. KLD has already described this section of the highway as congested from Concession 6 southbound to Kincardine.

Horse and buggy are calculated to travel at between 8-13 km/h. It is impossible to conceive of a circumstance whereby this in itself would not create a bottleneck along this congested route.

#### **How Many Vehicles Will There Be Evacuating Towards Kincardine from the BPS?**

KLD identifies 3008 Bruce Power employee vehicles. It adds in 1428 vehicles that are using the highway from other locations. In addition, there will be 944 vehicles from outage workers, 276 vehicles from the transient population of 1170 in the Provincial Park plus the 495 camper trucks and trailers. This totals 6201 vehicles, or 7687 if vehicle size is considered to be significant. According to KLD, all these vehicles are travelling this route as if the highway were a freeway, while acknowledging that there will be congestion throughout the entire region. In its plan, KLD on page 3-20 calculates the total numbers of people and vehicles to be evacuated:

A summary of population and vehicle demand is provided in Table 3-7 and Table 3-8, respectively. This summary includes all population groups described in this section. Special facilities are described in greater detail in Section 8. A total of 9,194 people and 6,906 vehicles are considered in this study.

KLD again fails to account for the 1428 passenger cars it has acknowledged will be coming from other locations.

Although a total of 9194 people are modeled for this study, some of these will at first be advised to shelter in place. That includes the estimated 355 seasonal and permanent residents of Inverhuron as well as those residents and transients in the Primary Zone to yield the 6201 vehicles from workers, contract workers, provincial park campers and transients. Even at a capacity of 1900 vehicles per hour, this accounts for a full three and a quarter hours' worth of traffic. However, each camper truck and trailer has a length equal to four passenger cars, more or less. This will increase the equivalent number of 'vehicles per allotted space' by 1486 vehicles, adding another three quarters of an hour to the journey for a total journey time of about four hours.

With four hours of traffic, it is difficult to conceive how KLD can assume that the entire Primary Zone will be evacuated within fifty minutes to two hours under ideal weather conditions. It does state that there are two alternate routes some of the vehicles might take but it also states that there will be an increase in this traffic by some 20% because of what it refers to as the 'shadow population'. On page 3-8, it states:

A portion of the population living outside the evacuation area extending to 15 kilometres radially from the BPS (in the Shadow Region) may elect to evacuate without having been instructed to do so. Based upon NUREG/CR-7002 guidance, it is assumed that 20 percent of the permanent resident population, based on the extrapolated 2016 Census data, in this Shadow Region will elect to evacuate.

When this pack reaches Russell St, it will come to a full stop as vehicles prepare to turn right. With roads fully congested for at least four hours, this can only mean that traffic will be stop-and-go for the duration of the trip rather than a free-flowing freeway.

And we still have not included the transient seasonal population from Inverhuron or the resident population of the Primary Zone with their 2.33 passengers per vehicle as determined by the February 2016 telephone survey. Table 3.2 describes the permanent resident population of the Primary Zone and Table 3.3 the number of vehicles. It estimates the Primary Zone population to be 2424 and the number of evacuating vehicles to be 1211, on page 3-5, Tables 3.1 and 3.2. This will add another three quarters of an hour of travel time, bringing the time required to four and three quarters hours under ideal conditions.

While the Amish horse and buggies have not been added to this traffic flow yet, if traffic is stop-and-go, this mode of transport might be the fastest overall, even if it does travel at only 8 km/h. It will be able to use the shoulders of the road rather than the highway itself. Nor have the Inverhuron residents been added to this mix but, at this stage, the roads will be clogged and there will be nowhere for them to go other than to continue to shelter in place in shelters that will expose them to the highest degree of radioactive and other toxic emissions from the steam when it is released.

Once these vehicles arrive at the Davidson Centre, there will be precisely 276 parking spaces. Where will they park and how much will this cause the evacuation route to back up and bottleneck? We don't know because KLD does not address this issue. But with some 7000 vehicles, it is certain to be problematic for the Contiguous Zone evacuees and will eliminate the possibility of Inverhuron residents from evacuating at all.

## **Weather Dependent**

KLD observes, on page 1-2, that:

According to guidance defined in Section 2.4 of the Provincial Nuclear Emergency Response Plan, the PZ is divided into 10 Response Sectors (3 of which are water Response Sectors) along major roadways and physical landmarks such as streams and Lake Huron, which were used to define Evacuation Regions. Evacuation Regions are groups of Response Sectors for which ETE are calculated. The configurations of these Regions reflect wind direction and the radial extent of the impacted area. Each Region,



other than those that approximate circular areas of 3km (known as the contiguous zone), 6km (known as the middle ring), and 10km (known as the full PZ), approximates a “key-hole section” within the PZ as recommended by NUREG/CR-7002.

In order to describe the various permutations and combinations related to both weather conditions and the various zones, KLD describes on page 2-2: “A total of 14 “Scenarios” representing different temporal variations (season, time of day, day of week) and weather conditions are considered. These Scenarios are outlined in Table 2-1”, including one that considers a road closure: “Scenario 14 considers the closure of Highway 21 southbound from the intersection with Concession Road 4 to the intersection with Russell Street”. Later, on page 2-5, it describes the weather conditions it considers:

13. Two types of adverse weather scenarios are considered. Rain may occur for either winter or summer scenarios; snow occurs in winter scenarios only. It is assumed that the rain or snow begins earlier or at about the same time the evacuation advisory is issued. No weather-related reduction in the number of transients who may be present in the PZ is assumed. It is assumed that roads are passable and that the appropriate agencies are ploughing the roads as they would normally when snowing.

14. Adverse weather scenarios affect roadway capacity and the free flow highway speeds. The factors applied for the ETE study are based on recent research on the effects of weather on roadway operations; the factors are shown in Table 2-2.

However, not all winter storms are equal in intensity or duration. Even with relatively modest winter storms, these will impact on the amount of time required to evacuate the region. On pages 5-8 to 9 it offers this:

Inclement weather scenarios involving snowfall must address the time lags associated with snow clearance. It is assumed that snow equipment is mobilized and deployed during the snowfall to maintain passable roads. The general consensus is that the snow-ploughing efforts are generally successful for all but the most extreme blizzards when the rate of snow accumulation exceeds that of snow clearance over a period of many hours (**Note – evacuation may not be a prudent protective action under such blizzard conditions**).

In addition to this, evacuees will have more preparation work before being able to evacuate when it states on page 5-9:

Nevertheless, for the vehicles to gain access to the highway system, it may be necessary for driveways and employee parking lots to be cleared to the extent needed to permit vehicles to gain access to the roadways. These clearance activities take time; this time must be incorporated into the trip generation time distributions.

This is not accurate. Tractors may need to be plugged in to warm unless others come to plow-out or blow-out all households and enterprises within the Primary Zone. In spite of all these difficulties, it estimates that under the worst case scenario, evacuation will take longer, at three hours and fifty-five minutes when it states this on page ES-2: “Table 7-1 and Table 7-2 document the ETE for the 90th and 100th percentiles. These ETE range from 50 minutes to 2:00 (hr:min) at the 90th percentile and 3:15 to 3:55 at the 100th percentile.”

This time estimate is still considerably faster than the time our analysis has determined under ideal weather conditions.

It is partially assisted in making this calculation because, as it states on page 6-2: “Transient activity is less in the winter – 20% during the week and 35% on the weekends”.

In Appendix F on page F-10, it raises the following concern:

***“How long would it take the family to pack clothing, secure the house, and load the car?”***

Figure F-11 presents the time required to prepare for leaving on an evacuation trip. In many ways this activity mimics a family’s preparation for a short holiday or weekend away from home. Hence, the responses represent the experience of the responder in performing similar activities.

The distribution shown in Figure F-11 has a long “tail.” About 97 percent of households can be ready to leave home within 60 minutes; the remaining 3 percent of households require up to an additional 45 minutes.

It next considers this:

***“How long would it take you to clear 15 to 20 centimetres of snow from your driveway?”***

During adverse, snowy weather conditions, an additional activity must be performed before residents can depart on the evacuation trip. Although snow scenarios assume that the roads and highways have been ploughed and are passable (albeit at lower speeds and capacities), it may be necessary to clear a private driveway prior to leaving the home so that the vehicle can access the street. Approximately 11 percent of households said they will not shovel the driveway prior to evacuation; therefore those households will have zero shovel time. Figure F-12 presents the time distribution for removing 15 to 20 centimetres of snow from a driveway. The time distribution for clearing the driveway has a long tail; about 97 percent of driveways are passable within 60 minutes. The last driveway is cleared 30 minutes later.

KLD, apparently, fails to recognise that this is a rural region of Ontario. Driveways will be much larger and longer for these people than for those who live in a suburban home. For example, I might have to blow snow for more than 1000 meters before I would get to Albert Rd., as I have had to do in the past. However, while it acknowledges that there are adverse weather conditions whereby evacuation would either be impossible or ill-advised, it recommends that these evacuees shelter in place until the storm blows over or is cleared. But when there is inadequate shelter for these residents, is that a concern? Apparently not because there is no recommendation that shelter be constructed that will be adequate for the resident population.

In the time we have lived here, we have been snowed-in here for as long as ten days. While conditions in Inverhuron might appear to be fine, wind and blowing snow can make roads impassable once we climb the escarpment. So, while it would be quite feasible to move around in Inverhuron, it would not be so to travel to the Davidson Centre in Kincardine. We have had hurricanes and tornadoes in Inverhuron as well. With climate change, storms are expected to increase both in frequency and in intensity. Is it assumed that a nuclear emergency would

never occur under these circumstances? The very opposite is more likely since it may be exactly this sort of event that triggers such an emergency, whether because employees become distracted and make a mistake or because the weather itself creates the emergency.

If an emergency plan's purpose is to prepare in order to protect those most vulnerable to this accident, and this very process which KLD identifies and there are circumstances when these very people will not be protected, wouldn't it be appropriate to ensure that they will be? By building emergency shelters that will be adequate for the population that will need it, it would be a small but necessary step to ensure maximum protection for those residents who will have the greatest adverse health effects from this accident.

### **Who Needs To Evacuate Immediately?**

KLD does not recommend a staged evacuation for those in the contiguous zone when it says on page ES-2 and elsewhere and later at page 7-5:

Inspection of Table 7-3 and Table 7-4 indicates that a staged evacuation protective action strategy provides no benefit to evacuees from within the contiguous (3km) zone and in a few cases adversely impacts evacuees located beyond the contiguous zone. Thus, staged evacuation is not beneficial and is not recommended for this plant. See Section 7.6 for additional discussion.

But the implementing plan does precisely this. Bruce Power puts out a brochure with safety recommendations that it claims to mail annually to local residents, although no one I have asked can remember ever receiving one. In this brochure (which is also available at: [www.bepreparedgreybrucehuron.com](http://www.bepreparedgreybrucehuron.com)) it recommends that Primary Zone residents stay put, shelter in place, and wait for the signal to evacuate. This is a staged evacuation.

No reasons are given about why there is a different recommendation for residents who are known to have inadequate shelter and who are in an identical geography as the Inverhuron Park transient population. The Inverhuron Park population is advised to evacuate immediately because they do not have adequate shelter. Is there a reason why the one transient population would be advised to evacuate because of inadequate shelter and the other to stay put? If so, none have been given.

Inverhuron residents, given the timeframes allotted in PNERP (2017), could be informed of this accident as much as an hour or more later, well past the period when the evacuation routes will have become clogged with traffic. Since cars themselves provide neither airtight security nor adequate shielding, no Inverhuron resident would be advised at this time to evacuate as long as the timing of an imminent release of radioactive steam from the vacuum building is unknown.

The Municipality's updated plan continues to assert that conditions will be as they were during the planned emergency practice in 2016. However, it lacks any explanation about why the roads will be clear for emergency evacuation in a real and dynamic situation.

In an emergency, before anyone or any other body is alerted, Bruce Power employees will be called to assembly to put all stations in emergency conditions. Perhaps as much as 15 to 30 minutes later, Bruce Power will inform the Provincial Emergency Operations Centre of this emergency as it develops. In turn it will coordinate emergency procedures with municipal and

other authorities, including the OPP. It is inconceivable that Bruce Power employees would not inform their loved ones and families about an emergency and this in itself could lead to all the evacuation routes becoming clogged with traffic well before the OPP has had an opportunity of creating an evacuation route. In an email, Bruce power does confirm that its employees might inform their loved ones when it says:

The immediate important issue is ensuring that our staff assembles and accounts to ensure that all of our staff is safe. While it is possible that some staff may phone loved ones, experience shows that we do not have this behaviour by the majority of our staff.

Bruce Power supported the Municipality to conduct a thorough Evacuation Time Study that includes variables for evacuation of not only the site but also surrounding residents within the 10Km radius of the site. These studies, led by independent experts identified that expected traffic patterns would not cause any concern for timely evacuation of the site and surrounding area. (A pdf copy of the evacuation study is included for your information).

The Municipality has recently updated its implementing plan, modifying the Contiguous Zone boundaries. It says:

The contiguous zone around the Bruce Power site ranges in distance between 3km to 5km from Bruce A or Bruce B Generating stations. The contiguous zone is defined by roads on the Bruce Power primary zone and response sectors map. Depending on the severity of the occurrence and weather conditions emergency public alerting may be extended past the set 3 km radius.

While this does appear to extend the zone to the parts of Inverhuron with inadequate shelter for shelter-in-place to be a protective action, there is no indication at present whether, indeed, this is so. Absent the immediate evacuation of all Inverhuron residents who do not have adequate shelter as defined in the PNERP (2017), these residents will be at severe risk of being exposed to the highest possible doses of radiation when and as pressurized reactor steam is released from the vacuum building.

What or how is the severity of an accident to be determined fast enough to allow for extending the alerting system beyond the 3 km zone? We do have evidence that Bruce Power employees failed repeatedly to recognise an emergency as it was developing in the Bruce B tritium incident. Employees failed to recognise that their instruments were recording actual concentrations of tritium and allowed the entire unit to become contaminated to the extent that it needed to be shut down and the employees sent home. Worse still, Bruce Power management seemed not to understand the severity of the accident and recalled the employees at a time when they were once again exposed to doses of radiation many thousands of times higher than the maximum permissible doses and had to send them home again.

As the plan is currently written, only Inverhuron Park campers will be immediately informed of the emergency and advised to evacuate. As discussed above, camping today is generally with large truck and trailer and these will immediately clog the evacuation route with traffic. With only two evacuation routes available to the public, by the time Inverhuron residents follow the mandate given in the implementing plan, evacuation will not be possible. Inverhuron residents

will be directed to go indoors to look at their Alert FM monitors to learn what to do in this emergency.

Inverhuron's largest age cohort is those who have retired, followed by those about to retire. The next largest is children. Together, these three groups complete the set of the most vulnerable members of any population with respect to exposure to industrial toxins, including the radioactive and other particulate emissions in the pressurized steam from the vacuum building. These individuals will be forced, by necessity, to shelter-in-place in shelters that are acknowledged to provide neither shielding from radioactivity nor protection from outside air flows. The consequence is that each person will receive the maximum toxic pollution from emissions, both radioactive and non-radioactive, that would be released. Moreover, this will continue as the air swirls within this bounded geography, trapped by the escarpment to the east.

CNSC staff has not highlighted that it has any such concerns about the fate of Inverhuron residents. It is silent in all respects of this concern. Has staff considered the consequences for Inverhuron residents?

This situation is simply unacceptable on every front. In spite of knowing well in advance that many Inverhuron residents – both summer residents who cottage in the ancient buildings and permanent residents of Woodland Court who live in trailers – will not be protected in the event of an accident, we will be mandated to engage in 'protective' action that will expose us to the highest doses available when steam is released from the vacuum building.

The revised municipal implementing plan does not support building adequate shelter in Inverhuron to protect its residents. It says:

It is important that the residents of the contiguous zone, after hearing the emergency alerting sirens, go inside to listen for instructions to shelter in place or evacuate the area. Sheltering in place is only to be used temporarily when dose projections are to be very low or when safe evacuation is not possible.

The construction of a protective shelter in Inverhuron and asking residents to proceed to the shelter instead of evacuating to a location outside the primary zone will create unnecessary challenges for our emergency response planning.

If, of course, the instruction is to evacuate, (and it remains unclear whether Inverhuron below the escarpment is or is not in the Contiguous Zone (now called the Automatic Action Zone in PNERP (2017))), then this is indeed the best course of action, assuming evacuees are not just stuck on the road in stop-and-go traffic. We don't know whether this is the case and we don't know what CNSC's staff considers about this plan. When I asked, it failed to provide me with its review of Bruce Power's emergency plan, which in turn, fully informs the municipal implementing plan since Bruce Power is mandated to be part of the committee that develops it. Therefore, it is unclear whether CNSC staff, and in turn the Commissioners, are in favour of the plan as it now stands for Inverhuron residents in the event of such an emergency at Bruce Power.

Many residents in Inverhuron are in old age and suffer from the wide range of disabilities and disease associated with old age. There is no discussion about how emergency workers will be able to respond to this situation, other than to state that having an emergency shelter will: “create unnecessary challenges for our emergency response planning”. Nor is there a clear understanding by responsible authorities or Bruce Power just who these residents are or where they reside. However, while having an emergency shelter may “create unnecessary challenges” (of what nature?), there is reason to be concerned that the personnel responsible for emergency responses may not be able to handle a scattered population in their individual houses.

A recent house fire in Inverhuron was reported in the March 29<sup>th</sup> edition of The Kincardine News.

Every property in the Municipality of Kincardine is assigned a so-called Fire Number, sometimes also called a Civic Number. There is a green number plate posted at the entrance from the road for every municipal property, including every property in Inverhuron. In spite of this, and in spite of the visible smoke identifying the exact location of the fire at the top of the driveway (the house is on top of the hill behind trees), the Fire Department was unable to find the residence until after it had burned to the ground.

We experienced a similar situation many years ago when my mother was visiting. She fell down a small set of stairs and broke her back. We called 911 and gave them our Fire Number, 2 Alma St. The ambulance came but couldn't find us, looking first in an abandoned gravel pit before I walked down to Albert Rd and directed them to our house and business.

This same Fire Department is responsible for implementing the Emergency Plan in a nuclear emergency.

Protective shelters will give emergency crews the time and opportunity to shelter these vulnerable populations until there is time and opportunity to evacuate them safely. It is inconceivable that such shelters should not already be present in Inverhuron. Their absence is simply inexplicable in the circumstances.

CNSC staff and Commissioners have been silent entirely about this dismal situation with respect to Inverhuron residents, those both permanent and seasonally transient.

Are the CNSC and other responsible authorities simply dismissing the effects of accidents and releases of ionizing radiation on small communities, when safety and protection of residents, regardless of the numbers, should be the uppermost concern?

It is imperative that as a condition of its operating licence, Bruce Power must be required to provide adequate shelters and these must be constructed in Inverhuron. The structures must be ones which will accommodate the population that will require shelter for the duration that such shelter will be necessary. In addition, the Implementing Plan must be written in such a way that leaves no doubt that all of Inverhuron below the escarpment is in the evacuation zone, called the Automatic Action Zone (in the revised PNERP (2017)), rather than as it is now in the Detailed Planning Zone (what PNERP (2009) calls the Primary Zone).

PNERP 2017 identifies what it means by a “vulnerable population” when it states in Annex K:

**Vulnerable Populations:** members of the public who have additional needs before, during, and after a *nuclear emergency* in one or more functional areas.

It defines these terms in the following way:

Functional areas can include, but are not limited to, the following

1. maintaining independence;
2. communication;
3. transportation;
4. supervision; or
5. medical care

Individuals in need of additional assistance could include those who

6. have disabilities;
7. are from diverse cultures;
8. have limited to no proficiency in the local official language; or
9. are transportation disadvantaged

*(Source CSA N1600, General requirements for nuclear emergency management programs)*

Note: infants, children, those suffering from debilitating illnesses, etc. are not included in this list.

The PNERP does not give any reasons in the note about why infants, children, those suffering from debilitating disease should be excluded from such a list because one would think that these are the very people to whom one would want to provide the greatest protection possible.

The PNERP also identifies clearly that the role of the CNSC is: “(a): The top priorities in managing a **nuclear emergency** are health, safety, security and the environment.”

Why has CNSC, both staff and Commissioners, failed in its primary mandate to provide for the health and safety of vulnerable populations from the dire effects of a nuclear accident such as a Loss of Coolant Accident?

Bruce Power’s Emergency Plan for a nuclear emergency was written in 2009, nine years ago. CNSC can offer no excuse for its gross negligence towards this vulnerable population because it ought to have identified these deficiencies long before now.

## RADIOLOGICAL EFFLUENT DATA - BRUCE A AND B

Bruce Power monitors a select number of radionuclides and radionuclide groups released in effluent to water and air. The atmospheric releases are sampled and analyzed weekly while the waterborne releases are sampled monthly. The results are published in annual reports entitled Annual Summary & Assessment of Environmental Radiological Data and in Environmental Monitoring Program Reports [EMPR] and are submitted to the CNSC as required.<sup>5</sup>

The radionuclides monitored in atmospheric releases include Tritium Oxide (HTO), Noble gases, Radioiodine (I-131), Carbon-14 (C-14) and combined beta/gamma-emitting particulates ( $\beta/\gamma$ ) including Cs-134, Cs-137, and Co-60. Combined alpha-emitting ( $\alpha$ ) particulates (e.g. Pu-239, Pu-240, Am-243 and Cm-244) have been monitored since 2012.

Liquid effluent releases encompass Tritium Oxide (HTO), Carbon-14 (C-14), gross beta/gamma ( $\beta/\gamma$ ) emitters and alpha emitters (since 2012).<sup>6</sup> The sources of waterborne tritium emissions include active liquid waste systems, boiler discharges, as well as foundation drainage sump discharges.

The following sections examine the monitoring results for specific periods for Bruce A and B.

### a) Summary of Airborne Emissions - 2014-2016

#### Annual Radiological Airborne Effluent Emissions (Becquerels/yr)

Year	2014		2015		2016	
	Bruce A	Bruce B	Bruce A	Bruce B	Bruce A	Bruce B
Tritium Oxide	7.51E+14	4.13E+14	7.05E+14	3.74E+14	5.66E+14	5.70E+14
Noble Gas	5.30E+13	5.25E+13	5.62E+13	5.25E+13	5.63E+13	5.25E+13
Iodine-131	3.94E+08	4.02E+07	5.15E+07	4.01E+07	4.40E+06	< Ld
Particulate - Gamma Scan	3.13E+06	1.53E+07	1.06E+07	1.64E+07	3.14E+05	1.13E+06
Particulate - Gross Alpha	8.02E+05	2.26E+06	1.23E+06	2.34E+06	2.46E+03	1.85E+03
Carbon-14	1.64E+12	1.26E+12	3.15E+12	1.16E+12	1.69E+12	1.13E+12

Notes:

Scientific notation: e.g.,  $7.51 \times 10^{14}$  is expressed as 7.51E+14

Ld - Below detection limit

<sup>5</sup> Bruce Power's Environmental Monitoring Program. *Annual Summary & Assessment of Environmental Radiological Data and Environmental Monitoring Program Reports (2012-2016)*  
<http://www.brucepower.com/category/reports/environmental-reports/environmental-radiological-data/>;  
<http://www.brucepower.com/wp-content/uploads/2014/06/EMPreport.pdf> CNSC - Regulatory Standard S-99 Section 6.4.5

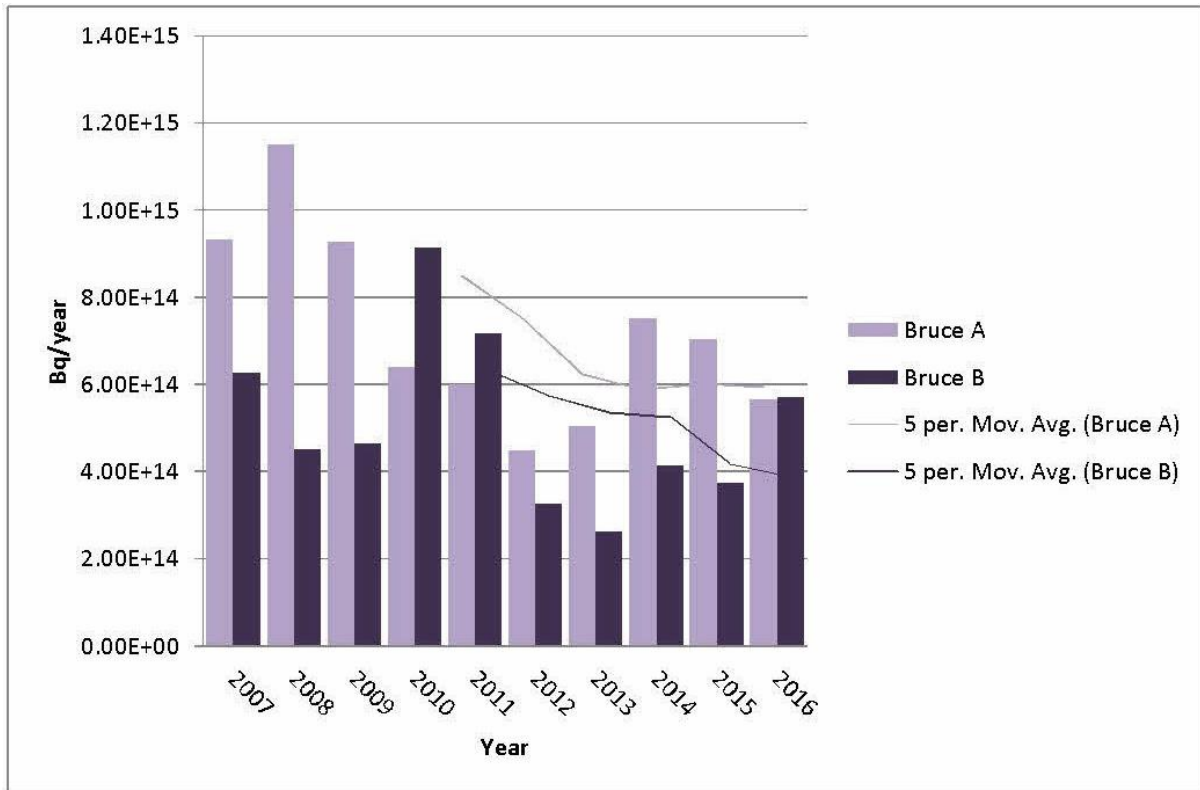
<sup>6</sup>2016 Environmental Monitoring Program Report (EMPR) <http://www.brucepower.com/2016-environmental-monitoring-program-report/> p. 69



## Tritium

As is evident, Tritium Oxide is the dominant radionuclide emitted to air. The following graph illustrates the annual atmospheric tritium emissions over a 10-year period.<sup>7</sup>

**Historic Airborne Tritium Emissions 2007-2016 (Becquerels/yr)**



Bruce A's elevated tritium emissions in 2014 and 2015 are attributed to outage work which included the moderator heat exchanger and end fitting work. As well, Bruce B's elevated tritium airborne emissions in 2016 may have been caused by maintenance on the primary heat transport system (PHT), moderator (Mod), cobalt removal, and the boiler program. The increase in tritium emissions from Bruce A in comparing 2013 to 2016 is attributed to outages in 2016.

## Iodine-131

Iodine airborne emissions at Bruce A were notably high. While emissions would be in the order of (or less than)  $5 \times 10^7$  Bq annually, they were in the order of approximately  $4.00 \times 10^8$  in 2014. This was attributed to debris in the heat transports system which caused failed fuel and a release of iodine. Iodine emissions from that station were also elevated ( $> 2.00 \times 10^8$  Bq) in 2012 due to iodine not being captured by exhausted HECA filter beds. These HECA filter beds have since been replaced.<sup>8</sup>

<sup>7</sup> EMPR 2016 p. 26, 28

<sup>8</sup> Ibid p. 26

## Comments:

- By reporting only one value for releases for a whole year, which presumably represents the average of measurements taken during the year, no information is available on any outliers (e.g., spikes) or fluctuations during that year. Variations in annual data could also be indicative of problems, such as leaks, lengthy outages, or a host of other issues. This makes it difficult to track performance or trends over time in emissions with a reasonable degree of reliability.
- The degree of accuracy of this data is not provided. As these numbers are annual averages, they should be accompanied by the number of measurements and the standard deviation.
- Release data for each unit of Bruce A and B should be provided, and not amalgamated into one number for each station.

## b) Summary of Liquid Effluent Data

The following table illustrates annual releases of specific radionuclides for the years 2014-2016.<sup>9</sup>

**Annual Radiological Waterborne Effluent Emissions (Becquerels/yr)**

Year	2014		2015		2016	
	Bruce A	Bruce B	Bruce A	Bruce B	Bruce A	Bruce B
Tritium Oxide	1.94E+14	6.42E+14	2.20E+14	6.72E+14	2.36E+14	5.07E+14
Carbon-14	1.13E+09	8.06E+09	2.45E+09	9.07E+09	1.66E+09	1.76E+09
Gross $\beta/\gamma$	1.02E+09	1.99E+09	9.17E+08	1.53E+09	9.96E+08	1.42E+09
Gross $\beta$	NA	NA	NA	NA	NA	NA
Gross $\alpha$	1.77E+06	1.49E+06	3.15E+12	1.16E+12	6.96E+04	<Ld

## Species of radionuclides monitored

In contrast to the EMPRs for 2015-2016, EMPRs in previous reports have included a select number of individual radionuclides in addition to Tritium Oxide, C-14, Gross  $\beta$ , Gross  $\alpha$  and Gross  $\beta/\gamma$  in liquid effluent results for Bruce A and B. These reports included beta/gamma emitters as well as alpha emitters.

It is worth noting that for the year 2013, Am-241, Co-60, Cs-137, Mn-54, Nb-95, Sb-124, Sr-90, U-235, and Zr-95, Sr-90, which were included in these reports individually, were found in liquid effluent from Bruce B.<sup>10</sup> Cs-137 and Sr-90 were also detected in effluent from Bruce A.

However, the practice of including such individual radionuclides has been discontinued as of 2015.<sup>11</sup> This decision is not acceptable. There is a distinct advantage and rationale for

<sup>9</sup> EMPRs 2014-2016

<sup>10</sup> For example, Table 5, EMPR 2014 p. 23.

<sup>11</sup> EMPR 2016 p. 69-70

monitoring and reporting emissions of individual radionuclides, and not as groups. If the presence of a particular substance and level of activity is unusual or unexpected, even if considered not ‘significantly large’, this could serve as an indicator of problems that may otherwise go unnoticed.

As a result of this change, emissions directly considered in the dose calculation process include HTO, 14C, noble gases, and radio-iodines. While beta/gamma-emitters are also considered, with the assumption that the full complement of the combined measure would consist of one of the three individual radionuclides known to have the highest associated dose (i.e., Cs-134, Cs-137 or Co-60), alpha emitters are not, in that “it has been determined in past analysis, including the most recent Pathways Analysis, that the dose associated with all alpha emitters is negligible.”<sup>12</sup>

Given the importance of dose calculations, and the data that has indicated the presence of alpha emitters in effluent, there are serious concerns why alpha emitters are not included.

To highlight concerns about limiting the reporting of individual radionuclides, the following table summarizes annual waterborne emissions from 2007-2014 for three specific radionuclides monitored, namely Americium-241 (Am-241), Cesium-137 (Cs-137), and Uranium-235 (U-235). These species are a small subset of the fission and activation products produced in the reactors and found in the liquid effluent.<sup>13</sup>

**Annual Waterborne Emissions Data 2007-2014 in Becquerels (Bq)  
(Americium-241, Cesium-137, Uranium-235)**

Year	Am-241		Cs-137		U-235	
	Bruce A	Bruce B	Bruce A	Bruce B	Bruce A	Bruce B
2007	7.41+E06	8.07E+08	5.21E+07	3.51E+08		1.29E+08
2008		3.71E+07	4.65E+07	2.85E+07		2.57E+07
2009	0	0	4.06E+07	4.46E+07	0	1.23E+07
2010		1.17E+07	3.37E+07	2.64E+07		4.39E+07
2011	<MDL	<MDL		8.51E+07		5.05E+07
2012	<MDL	<MDL	3.77E+07	2.72E+07	<MDL	2.79E+07
2013	<MDL	<MDL	1.90E+07	1.04E+07	<MDL	1.23E+07
2014	<MDL	<MDL	3.27E+07	<MDL	<MDL	1.47E+07

MDL: Minimum Detection Limit (i.e., the level that can be detected with a 95% false-negative confidence and a 5% false-positive confidence). Units 1 and 2 were off-line until the latter half of the year 2012. Units 3 and 4 were off-line for extensive periods from 2012-13.

With respect to these particular radionuclides, there are a number of issues, for example:

- In 2007, the reported activity level of Am-241 discharged to water from both Bruce A and B was  $8.07 \times 10^8$  Becquerels. Releases of Am-241 were reported in 2008 and 2010 (from Bruce B). Accordingly, a boiler tube leak identified at Bruce B in 2007 contributed

<sup>12</sup> EMPR 2016 p. 69-70

<sup>13</sup> EMPR 2013 p. 23, Table 5.

to higher than normal gamma emitting radionuclides such as Am-241, Cs-137, and U-235 in the effluent.

- The EMP Reports have noted that “While there were discharges of Am-241 in all the years beyond 2007 however the values recorded in 2008 onward were below the minimum detection limit. It should be noted that the methodology employed for reporting Minimum Detection Levels (MDLs) were not consistent from year to year.”<sup>14</sup> However, no explanation is given with respect to this inconsistency or with respect to the emissions of Cs-137 from both Bruce A and B from 2007-2014.
- The emissions of U-235 to water from Bruce B for 2007-2014 are disconcertingly high. If this data is credible, then substantial amounts of irradiated uranium would be emitted every year, along with other radionuclides.
- Based on the level of activity of these three radionuclides, one would expect other species found in irradiated fuel, such as Plutonium-239 and Uranium-238, to be present in the effluent.

### U-238 Emissions

While emissions of U-238 in liquid effluent are not included in the monitoring reports of 2007-2014, the amount of U-238 (in kilograms) accompanying U-235 in liquid effluent can be determined based on the recorded emissions of U-235 from Bruce B for that period, as shown in the following table.<sup>15</sup>

Year	U-235 (Bq)	U-238 (kg)
2007	1.29E+08	227
2008	2.57E+07	45.2
2009	1.23E+07	21.7
2010	4.39E+07	77.5
2011	5.05E+07	88.9
2012	2.79E+07	49.1
2013	1.23E+07	21.7
2014	1.47E+07	25.8

The amount of U-238 in liquid effluent Bruce B in 2007 (approximately 227 kilograms) is approximately equivalent to ten uranium fuel bundles. Similarly, the quantity of U-238 released to water in other years is inordinately and inexplicably high. During reactor operations, it is expected that uranium dioxide would be released to the coolant primarily from defective fuel, and to a lesser degree, from “tramp” uranium (that is, from surface contamination of fuel bundles). The typical amount of U-238 expected to be released would be, on average, about 100 grams a year, which is magnitudes less than the amounts calculated above.

<sup>14</sup> WMPR 2016 p. 33

<sup>15</sup> This amount is calculated based on the natural abundance of U-235 (0.711%) and the specific activity of U-235 (80,011 Bq/g).

This raises questions with respect to the methodology used to determine the activity of U-235 in effluent, and the determination of the regulatory limit of releases of U-238, or for that matter, other radionuclides. It also raises concerns as to whether these emissions are the result of very serious problems with emissions from the reactors that are not being addressed.

### Tritium Waterborne Emissions

The following table provides annual waterborne emissions of tritium for the years 2007-2016.<sup>16</sup> This data includes tritium in active liquid waste, boiler discharges and foundation drainage.

**Tritium Waterborne Emissions (2007-2016)**

Year	Tritium Oxide (Becquerels)		
	Bruce A	Bruce B	Total
2007	1.68E+14	1.08E+15	1.25E+15
2008	2.35E+14	2.32E+14	4.57E+14
2009	2.50E+14	3.78E+14	6.28E+14
2010	2.29E+14	4.86E+14	7.15E+14
2011	2.95E+14	5.10E+14	8.05E+14
2012	1.40E+14	1.14E+15	1.28E+15
2013	1.96E+14	4.19E+14	6.15E+14
2014	1.94E+14	6.42E+14	8.36E+14
2015	2.20E+14	6.72E+14	8.92E+14
2016	2.36E+14	5.07E+14	7.43E+14

### Comments

As has been previously noted, these emissions are annual totals. Any irregularities that have occurred over the year, such as spikes or variations in emissions from one period to another in that year, are not indicated in these Reports, and thus unavailable to the public.

As well, emissions from all four units of Bruce A and those of Bruce B are represented by one number for each station. Clearly not all units will have the same pattern of emissions.

Tritium emissions from Bruce B were elevated in 2007 and 2012 compared to the other years. According to the Environmental Monitoring Program Reports, the elevated tritium releases were associated with boiler leaks.<sup>17</sup> No information is provided on how much tritium leaked, when these leaks occurred, or from which units specifically. The increases in tritium from station in 2014 and 2015 are attributed to the draining of the Emergency Water Storage Tank (EWST) in preparation for the Vacuum Building Outage (VBO).

Except for information on tritium levels in drainage foundation sumps in individual units, no information is provided on the different sources of tritium released in effluent (i.e., active liquid waste, boiler discharges).

<sup>16</sup> The Annual Summary & Assessment Environmental Monitoring Reports for the years 2007-11 and the EMPR for 2012, 2013, provided the source for these data.

<sup>17</sup> EMPR 2013 p. 23 <http://www.brucepower.com/wp-content/uploads/2014/06/EMPreport.pdf>

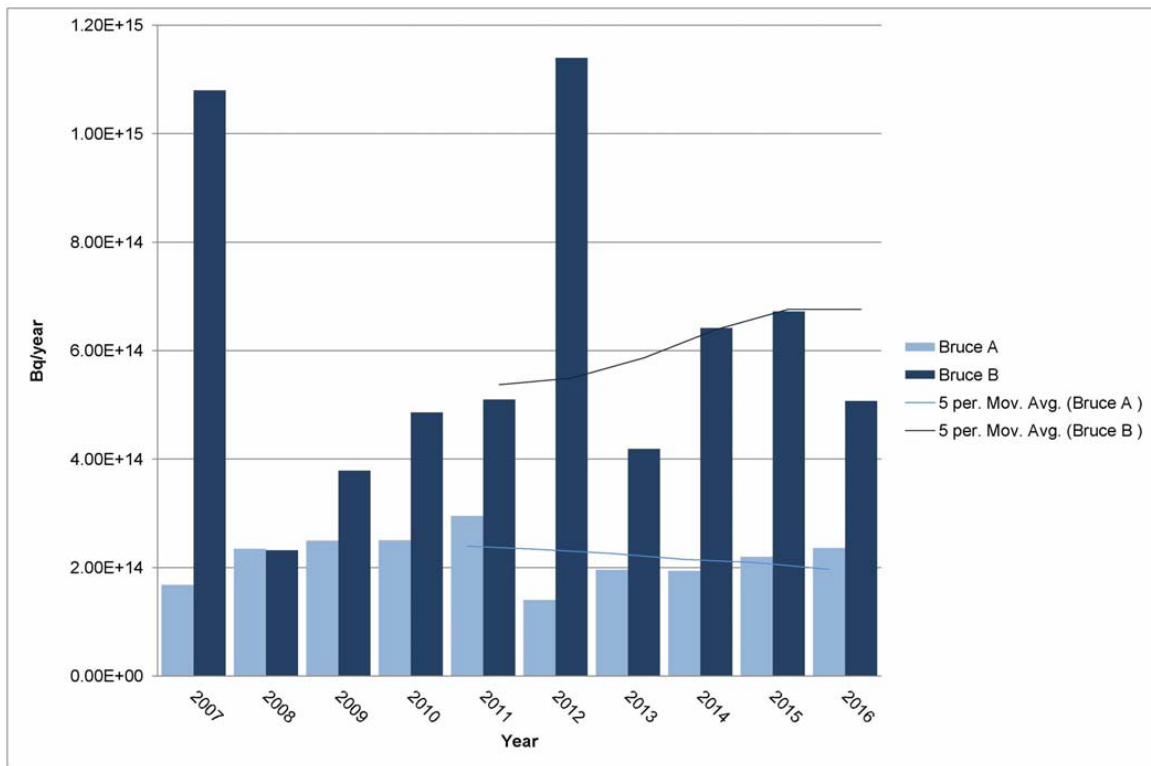
This speaks to the need to have information on tritium releases from all sources. Otherwise, these environmental reports are very limited and not as informative as they could be.

### “Trends” in Tritium Emissions

As has been noted, while trends in air and waterborne emissions of a substance, for example tritium, are shown graphically, these graphs are based on annually averaged data, and thus, do not provide the level of detail needed to show any irregularities or spikes.<sup>18</sup>

For example, the following graph in the 2016 Environmental Monitoring Report shows the “trend” in Tritium Waterborne Emissions for both Bruce A and B, and five and ten-year moving average lines.<sup>19</sup>

**Historical Tritium Waterborne Emissions (Becquerels/year)**



### Comments

Bruce A Units 1 and 2 were off-line until late in 2012. Units 3 and 4 experienced extended outages in 2012-13. This would account for the lower values of tritium from Bruce A compared to Bruce B.

There is no apparent trend for Bruce B. There are years when tritium emissions notably peaked (2003, 2007, and 2012). The “moving averages” are averages of averages. This is useless.

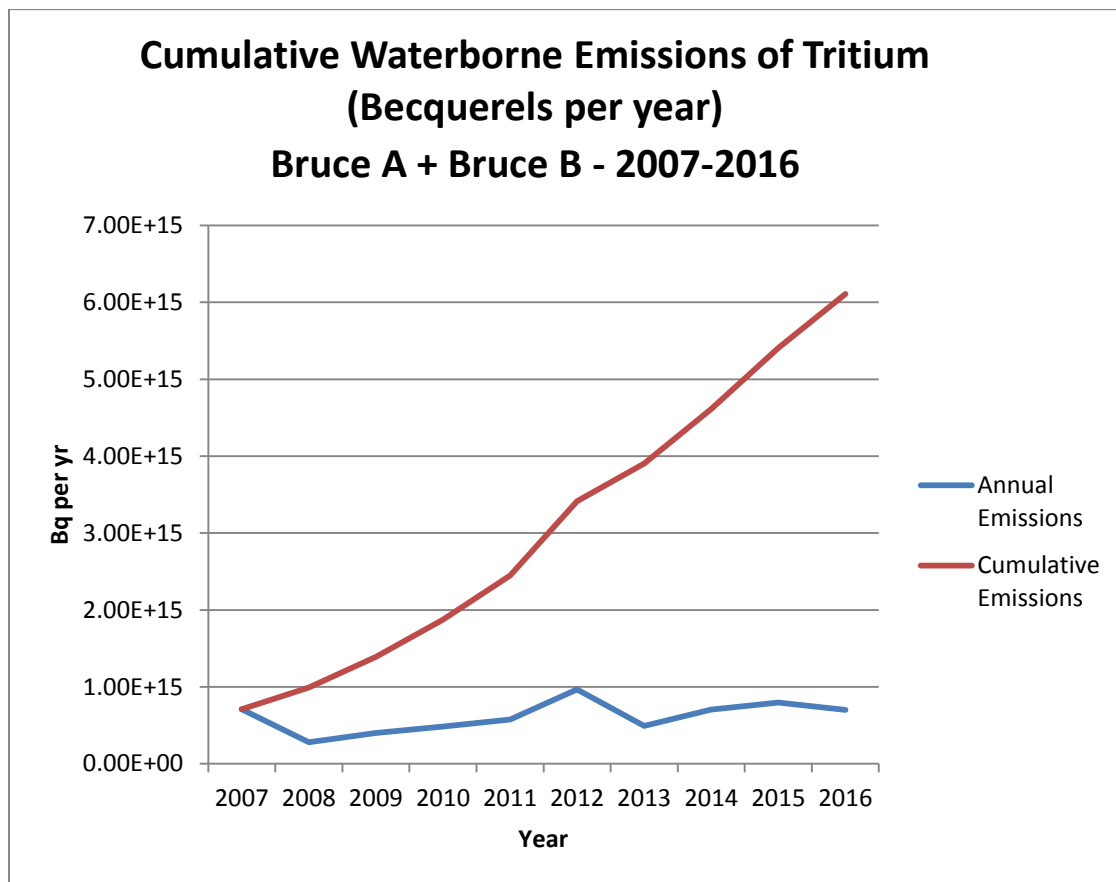
<sup>18</sup> Ibid pages 20 and 24

<sup>19</sup> Ibid p. 32

## Cumulative Waterborne Emissions of Tritium

Cumulative emissions of tritium are not addressed at all. Tritium has a half-life of 12.3 years. It will take over 10 half-lives (120 years) for the tritium activity to decay to 1/1000<sup>th</sup> of its initial level. Over the 12 year period of this graph alone, only about half of the tritium emitted in the early years has decayed. Over 30 years of operation, approximately 18.5% of the tritium that was released at the start of operations will still remain.

If cumulative levels of tritium released were taken into account for every year of operation, it would demonstrate that levels of tritium in water are increasing, even though some tritium will have decayed. The following graph highlights 10 years of cumulative tritium emissions to water, taking into account the decay of tritium in this period.



## Foundation Drainage Waterborne Effluent Results

The foundation drainage system for Bruce A and Bruce B maintains water levels of 577 ft (176 m) or less, thereby creating a local hydraulic sink. The system is designed to collect groundwater seepage. This water is discharged to Lake Huron through the CCW (Condenser Cooling Water (CCW)) duct and is monitored for tritium on a monthly basis.

The effluent results for tritium are reported for each unit and are included in the total water effluent results for each station.

As noted, the tritium concentrations vary considerably from month to month, resulting in higher than expected tritium levels that would come from groundwater seepage alone. While a number of reasons have been postulated for such variations, no clear explanation has emerged that would account for the extent of the variation in the tritium levels.<sup>20</sup>

The following table provides monthly data for tritium levels in the drainage sumps for the years 2013 to 2016 for Units 3 and 4 of Bruce A.<sup>21</sup>

**Tritium Monitoring Results (Bq/L) - Units 3 and 4 Foundation Drainage (2013-16)**

Month	Unit 3				Unit 4			
	2013	2014	2015	2016	2013	2014	2015	2016
January	15,170	539,460	260,110	160,210	740	724,460	64,010	240,500
February	42,180	658,600	392,940	266,030	11,470	77,700	36,360	66,970
March	12,950	494,320	219,040	750,360	5,550	403,670	235,690	69,970
April	24,050	1,132,940	303,030	110,630	233,100	12,580	210,900	24,790
May	41,440	98,050	443,260	56,610	643,060	124,690	72,520	118,400
June	30,340	116,180	1,218,040	25,900	616,050	382,210	112,110	20,720
July	202,760	3,330	122,100	2,960	52,540	27,380	n/a	21,090
August	376,290	41,070	52,540	44,770	1,023,050	83,990	26,640	8,880
September	325,600	343,730	31,450	232,730	944,240	532,060	7,770	140,600
October	444,370	227,920	56,980	81,030	752,950	65,490	5,180	21,830
November	189,440	413,660	315,240	84,360	14,800	97,310	740	39,960
December	912,050	862,840	335,220	312,280	1,150,330	8,510	45,140	183,150
<b>Average</b>	<b>218,053</b>	<b>411,008</b>	<b>312,496</b>	<b>177,323</b>	<b>454,083</b>	<b>211,671</b>	<b>74,269</b>	<b>79,735</b>

**Comments**

The data in this table vividly demonstrates the extensive fluctuations in the monthly concentrations of tritium and the extraordinarily high concentrations in the drainage sumps of Units 3 and 4. For example:

- In 2015, tritium concentrations in Unit 3 ranged from a low of 31,450 Bq/L in September to a high of 1,218,040 Bq/L in June. Tritium concentrations in Unit 4 ranged from a low of 740 Bq/L to a high of 1,150,330 Bq/L in 2013.
- The average tritium concentration in Unit 3 in 2014 was almost double of the average in 2013. Average concentrations in 2013 were a factor of 2-4 times higher as for the following years. What is the explanation for this?

These data are far more informative than the annual data that have otherwise been provided on tritium releases to water. The data illustrate the importance of having monthly

<sup>20</sup> REMP 2016 p. 34

<sup>21</sup> Data for 2013 - 2016 (EMPR 2013 -2016)



measured data rather than an annual “average” of tritium concentrations, particularly in light of the variations in the monthly data.<sup>22</sup>

Tritium concentrations drastically decrease from one month to the next in some cases.

What is the fate of this tritium?

Are spills of moderator heavy water loaded with tritium winding up in drains and sumps that are leaking into the layers of rock and soil underneath the reactor building?

Is the tritiated water slowly diffusing away from the reactor site and eventually reaching Lake Huron?

Since Bruce Power has a tritium removal facility that is used by the WWMF, is this facility being used to remove tritium before discharging the effluent to the lake?

This pattern of high and variable tritium concentrations in drainage foundation sumps has had a long history. For example, In the Annual Follow-Up Monitoring Report 2010, the CNSC commented that “Bruce Power should examine the root cause on why tritium concentrations in the sumps of Unit 3 was more than doubled (compared to 2008) instead of comparing the numbers with historical ranges and a 300,000 Bq/L generic criterion designed to deal with historic tritium contamination only.”

Similarly, Bruce Power should not use the argument that “tritium levels in the Unit 4 sump fluctuated between 30,000 and 800,000 Bq/L following restart to judge whether it is acceptable to have high concentrations of tritium in the sumps.”<sup>23</sup>

Based on the tritium levels in foundation drainages for the years 2013-2016 for these two units, it is not clear whether Bruce Power has acted on these comments, or if it has implemented measures to address these issues.

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<sup>22</sup> Annual Follow-up Monitoring Report, 2011, Golder Associates Report No. 11-1151-0243 Review of the 2009 Annual Report of the Bruce A Refurbishment Follow-up Monitoring Program Table 20 p. 74

<http://www.brucepower.com/wp-content/uploads/2014/06/2010-Bruce-A-EA-FUP-report.pdf>

<sup>23</sup> Ibid - Appendix A Table A1. Reviewer – CNSC: Comments and Proposed Change, Items 1 and 2.

## DERIVED RELEASE LIMITS (DRLS)

“Derived Release Limits” (DRLs) are the legal upper regulatory bounds set by the CNSC for releases of radioactive substances to the environment. The DRL represents the quantity of a radionuclide that, if released from the specified facility in a year, would result in a dose to the most exposed member of the public of 1 mSv/yr, i.e., the International Commission on Radiological Protection (ICRP) public dose limit. Exceedances of the DRL trigger reporting to the CNSC, followed by a formal investigation and regulatory oversight.<sup>24</sup>

DRLs are calculated for specific radionuclides expected to be found in the airborne and liquid operational effluents as defined in CSA Standard N288.1.<sup>25</sup> Each of these radionuclides belongs to one of the radionuclide groups identified in the Bruce Power’s Licence Condition Handbook.<sup>26</sup>

The following table illustrates the DRLs for specific radionuclide groups for Bruce A and B.

**Current Derived Release Limits**

		<b>Bruce A</b>	<b>Bruce B</b>
Release Category	Radionuclide Group <sup>1</sup>	DRL Becquerels/year (Bq/yr)	
Air	Tritium	1.98E+17	3.16E+17
	Carbon-14	6.34E+14	7.56E+14
	Iodine (mixed fission products)	1.14E+12	1.35E+12
	Noble Gases <sup>2</sup>	1.12E+17	2.17E+17
	Particulate (Alpha)	2.96E+11	5.77E+11
	Particulate (Beta/Gamma)	1.73E+12	3.61E+12
Water	Tritium	2.30E+18	1.84E+18
	Carbon-14	1.03E+15	1.16E+15
	Gross Alpha	1.12E+14	1.21E+14
	Gross Beta/Gamma	4.58E+13	5.17E+13

<sup>1</sup> The unit DRL for Noble gases is in Bq-MeV/year

As indicated in Bruce Power’s Licence Conditions Handbook (LCH): “Individual DRLs are calculated for about 118 radionuclides and isotopes. Only the significant radionuclide groups which are given in the table are monitored and reported to the CNSC.”<sup>27</sup>

The lowest value of the DRLs of radionuclides within a particular group is selected as the limiting DRL for the radionuclide group. For example, the Particulate or Gross Alpha group includes the following radionuclides: Am-241, Am-243, Cm-242, Cm-244, Np-237, Np-239, Pu-238, Pu-239, Pu-240, Pu-242, U-234, U-235, U-236, and U-238.

<sup>24</sup> CMD 15-H.2 e-Doc: 4579312 Environmental Assessment Information Report p. 16

<sup>25</sup> The methodology for establishing DRL models is based on the Canadian Standards Association (CSA) standard CSA N288.1-08: *Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities.*

<sup>26</sup> Licence Conditions Handbook (LCH-BNGS-R003) for Bruce Power July 2017, CNSC e-Doc 5184184 p. 68,69

<sup>27</sup> P. 69 Licence Control Handbook (LCH) July 2017

The DRL for Gross Alpha for Bruce A waterborne emissions,  $1.12 \times 10^{14}$  Bq/yr, is based on the most restrictive alpha emitter identified in this group, which is Cm-244. In comparison, the DRL for U-235 is  $8.43 \times 10^{14}$  Bq/yr, which would be less restrictive.

A review of DRLs for a number of nuclear facilities, including Bruce Power clearly indicates serious issues as to their veracity and thus, their effectiveness as regulatory tools. For example:

- DRL models are prepared by the licensee and reviewed by the regulator. Models are used in preference to monitoring actual emissions as a basis for establishing the limits. Licensees may choose model parameters that underestimate doses without the benefit of public or independent expert peer review.
- Dose estimates for air emissions are based on assumptions about the behaviour of stack plumes, which are notoriously difficult to model. Compounding the problem is the local meteorology which Bruce Power, in its response about modelling data for the passive vs. active air sampling monitors, claims to be very unreliable for this region.<sup>28</sup>
- Estimates of public doses arising from waterborne discharges of radionuclides are based on the dilution capacity of receiving waters, which is calculated using the average rather than the minimum water flow. The latter would be more appropriate because of variations in water flow caused by climate change and other factors.
- The methodologies for determining DRLs do not take into account the cumulative effects of exposure to multiple radionuclides over time.

Nuclear licensees and the CNSC often report emissions as percentages of DRLs, in addition to reporting the actual emissions. Because of the sheer magnitude of difference between DRLs and emissions, these percentages lead to dismissing the actual emissions as insignificant. This is seriously misleading. It does not necessarily show that the emissions are insignificant. Rather, it could also indicate that the DRLs are not appropriate.

The following examples of the DRLs for tritium and U-235 demonstrate the degree of difference between reported emissions compared to the DRLs for these radionuclides.

**Tritium DRLs - Bruce A and B in Bq/yr**<sup>29</sup>

	<b>Water</b>	<b>Air</b>
Bruce A	2.30E+18	1.98E+17
Bruce B	1.84E+18	3.16E+17

<sup>28</sup> Bruce Power's quote - 12/2/18: "the geographical extent of the need for such measures is very specific to radioactivity deposition patterns that are affected by considerations such as particle size and regional topography that are not well predicted by computer models. Given the time delay related to ingestion pathways, it is preferable to rely on field and laboratory measurements to determine the extent of any mitigation measures, with the current Emergency Planning Zone radius as an initial guide for resource planning purposes."

<sup>29</sup> Licence Control Handbook Effective July 2017, CNSC e-Doc 5184184 p. 68,69

For the year 2016, the annual tritium air emissions are approximately 0.29% of the DRL for Bruce A and 0.18% of the DRL for Bruce B. Similarly, emissions of tritium to water are a maximum of 0.01% of the DRL for Bruce A and 0.03 % of the DRL for Bruce B.

**U-238 DRLs - Bruce A and B in Bq/yr**<sup>30</sup>

	Water	Air
Bruce A	9.37E+14	1.71E+12
Bruce B	7.56E+14	2.26E+12

In 2009, the DRLs for the annual waterborne emissions of U-238 were  $4.53 \times 10^{14}$  Bq/yr and  $4.83 \times 10^{14}$  Bq/yr for Bruce A and B respectively. The DRL for Bruce A has doubled from 2009 to 2014 and increased by more than 55% for Bruce B. No explanation has been given for this change in DRLs.

As in the case of tritium, there are different DRLs for U-238 for Bruce A and B. Apparently, this is a reflection of the process used to determine DRLs, but from a public perspective, it is not clear why there are different DRLs.

**Comparison of DRLs to Reported Emissions**

There is a total disconnect in terms of the sheer magnitude of the difference between the emissions reported for specific radionuclides, (e.g., Tritium) and the DRLs. In examining this problem, two fundamental issues need to be addressed:

- i) The methodology used to determine DRLs; and/or
- ii) The accuracy of the releases that are reported and whether they account for what is actually being emitted (both monitored and fugitive emissions).

The following table illustrates the Annual Airborne Emissions of Tritium Oxide from Bruce A and B, the Central Maintenance and Laundry Facility (CMLF), and the Western Waste Management Facility (WWMF) for the years 2014-2016 and their respective DRLs.<sup>31</sup>

Facility	Airborne Emissions (Bq/yr) of Tritium 2014-2016			DRL (Bq/yr)
	2014	2015	2016	
Bruce A	7.51E+14	7.05E+14	5.66E+14	1.98E+17
Bruce B	4.13E+14	3.74E+14	5.70E+14	3.16E+17
CMFL	6.55E+09	1.06E+10	6.99 E+9	2.45E+17
WWMF	7.17E+12	4.14E+12	2.06E+13	2.96E+17

The DRL for the CMFL is a hundred million times greater than the reported emissions. Furthermore, it is almost identical to the DRLs for Bruce A or B and the WWMF. There is no explanation as to why a laundry facility would have such a large DRL.

<sup>30</sup> Correspondence from Bruce Power.

<sup>31</sup> Refer to Environmental Monitoring Reports, 2014 to 2016. Tthe Douglas Point Waste Management Facility (DPWMF), also on the Bruce site reports releases of Tritium of  $2.74 \times 10^{11}$ ,  $1.33 \times 10^{10}$ , and  $1.59 \times 10^{11}$  for those years.

The DRLs for Bruce A and B are at least 100 to 1000 times the reported emissions. The sheer magnitude of these differences, and especially for the CMFL, should raise serious questions and a call for explanations to account for these results.

If the basis for these differences lies with the reported emissions, then one would presume that there are problems with monitoring and the applications of and assumptions made by models. Even if the reported releases are off by a factor of two or three, that would not, by any means, make the DRLs more plausible or credible because of the sheer differences in magnitude.

Thus, we surmise that there are very serious issues with the determination of the DRLs. This is a critical problem, given that DRLs are annual legal limits. Even Action Levels (ALs), which are based on DRLs, and serve as an early warning system of a potential problem, are useless.

DRLs are independent of how a radioactive emission is produced, but depend on the degree of exposure of an individual to the emission which, in turn, depends on a number of factors, including the proximity of the individual to the source of the release, their age, (child, adult, sex), their lifestyle etc. Exposed individuals are classified as groups. The group predicted to receive the highest dose is referred to as the representative or critical group.

The determination of DRLs involves models (e.g., the Environmental Transfer Model) and many factors including identifying and characterizing representative persons, exposure pathways, meteorology, and dose conversion factors (also referred to as dose coefficients). These dose factors are used convert Becquerels to Sieverts for a specific radionuclide and provide the estimated radiation dose imparted to a cell, tissue or organism by the radioactive decay of one atom of that radionuclide.

An underestimation of this factor can result in a misrepresentation of the impact of a particular radionuclide. For example, tritium's dose factors are, by some margin, the lowest among common radionuclides and potentially a serious underestimation of the impact of tritium. As a result, tritium is widely regarded as a "weak" radionuclide and is typically listed in the lowest radiotoxicity category.<sup>32</sup>

As well, there are complications with the variability in meteorology, the specific locations selected, and the critical (or representative) groups identified. The "safe" "public dose" of 1 mSv has come under criticism, and has been acknowledged, even by the CNSC, not to be a health standard.

Individuals or groups (*representative, critical*) residing in the proximity of the station are exposed to several sources of emissions of tritium and other radionuclides continuously, 24 hours a day, and have been exposed to these emissions for many years.

DRLs do not or cannot account for the combined, cumulative exposure from all the sources of emissions of a particular nuclide or the combination of nuclides, annually let alone for decades.

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<sup>32</sup> The dose coefficients for adults are  $1.8 \times 10^{-11}$  Sv/Bq for aqueous tritium (HTO) and  $4.2 \times 10^{-11}$  Sv/Bq for Organic Bound Tritium (OBT). Similarly, OBT's dose coefficient should be increased to be 4 to 5 times greater than that for HTO. Tritium Hazard Report June 2017: Ian Fairlie p. 47-51

## ACTION LEVELS (ALS)

The CNSC requires licensees to determine ALS to serve as an early warning to indicate when releases may be deviating from the norm.<sup>33</sup> ALS are typically about 10% of DRLs. Exceedances of ALS trigger reporting to the CNSC. While exceeding a DRL is a violation of a licence condition that would result in a CNSC enforcement action, it is not a regulatory noncompliance or violation. In the case of U-238, an action level would never be triggered.

Unlike DRLs, which are established on an annual basis, the ALS are established to compare with monitoring data and are in months (for water) and weeks (for air). For example, the ALS for tritium releases to water and air at Bruce Power are:

	<b>Water (Bq/month)</b>	<b>Air (Bq/week)</b>
Bruce A	$1.35 \times 10^{16}$	$2.70 \times 10^{14}$
Bruce B	$1.22 \times 10^{16}$	$5.40 \times 10^{14}$

While ALS may indicate spikes or irregularities, they are inordinately high in comparison to the actual monitored emissions. For example, the AL for emissions of tritium to air for one week is approximately the same as the annual monitored emissions of tritium to air. The AL for emissions of tritium to water is 100 times greater in one month than the emissions of tritium to water in a year.

Besides being non-regulatory, the methodology for establishing or calculating ALS, which is in the hands of the licensee, has not been consistently applied.<sup>34</sup> Even so, ALS have been exceeded during Bruce Power's previous licence period.<sup>35</sup>

In that both the DRLs and ALS are orders of magnitude greater than the reported releases, they do not serve as effective and meaningful measures to protect the public and the environment. It is essential that the CNSC address this matter, which has been pointed out for quite some time.

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<sup>33</sup> <http://nuclearsafety.gc.ca/eng/resources/educational-resources/feature-articles/radiation-dose-limits-release-limits-and-action-levels.cfm>

<sup>34</sup> CNSC DIS-12-02: Process for Establishing Release Limits and Action Levels at Nuclear Facilities February 2012

<sup>35</sup> CNSC CMD 15 H-2 p. 61 Exceedances of ALS: the Bruce A Unit 1 Alpha Event in November 2009, and the Bruce B Unit 6 Moderator Spill Event on May 31, 2010.

## OPERATIONAL AND AGING ISSUES

### Overview

The following table shows the in-service dates for the reactors at Bruce A and B from their initial start-up to December 2017.

**Bruce A and B: In-Service dates (m/d/y) to Dec. 31 2017**

Unit	Start-up Date	Lay-up Date	Return to Service	Total years in service (y/m)
1	9/1/1977	10/16/1997	9/19/2012	25 y 4.5 m
2	9/1/1977	10/18/1995	10/16/2012	23 y 3.5 m
3	2/1/1978	4/9/1998	1/9/2004	34 y 1 m
4	1/18/1979	3/16/1998	10/7/2003	33 y 4.5 m
5	3/1/1985			32 y 9 m
6	9/14/1984			33 y 3 m
7	4/10/1986			31 y 8 m
8	5/22/1987			30 y 4 m

Units 1 and 2 of Bruce A were shut down for about 17 years and underwent full refurbishment. Units 3 and 4 underwent a lengthy shutdown during the period 1998-2003-4, during which Bruce Power was required to perform several improvements prior to their restart.<sup>36</sup> In addition, these two units experienced very lengthy outages of well over 200 days duration, during the period from 2011-2013.

As the table indicates, Units 3-8 have been operating for approximately 30-34 years, and thus, highly prone to aging issues that can occur in CANDU reactors that have operated for such a long time. Bruce Power plans to refurbish units 3-8 over a thirteen year period, starting with Unit 6 in 2020. Thus, these reactors would be required to remain in operation for several more years, despite their lengthy operation to date.

### Aging Issues of CANDU Reactors

The aging of fuel channels (calandria and pressure tubes) is considered to be the single greatest cause of declining performance in CANDU reactors. Over time, fuel channels are subject to deterioration and embrittlement, which could lead to rupturing. Steam generators are the second greatest cause of performance problems.

Replacing fuel channels is essentially re-building the reactor core, an operation characterized as a “heart transplant”. Replacing steam generators is essential to protect the integrity of the radioactive/non-radioactive barrier.

The following sections examine specific aging issues of fuel channels, in particular pressure tubes and steam generators.

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<sup>36</sup> Communication from CNSC October 11, 2012

## **A. Fuel Channels**

The fuel channel components most affected by degradation are the pressure tubes. Problems with pressure tubes have plagued CANDUs since the mid-70s, including leakages at the pressure tube rolled joints, neutron-induced creep, embrittlement and blister formation due to excessive hydrogen pickup, fretting and corrosion, and have resulted in the replacement of some of the tubes causing lengthy outages.

As the reactors age fuel channels become more vulnerable to such problems, resulting in an increased potential for cracks to develop. If not detected or repaired (if that is even possible), this could lead to a Loss of Coolant in the Heat Transport System (HTS).

Aging issues in fuel channels are particularly critical in light of Bruce Power's application for a ten-year operating licence for Bruce A and B, not only because of the current age of Units 3-8, but also because the licence renewal application includes extending the end-of-life of the fuel channel components beyond the current licence limit, referred to as the "hold point", from 247,000 Equivalent Full Power Hours (EFPH) to 300,000 EFPH before replacing these components.

The following sections describe specific aging issues with respect to major components of fuel channels, namely, Pressure Tubes, Calandria Tubes, Spacers (i.e., the Annular Gas System) and Feeder Pipes.

### **a) Pressure Tubes**

The 480 fuel channels in each of the Bruce Power's reactors consist of an outer calandria tube and an inner pressure tube. The principal function of pressure tubes is to support and locate the fuel in the reactor core, and allow for slightly alkaline heavy water coolant to be pumped at high pressure through the fuel in order to remove the heat created by the fission process.

Pressure tubes are prone to aging problems from a number of factors, such as the weight of the fuel bundles, the high temperatures, pressures and radiation fields (neutron radiation) in the reactor core, the absorption of hydrogen, the embrittlement of their metal walls (zirconium alloy), corrosion and deterioration.<sup>37</sup>

These stressors change the dimensions and material properties of pressure tubes. Over time, the tubes increase in diameter (known as diametrical creep) and length, causing their walls to thin out and sag and potentially come into contact with the outer calandria tube, which increases the likelihood that they will rupture. As a result, their useful life and the maximum power a reactor can provide are limited.

### **i) Fracture Toughness - Hydride Formation**

A reduction in fracture toughness caused by an increase in hydrogen concentration (also referred to as deuterium uptake) is the dominant contributor to the failure pressure tubes.<sup>38</sup> As the operation time of the reactor increases, so does the concentration of hydrogen. The

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<sup>37</sup> [http://www-pub.iaea.org/MTCD/publications/PDF/te\\_1037\\_prn.pdf](http://www-pub.iaea.org/MTCD/publications/PDF/te_1037_prn.pdf)

<sup>38</sup> CMD 15-H2 Aging Management p. 49-53: CNSC Commission Public Hearing Part 2 – Licence renewal re Bruce Power CNSC staff February 27, 2015



accumulation of hydrogen results in the formation of blisters and cracks, a process referred to as hydrogen embrittlement. This can result in a loss of toughness, and cause a stable, time-dependent crack growth mechanism called Delayed Hydride Cracking (DHC). This is most pronounced during the reactor's transition states between shut down to full power and vice versa.

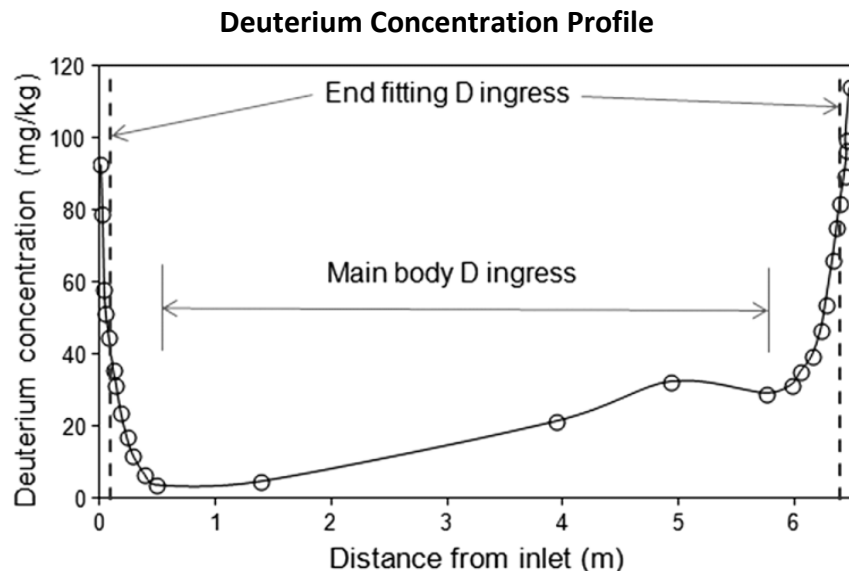
During DHC, hydrides migrate to stress regions and promote crack growth. When a critical condition is reached, probably related to size, a fracture develops, the crack extends, and the process continues on the newly exposed metal.

## ii) Deuterium Ingress and Corrosion

During "hot" operation conditions, i.e., when the reactor is operating, pressure tubes react with the heavy water coolant, resulting in an increase of the concentration of hydrogen (that is, deuterium in terms of the equivalent hydrogen concentration,  $H_{eq}$ ) over time. The pressure tubes absorb deuterium in two main locations, the inside surface of the main body of the pressure tube and the end fittings where the ingress of hydrogen is much more rapid than in the body of the tube.

Pressure tube material has a limited solubility of hydrogen, referred to as terminal solid solubility (TSS) that increases with increasing temperature. If sufficient quantities of deuterium are absorbed the TSS is exceeded, leading to the formation of zirconium hydrides. These hydrides weaken the cladding of the pressure tubes by decreasing its hardness, ductility and density, making them susceptible to DHC, which could cause pressure tube failures.

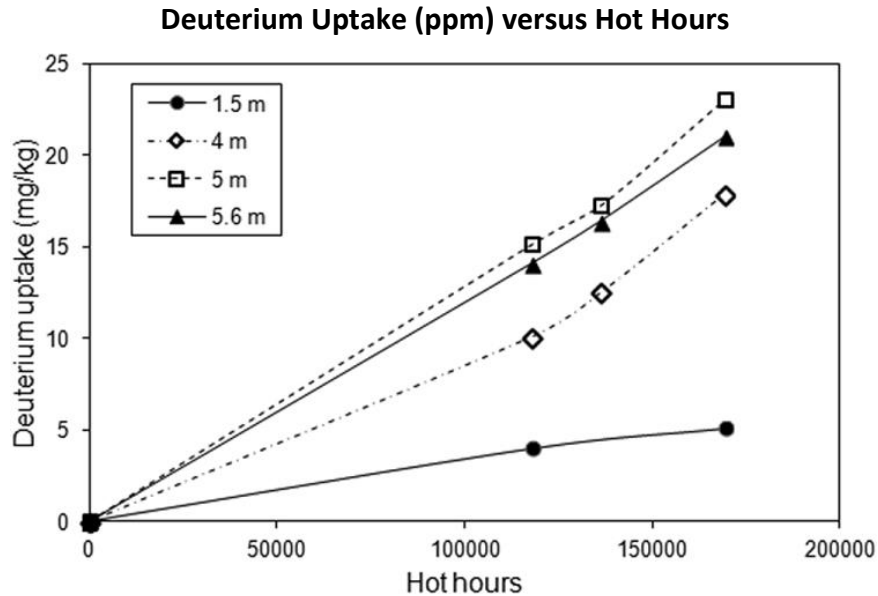
The following figure shows a typical deuterium concentration profile (in mg/kg, equivalent to parts per million-ppm) along the axial length of a pressure tube after ~17 hot years of service.<sup>39</sup>



<sup>39</sup> PERFORMANCE OF PRESSURE TUBES IN CANDU REACTORS, June 2016; Malcolm Griffiths et al, Canadian Nuclear Laboratories, Chalk River, ON, K0J 1J0 Canada p.8 <http://pubs.cnl.ca/doi/full/10.12943/CNR.2016.00007> The vertical dashed lines represent the location of the burnish mark.

As the graph illustrates, the deuterium concentration increases along the main body of the pressure tube and peaks near the outlet end. Approximately 2%–10% of the deuterium generated by the corrosion process is absorbed along the body of the tube. The rolled joints at the ends of the pressure tubes are particularly susceptible to enhanced deuterium pickup. The primary cause may be due to corrosion in the crevices between the pressure tube and the end-fittings.

The following graph illustrates the relationship between deuterium uptake (in ppm) to “hot hours” at various locations in the main body of the pressure tube. i.e., 1.5, 4, 5.6 meters.<sup>40</sup>



As demonstrated, the rate of uptake of deuterium further along the tube (at the 4 to 5 m locations) is accelerating, in comparison to an approximate steady rate at 1.5 m. However, there is also variability in the rate of deuterium ingress between reactors and pressure tubes.

CSA (Canadian Standards Association) N285.8 limits the allowable  $H_{eq}$  in the main body of a pressure tube and in the tensile portion of the rolled joint region to 70 ppm at the inlet and 100 ppm at the outlet. Because of the limited fracture toughness data at high  $H_{eq}$  values to date, it has been difficult to demonstrate that operation is safe at  $H_{eq}$  values approaching N285.8 limits.

Although hydrogen pick-up in pressure tubes has been researched for decades, it remains a major issue of uncertainty. Bruce Power is employing models and performing tests to determine the resilience of pressure tubes with increasing levels of  $H_{eq}$ .

It remains to be seen whether these models and tests will guarantee safe operation before Bruce Power plans to carry out the required maintenance work on Units 3-8.

<sup>40</sup> Ibid p. 8 Note that the concentration of deuterium in mg/kg is ppm.

### **iii) Material Wear and Fretting**

Pressure tubes sustain varying degrees of mechanical wear caused by the passage of fuel bundles. Repeated residence pads bearing fuel bundles in the same location, and small pieces of trapped debris, can lead to fretting flaws and crevice corrosion. These local stress concentrators, under certain conditions, can act as initiation sites for DHC.

Pressure tube oxide spalling (i.e., flakes of material broken off by corrosion) can be caused by fretting. Because oxide thickness provides a measure of hydrogen pick-up, oxide spalling could affect this measurement and lead to uncertainties as to the hydrogen pick-up level that has occurred.

The design analyses of these tubes must take into account the dimensional changes of pressure tubes from the effects of creep and growth over their intended design life. With the inevitable deterioration of the pressure tubes, resulting in the degradation of the Heat Transport System (HTS), the safety margins of the operation of the reactor are compromised.

Issues related to the aging of fuel channel components other than pressure tubes, specifically, calandria tubes, feeder pipes and spacers are briefly described in the following section.

#### **i) Calandria tubes**

The main integrity issue for calandria tubes is irradiation-enhanced deformation which causes sagging and localized deformation at spacer locations. This could make it difficult for fuel bundles to pass through the sagged calandria tube during replacement. It could also result in contact between sagged calandria tubes and other reactor structures, which could lead to fretting damage of the calandria tubes and compromise integrity.

#### **ii) Feeder pipes**

Feeder pipes, which are connected to both ends of a fuel channel, carry the heavy water coolant to and from the steam generators. These pipes are bent, highly radioactive, have a very small diameter, and are very difficult to monitor. Over time, they are subject to severe degradation due to pipe cracking and wall thinning. This is the limiting active degradation factor in Bruce A and B feeders. It is particularly widespread in CANDU outlet feeders, and is a very serious issue for aging reactors.

The wall thickness at a feeder pipe bend is subject to considerable variability, making it necessary to take measurements in a number of different places to determine whether thinning has made the feeders unfit for service.

As acknowledged by the CNSC in a technical presentation at an IAEA workshop on the corrosion of feeder pipes, "The limited knowledge regarding the causes of the degradation may lead to susceptible areas that are not inspected."<sup>41</sup>

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<sup>41</sup> Abstract of the technical presentation by CNSC presented at: IAEA workshop Moscow, Russia April 21-23, 2009  
Prepared by John C. Jin and Raoul Awad, CNSC  
[http://nuclearsafety.gc.ca/eng/readingroom/technical\\_papers\\_presentations\\_and\\_articles/2009/apr09.cfm](http://nuclearsafety.gc.ca/eng/readingroom/technical_papers_presentations_and_articles/2009/apr09.cfm)

### iii) Spacers (The Annulus Gas System (AGS))

The integrity of annulus spacers (loose and tight-fitting), which are used to keep each pressure tube separated from the surrounding calandria tube is mainly affected by neutron irradiation, imposed loads, rolling wear, and deuterium (hydrogen) uptake during operation.

The movement of loose-fitting annulus spacers and the potential small movement of tight-fitting spacers (as discovered during the Bruce Unit 8 2013 outage) can increase the risk of contact of the pressure tube with the calandria tube. In the presence of sufficiently high hydrogen concentrations in the pressure tubes, this can lead to hydride blister formation on the outside of the pressure tube. With prolonged contact, hydride blisters may become large enough to initiate DHC and thereby compromise the integrity of the pressure tube.

## B. Steam Generators

Steam generators incorporate thin-walled pipes (also called tubes) where coolant from the reactor core circulates to transfer heat to the turbine side of the station. These pipes constitute one of the primary barriers between the radioactive and non-radioactive sides of the plant. If a tube bursts while a plant is operating, radioactivity from the primary coolant system could escape directly to the atmosphere in the form of steam. For this reason, the integrity of the tubing is essential in preventing the leakage of radioactivity into the environment.

Steam generators are very sensitive to corrosion induced by chemical attack, and particularly to attack from deposits left by the concentration of boiler water contaminants. Problems with steam generators also include clogging of the pipes due to mineral deposits, 'fretting' or breakage of the internal pipes due to excessive vibration, and stress corrosion cracking of the metal that can result in the release of radioactive water.

U-bend fretting has occurred at Darlington units, which could also be the case for any of the units at Bruce Power. Even with water chemistry improvements, inspections, and cleaning programs, problems with steam generators are known to persist.<sup>42</sup> To date, no information has been provided as to U-bend fretting of steam generators at any of Bruce units.

Prolonged operation with degraded steam generators will ultimately increase radiation exposure and result in extended outages due to the increasing need for extensive tube inspection and repair.

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<sup>42</sup> Babcock and Wilcox, the manufacturers of the Steam Generators for Darlington, Bruce and Pickering [http://www.iaea.org/inis/collection/NCLCollectionStore/\\_Public/31/018/31018404.pdf](http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/31/018/31018404.pdf); <https://canteach.candu.org/Content%20Library/NJC-1-4-10.pdf>; and <http://www.power-eng.com/articles/print/volume-100/issue-1/features/steam-generator-replacement-overview.htm>

## FITNESS FOR SERVICE

### Equivalent Full Power Hours (EFPH) – Hold Points

Equivalent Full-Power Hours (EFPHs) are the number of hours per year that a reactor is operating at full power.<sup>43</sup> If a reactor operates at approximately 80-90% of its power capacity in a particular year, the EFPH ranges from approximately 7000 to 8000 EFPH. The cumulative EFPHs over the years of operation of a reactor are “hold point” limits set by the CNSC.

For decades, the hold point for CANDU reactors was 210,000 EFPH, based on a planning assumption that the reactors would operate at 80% power capacity for at least 30 years to satisfy function and economic life requirements.<sup>44</sup> However, as Bruce units 5 and 6 would reach this limit prior to its licence renewal in 2015, the CNSC Commission authorized these units to surpass this limit to allow operation up to 245,000 EFPH. Bruce Power subsequently requested and was given approval to operate all of its units up to 247,000 EFPH for its current licence period, which would align it with the hold point for OPG’s Pickering units.<sup>45</sup>

Bruce Power’s maximum licensed capacity factor power is 93% of full power, equivalent to 8147 EFPHs in a given year.<sup>46</sup> Over decades of operation, this optimum EFPH has rarely been attained. EFPHs have tended to range from 7,000 to 8,000 annually for most units, except for periods of extensive outages.

Once more, Bruce Power is requesting approval by the Commission to further extend its current EFPH limit, this time to 300,000 EFPH, for its operating licence renewal for the years 2018-2028.

### Outage Schedule for Major Component Replacement (MCR)

The following table illustrates the estimates of the predicted EFPH for Units 3-8 at the time of their corresponding Life Extension Outage and the estimated maximum Heq at that time.<sup>47</sup>

Unit	Estimated Year to reach 120 H <sub>eq</sub> ppm	MCR Outage Date	Predicted EFPH at MCR	Estimated H <sub>eq</sub> ppm at MCR
3	n/a	2023	245,000	102
4	n/a	2025	255,000	104
5	2020	2026	294,000	151
6	Dec. 2019	2020	245,000	121
7	2022	2028	300,000	147
8	2027	2030	300,000	139

<sup>43</sup> EFPHs are calculated by subtracting from the total number of hours per year (i.e., 24x365 = 8760 EFPH) the number of hours of outages that year, that is, no power is being produced. [Candu 6 Equipment Design Life Lepreau](#)

<sup>44</sup> Licence Control handbook (LCH) Bruce Power: Page 58-9

<sup>45</sup> CNSC Commission Public Hearing Part 2 – Licence renewal re Bruce Power CNSC staff February 27, 2015

<sup>46</sup> Correspondence with Bruce Power, November 2017

<sup>47</sup> CMD 18-H4 Supplementary Presentation by CNSC March 14, 2018, p. 47 (Note, EFPHs estimated by CNSC are approximately 2,000-3,000 EFPH higher than predicted by Bruce Power (CMD 18-H4.1A Supplementary Presentation by Bruce Power March 14, 2018, p. 27)

Based on the life extension outage schedule and the current cumulative 2017 EFPH levels, these units would be operating, on average, at less than 7000 EFPH per year, in particular, Units 3, 4 and 6, prior to the commencement of their MCR outages. This indicates that outages planned for routine maintenance of Units 3-8 will be lengthy.

In fact, Bruce Power expects that the duration of the planned outages will vary from 45 days to over 100 days, depending on the maintenance work and inspections required. The longer outages (i.e. over 100 days) are intended to ensure that the last units to undergo MCR outages will not exceed 300,000 EFPH for the pressure tubes prior to the scheduled outage dates. Bruce Power also notes that its outage predictions do not take into account any forced loss rate.<sup>48</sup>

### Comments on Outage Schedule

- The EFPH for three of the units (5, 7 and 8) will be approaching 300,000 EFPH limit and could exceed the predicted EFPHs by the time their outage date is planned. If the timetable for life extension and MCR outages is extended, then it is very likely that the proposed EFPH limit will be exceeded for these units.
- Unit 6 is slated to be the first unit to undergo MCR work although the predicted EFPH for that Unit at that time will be 243,000, at least 50,000 less than Units 5, 7 and 8. The rationale for setting the outage dates for each unit has not been explained.
- Units 3 and 4 have undergone major outage periods during their long life span, not only for several years during the period 1998-2003-5, but even more recently in 2011-13.

In the case of Unit 3 an outage lasting 210 days, from November 2011 to June 2012, was related to the elongation of pressure tubes to a point where the tubes would soon have exceeded the allowable length tolerance.<sup>49</sup> During this outage, crews shifted the position of all of the pressure tubes to allow room for their elongation. This work, referred to as the “West Shift program”, was intended “to ensure the operation of the reactor through at least the end of the decade.”<sup>50</sup>

With respect to Unit 4, the extensive outage lasted 255 days, from August 2012 to April 2013, during which its generator rotor was replaced. This unit had also exhibited a higher frequency of predicted Delayed Hydride Cracking (DHC) initiations and pressure tube ruptures than other units.

The experience with these units could be indicative of further problems with them prior to their proposed MCR outage dates. This raises the question as to whether Bruce Power and/or the CNSC should consider not proceeding with refurbishing these units if it could be unsafe to keep them operating to the current EFPH limit, or for that matter, the requested 300,000 EFPH limit.

While outages are planned for routine maintenance work prior to a unit undergoing MCR, unplanned (forced) outages and emergencies can and should be expected to occur and would

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<sup>48</sup> Ibid – Correspondence from Bruce Power: The MCR EFPH’s are calculated based on the assumption of 93% reactor full power (our current licensed maximum power) and take into account the planned outages.

<sup>49</sup> CNSC: Commission hearing CMD 15-H2 p. 23, also Submission by Eugene Bourgeois and Anna Tilman, 2015

<sup>50</sup> Bruce Power CMD 15-H2.1 p.6

require immediate attention. Not only would this affect the timing of Bruce Power's refurbishment, it would also place stress on the workforce needed to handle emergencies.

Delays in schedules, shortages in equipment and skilled workers, unforeseen circumstances, and emergencies could all jeopardize Bruce Power's plan. Bruce Power should have prepared different schedule scenarios that at the very least, would allow for some variants to be handled. At the same time, the CNSC should set boundaries on the flexibility that would be required for safety if the EFPH limit were extended even beyond 300,000 EFPH.

The increases in EFPH limits are potentially pushing the boundaries of safety. This calls to question as to whether the increase in the EFPH limit is being determined by the proposed outage schedule. What is the fall-back plan if the schedule is delayed? Does Bruce Power then request a further increase in EFPH for the remaining units?

While Bruce Power has indicated in its licence application that it would be safe to operate these units up to 300,000 EFPH, it also indicated that it would shut down a unit if any problems should develop.

While we sincerely expect and trust that such action would be taken, this does not alleviate the safety concerns resulting from a substantial increase in the permissible EFPH, especially considering the adverse aging effects that are more pronounced with time.

### **Hot Hours vs EFPH**

Many of the aging mechanisms discussed affecting fuel channel components are driven by thermal conditions i.e., high temperatures, and thus depend on the time that a reactor is at its operating temperature, that is the "hot hours", whether or not the reactor is producing power. This is greater than EFPHs which include only the time during which power is produced.

While cumulative EFPHs are the determining factor used by CNSC and nuclear operators in assessing the safety of fuel channel components, the accumulated "hot hours" is far more relevant in assessing the effects of aging on these components, particularly as this metric includes all of the time that the components are subjected to thermal effects. In fact, many references in the literature pertaining to aging effects on CANDUs refer to hot hours, not EFPH.<sup>51</sup>

While the difference between EFPHs and Hot Hours on an annual basis may be relatively small (e.g., 5% or so), over time (20 or more years of operation), this difference can become significant in assessing the effects of aging, especially with respect to pressure tubes.

Furthermore, not using "hot hours" of operation of a reactor rather than EFPHs as the appropriate metric to assess the long-term safety of pressure tubes, this could result in approving a "hold point" that is potentially not safe, which is contrary to CNSC's mandate.

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<sup>51</sup> References re hot hours, for example:

AECL: Corrosion and Hydrogen Ingress of Pressure Tubes <https://www.nrc.gov/docs/ML0300/ML030020286.pdf>;  
Canadian Nuclear Laboratories, <http://pubs.cnl.ca/doi/full/10.12943/CNR.2016.00007>

## Models and Tests

The methodologies used by Bruce Power to assess Fitness for Service for major components, i.e., fuel channels, feeders, and steam generators/pre-heaters, are addressed under Life Cycle Management Plans (LCMPs). These plans cover Leak-Before-Break (LBB) assessments and Research and Development, including fracture protection models, and burst tests. LCMPs also include relevant technical information, regulatory requirements, maintenance activities and fuel channel mitigation activities to ensure that the components are fit for service. Bruce Power has revised and updated its LCMP for the major components in preparation for the work planned in its licence renewal.

Bruce Power uses two fracture toughness models as key inputs into the LBB and fracture protection assessments in order to demonstrate the safe operation of pressure tubes in the event of a through-wall crack penetration.<sup>52</sup>

Leak-Before-Break evaluations are intended to ensure that if a crack develops in a pressure tube, the consequential leak can be detected in time to shut down the reactor and cool and depressurize the primary heat transport system before the pressure tube ruptures.

Fracture protection models and tests are intended to establish the pressure and temperature limits to prevent the fracture of tubes due to delayed hydride cracking (DHC), in particular, during transition periods while the primary heat transport system pressure is being increased to or decreased from the normal operating pressure during reactor start-up and shutdown, i.e., the time periods where DHC is most likely to occur.

Burst tests measure the toughness of pressure tubes by increasing pressure until the tube bursts. These tests provide data on the potential risk of the reduction in fracture toughness at the targeted concentration of hydrogen [ $H_{eq}$ ] from full-power operation of the Bruce units. Thus they are critical to supporting and validating fracture toughness models.

Prior to the issuance of Bruce Power's current licence in 2015, fracture toughness models were validated to a  $H_{eq}$  of 124 parts per million (ppm), which corresponds to 247,000 EFPH, the hold point for the licence period.<sup>53</sup> This EFPH limit, which was a substantial increase from that of the previous licence period, would thus accommodate Unit 5, which is expected to be the first unit to reach this level by the end of the licence period in 2020.<sup>54</sup>

In light of the timetable planned for refurbishing six reactors, Bruce Power's request to the CNSC to operate beyond 247,000 EFPH to 300,000 EFPH would require validation to operate to a target  $H_{eq}$  of 160 ppm. This would necessitate Bruce Power to conduct burst tests on pressure tubes under a number of circumstances, in addition to other work that would need to be done during maintenance outages to support its request.<sup>55</sup>

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<sup>52</sup> Performance Review of Bruce A and B pp 82, 84. The models include a statistical model for the upper shelf temperature region and a cohesive-zone model for the transition temperature region.

<sup>53</sup> Ibid p. 95-96; Correspondence from Bruce Power

<sup>54</sup> Written submission from Bruce Power Inc. August 2014 CMD 14-H115.1 p. A3

<sup>55</sup> Supplement to Bruce Power's Application for licence renewal, October 13, 2017: Performance Review of Bruce A and B. Table 11 p. 96



According to plan, the hydrogen equivalent concentrations for burst tests are targeted to include 160 ppm  $H_{eq}$ , corresponding to 300,000 EFPH, on the outer section of the pressure tube, and 60/70 ppm  $H_{eq}$  to be conducted only on inlet sections of the pressure tubes.

CNSC staff have expressed concern regarding the need for tests for  $H_{eq}$  exceeding 125 ppm, as they expect that the pressure tubes would be unlikely to exceed this value prior to their Major Component Replacement. Nonetheless, they note that for Units 5 and 7, a sizable population of pressure tubes (approximately 680) will have a predicted  $H_{eq}$  greater than 120 ppm at the target operating life, while approximately 120 pressure tubes have predicted  $H_{eq}$  greater than 150 ppm.<sup>56</sup> So the expectation that  $H_{eq}$  levels will not exceed 125 ppm may not be valid, especially if the timing for Major Component Replacement is delayed and the reactors have to operate longer than anticipated.

With respect to burst tests to date, as an example, a test carried out at a  $H_{eq}$  of 145 ppm in 2016 indicated that the results were consistent with model predictions. A fracture test conducted in 2017 at 204 ppm met “acceptance criteria”, according to Bruce Power. Additional burst tests are intended to expand the validity of this fracture test.<sup>57</sup>

Bruce Power is planning on conducting pressure tube burst tests through to 2022, and perhaps beyond. These tests require specialized equipment, qualified personnel and “hot-cell” facilities. Currently, industry capability to conduct these tests is limited and is available only at Canadian Nuclear Laboratories (CNL) in Chalk River.<sup>58</sup> This could very well lead to delays in the proposed outage schedules, and fewer tests being conducted. As a consequence, decisions as to the safety of pressure tubes may be made without sufficient testing.

As of 2015, the  $H_{eq}$  measured in the main body of pressure tubes for all of Bruce Power reactors ranged from 20 to 40 ppm. The highest concentrations occurred within a small band at the inlet and outlet of the tubes and fell within the 40-60 ppm range.<sup>59</sup> These values are far below the  $H_{eq}$  values being modelled or tested.

The current Canada Standards Association (CSA) Standard N285.8 sets allowable limits of  $H_{eq}$  (as of 2015) at 70 ppm in the main body of a pressure tube and in the tensile portion of a rolled joint region at the inlet and at 100 ppm at the outlet.<sup>60</sup> These limits would necessarily impose a restriction on allowing increases to  $H_{eq}$  concentrations to levels of the order of 160 ppm.

However, according to Bruce Power, “the higher values of  $H_{eq}$  are being examined based on projected end of life conditions of the pressure tubes which will exceed the current levels in the CSA standard. These are part of on-going research and development work carried out by the

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<sup>56</sup> Supplement to Bruce Power’s Application for licence renewal, Attachment A October 13, 2017

<sup>57</sup> Ibid, and Correspondence from Bruce Power Nov. 14, 2017: The test reports are being drafted and will be submitted to the CNSC. The criteria for acceptance are the CSA standard (N285.8) and corresponding Fracture Toughness Models.

<sup>58</sup> Supplement to Bruce Power’s Application for licence renewal, October 13, 2017

<sup>59</sup> Written submission from Bruce Power Inc. August 2014 CMD 14-H115.1 p. A3

<sup>60</sup> CSA N285.8-10 - Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors <http://shop.csa.ca/en/canada/nuclear/n2858-10/inv/27023692010>

Candu Owners Group (COG). The research and development (R&D) results will then be used to update the CSA standard if justified from the R&D results.”<sup>61</sup>

While Bruce Power expects that the CSA allowable limits will change in light of the research and development work being done, that could be presumptuous and premature.

Given that these tests for Fitness for Service are critical to assess the safety of the operation of Units 3-8 prior to their Major Component Outage, it is essential that they validate the increase in  $H_{eq}$  to 160 ppm to a very high level of assurance.

Based on information to date, there are serious concerns as to whether the models and tests are robust, complete and accurate to support the increase in  $H_{eq}$  (and corresponding EFPH) that Bruce Power has requested. For example:

The burst test that was carried out at a  $H_{eq}$  of 124 ppm used an irradiated pressure tube that was removed from a reactor for testing purposes. The test specimen was artificially aged by increasing its hydrogen content,  $H_{eq}$ .<sup>62</sup>

How long was this tube irradiated and at what intensity? Given the variability in pressure tubes in a unit and amongst units, how many irradiated tubes would need to be tested?

How does artificial irradiation of pressure tubes compare to the actual irradiation that occurred in the reactors during more than thirty years of operation?

Apparently, an increase of EFPH from 147,000 to 300,000 corresponds to an increase in  $H_{eq}$  from 124 ppm to 160 ppm. What is the relationship between  $H_{eq}$  and EFPH to explain this correspondence?

What is the level of confidence or degree of uncertainty of the fracture test models? Similarly, what is the level of accuracy of the burst tests?

Several other factors could well influence the condition of pressure tubes. For example:

The *pick-up rate* of hydrogen in pressure tubes increases over time, and may be greater further along a pressure tube. In particular, the rolled joints, which may be acting as a sink for hydrogen, have a higher pick-up rate than other sections of a pressure tube.

Factors such as temperature, neutron flux, impurities in the Zirconium-2.5% Niobium (Zr-2.5Nb) pressure tube material, e.g., chlorine, carbon, phosphorus, will also influence the embrittlement of pressure tubes.

How are these factors taken into account in assessing the safety of the pressure tubes?

Since not all of the 480 tubes in a unit can be inspected during each maintenance outage, there is no guarantee that a critical tube will not be missed, and therefore no guarantee of safety. Reliance is being placed on fracture protection models and LBB evaluations to assess the risk of failure of uninspected tubes. No model can reliably predict which pressure tube or tubes pose a critical risk of rupture.

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<sup>61</sup> Correspondence from Bruce Power.

<sup>62</sup> Bruce Power: Supplement to the Application for the Renewal of the Power Reactor Operating Licence: Fitness-for-Service of Pressure Tubes October 13, 2017 NK21-CORR-00531 -13854, NK29-CORR-00531 -14517

This raises serious issues, for example:

How many tubes out of the 480 in one unit are actually inspected during an outage?

How is the variability amongst pressure tubes within any one unit and in different units accounted for?

How does one ensure that all leaks are detected quickly enough to prevent rupture?

With respect to aging issues and fitness for service, as stated in CNSC's Regulatory Document REGDOC-2.6.3, on Fitness for Service: Aging Management:<sup>63</sup>

Over time, and if not properly managed, physical aging can reduce the ability of a structure, system or component to perform its safety functions within the limits and specifications assumed in the design basis and safety analysis. Several aging mechanisms can combine synergistically to cause unexpected or accelerated aging effects, or premature failure of a component or structural element. The aggregate of multiple degraded components or elements can significantly degrade the safety performance of a system or structure. For instance, while individual degraded components might meet their respective fitness-for-service criteria, the combined effect of all the multiple degraded components could still result in unacceptable safety performance of a system or facility.

So much depends on trust that all things will work out, that safety is guaranteed. The CNSC cannot make decisions for a 10-year licence request with so many outstanding questions about the safety of the aging reactors.

It is unlikely that Bruce Power will have much more information regarding burst tests,  $H_{eq}$  levels etc., than is currently available by the time that its licence hearing takes place.

Overall, inadequate information has been provided on the critical issue of  $H_{eq}$  levels in pressure tubes. As yet, there is no solid evidence that the life of the pressure tubes for Units 3-8 can be safely extended to 300,000 EFPH at a hydrogen uptake of the order of 160 ppm.

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<sup>63</sup> <http://www.nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents/index.cfm>

REGDOC-2.6.3, Fitness for Service: Aging Management p. 3 © Canadian Nuclear Safety Commission (CNSC) 2014

## SAFETY ANALYSIS - METHODOLOGY

The Probabilistic Safety Analyses (PSAs), and the models they are based on to determine the probability of an accident at a nuclear power plant, are not mathematically or scientifically valid for a great many reasons. First of all, a mathematical model is only valid, and can only give reliable results, if it is both complete and accurate. This means that it must take into account everything that might affect every number it is calculating, and must represent every last one of these essential factors accurately enough to give accurate final results. It is a well-known principle of mathematics (and computer science) that the final result of a computation is only as accurate as the least accurate number that went into it.

It is completely impossible to foresee everything that could cause a serious nuclear accident, let alone take it into account in a mathematical model. There's no telling what human errors might occur, such as the one that caused the accident at Chernobyl. The reactors at Fukushima were able to withstand a major earthquake, because the possibility was foreseen, but the resulting tsunami was larger than anyone foresaw, so adequate provision was not made for it. Just one oversight like this is enough to make any model that calculates the probability of a nuclear accident completely worthless, and it is impossible to avoid all oversights of this kind.

Furthermore, it is impossible to determine accurately the probabilities of all the accident scenarios that are foreseen. Just as logic and experience are the sole basis for all genuine science, so logic and experience are the sole basis for determining probabilities. There is no logical basis for determining the probability of any particular kind of human error, or act of terror, or a tsunami such as the one at Fukushima, or many other chance disruptive occurrences that might cause a serious nuclear accident. As we can never have long enough experience with nuclear accidents (without being destroyed by them first) to determine such probabilities on the basis of experience, there is simply no way to determine them accurately at all.

Finally, even if we could accurately determine the probability of a serious nuclear accident at the Bruce Nuclear Station, it would provide no guarantee of safety, no matter how small it was. Probabilistic predictions are only reliable when they are applied to a large number of cases. In a single case anything can happen at any time, even when it's highly improbable. As CNSC staff has admitted, its probabilistic risk models have no predictive value.

Following the accident at the American Three Mile Island nuclear station in 1979, an all-party committee of the Ontario Legislature (the Select Committee on Hydro Affairs) investigated Ontario's nuclear policies. In its 1980 report to the legislature, the committee concluded that:

“Accidents, mistakes and malfunctions do occur in [CANDU] nuclear plants: equipment fails; instrumentation gives improper readings; operators and maintainers make errors and fail to follow instructions; designs are inadequate; events that are considered 'incredible' happen...no matter how careful we are, we must anticipate the unexpected.”<sup>64</sup>

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<sup>64</sup> <http://www.greenpeace.org/canada/en/Blogentry/can-a-nuclear-accident-happen-in-canada-quest/blog/33777/>

Even when accidents are deemed possible and probabilities are estimated, they are not based on sound logic or experience because of an inherent bias that harmful events are either impossible or less than extremely unlikely.

A recent example of the failure of probabilistic risk analyses occurred at the Waste Implementation Pilot Project (WIPP) in Carlsbad, New Mexico in February 2014. The U.S. Department of Energy (DOE)'s risk analysis failed to consider the possibility that a container could be breached by a reaction or explosion within it. It estimated the probability of sustained combustion in a one-half full waste room to be  $5.3 \times 10^{-6}$  per year (that is, about once in 188,000 years) so it was deemed to be a less than extremely unlikely event.<sup>65</sup> But in just 15 years of operation, both a fire and a breach of a waste container explosion occurred at WIPP, and the facility remains closed.<sup>66</sup>

The disaster at Fukushima has vividly demonstrated that not taking catastrophic accidents seriously leads to a lack of emergency preparedness, which makes a great tragedy for so many people even greater.

As stated by Toshimitsu Homma of the Japan Atomic Energy Agency, at IAEA Regulator's Conference in Ottawa, April 2013

“There was an implicit assumption that such a severe accident could not happen and thus insufficient attention was paid to such an accident by authorities.”

Regardless of the risk of such accidents, the consequences are devastating. The institutional thinking that such accidents are too unlikely to happen is all too prevalent in the industry and the CNSC. It results in studies that have no credibility, and inadequate emergency preparedness that costs people their health and well-being.

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<sup>65</sup> [http://www.wipp.energy.gov/library/cca/CCA\\_1996\\_References/Chapter%209/CREL2441.PDF](http://www.wipp.energy.gov/library/cca/CCA_1996_References/Chapter%209/CREL2441.PDF)

<sup>66</sup> US DOE Report EEG-75 May 2000

## CUMULATIVE EFFECTS

### Overview

Bruce Power's Environmental Risk Assessment (ERA) Summary Report acknowledges the need to address the cumulative environmental effects of multiple stressors "when and where it is warranted". The Report states that "the science behind the determination of cumulative effects is at its infancy: there is no consensus on a definition of 'cumulative impact' and assessment methods are largely absent."<sup>67</sup>

While a study of cumulative effects is complex, broad-based in scope, and not a precise science, the potential for adverse cumulative effects must nevertheless be considered and explored. The combination of various factors or stressors resulting from numerous activities occurring over the same time period and location cumulatively could be far more detrimental than the effects of each stressor individually.

This has been recognized for decades. In 1999, the United States Environmental Protection Agency, in its guidance on cumulative impacts assessment, stated:

"The combined, incremental effects of human activity, referred to as cumulative impacts, pose a serious threat to the environment. While they may be insignificant by themselves, cumulative impacts accumulate over time, from one or more sources and can result in the degradation of important resources."

A similar statement is found in the *Introduction in Cumulative Effects Assessment Practitioners' Guide*, prepared for the Canadian Environmental Assessment Agency.<sup>68</sup>

Even though progress in this field may be limited, the issue remains valid and cannot be ignored.

In considering the intense work entailed in refurbishing six reactors (Major Component Replacement (MCR)) sequentially over a period of at least 15 years at the Bruce site, as well as other operations that would be carried out concurrently at that site, the potential for cumulative adverse effects needs to be addressed.

Pursuing a cumulative approach may well lead to improved understanding of potentially adverse effects that a project may have, in conjunction with other projects occurring over the same time period and space on an ecosystem.

A study of cumulative impacts on human health resulting from certain activities, exposure to multiple pollutants, etc., is multi-dimensional. It is not limited to the actual physical exposure to

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<sup>67</sup> <http://www.brucepower.com/environmental-risk-assessment-data-update/> Summary of the Bruce Power Environmental Risk Assessment (ERA) p.6,7

<sup>68</sup> "Consideration of Cumulative Impacts, "PA review of National Environmental Policy Act Documents, May 1999, p. 13. [https://19january2017snapshot.epa.gov/nepa/cumulative-impacts-guidance-national-environmental-policy-act-reviews\\_.html](https://19january2017snapshot.epa.gov/nepa/cumulative-impacts-guidance-national-environmental-policy-act-reviews_.html) Refer also to: Cumulative Effects Assessment Working Group a1.0 *Introduction in Cumulative Effects Assessment Practitioners' Guide*, prepared for the Canadian Environmental Assessment Agency February 1999.

excessive noise, air pollution, groundwater contamination, etc. It must also consider vulnerable populations in the affected communities, as well as socio-economic factors brought on by the ongoing activities that these projects entail and the overall well-being of a community in the long-term.

Even if each effect may be considered “insignificant” or “unlikely” on its own to cause a potential adverse effect, it is precisely the cumulative impact of some and possibly all of these adverse effects occurring at the same time, or even over a period of time and location that is the essence of cumulative effects, not the potential adverse impacts arising from one project in an isolated or segregated fashion.

The numerous activities ongoing and planned at the Bruce site would span many years, and even decades, let alone all the activities that have been going on at that site for years. This is particularly important, especially considering the proximity of local communities and residents to the Bruce Power site, their exposure to multiple pollutants, the population vulnerability, such as susceptible populations and socio-economic factors, as well as factors such as anxiety and stress brought on by the ongoing activities that these projects entail and the overall well-being of the community in the long-term.

Even if Bruce Power considers the science of cumulative effects to be in its infancy, this field is recognized as important and cannot be dismissed. An exploration of cumulative effects may lead to predictions of potential adverse effects that would otherwise be ignored.

### **The Elephants in the Room**

The Western Waste Management Facility (WWMF) at the Bruce Nuclear site operated by Ontario Power Generation (OPG) has stored Low and Intermediate-Level Radioactive Waste (L&ILW) produced by Ontario’s nuclear power reactors for decades (since 1974). The ERA states that “it is not possible to isolate any potential effects due to the WWMF from the Site as a whole.”<sup>69</sup> However, the operations and expansion of the WWMF have not come under any consideration as to potential adverse impacts that could arise in conjunction with the MCR work. This is a very serious omission, especially regarding cumulative effects.

Further absent from consideration is the potential of a Deep Geological Repository (DGR) at the Bruce site for the longterm storage of this waste. The DGR Project would be located in watersheds that ultimately discharge into Lake Huron. While the final decision with respect to the DGR is “currently subject to regulatory review and not part of the ERA”<sup>70</sup>, it is nonetheless critical to address the potential cumulative effects of that project in conjunction with other activities ongoing and/or planned at the Bruce site.

Considering the level of activity at Bruce that would be involved in the Major Component Replacement (MCR) of six reactors alone, in addition to the maintenance work that needs to be done on the reactors to extend their life while awaiting refurbishment, the routine operation of the reactors, and the operations at the WWMF and at other facilities on site, the construction work, the increase in transportation of material and wastes to the Bruce site, the potential for

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<sup>69</sup> ERA p. 40 2.1.11 B-REP-03443-29 JUN2017-01

<sup>70</sup> Ibid 2.1.2

adverse cumulative effects to occur is not only a distinct possibility, it is a reality. The potential for accidents, malfunctions, and malevolent acts is also all the more possible.

### **“Adverse” Effects**

The assertions made by Bruce Power and the CNSC in their documents that there will be “no significant adverse effects” is virtually impossible to make in a scientifically verifiable way, given the extent and complexity of the MCR project, and other large projects (e.g., refurbishment, expansion of the WWMF, potential construction of a DGR). This is so because Bruce Power states at the outset that: “there is no consensus on a definition of ‘cumulative impact’ and assessment methods are largely absent.”

Nor is the confidence expressed by these two bodies that mitigation measures can address or prevent any and all such effects, if such were to occur, warranted, as exemplified in CNSC’s statement that “CNSC staff determined that Bruce Power has established and implemented an environmental management program to prevent or mitigate adverse environmental effects at Bruce A and B.”<sup>71</sup> For similar reasons, CNSC staff’s ‘determination’ is suspect.

It is highly doubtful whether “all” adverse effects can be prevented or mitigated, especially when the possibilities and considerations of adverse effects are limited. It defies logic. Regardless of whether Bruce Power and the CNSC consider adverse effects unlikely, the consequences are not.

Regrettably, no mention of cumulative effects has been made in documents submitted by Bruce Power or the CNSC for Part 1 of the public hearing.

The failure to address this topic is indicative of an unwillingness to acknowledge the potential for adverse effects to occur. This is most disturbing, especially considering the complexity of the refurbishment project alone, in addition to other activities that would be occurring at the site.

The potential for adverse cumulative effects does exist and will span over a very long period. Bruce Power and the CNSC have failed to consider the full extent of impacts to the environment and the health of the local community.

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<sup>71</sup> CNSC CMD 18-H-4 p. 101



## HUMAN HEALTH CONCERNS

### Bruce Power's Refurbishment Plans and Other Activities

The level of activity entailed at the Bruce site over the 10-year renewal licence period, as proposed, is intensive and would continue well beyond that period. These activities not only include refurbishment of six reactors, but also the expansion of OPG's Waste Management Facility (WWMF) and potentially, the construction of the proposed Deep Geological Repository (DGR) for Low and Intermediate-Level Waste (L& ILW) produced by Ontario's nuclear power plants. All of these activities, collectively, will add to the multitude of activities already ongoing at the Bruce Nuclear site.

Construction activities would include clearing to provide additional areas for the expansion, excavation, grading, expansion of the stormwater management system (excavation), road construction, etc. Added to that is increased transportation to and from the site, particularly heavy construction vehicles equipment, increased traffic of L& ILW from the other nuclear stations to the WWMF, and additional personnel that would be needed to take on the refurbishment work and other work at the station.

The construction operations alone will result in increased emissions of "dust" and other contaminants to air and water, as well as contributing to excessive noise levels (cacophony). The range of air pollutants emitted from these activities include Particulate Matter (PM, fine and coarse), Volatile Organic Compounds (VOCs), sulphur dioxide (SO<sub>2</sub>), nitrous oxides (NO<sub>x</sub>), polycyclic aromatic hydrocarbons (PAHs), and many other contaminants. Many of these substances are listed as toxic under the *Canadian Environmental Protection Act* (CEPA 1999).

NO<sub>x</sub> and SO<sub>2</sub> are precursors to acid precipitation and also can cause respiratory and other internal diseases when inhaled in high concentrations. Particulate Matter, particularly fine PM, (PM<sub>2.5</sub>, i.e., particulate matter with aerodynamic diameters <2.5 µm) is inherently toxic to human health. Inhalation of fine and ultrafine particles can cause include asthma, lung cancer, pulmonary emphysema, and cardiovascular disease.

While adverse health effects from exposure to PM<sub>2.5</sub> affect children and adults alike, the most susceptible groups in the exposed population include senior citizens, people with existing lung or heart problems, diabetics, children with asthma, and people who spend more time outdoors.<sup>72</sup> Exposure to PM<sub>2.5</sub> can also harm the brain, accelerating cognitive aging, and may even increase risk of Alzheimer's disease and other forms of dementia.<sup>73</sup>

As Health Canada has noted, "Health risks for certain air quality indicator compounds (e.g. particulate matters – PM<sub>10</sub>, PM<sub>2.5</sub>) exist below ambient standards and objectives. However, air quality standards should not necessarily be regarded as "pollute up to" criteria."<sup>74</sup>

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<sup>72</sup> [http://www.env.gov.bc.ca/soe/archive/reports/et07/chapters/ET2007\\_Air\\_Quality\\_Chapter.pdf](http://www.env.gov.bc.ca/soe/archive/reports/et07/chapters/ET2007_Air_Quality_Chapter.pdf)

<sup>73</sup> <http://www.sciencemag.org/news/2017/01/brain-pollution-evidence-builds-dirty-air-causes-alzheimer-s-dementia> and <http://www.nature.com/tp/journal/v7/n1/full/tp2016280a.html>

<sup>74</sup> Health Canada's Technical Review of Ontario Power Generation's Response to the Request for Additional Information for the Deep Geologic Repository for Low and Intermediate-Level Radioactive Waste Project March 7, 2017

VOCs are toxic substances and are also of concern as a precursor (along with NO<sub>x</sub>) to the formation of photochemical oxidants near ground level, i.e., smog.

The extensive work involved in refurbishment, in addition to ongoing activities at the Bruce Nuclear site, pose many risks to human health and the environment, especially to the local community. For example:

- The potential generational, long-term and cumulative effects resulting from exposure to both radiological and hazardous non-radiological substances from contaminated groundwater, food and air;
- The effects of exposure to radiological and hazardous non-radiological substances on the health and well-being of specific populations, including but not limited to:
  - Repository workers who are exposed to occupational radioactivity;
  - Families of workers who are exposed through direct contact or genetic harm;
  - Local communities who live in close proximity to and downwind of the Bruce site;
  - Vulnerable populations including foetuses, infants, pregnant women, the elderly, and people whose health is already compromised (e.g., asthmatics);
  - The impact on the health and quality of life of local communities and workers during the construction period (noise, increased traffic, air quality, etc.).

## Health Effects of Radiation Exposure

The currently allowed level of exposure to ionizing radiation for the public is 1 mSv/year, and for nuclear energy workers it is 100 mSv over 5 years with a maximum of 50 mSv in one year. These limits have been set by the International Commission on Radiological Protection (ICRP) and are used by the CNSC and OPG based on fatal cancer. The CNSC has stated that “the public dose limit of 1 mSv per year is a regulatory limit in the *Radiation Protection Regulations*, not a health limit. Dose limits have mistakenly been regarded as a line between what is safe and what is not safe”.<sup>75</sup>

According to the BEIR VII Report on *Health Risks from Exposure to Low Levels of Ionizing Radiation*, the dose-response to radiation follows a Linear No-Threshold (LNT) model. Thus, there is no dose for which there is no risk.<sup>76</sup>

The following summarizes, in general, the health risks from exposure to radiation:

- 1) Radiation damage can affect any part of a cell, and can interfere with many cellular processes. Damage to the genetic material of the cell can lead to cancer, non-cancerous tumours, birth defects, hereditary illness, and immune system diseases. While this damage can sometimes be repaired by mechanisms within the cell, that is not always the case. Damage to eggs or sperm can be passed on to future generations.

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<sup>75</sup> Study of Consequences of a Hypothetical Nuclear Accident and Effectiveness of Mitigation Measures – CNSC draft report, December 2014 e-Doc 4449079 A0043878\_000188

<sup>76</sup> <http://www.cirms.org/pdf/NAS%20BEIR%20VII%20Low%20Dose%20Exposure%20-%202006.pdf>; see also BEIR VII report: [http://dels.nas.edu/resources/static-assets/materials-based-on-reports/reports-in-brief/beir\\_vii\\_final.pdf](http://dels.nas.edu/resources/static-assets/materials-based-on-reports/reports-in-brief/beir_vii_final.pdf)

- 2) Radiation from internal emitters is very different from external radiation, and more dangerous. If a radioactive particle is inhaled or ingested, that particle will continue to emit radiation as long as it is in the body and the particle remains radioactive. When exposed externally to a source of radioactivity, the exposure lasts only as long as the person remains close to the source of radiation.
- 3) Not all people exposed to radiation are affected equally. These limits do not make proper allowance for the most vulnerable members of society, fetuses and children. At these life stages, individuals are far more sensitive to radiation than in adulthood. Most of our standards are based on adult exposures.
- 4) Some radionuclides bioaccumulate in an organism and biomagnify, i.e. build up in the food chain. For example, they may reach higher concentrations in fish or seafood than in the surrounding water, thereby posing a greater risk to anyone or any species eating the contaminated food than the surrounding water would.
- 5) The current ICRP limits do not make proper allowance for the most vulnerable members of society, fetuses and children. At these life stages, individuals are far more sensitive to radiation than in adulthood.
- 6) The CNSC and OPG typically compare exposure levels to radiation due to the nuclear activities, to natural background levels of radiation, the presumption being that the level of emissions from these facilities would be a very small fraction of background levels, and thus the effects on human health will be negligible. Background radiation gives us background levels of cancer and hereditary disease. Any radiation exposures from man-made sources will be added to background, and will cause additional harm.
- 7) Many radionuclides are chemically toxic as well as radiotoxic. Their chemical toxicity may be far more serious than their radiotoxicity. For example, even though the specific activity of uranium (Bq/gm) is low, its nephrotoxicity is well known.

Once released into the biosphere, radionuclides can work their way through the ecosystems, as do other industrial toxins. Multiple migration mechanisms are involved, including transport by air, water, particulate matter and biota.<sup>77</sup> Some of the radionuclides are able to biomagnify up the food chain, becoming progressively more concentrated in foodstuffs and in complex forms of life, including human life. The potential transfer of radionuclides in animal feed to domestic farm animals could contaminate the human food chain via meat and milk. The very long-term health consequences of radionuclides in the global environment are not known, but are likely to be cumulative as the contamination accumulates.<sup>78</sup>

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<sup>77</sup> <http://www.ceaa.gc.ca/050/documents/55688/55688E.pdf> p. 38,39

<http://www.ceaa.gc.ca/050/documents/55688/55688E.pdf>

<sup>78</sup> <http://www.psr.org/environment-and-health/environmental-health-policy-institute/responses/radiations-risk-to-public-health.html>

## Potential Cumulative Effects on Workers and the Local Community

The effects of exposure to multiple pollutants are cumulative and may be synergistic or additive. For example, some pollutants may compromise the immune system and this in turn could result in an enhanced susceptibility to the effects of exposure to other pollutants.

How well protected are the local community and the workers currently are from exposure to the pollutants resulting from all the construction work and from ionizing radiation emitted from the operations at the Bruce station? The answer is simply, we do not know. No baseline data is available that would at least provide us with some information against which we could measure or at least account for changes over time due to these new activities in addition to current activities and projects in the local regions. Thus our comments reflect the current status of standards and health effects of radiation exposure.

Accidents (from construction activities to events such as spills, fires, potential loss of containment, etc.) and emergencies place front-line workers at serious risk and can lead to exposure to ionizing radiation as well as non-threshold carcinogens and other toxic substances. The cumulative, synergistic, and long-term effects of their exposure to both radioactive and non-radioactive hazardous substances are not recognized, let alone addressed.

While both the CNSC and Bruce Power assert that no “adverse” health or environmental effects are likely from all the activities taking place, this position is not only unrealistic, it is without merit. There is no evidence that this is the case at present and will remain the case regardless of the level of activities and operations that will occur on site.

## Concluding Comments

Over the years, as more has been discovered about the hazards associated with certain substances, standards have become more stringent. The limits set for exposure to certain substances that are currently in place are very likely to change with increased knowledge and awareness of the harm that exposure to these substances can cause singularly and cumulatively. Furthermore, even though emissions lie within or below current standards, it cannot be inferred that they do no harm. The effects on human health are cumulative and must be considered so, whether or not these effects can be quantified at this stage.

The burden of proof rests on Bruce Power and the CNSC to demonstrate that the level of exposure to radioactivity and to other contaminants, singly and/or cumulatively, is safe and thus not harmful to human health.

Can Bruce Power and the CNSC provide science and health-based evidence that this is so?

Can it be proven unequivocally that exposure to radioactivity and to other contaminants is not harmful, or that the health of no one will be adversely affected by long-term exposure to radioactivity and to other contaminants?

Can Bruce Power provide assurance that that there will be no accidents, no intrusions, and no malfunctions, no human error from the operations taking place at the Bruce site?

Without any definitive answers, we can conclude that Bruce Power and the CNSC cannot make scientifically verifiable assertions that there will be no adverse health effects.

## TRITIUM – HEALTH EFFECTS

Tritium is one of the major radioactive contaminants produced and released from CANDU reactors. Both gaseous and aqueous forms of tritium (HT and HTO respectively) are very radioactive and pervasive. HT permeates most materials, including rubber and many grades of steel, with relative ease. HTO is chemically identical and physically similar to ordinary water, and very rapidly mixes everywhere.

Tritium is a carcinogen, mutagen, teratogen and developmental toxin. It is easily absorbed into the body through inhalation, ingestion and dermal absorption. Some of this absorbed tritium reacts with organic compounds and is referred to as organically bound tritium (OBT), a very important component of tritium exposures. The cells most at risk from tritium are those dividing at the time of exposure (precursor cells for the ovum and sperm), the embryo, and nerve cells. Since tritium easily crosses the placenta, it can contribute to spontaneous abortions, stillbirths, and congenital malformations.

Furthermore, when tritium spontaneously disintegrates, the resulting recoil excitation can disrupt chemical bonds. These disruptions, when repeated, can cause chronic diseases such as allergies or hormonal dysfunction.<sup>79</sup>

### Organic Bound Tritium (OBT)

While the organic form of tritium has been well recognized for years, there has been little movement in dealing with the extent to which OBT affects human health and biota.

Repeated (i.e., chronic) exposures to tritium lead to a gradual increase in concentrations of OBT in all biota. Humans accumulate OBT through the consumption of tritium-contaminated food and tritiated water (HTO). OBT is more problematic than HTO because of its much longer residence time in the body and its location near organic molecules (for example, DNA).<sup>80</sup>

The OBT fraction of tritiated water has two components. OBT 1 reacts easily with other chemicals in the internal environment and binds with oxygen, sulfur, phosphorus or nitrogen atoms, to form amino acids, proteins, sugars, starches, lipids, and cell structural material which are then used and 'destroyed' within the body and excreted in time. OBT1 has a biological half-life of about 40 days, and thus will remain in and accumulate with daily ingestion in the body for about that length of time.

The second component, OBT 2, also referred to as non-exchangeable OBT, binds with the carbon atoms of the DNA. OBT2 has a biological half-life of about 550 days. Since the DNA in the cell is not frequently replaced, being bound to DNA will keep the tritium inside the cells for an average of 550 days. The longer exposure time will increase the deposit of energy in a tissue by a factor of three.

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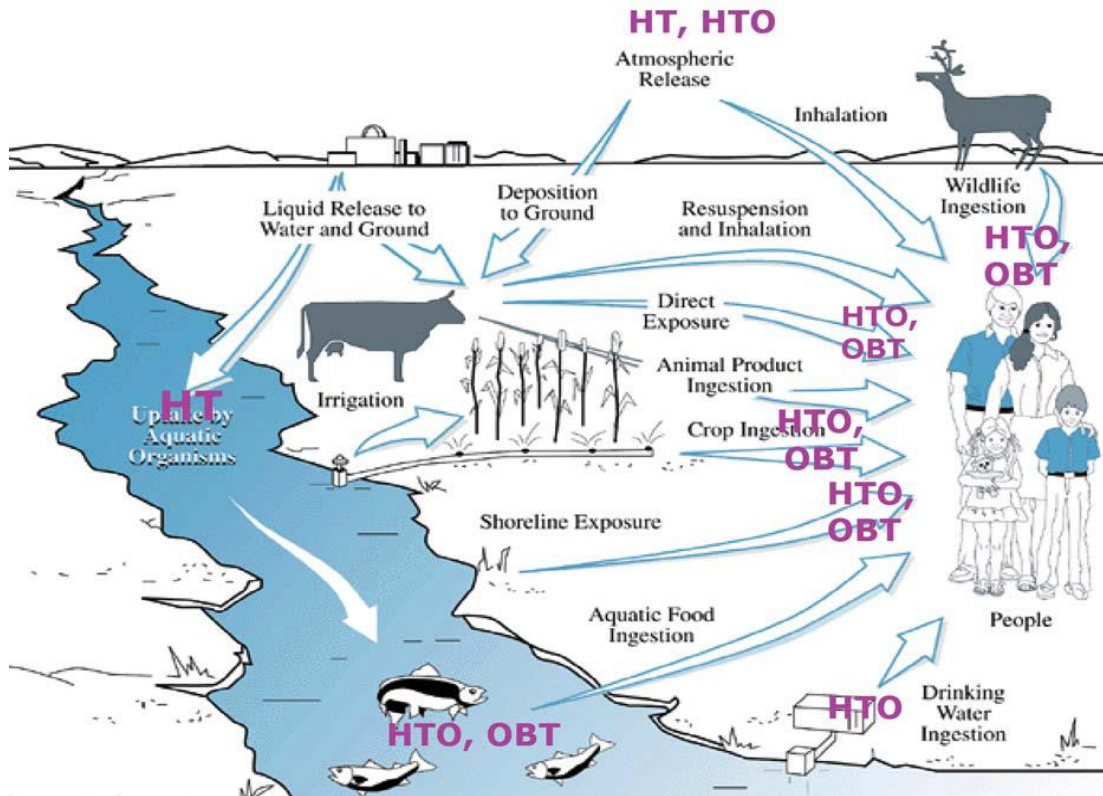
<sup>79</sup> <http://iicph.org/files/health-effects-of-tritium.pdf> (Dr. Rosalie Bertell)

<sup>80</sup> Dr. Ian Fairlie, *Tritium Hazard Report Pollution and radiation Risks from Canadian Nuclear Facilities*, June 2007 <http://www.greenpeace.org/raw/content/canada/en/documents-and-links/publications/tritium-hazard-report-pollu.pdf>

The non-homogeneous distribution of the two OBT components in the body will mean higher localized absorbed doses, each at least four times higher than the average dose for uniform spread of HTO, which will increase the estimate of energy deposited generally by another factor of three.

## Environmental Pathways of Tritium

The following figure, from CNSC's document on "Tritium Doses and Consequences in Canada", demonstrates the numerous exposure pathways of tritium:<sup>81</sup>



### Sources of Exposure:

- Plume: Inhalation of HT and HTO
- Soil: Inhalation and dermal absorption of HTO
- Food: Inhalation of HTO and OBT

### Exposure variables:

- Location relative to plume
- Duration in the plume area
- Inhalation rate
- Amount and type of food grown in initial plume area that is consumed, and
- Age, sex, etc.

<sup>81</sup> Reference: CNSC 2009: "Tritium Releases and Dose Consequences in Canada in 2006", p.11  
[http://nuclearsafety.gc.ca/pubs\\_catalogue/uploads/CNSC\\_Release\\_and\\_Dose\\_eng\\_rev2.pdf](http://nuclearsafety.gc.ca/pubs_catalogue/uploads/CNSC_Release_and_Dose_eng_rev2.pdf)

A number of studies in Canada have demonstrated the health detriments of tritium, including an increase in the number of fatal birth defects and neonatal deaths in the area of the Pickering nuclear facility, an increase in Down's syndrome and central nervous system anomalies in births in the Pickering area, and an increase in child leukemia deaths near the Bruce plant. The IARC () study of Nuclear Workers by International Agency for Research on Cancer (IARC) found that radiation related cancer rates of Canadian nuclear workers are higher than that of other nuclear workers receiving the same radiation dose.<sup>82</sup>

## **Dosimetry - International Commission on Radiological Protection (ICRP)**

The Sievert is a risk-based unit of measurement of ionizing radiation that estimates the probability that a given exposure will result in a fatal cancer. Basing risk on fatal cancers alone does not mean that other radiation related health effects will not occur.

The ICRP methodology and underlying assumptions for calculating the internal absorbed dose are flawed for a number of reasons.<sup>83</sup> For example, with respect to tritium:

- ICRP considers that HTO doses from inhalation and ingestion are 25,000 times greater than for HT, because the body is not thought to absorb or metabolize hydrogen gas, whereas water is a vital component of all body tissues and metabolic processes. However, HT dispersed into the atmosphere diffuses readily into the soil and is converted to HTO. The converted HT is subsequently transported as HTO.
- Lack of consideration is given to the greater harmfulness of OBT compared to HTO. The duration of OBT1 and OBT 2 in the human body after long-term exposure is significantly underestimated.
- The distribution of OBT in the whole body is assumed to be homogeneous. This is not the case, as it is actually localized in certain tissues.
- The increases in OBT concentrations from repeated exposures are not recognized, thus chronic exposures to tritium are ignored. These exposures are important, especially for residents living downwind from facilities which discharge tritium 24 hours a day.
- ICRP recognizes only severe genetic effects in live-born offspring. Miscarriages, stillbirth, teratogenic effects, such as congenital malformations or diseases, are not accounted for.
- Salient factors such as non-cancerous effects, childhood asthma, and chronic illnesses due to non-functional enzymes, hormones and essential proteins are not considered.

With respect to Derived Release Limits (DRLs) set by the CNSC, these limits are based on the ICRP limit of exposure of 1 mSv/yr and assume that the tritium dose received from a single facility is the ONLY manufactured radiation dose the individual would receive in one year. The

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<sup>82</sup> Dr. Rosalie Bertell: [Health effects of tritium](#). (*Health Effects of Tritium*, Submitted to the CNSC, November 27, 2006) See also CMD 15-H2.110 – submission by Eugene Bourgeois and Anna Tilman, April 2015

<sup>83</sup> Ibid, and Tritium Hazard Report: Pollution and Radiation Risk from Canadian Nuclear Facilities  
Ian Fairlie June 2007 p. 47-51



multiple sources of tritium emitted along with the cumulative doses received over a number of years are not accounted for. This is particularly important for populations living near these sources.

### **Workplace Monitoring of Tritium**

One of the serious difficulties in dealing with tritium exposures in the workplace and elsewhere is the ease and rapidity with which it moves in and out of all biological entities, including humans. Another is the technical difficulty in measuring it once inside the body.

There is no indication in any of the documents received so far as to how or if Bruce Power or OPG measures tritium exposure in its workers. If not, this is a serious omission. If tritium exposure is measured, it is not clear whether these exposures are added to the gamma exposures, or whether they are relying solely on gamma dosimetry for their exposure tallies.

### **Relative Biological Effectiveness (RBE)**

The RBE is an indication of the amount of damage caused in biological tissue by a given type of radiation. ICRP applies an RBE Factor of 1 for tritium in determining its dose limit, whereas the RBE for electron and photon radiation is 1, 10 for neutron radiation, and 20 for alpha radiation.

The CNSC study “Health Effects, Dosimetry and Radiological Protection of Tritium” states:<sup>84</sup>

“Tritium beta radiation is about 1.4 times more effective in causing biological effects than x-rays and 2.2 times more biologically effective than gamma ray radiation.”

The study also notes:

“The use of a RBE of 1 in the current ICRP radiation protection framework has not decreased the level of protection afforded to workers or members of the public. This is because implementation of optimization has resulted in exposures to tritium that are very low and well below doses at which an increased risk of cancer has been observed.”

It concludes that:

- Current dosimetry and biokinetic models for assessing dose are acceptable for radiation protection purposes.
- Studies have shown that tritium exposures at current levels in Canada are highly unlikely to cause adverse health effects.
- Canada’s current regulatory framework has effectively controlled tritium exposures.

In other words, despite information in that study indicating otherwise, the status quo is acceptable to the CNSC.

In contrast, a consensus of scientific research finds that the RBE for tritium is severely underestimated and should be increased by a factor of two to three.<sup>85</sup> If that adjustment were made, then all exposure standards for tritium would have to be adjusted accordingly, and the

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<sup>84</sup> CNSC: *Health Effects, Dosimetry and Radiological Protection of Tritium*, Tritium Studies Project April 2010 [http://www.nuclearsafety.gc.ca/pubs\\_catalogue/uploads/CNSC\\_Health\\_Effects\\_Eng-web.pdf](http://www.nuclearsafety.gc.ca/pubs_catalogue/uploads/CNSC_Health_Effects_Eng-web.pdf) pp. ix-xii, 80-86

<sup>85</sup> <http://tapcanada.org/wordpress/wp-content/uploads/cerrie-report-on-tritium.pdf>



new drinking water standard would be set at 7-10 Bq/L, which would more accurately reflect the impact of tritium on the human body.

### **Tritium in Drinking Water “Standard”**

CNSC continues to rely on the current Canada Guideline and Ontario Drinking Water Quality Standard for tritium of 7,000 Bq/L as being “safe”, despite recommendations dating back to the 1990s that this level be reduced to 20 Bq/L. These recommendations have come from the Ontario government’s own Advisory Committee on Environmental Standards (“ACES”) in 1994 and the *Ontario Drinking Water Advisory Council* (ODWAC) in 2009, as well as other organizations such as the Canadian Environmental Law Association (CELA).<sup>86</sup>

The current drinking water guideline of 7,000 Bq/L is based on the permissible ICRP limit of 1 mSv/year (lowered to 0.1 mSv in water) and the RBE of tritium of 1.<sup>87</sup> This “standard” allows 350 excess fatal cancers per million people.

A standard of 20 Bq/L as recommended is based on the health effects from long-term, chronic exposure over a lifetime of 70 years, and limits the lifetime risk to about one excess fatal cancer per million people. This aligns with the current Canadian Federal (and Provincial) limit for chemicals, which is set at levels that provide a lifetime risk of 1-10 excess fatal cancers per million people. The risks used to determine standards for radioactive substances in Canada, such as for tritium in drinking water, must be at least as stringent as for non-radioactive chemicals.

If the RBE for tritium were increased by a factor of two to three, then all exposure standards for tritium would have to be adjusted accordingly. The new drinking water standard would be 7-10 Bq/L, which would more accurately reflect the impact of tritium on human health.

According to the Canadian Nuclear Association, a 20 Bq/L tritium standard is achievable without significant cost to the nuclear power industry. In fact, the CNSC study shows that levels of tritium in drinking water near nuclear stations tend to be below 20 Bq/L for the most part. None are anywhere near the current standard of 7,000 Bq/L.<sup>88</sup> There is no need for Canada to maintain a tritium level in drinking water that is excessive, unnecessary, and potentially detrimental.

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<sup>86</sup> Ontario Drinking Water Advisory Council, *Report and Advice on the Ontario Drinking Water Quality Standard for Tritium* (Toronto: ODWAC, 2009) [http://www.odwac.gov.on.ca/reports/052109\\_ODWAC\\_Tritium\\_Report.pdf](http://www.odwac.gov.on.ca/reports/052109_ODWAC_Tritium_Report.pdf); Canadian Environmental Law Association, *Comments to the Ontario Ministry of the Environment Regarding the Proposal to Adopt the Canadian Drinking Water Quality Guideline for Radiological Characteristics as an Ontario Drinking Water Objective for Radionuclides* (Toronto: CELA, October 1999). See also Canadian Environmental Law Association “Proposed Tritium Drinking Water Standard Too High Say Groups” (October 26 1999).

<sup>87</sup> CNSC Standards and Guidelines for Tritium in Drinking Water (January 2008)

[http://nuclearsafety.gc.ca/pubs\\_catalogue/uploads/info\\_0766\\_e.pdf](http://nuclearsafety.gc.ca/pubs_catalogue/uploads/info_0766_e.pdf)

<sup>88</sup> [http://nuclearsafety.gc.ca/pubs\\_catalogue/uploads/info\\_0766\\_e.pdf](http://nuclearsafety.gc.ca/pubs_catalogue/uploads/info_0766_e.pdf)

## WORKER HEALTH AND SAFETY

The currently allowed level of exposure to ionizing radiation, referred to as the effective dose limit (in millisiverts, mSv), is 1 mSv/year for the public, and 100 mSv over 5 years, with a maximum of 50 mSv in one year for Nuclear Energy Workers (NEWs). In special circumstances, an effective public dose of 5 mSv/year may be permitted.<sup>89</sup> These limits have been set by the International Commission on Radiological Protection (ICRP) and are used by the CNSC, Bruce Power, and OPG as regulatory limits.

The Biologic Effects of Ionizing Radiation (BEIR) VII Report has concluded that there is a linear-no-threshold (LNT) response to radiation, that is, that there is no threshold dose below which the risk of tumor induction is zero.<sup>90</sup> Any level of exposure to ionizing radiation can cause harm. Thus, the regulatory dose limits are administrative in nature, not health limits. In fact, the CNSC has acknowledged this stating that “the public dose limit of 1 mSv per year is a regulatory limit in the *Radiation Protection Regulations* – not a health limit. Dose limits have mistakenly been regarded as a line between what is safe and what is not safe”.<sup>91</sup>

As workers in the nuclear industry, whether they are identified as Nuclear Energy Workers (NEWs) or contractors, are much more readily exposed to ionizing radiation, not only during routine operations but so much more so, during the planned refurbishment work, how well are they protected against the effects of exposure to such radiation? This is of particular concern, not only because of the nature of the work that would need to be done, but also, because of the additional workforce (contract workers) that would be hired to carry out the tasks required.

Nuclear licensees, in this case, Bruce Power, set Action Levels (ALs) and Administrative Dose Limits (ADLs) for employees and contractors. ALs are designed to alert licensees before regulatory dose limits are reached, while ADLs are designed to ensure that individuals do not exceed regulatory limits. However, there is a notable difference between the ADLs set for employees compared to the ADLs for contractors (i.e., contract and building trade union employees) as seen in the following table.<sup>92</sup>

<b>Administrative Dose Limits (ADL)</b>			
<b>Category of Worker</b>	<b>Dose Period</b>	<b>Employees</b>	<b>Contractors</b>
Nuclear Energy Worker (NEW)	One-year dosimetry period	20 mSv	40 mSv
	Five-year dosimetry period	50mSv	90 mSv
Pregnant NEW	Balance of pregnancy	0.5 mSv	0.5 mSv
Non-NEW	One calendar year	0.5 mSv	0.5 mSv

<sup>89</sup> <http://www.hps.org/documents/publicdose03.pdf>

<sup>90</sup> BEIR VII report: [http://dels.nas.edu/resources/static-assets/materials-based-on-reports/reports-in-brief/beir\\_vii\\_final.pdf](http://dels.nas.edu/resources/static-assets/materials-based-on-reports/reports-in-brief/beir_vii_final.pdf)

<sup>91</sup> Study of Consequences of a Hypothetical Nuclear Accident and Effectiveness of Mitigation Measures – CNSC draft report, December 2014 e-Doc 4449079 A0043878\_000188

<sup>92</sup> Bruce Power Licence Conditions Handbook (LCH-BNGS-R003, effective July 2017) p. 62-64

As indicated in the table, the ADL for a one year period for contract workers is set at twice the value set for employees. Similarly, the ADL for contractors for a five-year period is 90 mSv, while it is 50 mSv for employees. While the same ADLs are used at the Darlington Nuclear Generating Station (DNGS), in addition, an ADL of 10 mSv/year is also specified for NEWs who has had a lifetime whole body dose greater than 500 mSv. However, this category does not apply to contract workers.<sup>93</sup>

With respect to Bruce Power's plans in its relicensing proposal, routine maintenance and repair work by NEWs and contract workers, including testing and measurement, would be carried out on fuel channel components (e.g., pressure tubes, feeder pipes, garter springs, etc.). As these components age, it will be necessary to increase the frequency of monitoring, inspecting, and repair of these components as they age. Such routine and intensive work could very well result in higher exposure of workers to all forms of ionizing radiation, and also to other hazardous substances, and have serious long-term effects on the health of the workforce.

The work involved in refurbishment (i.e., Major Component Replacement) is that much more hazardous. The majority of this work is done typically by contractors. This is partly reflected by the higher ADL set for contractors as compared to Bruce Power's employees. That, in itself, is highly objectionable and should not be permitted.

All phases of the refurbishment project, including construction, defueling, replacement of reactor components, continued operation, the loading, transfer and storage of waste, the transportation of materials, and end-of-life shutdown, will impact heavily on the workforce. Many of the contract workers may be doing these jobs on short-term contracts, but perhaps repeatedly for each of the six reactors. This could place them in a very hazardous position regarding their total exposure to ionizing radiation.

Some of the most dangerous work is done manually, such as the cutting and grinding of feeder tubes which caused the exposure of over 550 contract workers to alpha particles during the refurbishment of Unit 1 of Bruce A in 2009.

Any of this work, be it routine maintenance, repair or refurbishment, can lead to accidents (spills, fires etc.) and emergencies, some very serious, and place front-line workers at a high risk of exposure to ionizing radiation and other contaminants. In fact, a survey of reportable events at the Bruce Nuclear Station indicates the vulnerability first and foremost to workers as a result of a number of these events.<sup>94</sup>

According Bruce Power's proposed timelines, each of the 6 units will be shut down for a very short period (approximately 6 months or a year) before refurbishment work begins. This contrasts with the refurbishment at Units 1 and 2, which were shut down for approximately 10 years before the commencement of refurbishment. Thus, the radiation fields of Units 3-8 will be much higher than they were at Units 1 and 2.

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<sup>93</sup>Darlington LCH 2015 p. 75

<sup>94</sup> Refer to Submissions from Eugene Bourgeois and Anna Tilman: 1) re-licensing Bruce Power March 2015 CMD 15-H.210 p. 83-102, p.118 -120 and 2) re-licensing the WWMF April 2017 CMD 17-H3.20 p. 17-20

The main source of reactor face fields is Cobalt-60 deposited on the inlet feeder pipes. Since Cobalt-60 has a half-life of about 5 years, for a reactor that has been shut down for 10 years, the activity will be 1/4 of its value at shutdown. As there will be no significant delay from shutdown to refurbishment for Units 3-8, the reactor face fields may be as high as 5mSv/hour.

Based on the maximum annual dose limit for NEWs, a worker could spend just 10 hours at the reactor face before exceeding the annual dose limit of 50 mSv. By comparison, the contract workers for the refurbishment of Units 1 and 2 spent up to 30 hours at the reactor face in fields up to 1 mSv/hour, thereby receiving a dose of 30 mSv.

Not only will workers be exposed to high levels of cancer-causing radiation, they will also be exposed to non-threshold carcinogens and other toxic substances. The cumulative, synergistic, and long-term effects on workers of their exposure to both radioactive and non-radioactive hazardous substances are not even recognized, let alone addressed.

The contract workers are to receive training, but it is not clear how thorough this training will be, and whether the hazards of the work they will be carrying out and the potential for accidents will be properly explained. Will there be a strong focus on the risks of exposure to radiation? Will these workers have the option to opt out of a task if they feel that it is too dangerous?

As described in Bruce Power's Licence Application, it has in place a contractor management program that defines the requirements and processes for the management of workers under contract to complete work on behalf of in accordance with safety regulations, procedures, budget, schedule, and appropriate quality standards. This program includes oversight processes and defines the roles and responsibilities of Bruce Power and its contractors. The expectation for contractors is the same as it is for its employees.<sup>95</sup>

In 2017, Bruce Power launched its "You Can Count On Me" initiative, which is focussed on contractor performance, their commitment to high standards and their responsibility for safety. A number of other training initiatives are being developed such as simulator to be built for training purposes, and certification and qualification tests.

As we have no details of these training programs, it is difficult to comment on them. However, a major concern is whether this training is more than just adequate, and whether it reflects the potential hazards that workers are exposed to in an unbiased manner. It is also important that all workers wear fully protective clothing according to the tasks they are carrying out and the location of the work.

If incidents, accidents or events do occur, as they do under normal operations, maintenance work or refurbishment work, will Bruce Power troubleshoot and review these incidents with workers, as a precautionary matter? Will Bruce Power be open to discussions with workers as to concerns they may have in carrying out an assigned task?

A major issue regarding the work by contractors as well as employees is that it is primarily shift work. In its licence application, Bruce Power acknowledges that anyone working past 13 hours

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<sup>95</sup> Licence Application – Performance Review pp. 29, 40-42, 48,49

is potentially fatigued mentally and physically. However, it also notes that there are times when “certified staff are required to work extended shifts beyond 16 hours”<sup>96</sup>.

Inclement weather and road conditions and closure, which are frequent enough in winter, could lead to prolonged working hours, making it difficult for people to be able to make their shift and replace other workers.

Lengthy shiftwork, up to 16 hours, is a recipe for work stress, mentally and physically. Rest periods within a shift, as suggested by Bruce Power, are not necessarily going to suffice to overcome fatigue or the potential effects from such fatigue over o many hours of work requiring precision and alertness at all times.

While Bruce Power claims that there have been no incidents in its current licence period in which fatigue has played a role, the pattern and level of activity of the current licence period cannot be applied to that of the requested upcoming licence period by any means.

Certainly there is one lesson that must be learned and that relates to the alpha contamination of over 500 contract workers while refurbishing Unit 1.

What changes, if any, has Bruce Power adopted in light of this major workers’ accident? Has Bruce Power put in place a plan to track the health of these workers and their families in the long-term? Will contract workers to be hired for the upcoming work be informed of this accident? That would be a necessary and responsible step to take and be a component of their training program.

Regrettably, Bruce Power has not made any reference to that incident. Yet the possibility of alpha contamination is definitely there. Just recently, on February 6, 2018, there was internal contamination of alpha particles at the Darlington Station’s retube waste processing building which affected 2-3 workers. This should serve as a strong reminder to Bruce Power to ensure that its workers are made fully aware of this “event”, as well as past experience with alpha exposure.

While Bruce Power is commencing this work, refurbishment for the four reactors at the DNGS has already begun. Both of these refurbishing projects will extend well past a decade, even longer, based on past experience. At both stations, it is essential to have ongoing training and inspections, not just walk-throughs, but detailed inspections frequently by the CNSC and/or independent inspectors. This should not be only after an incident has occurred but as a matter of routine and cautionary practice.

Exposure to radiation is silent – it eludes all senses. Any deleterious effects may be latent and not appear for many years later. Bruce Power, the CNSC, and the province of Ontario must keep this uppermost as it continues its pursuit of nuclear power.

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<sup>96</sup> Ibid p. 48

## REPORTING EVENTS - PUBLIC ACCOUNTABILITY

### CNSC Requirements

Since 2003, Nuclear Power Plant operators were required to submit “Event Reports”, known as S-99 Reports, to the CNSC on a yearly basis under the S-99 regulatory standard.<sup>97</sup> The regulatory document, REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants* replaced the S-99 regulatory standard as of June 2015.<sup>98</sup> The requirements under this regulation set out the timing and information that nuclear power plant licensees are required to report to the CNSC to support the conditions of their operating licences, similar to those of the S-99 regulations.

Accordingly, for every “reportable” event a nuclear facility must file a full report that provides details regarding the event, including the effects on the environment, the health and safety of persons, and the maintenance of security that has resulted or may result from the situation, and actions that the facility has taken or proposes to take with respect to the reportable event.<sup>99</sup>

The regulation also states that “Licensees should use the situation or event reporting according to this regulatory document as an input to their public disclosure protocol.”<sup>100</sup>

However, there are limitations as to what is considered a reportable event and the information that is made publicly available. For example:

- The websites of licensees include only a list of events that have occurred at a specific station for a specific year and a report number.<sup>101</sup> No further information is provided as to how one could access reports on any of these events. Thus, the public has no indication as to the cause of the accident/incident; its relative severity; or whether there were releases of radioactive and other hazardous substances that resulted in exposure by workers and/or the public.
- The lists of events exclude those considered to involve confidential or security-based information. While a request can be made for such information under Access to Information, some of that information could still be redacted. This limits public access to reports of events beyond those submitted under REG 3.1.1. Thus the public is uninformed as to how such events may have affected them.

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<sup>97</sup> Section 6.3 of the S-99 regulatory standard, *Reporting Requirements for Nuclear Power Plants* CNSC March 2003 [http://nuclearsafety.gc.ca/pubs\\_catalogue/uploads/S99en.pdf](http://nuclearsafety.gc.ca/pubs_catalogue/uploads/S99en.pdf) (Criteria - p. 24, 25)

<sup>98</sup> [nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory.../regdoc3-1-1/index.cfm](http://nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory.../regdoc3-1-1/index.cfm)

<sup>99</sup> CNSC CMD 17-H.3 p. 31: Sections 29 and 30 of the *General Nuclear Safety and Control Regulations* outline specific scenarios under which a licensee must file a report to the CNSC.

<sup>100</sup> <http://nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents/published/html/regdoc3-1-1/index.cfm#appA>

<sup>101</sup> <http://www.brucepower.com/2017-reportable-events/>: <http://www.brucepower.com/site-updates/>

- Only those events that meet specific criteria are required to be reported to the CNSC. Even when an event is reported to the CNSC, its staff decides whether it has enough “significance” to warrant further review by the CNSC Commission. There are no clear guidelines as to what would determine the significance of an event as to whether it should be reported.

A pertinent example of an event that was not reported to the CNSC was the exposure of workers to alpha radiation during refurbishment at the Point Lepreau Nuclear Station in 2009. This occurrence did not trigger reporting because the predicted dose to workers was below the Action Levels set by New Brunswick Power Nuclear (NBPN), the operator of the facility.

- Even if an event is initially reported under Event Initial Reports (EIR), there may be no follow-up action that the CNSC deems warranted.
- There is no indication as to whether the findings of the investigation of the causes of an event are verified by an independent third party. Nor is there a requirement for these reports to include recommendations as to specific measures that should be taken to remedy/prevent these events, especially those that are recurring.

Despite weaknesses in the system of reporting as noted, these events, even as a list, tell us a number of things. Firstly, there are several incidents, irregularities etc., at these facilities, year after year, happening with a disconcerting frequency. Some of them result in the release highly toxic substances to the environment, both radiological and non-radiological. Workers are on the frontline of exposure to these substances.

Tritium spills are common. Diesel fuel from corroded pipe lines has ended up on the shores of Lake Huron. Highly toxic substances such as hydrazine, morpholine, and ammonia are released into the environment. Lethality tests of essential organisms for fish in Lake Huron and its tributaries have been positive.

We question whether the change in regulation as to reporting events has had a negative impact on the public’s ability to access event reports. For example, for Bruce Power’s Licence Hearing in 2015, we were able to obtain S-99 reports and follow-up reports from the CNSC. However, that does no longer seem possible. That is unfortunate, if that is the case.

In our review of S-99 reports for the years 2009-2014, which we obtained by request from the CNSC, we noted that the root causes for these events included failure to follow procedures, equipment failures, lack of organizational oversight, and delays in actions. These root causes, cumulatively, speak to an inadequate “safety culture”, in sharp contrast to statements made by both Bruce Power and CNSC staff professing the robust nature of the safety culture at Bruce Power.<sup>102</sup>

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<sup>102</sup> Refer to Submission from Eugene Bourgeois and Anna Tilman re re-licensing Bruce Power March 2015 CMD 15-H.210 p. 83-102, p.118 -120

## Review of Two Event Reports

Two “events” of particular interest related to Bruce Power and refurbishment were discussed at a CNSC Commission meeting held March 15, 2018.<sup>103</sup> Following is a brief description of these events.

### 1) Bruce Power: Unit 4 March 4 2018 - Failure of the Primary Heat Transport (PHT) Seals<sup>104</sup>

On March 4, 2018, Bruce A Unit 4 was operating at 88.6% full power. Indications of a potential problem led to shutting down the unit. After shut down, a leak developed on the gland seal of PHT pump 4, which caused approximately 5 drums of heavy water to leak out of containment into a dyked area of the powerhouse, causing a tritium and loose containment hazard.

Thirty workers involved in the clean-up were exposed to tritium.

At the Commission hearing, it was noted that a similar event had occurred in Unit 3 on August 3 2017. There is no report, at least publicly available, pertaining to this event. Similarly, reference was made to Unit 2 regarding the failure of these seals. This unit was placed into an unplanned outage on March 11<sup>th</sup>, 2018. However, as with Unit 3, no information or report has been provided.

The failure of these seals in 3 units of Bruce A is disconcerting. It remains to be seen how the CNSC and Bruce Power will address this problem. A root cause analysis is required, at least for Unit 4. It would be advisable if the situation at Units 2 and 3 were further investigated.

### 2) Ontario Power Generation (OPG) - Darlington: Retube Waste Processing Building (RWPB) February 6 2018 - Internal Contamination Event<sup>105</sup>

Contamination was detected on two workers performing bolting operations in the waste Tooling Building (WTB) in the RWPB. Whole body monitoring revealed facial contamination on one of the workers. Follow-up monitoring indicated the presence of internal contamination. No respiratory protection was being used and no continuous air monitoring was set up in the immediate area.

At the time of the event, the WTB was designated as an Alpha Level I area, in that it was assumed that alpha contamination was minimal. The WTA was then reclassified as a Level III area.

The classification Alpha I, Alpha II and Alpha III areas is based on the relative abundance of loose alpha contamination compared to beta/gamma contamination. In Alpha I areas, internal exposure from loose alpha emitters is not likely to exceed 10% of total internal

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<sup>103</sup> <http://nuclearsafety.gc.ca/eng/the-commission/whats-new.cfm>; also <http://nuclearsafety.gc.ca/eng/the-commission/pdf/2018-03-15-Meeting-e.pdf>;

<sup>104</sup> CMD 18-M13 Event Initial Report (EIR.) <http://www.nuclearsafety.gc.ca/eng/the-commission/meetings/cmd/pdf/CMD18/CMD18-M13.pdf>

Note: A gland seal serves to keep heat transport fluid, or heavy water, from escaping from around the rotating shaft of the pump. A leak from a PHT is considered a design basis event.

<sup>105</sup> <http://www.nuclearsafety.gc.ca/eng/the-commission/meetings/cmd/pdf/CMD18/CMD18-M14.pdf>



dose, while in Alpha III areas, the internal exposure is likely to exceed 90% of the total internal dose based on inhalation. Thus, alpha is the primary inhalation hazard to be monitored and controlled.<sup>106</sup>

The CNSC staff is currently conducting a “reactive Type II inspection” of OPG’s Radiation Protection Program in the RWPB and monitoring the current radiological stand down and return to operational status of the contaminated areas.

Whenever the issue of alpha contamination arises, concern is heightened as well it should be. While the CNSC consider the alpha case in Bruce A closed, this event at Darlington once more demonstrates that alpha contamination can happen and that inadequate worker protection and enforcement of such protection is a serious problem, as is the lack of appropriate air monitoring, and the failure to anticipate a higher level of alpha in the areas that the work was going on. Indeed, the Commissioners expressed concern over the initial Alpha I designation and the absence of protective respiratory equipment.

We question whether the level of inspection being conducted by the CNSC (Type II) is even adequate, especially as cases such as these events point to the need for more thorough inspections. We also expect the results of the investigation to be made available to the public. This is especially important as both Bruce Power and OPG express their utmost confidence in the safety of the massive refurbishment work planned and in the case of OPG, already underway.

These are just two examples of “events” for which reports were issued and were accessible as a result of the CNSC hearing. However, we (the public, and potentially the workers) have little knowledge of events for which no information is provided.

Nuclear operators and the CNSC must make the necessary effort to provide informative communication to the public with respect to “events”.

Withholding this information, or making it difficult to access, harms the public good, and is contrary to the mandate of the CNSC. It is also not indicative of a strong safety culture, as continually professed by CNSC and nuclear operators. It also speaks to the lack of public transparency on such important issues.

A table listing reportable events at the Bruce Stations A and B for the year 2017 is found at the link <http://www.brucepower.com/2017-reportable-events/>.<sup>107</sup> This table clearly demonstrates our concerns over the manner in which we, the public, are informed about events. The titles alone, for example, “loose contamination”, “Unit 7 Shutdown”, “Unit 6 Turbine Runback”, “Unposted Radiological Hazard”, and so on, are industrial jargon, with absolutely no meaning for those on the outside, the public. This practice must change.

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<sup>106</sup> EPRI Alpha Monitoring and Control Guidelines for Operating Nuclear Power Stations, Revision 2, 2013 Technical Report.

<sup>107</sup> Refer also to <http://www.brucepower.com/site-updates/>

## INSPECTIONS AT NUCLEAR POWER PLANTS (NPPS)

In the fall of 2016, the Commissioner of the Environment and Sustainable Development under the Office of the Auditor General (OAG) issued a report that commented on and made recommendations on the inspection of nuclear power plants.<sup>108</sup>

In particular, the OAG Report reviewed two types of inspections, Type I and Type II, undertaken by the CNSC, and made recommendations specific to the application of these inspections.

With respect to these two types of inspections, their purpose and features are as follows:

### **Type I:**

The purpose of Type I inspections is to determine whether licensees' programs comply with all applicable regulatory requirements and to verify that the programs have been carried out. Type I inspections are normally broad, program-based inspections similar to audits or evaluations.

- They are in-depth examinations of licensees' processes and operations.
- They normally require a multidisciplinary inspection team due to their broad scope.
- The Canadian Nuclear Safety Commission (CNSC) did not conduct Type I inspections on nuclear power plants during the 2013–14 to 2014–15 fiscal years.

### **Type II:**

The purpose of Type II inspections is to verify the delivery (results) of licensees' programs through routine item-by-item checklist inspections. Type II inspections are usually inspections of specified equipment, facility material systems, or of records, products, or outputs that result from the process the licensee must follow.

- They are an on-site snapshot of the licensees' operations.
- They can be conducted by only one inspector.

The OAG Report noted that:

“Overall, we found that the CNSC could not show that inspectors always followed CNSC procedures when carrying out and documenting inspections of nuclear power plants. This has led to inconsistencies, gaps in documentation, and missed opportunities for identifying improvements in conducting inspections.”

The Report recommended that CNSC develop detailed criteria to help identify when to conduct Type I inspections.

The CNSC responded that during the audit period, several major relicensing or refurbishment activities for nuclear power plants entailed comprehensive compliance reviews (including desktop reviews, site inspections, and reviews of unplanned events). These reviews provided the required information needed to ensure regulatory compliance, and as a result Type I inspections were not required during that period.

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<sup>108</sup> [http://www.oag-bvg.gc.ca/internet/English/parl\\_cesd\\_201610\\_01\\_e\\_41671.html](http://www.oag-bvg.gc.ca/internet/English/parl_cesd_201610_01_e_41671.html)

## CNSC Comments on Inspections

As indicated on the CNSC website, two types of inspections are undertaken:<sup>109</sup>

**Type I** inspections: These inspections are thorough, resource-intensive, complex on-site reviews that assess and verify key areas of licensee compliance. They are usually conducted by a CNSC inspection team and are systematic, planned, and documented.

**Type II** inspections: These inspections may be planned or reactive, announced or unannounced, and are conducted by one CNSC inspector or a team. They verify the results of licensee processes and include routine inspections or rounds to check equipment, systems, records and products.

In a briefing note to the President, CNSC staff raised concerns with respect to the level of inspections that have been or are being carried out, in particular:<sup>110</sup>

CNSC staff used Type I inspections more frequently in the past to assess program implementation and the appropriateness of program elements against expectations. The baseline compliance program for nuclear power plants (NPP) no longer includes routine Type I inspections. Specialist staff are of the opinion that properly scoped and executed inspections continue to represent a valuable tool in identifying and assessing programmatic weaknesses. **A Type I inspection has not taken place at Bruce Power since September, 2005. [Emphasis added]**

Type II inspections are item-by-item checklists style inspections. Programmatic weaknesses are usually not identified by these inspections. While a reactive (Type II) inspection was performed at Bruce Power in May 2011, a Type I inspection would have been more appropriate, particularly as declining performance or major changes were noted by CNSC staff, for example, average collective doses for the operating units at Bruce Power (over at least the past 5 years) were higher than that seen in the rest of the Canadian CANDU fleet, and in excess of Institute of Nuclear Power Operations (INPO) goals for CANDU units.

### CNSC's Corrective Action Plan

In response to the findings of OAG's 2016 report and its recommendations on the inspection of nuclear power plants in which the OAG recommended that the CNSC should develop detailed criteria to help it identify when to conduct Type I inspections, the CNSC Management Response was as follows.

Agreed. Criteria for determining when Type 1 site inspections are to be conducted are currently being formalized and the CNSC will include them in its management system by December 2016.

**CNSC Actions:** The compliance planning process has been updated to include detailed criteria for when to conduct Type I inspections as part of the CNSC's management system. The criteria which would trigger the need for a Type I are:

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<sup>109</sup> [http://nuclearsafety.gc.ca/pubs\\_catalogue/uploads/CNSC-Public-Information-Brochure\\_e.pdf](http://nuclearsafety.gc.ca/pubs_catalogue/uploads/CNSC-Public-Information-Brochure_e.pdf)

<sup>110</sup> Briefing Note for the President – CNSC Assessment of Internal Practices based on Lessons learned from the Alpha event at Bruce A: E-doc 3796413, (FOI request)] 164 CMD 15-H2.1 p.61-62

- a new licensing basis program
- a significantly changed licensing basis program
- an unacceptable systematic compliance performance of a licensing basis program

### **Inspections at Bruce Power**

According to the CNSC staff document CMD 15-H2 December 2014, eight CNSC Type II compliance inspections focusing on elements of radiation protection were conducted at Bruce Power from 2009 to 2014. The conclusion of the staff was that “No areas for improvement were identified which resulted in an increased risk to the health and safety of workers or members of the public.” As has been noted, no Type 1 inspection has been carried out at Bruce Power since 2005. The alpha incident at Unit 1 during its refurbishment certainly would have and should have heightened the need to conduct detailed inspections of the nature of Type I inspections, at the very least.

In light of Bruce Power’s operating license application for the years 2018-28, which includes refurbishing 6 CANDU units, one would expect that the CNSC would require Type 1 inspections, given the nature of the work being planned. There is only one reference to inspections in its licence application:

“During the past licence period, Bruce Power completed an internal audit of the program (i.e. the contractor management program). Additionally, CNSC staff completed a Type II inspection of the program.”<sup>111</sup>

This sends a disturbing message that no Type 1 inspections are planned to be carried out. Is one to infer that there is no need for such inspections or that Bruce Power has enhanced its alpha monitoring and control program to a level that the CNSC and Bruce Power consider at a satisfactory level that would avoid the problems encountered with alpha contamination in 2009?

The shift to few, if any, thorough inspections does not respond to recommendations made in the OAG Report. Furthermore, it is contrary to the safety ethic or “safety culture” which CNSC and Nuclear Power Plant operators claim to embrace and is unacceptable.

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<sup>111</sup> Performance Review of Bruce A and B p. 30

# RADIOACTIVE WASTE ISSUES

## Overview

Bruce Power's licence application includes the continued operation of two reactors (Units 1 and 2, of Bruce A) and the refurbishment of Units 3-8 (referred to as the Life-Extension Program) spanning over at least a 13-year period. While one reactor is undergoing refurbishment, maintenance work is to be conducted on other reactors. This Program proposed by Bruce Power is intended to extend the life of Units 3-8 by approximately 30 years.

The refurbishment work for Units 1 and 2 of Bruce A was completed in 2012. These units are expected to operate for 30 years following refurbishment and would be shut down at the end of 2042.

Considering the times at which this work is scheduled to commence for each unit, the estimated life cycle timeline for the preparation for safe storage and dismantling for Bruce A is projected to commence in the year 2044 and extend to 2062. Similar preparations for the 4 Units at Bruce B would commence in 2059 and extend to 2063.<sup>112</sup>

Throughout the operational and life-extension periods, radioactive waste from refurbishment and continuing reactor operations will be generated. After the reactors are shut down, and placed in a state of "safe storage", which includes removal of fuel and drainage of the moderator and heat transport systems, they will be stored for about 30 years to allow for radioactive and thermal decay of the used fuel and activated components prior to commencing active decommissioning. And then, decommissioning waste will have to be dealt with.

Neither Bruce Power nor the CNSC have provided neither an inventory that would include estimates of the quantities nor the activities of the radionuclides in the waste streams that would be generated from refurbishment, the maintenance and repair of the reactors awaiting refurbishment, or for the continuation of operations of all the reactors until their closure. Such information is essential and must be a component of Bruce Power's licence application.

Nor has Bruce Power or the CNSC provided specific information with respect to the storage of radioactive waste in the short, medium and long term. While both parties emphasize "minimizing waste strategies", specific strategies are not discussed, other than mentioning segregating the waste and clearing the waste for "free release".

In total, 2-3 pages in the CMDs from Bruce Power and the CNSC speak in generalities about "waste".<sup>113</sup>

According to CNSC's CMD: "The waste management program is captured under Bruce Power's BP-PROC-00878, *Radioactive Waste Management Program*, which is a procedure level document and fell under the overall environmental program in BP-PROG-00.02, *Environmental Safety Management*."<sup>114</sup>

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<sup>112</sup> CMD18-H4 Submission by CNSC p. 4, 116

<sup>113</sup> Bruce Power's 2018 Licence Briefing provides a minimal description of waste classification, and references re-tube waste and steam generator waste <http://www.brucepower.com/2018-licence-renewal-briefing/>

<sup>114</sup> CMD18-H4 p. 116

In response to our request to Bruce Power for this document, we were informed that “the requested document (BP-PROC-00878) is considered proprietary information by Bruce Power and will not be released to the public. The description in the Bruce Power CMD adequately covers the function of the radioactive waste management process at Bruce Power.”<sup>115</sup>

We strenuously argue otherwise. As has been mentioned above, the scant material in both CNSC’s and Bruce Power’s CMDs on waste is meaningless and completely uninformative.

Radioactive waste is the legacy of the nuclear industry and its “Achilles Heel”. It is the hot button topic of public concern with respect to the nuclear industry and has been for decades. This issue is not going to disappear magically. Its importance must be brought to the forefront, not relegated to a position that makes light of the long-term problems created by this waste.

### **Classification and Description of L&ILRW**

In Canada, low-and intermediate-level radioactive waste (L&ILRW) is defined by exclusion, that is, if radioactive waste does not include used nuclear fuel waste or uranium mine and mill tailings, it is classified as low level radioactive waste (LLRW) or intermediate level wastes (ILRW).<sup>116</sup>

The classification of radioactive waste identified by Bruce Power that would be generated during normal station operations and during the Life-Extension Program, are as follows:<sup>117</sup>

**LLRW** typically consists of equipment and material that has come into contact with radioactive material from within a reactor, such as mops, rags, paper towels, temporary floor coverings, floor sweepings, protective clothing, and hardware items such as tools. It also includes steam generator segments. Radiation levels associated with LLRW do not, for the most part, require shielding or specialized packaging.

**ILRW** consists of ion exchange resins, filters and irradiated reactor core components. ILRW has higher radiation fields than LLRW and often requires shielded containment for handling, transport and interim storage prior to final disposal. Because of its greater levels of radioactivity compared to LLRW, ILRW is “non-processible”.

**High-Level Radioactive Waste (HLRW)** is confined to irradiated (‘used’ or ‘spent’) reactor fuel and is overseen by federal and international authorities. HLRW is not included in the scope of the Life-Extension Program.

In addition to routine LLRW and ILRW, Bruce Power’s Life- Extension Program would generate re-tube and feeder waste, which consists of both LLRW and ILRW, and steam generator waste.

Bruce Power’s plans for these wastes are as follows:

**Re-Tube Waste:** The ILRW stream includes reactor fuel channel assembly components, such as end-fitting assemblies, pressure and calandria tubes, calandria tube inserts and pressure tube-calandria tube spacers. The pressure and calandria tubes to be removed from the

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<sup>115</sup> Communication via e-mail with Bruce Power

<sup>116</sup> [NWMO Background Papers 7-2 Rennick & Associates](#) p. 22

<sup>117</sup> <http://www.brucepower.com/2018-licence-renewal-briefing/>

reactors are to be volume-reduced, and the pieces deposited directly into an engineered, disposal-ready shielded waste container. The remaining components, considered as LLRW, are to be sent to an off-site facility for volume reduction.

The removed feeder piping and its associated hardware is also considered to be LLRW. The feeder piping connecting reactor fuel channel assemblies to the Steam Generators is to be sectioned and boxed for storage at the on-site waste management facility. Other metal components associated with feeder piping are to be transported off site for volume reduction processing.

**Steam generators (SGs):** All of the SGs are to be removed and replaced. The removed SGs are considered LLRW. Bruce Power plans to seal the SGs prior to being stored intact at the waste management facility on site. Accordingly, sealed waste SGs would provide containment and shielding of the radioactive material contained within. At a future time, the waste SGs is to be sectioned and volume reduced in preparation for disposal.

## **Bruce Power's Planned Waste Minimization and End State**

Radioactive waste is to be handled, transported and processed "according to established procedures". What that means is that "to the extent practical, LLRW will be transported to a service provider for volume reduction." The volume-reduced end product would be returned to site for storage at the on-site waste management facility. Bruce Power expects that this initiative would reduce the volume of LLRW to be stored and disposed by about 90 per cent.

The final stage of the Life-Extension Program would include demobilizing equipment to maximize the re-use of tools and equipment and thus minimize discarding contaminated tools and equipment as radioactive waste.

There are several issues and clarifications that need to be raised with respect to Bruce Power's plans pertaining to radioactive waste. These issues relate to the classification of wastes; the exclusion of consideration of HLRW; the processing of waste for volume reduction both on-site and off-site; and the minimization of waste plans, including clearance levels; and the absence of waste inventories.

### **i) Waste Classification**

The inherent ambiguity and interpretation as to what precisely is included in L&ILRW has resulted in varying descriptions of these wastes and how they may be treated. For example, with respect to addressing whether shielding is required in handling L&ILRW, Ontario Power Generation (OPG) uses the following radiation levels:<sup>118</sup>

LLRW is radioactive waste having a dose rate that is less than 10 mSv/h at 30 cm (unshielded). ILRW is radioactive waste having a dose rate greater than or equal to 10 mSv/h (1 rem/h) at 30 cm. ILRW requires shielding to protect workers during handling. This waste is not processed for volume reduction. It typically comprises about 5% of the total volume of non-fuel waste produced by Nuclear Generating Stations.

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<sup>118</sup> OPG Licence Renewal Document for the WWMF p. 12, or 4,5; OPG CMD 17- H.3.1 p. 4,5

Other variations in the classification of L&ILRW are, for example:

**LLRW** – Radioactive waste in which the concentration or quantity of radionuclides is above the clearance levels established by the regulatory body (CNSC), and which contains primarily short-lived radionuclides (i.e., half-lives shorter than or equal to 30-years). This waste normally does not require significant shielding for worker protection during handling and storage.

**ILRW** – Radioactive non-fuel waste, containing significant quantities of long-lived radionuclides (generally refers to half-lives greater than 30 years).<sup>119</sup> This category also includes alpha emitting waste that is not used fuel waste, LLRW or high thermal spent cobalt waste; or all filters and ion exchange columns with long half-life radionuclides, and reactor core components and bulk ion exchange resins. ILRW often requires shielding for worker protection during handling.

This classification of LLRW, also used by OPG, refers to “clearance levels”, that is, levels at which radioactive materials can be freely released into the environment into landfills, and through recycled products, into the marketplace, without regulatory control. This practice is permitted under the *Nuclear Substances and Radiation Devices Regulations* (NSRDR) Act.

It should be noted that ILRW contains many highly radioactive long-living radionuclides that are produced by fissioning in a nuclear reactor, albeit in much smaller amounts (in activity and volume) than is found in nuclear fuel waste.

The inherent vagueness and the difference of these descriptions of waste, along with the use of terms such as “clearance levels”, “non-processible”, “radiation fields”, “unshielded” and “half-lives”, easily leads to confusion as to the nature of these wastes and their hazards. The only category of radioactive waste clearly defined is high-level waste, i.e., used fuel.

## **ii) High Level radioactive waste (HLRW) – nuclear fuel waste:**

While Bruce Power states that HLRW is not included in the scope of the Life-Extension Program, we fail to see why it is not being considered. After all, this waste will continue to be generated for decades and will require long-term storage on site in the Irradiated Fuel Bay owned and operated by OPG, nominally for 10 years (wet storage), and then moved into Dry Storage Containers (DSCs) for interim storage on-site.

The Nuclear Waste Management Organization (NWMO), established by the federal government, is working on plans for a centralized long term disposal facility for Canada’s used fuel. This process is ongoing and likely will be for a very long while before any “solution” is reached for storing this waste.<sup>120</sup> Consequently, and of necessity, nuclear fuel waste will remain on the Bruce site for a very long indeterminate time, extending well into the 21<sup>st</sup> century at the very least. For example, for each year that all four units of Bruce B operate, 23,500 additional bundles of nuclear fuel waste are generated.<sup>121</sup>

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<sup>119</sup> Ibid Vol. 1 Acronyms (p.15.27)

<sup>120</sup> CMD 15-H8.1 OPG p. 80; <http://www.knownuclearwaste.ca/>

<sup>121</sup> The Nuclear Waste Management Organization (NWMO) of Canada was established in 2002 under the Nuclear Fuel Waste Act (NFWA) to investigate approaches for managing Canada's used nuclear fuel. Refer to:



## ii) Volume reduction of LLRW - on-site and off-site

Some of the LLRW is to be transported off site for volume reduction. It is not clear if this LLRW has specific characteristics or level of activity for allowing it to be transported off-site.

Presumably, once treated for volume reduction, this waste would be returned to be stored at the on-site waste management facility at the Bruce station.

## iii) Clearance Levels - Free-Release of Radioactive Material

One of the current practices to reduce the quantity of LLRW to be stored is diverting this waste via “free-release” to municipal landfills, metal recyclers, etc. Some of this waste could be incorporated into commercial and consumer products, ranging from building materials, steel, roads, vehicles, tools, utensils, furniture, playgrounds, fertilizers, etc.

As a result, this waste is being dispersing in the public domain without public knowledge or consent and no means to track it. No labelling is required that would indicate that this product may contain radioactive-contaminated material. Thus the nuclear industry can claim that it has “minimized” or “reduced” its radioactive wastes, without consequences, that is, no responsibility or liability for this waste.

This is not a sound or safe practice. In fact, dispersing radioactive waste into the environment is exactly what these facilities should not be doing.

Furthermore, minimizing the quantities of radioactive waste does not reduce its activity. The only way that the level of radioactivity is reduced is through the natural decay of the radionuclides contained in the waste.

## iv) Waste Characterization and Management - “Likely Clean Waste”

With respect to clearance of radioactive waste, Bruce Power states that:<sup>122</sup>

Some Zone 2 waste is anticipated to be free of radioactive contamination (“likely clean” waste). Bruce Power packages and handles this waste separately from other Zone 2 wastes. After monitoring in the facility, this waste is cleared for disposal as non-radioactive waste. A portal radiation monitor at the Bruce site main gate will identify any unplanned release of solid radioactive waste from the site.<sup>123</sup>

Bruce Power continues to produce less low-level radioactive waste than planned through its internal programs to reduce and to minimize the volumes of waste required for long-term storage. Through these efforts, the company is consistently diverting 90% of its waste through this program.

Bruce Power provides no details as to a “likely clean” program. Consequently, we are referring to OPG’s program at the WWMF. Accordingly,

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<https://www.nwmo.ca/en/Reports> Nuclear Fuel Waste Projections in Canada – 2017 Update NWMO-TR-2017-14

<sup>122</sup> CMD18-H-4 Submission by Bruce Power: 1.1.1 Relevance and management Section 11.1, 11.3 p.136

<sup>123</sup> Zone 2 refers to an area inside the *zoned area* that is normally free of contamination but is subject to infrequent cross-contamination due to the movement of personnel and equipment from contaminated areas.

**Likely Clean waste** is monitored for tritium, alpha, beta, and gamma emitters. If the waste is determined to be radioactive, it is monitored and transported off-site as active waste for processing at the WWMF.<sup>124</sup> The non-radioactive or radioactive material below the acceptance waste criteria is sent for disposal at licensed landfills, in accordance with the *Nuclear Substance and Radiation Devices Regulations*.

The “acceptance waste criteria” are not specified. Nor is there a limit as to the actual amount of waste that would be “free- released.”

Furthermore, while this waste is supposedly monitored for alpha emitters, it is not specified whether the evidence of alpha emitters in this waste would prevent it from being free-released.

Once again, we reiterate that reducing the volume of waste that is stored by dispersing the waste merely shifts the burden of waste away from OPG and Bruce Power to the public.

### Waste Inventories

In planning for refurbishment, it is essential to have an inventory of the wastes as complete and accurate as possible that are currently stored and projected to be stored. It is incumbent upon the CNSC to require Bruce Power to provide a waste inventory for L&ILRW that would include a list of radionuclides and estimates of their respective activity and volume in both operational and refurbishment waste streams currently projected to the end-of-life of the reactors.

The following table indicates the volume of L&ILRW in (m<sup>3</sup>) and the activity of this stored waste in TBq (10<sup>12</sup> Becquerels) stored at the WWMF from 2007 to 2014. This includes the period during which Units 1 and 2 of Bruce A were undergoing refurbishment, as well as L&ILRW from Darlington and Pickering reactors.

**L&ILW Waste at WWMF**<sup>125</sup>

Year	Total L&ILW (m <sup>3</sup> )	Total Stored Activity (TBq)
2007	3530	130
2008	4492	28242
2009	3301	2207
2010	1999	38
2011	3719	157
2012	2639	39
2013	2455	99
2014	2402	65
2015	2960	30

The total stored activity for this period is approximately 3.1 x 10<sup>16</sup> Bq. Of particular note is the activity of the stored waste in 2008, and to a lesser extent, in 2009. This is attributed to the Bruce A refurbishment waste during those years.<sup>126</sup>

<sup>124</sup> CMD17-H3.1 p. 31, 108

<sup>125</sup> CNSC CMD 17-H3 Table 6 p. 27

Based on OPG's "Reference Low and Intermediate Level Waste Inventory Report for the Deep Geological Repository" which includes the amount and activity of L&ILRW and Refurbished Waste projected to be stored at the WWMF by 2018 for a select number of radionuclides, refurbished waste contributes approximately 87% of the total activity of L&ILW.<sup>127</sup>

To date, no waste inventory has been assembled. This is most unfortunate and irresponsible, not only on the part of the nuclear operator, especially considering refurbishment, but also on the part of the CNSC, which should make this a requirement of Bruce Power as part of its licence.

### **Estimated Radioactive Waste (Volumes) - Bruce Power Operations**

Referencing both the Reference Low- and Intermediate-Level Waste Inventory for the Deep Geologic Repository, Ontario Power Generation, and the 2010 Inventory of Radioactive Waste in Canada, if the six reactors are refurbished as planned, and continue to operate for approximately 30 years afterward refurbishment, these reactors, in addition to the continued operation of Bruce 1 and 2 for at least another 20 years, would generate:

- LLRW at a rate of approximately 200 m<sup>3</sup> per reactor unit per year (after minimizing strategies of this waste)<sup>128</sup>, for a total of 40,000 m<sup>3</sup>.
- ILRW at an annual rate of 37 m<sup>3</sup>/year total per station<sup>129</sup>, for a total of 2220 m<sup>3</sup>.
- Approximately 23,500 fuel bundles of HLRW would be generated by the 4 reactors at Bruce B annually<sup>130</sup>.

As a comparison, the ILRW component generated through refurbishment of the 4 reactors at the Darlington Nuclear Station has been estimated to include 3,860 m<sup>3</sup> of retube waste.<sup>131</sup>

Of course, as has been noted, volumes are not the indicator of activity, which is, by far, the most important metric.

Clearly, Bruce Power's plan in the short, medium or very long term to safety manage all the waste that will be generated by refurbishing the six reactors and the continuing operation of these reactors is sparse.

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<sup>126</sup> Communication with OPG in response to questions regarding the increased stored activities for those years.

<sup>127</sup> OPG Report No. 00216-REP-03902-00003 <http://www.nwmo.ca/uploads/DGR%20PDF/Licensing/Reference-L-ILW-Inventory.pdf> This Report is based on the assumption that L&ILW would be retrieved from the WWMF and transferred to OPG's proposed DGR. (p. 7 and pp. 15-20, 30,31)

<sup>128</sup> Reference Low- and Intermediate-Level Waste Inventory for the Deep Geologic Repository, Ontario Power Generation, pp. 48-50

<sup>129</sup> Ibid

<sup>130</sup> Inventory of Radioactive Waste in Canada, 2010 Table 5.1: Nuclear Fuel Waste Accumulation Rate and Inventory,

<sup>131</sup> CNSC Proposed Screening Report – DNGS Refurbishment and Continued Operation, Section 3.3.6, p. 14

## REFURBISHMENT OF CANDU REACTORS - EXPERIENCE TO DATE

To date, the experience in refurbishing CANDU reactors in Canada has clearly demonstrated that refurbishment, whether full or partial, has run into unforeseen incidents and accidents, resulting in delays, significant cost overruns, compromised safety, and in some cases, excessive or unnecessary exposure of workers to radiation.

The following section highlights a number of issues that have occurred related to refurbishment at three of Canada's nuclear stations, namely Bruce Power, Lepreau and Pickering.

### a) Bruce Power – Bruce A

On Oct. 17, 2005, Bruce Power launched a \$4.25 billion investment program to refurbish and restart Reactor Units 1 and 2. Both of these reactors were shut down in the 1990s, (Unit 1 in 1997 and Unit 2 in 1995).<sup>132</sup> The actual work began in 2006. However, the length of time for refurbishment was far longer and much more costly than anticipated. It also resulted in a major alpha contamination incident of over 550 workers in Unit 1. In spite of CNSC's wish that this accident is "closed", its importance overall means that it will come to the forefront whenever work such as that being done during refurbishment is carried out, especially as critical items regarding safety were ignored.

#### The alpha incident – in brief

Between November 24 and December 21, 2009, building trades workers were cutting and grinding feeder tubes in a part of the Unit 1 reactor building (the "reactor vault"). These tubes supply cooling water to each of the individual pressure tubes which contain the uranium fuel, and thus are a critical support system of the reactor. This work (referred to as "J-prep") consisted of removing the magnetite layer from the inner and outer surfaces of the cut ends of the feeder tubes so that a clean surface would be available for welding the replacement piping.

While beta-gamma radiation was being monitored using a portable air sampler, alpha monitoring was not, as it was assumed that even if there were alpha contamination, the activity levels would be very small compared to beta contamination, in the order of 1 to 10,000. That assumption turned out to be faulty.

Two grab samples taken November 26 and November 28 2009 showed spikes of airborne long-lived radioactive particulate in the general work areas of the reactor vault remote from the J-prep site.<sup>133</sup> These measurements indicated the presence of beta-gamma radiation in the reactor vault at two points in time, but not alpha activity. Follow-up analysis of the samples identified Cobalt-60, a beta-gamma emitter with a half-life of 5.3 years, the dominant radioactive species of the feeder pipes and considered as a long-lived radioactive particulate.<sup>134</sup>

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<sup>132</sup> For a full account of the alpha incident and the responses and actions by Bruce Power and the CNSC, refer to CMD 15-H2.110 Submission from Eugene Bourgeois and Anna Tilman April 2015 p. 87-97

<sup>133</sup> S-99 Additional Information Report, CNSC B-2010-28184910 A1, April 29, 2010; Radiation Safety Institute: Final Report, July 14, 2011 [Final Report], p. 29, 30 [RSIC-Final-Report.pdf](#)  
Levels measured: 7.5MPCa (Maximum Permissible Concentration in Air) and 5.0 MPCa respectively.

<sup>134</sup> In radiation protection in a nuclear power plant, a short-lived particulate has a short half-life, defined in the nuclear power plant workplace as less than 30 minutes. [RSIC-Final-Report.pdf](#) p.63

The presence of alpha in air filters from grab samples that were taken within the vault over several weeks was confirmed and quantified later by a third party December 21, after which work was halted.<sup>135</sup>

The workers cutting and grinding the feeder tubes were not aware that the dust created by their work contained alpha-emitting radionuclides that were traveling into the general atmosphere of the vault. Thus, any worker in the vault would inhale this dust and unknowingly be internally exposed to alpha radiation.

On November 28, 2009, a plastic tent was constructed around the prep work area. Work resumed on the grinding. However, the effectiveness of the plastic tent to contain the airborne particulate was never tested. Subsequently, an investigation revealed that the tent was poorly sealed and not effective in controlling the spread of contamination. As a result, airborne particulate spread far beyond the immediate work area throughout the general vault atmosphere, exposing workers to alpha-emitting particles for almost 4 weeks.<sup>136</sup>

While the workers doing the prep work wore plastic suits, as required by the Radiological Exposure Permit (REP) as protection from airborne contamination, this protection was not used or required in other sections and elevations of the reactor vault.

Consequently, approximately 557 workers were exposed to airborne particulate containing long-lived alpha-emitting radionuclides (e.g., Pu-238, Pu-239, Pu-240, Am-241 and Cm-244) within a 4-week period, many of whom were unprotected from airborne alpha contamination.

If alpha particulate is inhaled, ingested, or absorbed in the bloodstream, exposing sensitive living tissue, the resulting biological and genetic damage increases the risk of cancer, in particular, lung cancer, and other illnesses.<sup>137</sup>

The findings and conclusions of an independent root cause analysis conducted in 2010 by the Radiation Safety Institute of Canada (RSIC) clearly acknowledged Bruce Power's negligence by its failure to provide adequate oversight and analytical preparation prior to the J-prep work. It further indicated that a strong safety culture was absent during this period. In addition, the expertise of other operators was not sought out before beginning the operation, with the predictable result that an accident such as this was likely to occur.

Bruce Power was totally unprepared to deal with the alpha airborne particulate hazard, because it failed to consider its possibility or likelihood.

At a CNSC public hearing December 9, 2010, the cause of the alpha contamination was attributed to "the high ratios of beta-radiation to alpha-radiation in potential contamination produced during normal operations led to the reliance on protecting for beta radiation as a means to also provide protection against possible alpha radiation."<sup>138</sup> This explanation was incorrect. The actual cause was traced back to a fuel channel that had been accidentally crushed

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<sup>135</sup> S-99 reports- B-2010-28184910, [RSIC-Final-Report.pdf](#) Executive Summary, and p. 46

<sup>136</sup> Final Report [RSIC-Final-Report.pdf](#) p. 27-30

<sup>137</sup> <http://www.epa.gov/radiation/understand/alpha.html#exposure>

<sup>138</sup> CNSC hearing regarding re-licensing the Lepreau reactor which had experienced alpha contamination during refurbishment CNSC Document CMD 10-M72 November 23, 2010

during re-fuelling operations on April 19<sup>th</sup> 1979. As a result, up to 4 kg of Uranium Dioxide (UO<sub>2</sub>) was released into the Unit 1 Primary Heat Transport System (PHTS)<sup>139</sup>.

The sad reality is that thirty years after this accident, workers were exposed to airborne alpha-contaminated particulate from fuel debris arising out of the defective fuel bundle.

The other sad reality was that early project planning at Bruce A Restart had identified the potential likelihood for alpha radiation hazards. Approximately eighteen months prior to the alpha contamination incident, a Source Term Sampling (STS) Plan had acknowledged that pure beta and alpha emitters potentially represent a significant contribution to the source term for Units 1 and 2. The STS Plan specified that the alpha emitters Pu-238, Pu-239, Pu-240, Am-241, Cm-242 and Cu-244 should be analyzed in each smear and specimen collected under the Restart source term survey program.

It is not clear why Bruce Power did not pursue this analysis.<sup>140</sup>

### **Refurbishment Costs:**

The October 2005 agreement between Ontario Power Authority and Bruce Power estimated the costs to restart Units 1 and 2 refurbish Unit 3 and replace the steam generators of Unit 4 at \$4.25 billion. \$ 2.75 billion was allotted to Units 1 and 2, and the balance to Units 3 & 4.<sup>141</sup>

In 2008, the cost for refurbishing Units 1 and 2 was increased by \$650 million, and later to \$4.8 billion. Units 3 and 4 were not refurbished. Duncan Hawthorne, Bruce Power's Past President and CEO, stated that "he recalled saying in 2005 that the project would come in on time and on budget. Instead, it took twice as long and cost twice as much."<sup>142</sup>

### **b) Point Lepreau**

New Brunswick's Point Lepreau reactor had been in commercial operation since 1983. Refurbishment activities, intended to extend its life by another 25 years, included replacing all 380 fuel channels, calandria tubes and feeder tubes, as well as other maintenance work. NB Nuclear Power (NBPN) and Atomic Energy of Canada Ltd (AECL) were responsible for the refurbishment project.

The refurbishment began in March 2008, and was to be completed by September 2009. From the onset, this project was plagued by technical glitches, the most critical being the new calandria tubes, which were found to be faulty causing numerous delays and increased costs.

Between December 2009 and April 2010, all 380 calandria were removed, new tubes were installed and the 760 end joints connected and sealed. However, many of the tubes repeatedly failed air tightness tests after they were fused with special inserts to hold them in place. AECL

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<sup>139</sup> Refer to Bruce NGS In-Service Report BNGSA-IR-33000-7: "Unit 1 P13 Fuelling Incident – Monitoring of Heat Transport System", October 1979; and RSIC Final report

<sup>140</sup> [RSIC-Final-Report.pdf](#) p.63

<sup>141</sup> <http://www.powerauthority.on.ca/nuclear/bruce-restart-and-refurbishment-project-3000-mw-tiverton> The agreement is known as the Bruce Power Refurbishment Implementation Agreement (BPRIA)

<sup>142</sup> <http://www.independent.on.ca/site/?q=node/4049>

acknowledged that the tubes and their inserts weren't smooth enough to form a consistently tight seal, and that polishing the ends would have made them fit tighter.<sup>143</sup>

In fact, the tubes had been improperly polished causing microscopic scratching resulting in their failure to meet critical air leak tests. All 380 of the new calandria tubes had to be removed and replaced, and the sheet bores of the tubes polished to ensure an adequate fit. This work added 22 months to the project and raised costs by hundreds of millions of dollars.<sup>144</sup>

While the plant did finally return to service in November 2012, more than three years beyond its planned restart date, it has not been problem-free. Some issues relate to the refurbishment work itself and the failure to consider components that should have been replaced but were not, in particular, many of the steam generator tubes. This has the potential of making the steam generators the weakest link in the primary cooling circuit.<sup>145</sup>

During refurbishment, in 2009, workers were exposed to alpha contamination. This event was not reported to the CNSC as the dose levels were below the Action Levels. Consequently, there has been no follow-up on this issue.

As of March 31 2017, Lepreau operated 194 days less than NB Power originally projected for its first five years, costing nearly \$200 million in reduced production. In filings with the New Brunswick Energy and Utilities Board, NB Power lowered expected production by a further 136 days over the next 23 years to allow for extra maintenance and unexpected problems.

#### **Refurbishment costs:**

This project took at least three years longer than planned and cost \$1 billion more than the original estimate of \$1.4 billion. An additional \$1 billion has had to be spent on replacement power due to refurbishing delays.

### **c) Pickering**

After only 12 years of operation, on August 1 1983, Reactor 2 of Pickering A was shut down following a metre-long rupture in one of its pressure tubes caused by hydrogen absorption into the tube alloy. The remaining three units of Pickering A were shut down. All units underwent "retubing" (pressure tube replacement), a procedure that stretched out to 1993. These units were shut down again in 1997 because of technical and performance problems. The second "refurbishment" was slated for Units 1 and 4. The Provincial Government decided not to refurbish Units 2 and 3, presumably due to costs incurred in this second round of repair work, although safety may have also have played a role in this decision.

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<sup>143</sup> <http://www.cbc.ca/canada/nbvotes2010/story/2010/09/22/nb-lepreau-pc-promise.html#socialcomments>

<sup>144</sup> <http://www.cbc.ca/news/canada/new-brunswick/point-lepreau-insurance-refurbishment-delay-nb-power-1.4193688>

<sup>145</sup> Transcript of Point Lepreau re-licensing hearing December 2011, Dr. Gordon Edwards  
<http://nuclearsafety.gc.ca/eng/commission/pdf/2011-12-02-Transcription-Hearing.pdf>

In February 2010, OPG decided against full refurbishment of the four Pickering B reactors. OPG plans to extend the operation of the operating six Pickering units to 2024, well beyond its original planned closure of 2018.<sup>146</sup>

**Refurbishment costs:**<sup>147</sup>

The initial re-tubing of all four Pickering A units from 1983-93 cost \$1 billion more than the original capital cost. The cost for the Pickering 1 re-tubing alone was approximately \$ 1 billion, more than double the original estimate. The Ontario government decided to retire units 2 & 3 rather than refurbish them, as these units were considered uneconomical to refurbish. The estimated cost for restarting Pickering 4 was \$1.25 billion, more than five times the original estimate of \$230 million.

**d) Darlington**

The refurbishment of the 4 Units at the Darlington Nuclear Generating Station (DNGS) is at its initial stages. OPG's projected schedule is to have refurbishment completed by 2028. While major components are to be replaced, steam generators will not be replaced.

The total cost of the Darlington Re-Build Project is estimated to be \$12.8 billion.<sup>148</sup> Costs were well over \$4.1 billion year just one year into refurbishment and some work has already fallen behind schedule already but risen in cost.<sup>149</sup>

An alpha incident had occurred at the Retube Waste Processing Building (February 6, 2018), as noted in this submission. No continuous air monitoring for alpha was set up in the immediate work area and no respiratory protection was used or even mandatory. After the Bruce A experience with alpha contamination during refurbishment, it is indeed shocking that such an event would still occur, and that all precautionary measures would be employed to avoid such an incident.

The experiences to date should definitely raise concerns about Bruce Power's planned refurbishment of no less than 6 units. There is absolutely no guarantee that these reactors will last 30 or more years after being refurbished, or that the process of refurbishment will be relatively problem-free or accident-free.

Refurbishment has always ended up costing much more than estimated and taking much more time than planned. These exorbitant costs without any public accountability are unconscionable. No business or industry, government-supported or private, should make such unrealistic forecasts of expenditures, yet run up costs that far exceed these estimates, costing residents far more in the long run than expected.

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<sup>146</sup> This estimate has been revised by OPG to \$200 million [www.opg.com/power/nuclear/pickering/](http://www.opg.com/power/nuclear/pickering/)

<sup>147</sup> World Nuclear Association [WNA] Info sheet: <http://www.world-nuclear.org/info/inf49a> Nuclear Power in Canada.html, <http://pubs.pembina.org/reports/appendix2.pdf> p 122-7

<sup>148</sup> CMD 15-H8.1 A, p. 9

<sup>149</sup> <http://www.durhamradionews.com/archives/106419>; <http://www.cleanairalliance.org/global/>



## CONCLUDING REMARKS

The life extension of the Bruce Power Nuclear Generating Station will require refurbishing 6 reactors within a span of about 13 years, as estimated by Bruce Power. It will also require extending the life of aging reactors well beyond their original lifetimes, without solid evidence that this is even possible or safe.

This will be a massive project, one-of-a-kind, and one of the most intensive carried out on nuclear plants anywhere in the world. It must be recalled that just the refurbishment of one reactor unit at Bruce Power has resulted in a very serious accident (the internal exposure of over 550 workers to alpha particles) and cost overruns, delays and accidents at other stations that have undertaken refurbishment. Far greater problems can be expected when six units are to be refurbished in succession at one station.

To continue on this path is costly, potentially very dangerous, and unnecessary. It could be especially dangerous for the workers who will be carrying out most of the refurbishment. It will add greatly to our inventory of radioactive waste, for which we have no safe storage solution. Future generations, who will have not had electricity that was generated by nuclear power, will be left with its problems. That is unjust.

The possibility of accidents, including very serious ones, must be a major concern with any nuclear facility. However, Bruce Power, the CNSC, and the provincial government are convinced that severe accidents at nuclear power stations in Canada are very unlikely. This has been expressed over and over again in submission documents, in spite of the nuclear disasters at Chernobyl and Fukushima, whose consequences are still unfolding and will be for many years. This steadfast belief that an accident cannot happen drives further nuclear expansion, at the same time as it makes a serious accident more likely and reduces our preparedness for it.

Because such accidents are considered unlikely, there is no proper preparation for them. Hypothetical severe accidents are modelled using assumptions and values that do not represent a severe accident, such as the one in Fukushima. Adverse health effects are never predicted (except for children perhaps), even if a severe accident were to occur. The nuclear industry and the CNSC are in complete denial regarding adverse health effects caused by nuclear power plants, even to the point of claiming that no deaths could be attributed to Fukushima, and minimal fatalities have resulted from Chernobyl, even though it still has a 30 km exclusion zone.

The emergency plans that have been developed so far are totally inadequate for a major accident at the BNGS, let alone, a catastrophic one.

To presume that “it can’t happen here” is the height of arrogance and ignorance. It can happen anywhere, at any time, for countless reasons, which can’t all be foreseen or prevented. Fukushima has also demonstrated how important it is to have adequate and effective emergency plans in place. This is especially pertinent to a multi-unit facility such as the Bruce Nuclear Station and for local residents most susceptible to accidents, without appropriate enough shelters and emergency evacuation measures in the event of a serious accident.

Bruce Power's life extension plan would commit Ontarians to rely on these reactors for three or more decades as far out as 2064. But the aftermath of the use of nuclear power would not end in then. The reactors would have to be mothballed for at least thirty years, and then decommissioning would begin. Not only would future generations inherit the radioactive waste from refurbishment, there would be enormous waste resulting from decommissioning that would need to be managed somehow –though it is not evident how. This will go on into the 22<sup>nd</sup> century. All this nuclear waste, from the operation of nuclear plants, refurbishment and decommissioning, is a legacy that no government or company should be allowed to leave for future generations.

With respect to costs for all the work being planned, estimates of \$13 billion or so have little validity, especially in light of experience to date. Even if Bruce Power is allowed to proceed with its request, there must be an opportunity for decisions not to proceed with refurbishing a particular unit, if the costs exceed the estimated cost. Bruce Power must not be allowed to proceed to increase the EFPH to 300,000 and the Heq to greater than 120 ppm as there is no evidence that such levels are safe.

Furthermore, there is no justification whatsoever for proceeding with a 10-year licence period as requested by Bruce Power and recommended by CNSC staff. Such long licence periods are unacceptable, unnecessary, risky, and an impediment to public scrutiny.

Therefore, Bruce Power's 13-year licence application for refurbishment and continued operations should not be granted. Instead, it is recommended that it be granted a renewal of its operating licence for a maximum period of 5 -7 years to enable a full public review of its MCR work to date, the Heq of the units, and allow for re-assessing any future work that should or should not be continued. During this period, Bruce Power must be required to develop a detailed plan for decommissioning all of its eight reactors that would be subject to public scrutiny and consultation.

As Benjamin Goldman, an economist, has said <sup>150</sup>

Governments and agencies responsible for sanctioning nuclear operations have made a rather odious gamble with human life – potentially resulting in millions of cancer deaths and similar nonfatal afflictions to innocent bystanders, many of whom have not even been born. This is discounting the value of an untold number of human lives. Future generations will be forced to take man-made risks that have nothing to do with their well-being.

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<sup>150</sup> Goldman "Discounting Human Lives" p. 247-8

## APPENDIX

### A. Radionuclides Considered for DRL Calculation

Radionuclide/group	Individual radionuclide considered
<b>Airborne Emissions</b>	
Tritium	HTO
Carbon 14 (gaseous)	C-14
Noble gas	Noble gas mixture (as total gamma energy emitted)
Iodine	I <sub>mfp</sub> mixture of I-131, I-132, I-133, I-134, I-135
Particulate (Alpha)	Am-241, Am-243, Cm-242, Cm-244, Np-237, Np-239, Pu-238, Pu-239, Pu-240, Pu-242, U-234, U-235, U-236, U-238
Particulate (Beta/Gamma)	P-32, S-35, Sc-46, Cr-51, Mn-54, Fe-59, Co-58, Co-60, Sr-89, Sr-90, Zr-95, Nb-95, Ru-103, Ru-106, Sb-124, Sb-125, Cs-134, Cs-137, Pu-241, Ce-144, Gd-153, Tb-160, Th-234, Ba-140, Hg-203, La-140, Sn-113, Zn-65, Ce-141, Eu-152, Eu-154
<b>Waterborne Emissions</b>	
Tritium	HTO
Carbon 14	C-14
Gross Alpha	Am-241, Am-243, Cm-242, Cm-244, Np-237, Np-239, Pu-238, Pu-239, Pu-240, Pu-242, U-234, U-235, U-236, U-238
Gross Beta/Gamma	P-32, S-35, Sc-46, Cr-51, Mn-54, Fe-55, Fe-59, Co-58, Co-60, As-76, Sr-90, Hg-203, Zr-95, Nb-95, Ru-106, Sn-113, Sb-124, Sb-125, I-131, Cs-134, Cs-136, Cs-137, Eu-152, I-133, La-140, Mo-99, Na-24, Np-239, Ru-103, Sb-122, Sr-89, Eu-154, Gd-153, Tb-160, Zn-65, Ba-140, Ce-141, Ce-144, Tc-99, Th-234

## B. Reportable Events Filed in 2017 – Bruce Power

Date Reported	Stn	Report #	title
Jan 3, 2017	B	B-2017-28596939	Unit 6 - Loose Contamination
Jan 4, 2017	A	B-2017-28597416	Unit 1 Setback
Jan 9, 2017	A	B-2017-28598494	Incomplete REGDOC-3.1.1 Scheduled Report
Jan 10, 2017	A	B-2017-28598037	Fire Preventative Maintenance (PM) Testing Exceeded Due Date
Jan 12, 2017	B	B-2017-28598419	Category C Spill - Oil Leak in Pumphouse
Jan 17, 2017	B	B-2017-28599304	Relief Valve Nuclear Sampling Requirements Not Met
Jan 23, 2017	B	B-2017-28599829	Unposted Radiological Hazard
Jan 27, 2017	A	B-2017-28601815	Fuel Handling Relief Valve Mandatory Testing Missed
Jan 27, 2017	B	B-2017-28601126	Unposted Radiological Hazard
Feb 1, 2017	A	B-2017-28602507	Motor Oil Category C Spill
Feb 1, 2017	A	B-2017-28602112	ECl Valve Opened too Quickly
Feb 3, 2017	B	B-2017-28602658	Unit 7 Shutdown
Feb 6, 2017	A	B-2017-28602635	Domestic Water Spill
Feb 8, 2017	B	B-2017-28603567	Unit 5 Unplanned Actuation of Shutdown System #1 (SDS1)
Feb 8, 2017	A	B-2017-28595527	BA Analysis for Break on Top of Pressurizer Shows Reduced Margin
Feb 16, 2017	A	B-2017-28604612	Incomplete Records
Feb 21, 2017	A	B-2017-28605217	Less Than Minimum Number of Standby Generators Available
Feb 22, 2017	A	B-2017-28606176	Reactor Inner Zone Inlet Header (RIZIH)
Feb 22, 2017	A	B-2017-28604140	Missed Online Safety System Test
Feb 22, 2017	B	B-2017-28605220	Public Address Speaker blocked
Mar 6, 2017	B	B-2017-28606484	Radiolysis in End Shield Cooling
Mar 8, 2017	A	B-2017-28608361	Missed Monthly Fire Test
Mar 9, 2017	B	B-2017-28607692	Tritium Monitor Alarm Disabled
Mar 13, 2017	B	B-2017-28609891	Heat Sink Boiler Impaired
Mar 14, 2017	AB	B-2017-28606967	Pressure Tube Fracture Toughness from BT-29 Below CSA LB Curve
Mar 14, 2017	B	B-2017-28609464	Unposted Radiological Hazard
Mar 20, 2017	B	B-2017-28611051	Unit 6 Turbine Runback
Mar 28, 2017	B	B-2017-28612767	Worker Injured
Apr 12, 2017	B	B-2017-28614774	Public Address Speaker Function Compromised
Apr 13, 2017	A	B-2017-28614744	Preventative Maintenance Not Completed Per Schedule
Apr 21, 2017	B	B-2017-28615220	Certification Procedure Insufficient
Apr 24, 2017	A	B-2017-28616957	Station Shift Complement
Apr 24, 2017	A	B-2017-28617433	Unit 4 Emergency Coolant Injection System (ECI)
Apr 25, 2017	B	B-2017-28616768	Potential Exceedance of ECA Discharge Criteria
Apr 25, 2017	B	B-2017-28617918	Flame Observed during Pump Motor Return to Service
May 1, 2017	A	B-2017-28614406	Periodic Inspection Not Completed per Schedule
May 4, 2017	AB	B-2017-28616745	Characteristics of Emergency Transfer Scheme
May 12, 2017	B	B-2017-28620047	Unit 6 Stepback Impairment
May 16, 2017	B	B-2017-28621101	Unit 5 Stepback
May 17, 2017	B	B-2017-28621519	Level 2 Impairment of Shutdown System 2
May 17, 2017	B	B-2017-28620877	Radiation Safety Equipment Unplugged
May 19, 2017	A	B-2017-28621508	Unit 4 Unplanned Reactor Shutdown
May 23, 2017	B	B-2017-28622029	Unit 5 Turbine Tripped Manually
May 23, 2017	B	B-2017-28623011	Recertification Simulator Test Failure
May 26, 2017	B	B-2017-28622539	Radioactive Shipments Packaging Damaged

Jun 13, 2017	A	B-2017-28626140	Mandatory Relief Valve Testing Not Completed
Jun 16, 2017	B	B-2017-28624527	Preventative Maintenance Tests Overdue
Jun 16, 2017	A	B-2017-28626196	SDS1/2 Impairment during Testing
Jun 19, 2017	B	B-2017-28627290	Recertification Test Failure
Jun 20, 2017	A	B-2017-28626375	Minimum Shift Complement not met
Jun 21, 2017	B	B-2017-28626458	Unit 7 Forced Outage
Jul 6, 2017	B	B-2017-28625025	Possible Emergency Coolant Injection Impairment
Jul 13, 2017	A	B-2017-28630373	Mandatory Relief Valve Testing Missed
Jul 21, 2017	A	B-2017-28631630	Unit 1 Actuation of Shutdown System 1
Jul 21, 2017	A	B-2017-28632102	Unit 2 Change of Reactor Power
Aug 2, 2017	B	B-2017-28633177	Air Conditioning Reheat Hot Water Leak
Aug 3, 2017	B	B-2017-28633812	Below Minimum Complement
Aug 9, 2017	A	B-2017-28634560	Unit 3 Primary Heat Transport Pump Motor Seal Failure
Aug 18, 2017	B	B-2017-28635840	Air Conditioning Reheat Hot Water Spill
Aug 21, 2017	B	B-2017-28636327	Controlled Nuclear Information Exported without a Licence
Aug 30, 2017	B	B-2017-28637854	Unit 7 Unplanned Reactor Power Change
Sep 12, 2017	B	B-2017-28638393	Annual FAGM Calibration Preventative Maintenance Overdue
Sep 14, 2017	B	B-2017-28639366	Impairment due to Elevated Continuous Boiler Blowdown
Sep 25, 2017	A	B-2017-28640316	Mandatory Relief Valve Testing Missed
Sep 25, 2017	A	B-2017-28642584	Impairment of Emergency Coolant Injection System
Sep 29, 2017	B	B-2017-28643642	Late Report to CNSC
Sep 29, 2017	B	B-2017-28641968	Broken IAEA Seal
Oct 4, 2017	B	B-2017-28644499	Impairment of SDS1 and SDS2
Oct 13, 2017	A	B-2017-28644769	Periodic Inspection Not Completed as per Schedule
Oct 17, 2017	B	B-2017-28646212	Unposted Hazard
Oct 17, 2017	A	B-2017-28646891	Late Report of Employee Illness
Oct 17, 2017	A	B-2017-28642918	Employee Illness during Training
Oct 20, 2017	B	B-2017-28648307	Late Detailed Report
Oct 26, 2017	B	B-2017-28649012	Unit 7 Setback
Oct 27, 2017	A	B-2017-28648650	Unposted Hazard
Oct 31, 2017	B	B-2017-28649826	Unposted Radiological Hazard in Unit 7
Nov 7, 2017	A	B-2017-28651385	Safety System Tests Not Deferred Per Process
Nov 14, 2017	A	B-2017-28650556	Legacy Bruce A Mandatory Fire Preventative Maintenance
Nov 14, 2017	B	B-2017-28652191	Late Reporting of Spill
Nov 14, 2017	B	B-2017-28634397	Domestic Water Leak
Nov 14, 2017	A	B-2017-28652458	Unit 4 Reactor Inner Zone Inlet Header (RIZIH) Impairment
Nov 14, 2017	B	B-2017-28652413	Below Minimum Complement
Nov 15, 2017	A	B-2017-28651057	Loose Contamination in Zone 1
Nov 17, 2017	A	B-2017-28652400	Controlled Nuclear Information Export without a Licence
Nov 21, 2017	A	B-2017-28650625	Unit 3 SDS1 and SDS2 Impairment
Nov 22, 2017	A	B-2017-28654013	Unit 2 Pumphouse Sump Acute Lethality Test Failure
Nov 29, 2017	A	B-2017-28654464	Class III Power Unavailable during Testing
Nov 30, 2017	B	B-2017-28655437	Domestic Water Release
Dec 7, 2017	B	B-2017-28656368	Public Address Speaker System Out of Service
Dec 15, 2017	A	B-2017-28642604	Potential for Insufficient Gadolinium Insertion Rate
Dec 15, 2017	A	B-2017-28656320	Issue with Dose Calculation for Moderator Analysis
Dec 20, 2017	B	B-2017-28658538	Small Fire in Vehicle

## C. Health Studies – Review and Critique

### a) Health Effects of Radiation on Nuclear Workers

The International Agency for Research on Cancer (IARC), a 15-Country Nuclear Worker Study published in 2005, assessed cancer risks following low doses of ionizing radiation. The study, the largest worker study ever conducted, examined over 400,000 nuclear energy workers (NEWs) who wore a radiation dosimeter or badge, and who worked for at least one year in the nuclear industry in one of the 15 countries, including Canada.<sup>151</sup>

The IARC study found a small but significant increase in cancer risks, especially leukaemia, at the dose-rates typically received by the nuclear workers in this study. It also found that NEWs from Canada had the highest excess relative risk of mortality from all cancers excluding leukaemia among the 15 countries, and this risk was statistically significant.<sup>152</sup>

A previous study conducted by Zablotska et al., specifically on the same Canadian nuclear workers that contributed to the IARC study, found that the relative risk/Sievert was higher for Canadian nuclear workers than for other nuclear workers and the Atomic bomb survivors.<sup>153</sup>

A plausible explanation for the higher cancer risks for Canadian workers could be an under-estimation of the exposures to tritium in part or all of this population could be due to CANDU reactors which use heavy water as a moderator and thus would emit more tritium than other reactor designs.<sup>154</sup>

The CNSC's June 2011 report on verifying the radiation risk for Canadian NEWS was essentially criticism and dismissal of the findings of the IARC study.<sup>155</sup> If the CNSC were truly concerned about protecting the safety of Canadian nuclear workers, it would take every indication of possible risk extremely seriously, rather than dismissing it.

### b) Radiation and Health – Durham Region Report 2007

The 2007 report by the Durham Region Health Department is an update of a previous version in 1996 on the health effects resulting from operations at the two nuclear stations, Pickering and Darlington, in Durham Region. These stations are situated on Lake Ontario a mere 28 kilometres apart. Radiation and Health in Durham Region 2007 is an ecological study of the

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<sup>151</sup> Ethel Gilbert, Radiation Epidemiological Branch, National Cancer Institute: *Epidemiological Studies of Nuclear Workers* May 16, 2007 (IARC Report: Cardis et al. 2005)

[http://radepicourse2007.cancer.gov/content/presentations/slides/GILBERT\\_Workers\\_slides.pdf](http://radepicourse2007.cancer.gov/content/presentations/slides/GILBERT_Workers_slides.pdf) Refer also to [http://www.nuclear-free.com/PDF/TAP\\_Fact\\_Sheet.pdf](http://www.nuclear-free.com/PDF/TAP_Fact_Sheet.pdf) <http://www.iarc.fr/en/media-centre/pr/2005/pr166.html>

<sup>152</sup> CNSC Report 2011 [http://nuclearsafety.gc.ca/pubs\\_catalogue/uploads/INFO-0811-Verifying-Canadian-Nuclear-Energy-Worker-Radiation-Risk-A-Reanalysis-of-Cancer-Mortality-in-Canadian-Nuclear-Energy-Workers-1957-1994\\_e.pdf](http://nuclearsafety.gc.ca/pubs_catalogue/uploads/INFO-0811-Verifying-Canadian-Nuclear-Energy-Worker-Radiation-Risk-A-Reanalysis-of-Cancer-Mortality-in-Canadian-Nuclear-Energy-Workers-1957-1994_e.pdf) p.5

Zablotska I.B., Ashmore J.P., and Howe G.R: *Analysis of mortality among Canadian Nuclear Power Industry Workers after chronic low-dose exposure to ionizing radiation. Radiation Research* 161: 633-641 (2004).

<http://www.jstor.org/discover/10.2307/3581008?uid=3737720&uid=2129&uid=2&uid=70&uid=4&sid=21101139987693>

<sup>154</sup> Dr. Rosalie Bertell: *Health Effects of Tritium*, Submitted to the CNSC, November 27, 2006

<sup>155</sup> [http://nuclearsafety.gc.ca/pubs\\_catalogue/uploads/INFO-0811-Verifying-Canadian-Nuclear-Energy-Worker-Radiation-Risk-A-Reanalysis-of-Cancer-Mortality-in-Canadian-Nuclear-Energy-Workers-1957-1994\\_e.pdf](http://nuclearsafety.gc.ca/pubs_catalogue/uploads/INFO-0811-Verifying-Canadian-Nuclear-Energy-Worker-Radiation-Risk-A-Reanalysis-of-Cancer-Mortality-in-Canadian-Nuclear-Energy-Workers-1957-1994_e.pdf)

rates of various cancers, congenital abnormalities, and stillbirths in areas surrounding the Pickering and Darlington Nuclear Stations.<sup>156</sup>

As it is an ecological study, which examines rates of illness at the level of the community, and not individual cases or situations, no conclusions about causation are possible. There were also other limitations to the study, for example, the failure to include pancreatic cancer as an endpoint outcome; the broad age range (0 to 19 years) applied to the childhood cancer category; and the influence of confounding factors (for example, growth and migration of population in the region) which cannot be adequately dealt with in an ecological study.

In general, this report ignores so many potential paths for exposure to radiation and so many harmful consequences of such exposure, and its basic methodology is so weak, that its failure to identify any significant harmful consequences provides absolutely no scientific proof that people, above all nuclear workers, are not being harmed.

However some worrisome results were noted in the Report, including an increase in leukaemia in males, elevated bladder cancer mortality, and increased incidences of breast and thyroid cancers and Down's syndrome.<sup>157</sup>

Few studies of merit have been done on the health effects of living in close proximity to nuclear stations in Canada. This is especially a concern with respect to tritium, as Canada releases more tritium than any other country in the world due to the heavy water used in CANDU reactors.

It is well known that ionizing radiation causes cancers. It is scientifically impossible to release massive numbers of radionuclides without causing any harm, especially when internal exposure to a single radioactive atom can be deadly.

#### **d) The KiKK Study**

##### **Childhood Leukemia and Cancers near German Reactors<sup>158</sup>**

A childhood leukemia cluster was first reported in the late 1980s in the vicinity of the nuclear plant Krümmel near Hamburg. In response to citizen's concerns, the German government conducted an ecological health study of all German nuclear plants over an 11-year period (1980-90). Exploratory analyses of this study showed a statistically significant increase in acute leukemia in children younger than 5 years of age who lived less than 5 km from these plants. Another study found a non-significant increased risk for acute leukemia this population subset. However, these ecological studies work with *population averages*, and can only suggest, but not confirm or deny, a causal relationship between living in the vicinity of nuclear power plants and higher incidence of childhood cancer cases.

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<sup>156</sup> Durham Region Health Department, Whitby Ontario: *Radiation and Health in Durham Region 2007*

<sup>157</sup> Dr. Cathy Vakil M.D., C.C.F.P., F.C.F.P; Dr. Linda Harvey B.Sc., M.Sc., M.D. *Human Health Implications of Uranium Mining and Nuclear Power Generation* May 2009 p.35-38

<sup>158</sup> Rudi Nussbaum Portland State University, Portland, OR, USA: Childhood Leukemia and Cancers Near German Nuclear Reactors: Significance, Context, and Ramifications of Recent Studies INT J OCCUP ENVIRON HEALTH 2009; 15: 318-323; and <http://www.psr.org/chapters/oregon/assets/pdfs/halifax-talk-08.pdf>

In 2002, in response to the controversial findings, the federal childhood cancer registry, known in Germany as KiKK, initiated a case-control study of childhood cancer cases in the areas around all 16 nuclear reactors to confirm or negate whether childhood malignancy cases *do not increase* with proximity to nuclear power plants. The credibility of the KiKK study was enhanced by the appointment of a prestigious independent review committee of 12 scientific experts: 5 epidemiologists, 2 pediatricians, 2 statisticians and 3 physicists.

The study found a statistically significant continuous increase in the incidence of excess childhood leukemia and cancer cases within a radius of 50 km from the 16 German reactors, which was greater the closer the children lived to a nuclear plant at the time of diagnosis. Children living 5 km or less from a nuclear plant were found to be 27% more likely to develop a malignancy than children living farther than 5 km. Such a consistent correlation around all 16 reactors is a strong indicator for a causal relationship.

Yet the KiKK scientists concluded:

*“... based on current radio-biological knowledge and epidemiological studies [of health effects of radiation], the emitted radioactivity from normally operating German nuclear power reactors can on principle not be interpreted as having caused [the observed excess in leukemia and other cancers in children]” and*

*“... [since] possible confounders could not be identified, the observed positive distance trend remains unexplained.”*

This counter-intuitive interpretation of the study's findings by its investigators is in line with repeated claims by the World Health Organization (WHO) and the International Atomic Energy Agency (IAEA) that documented findings of excess cancers, neo-natal mortalities, spontaneous abortions and other health detriments all over Western Europe, even at large distances from the 1986 Chernobyl disaster, could not possibly be associated with its radioactive fallout, since population exposures, as estimated by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) were several factors of ten too small to cause the reported detrimental health effects.

However, the 12-member independent external review panel criticized the KiKK investigators for ignoring the findings of several other radio-epidemiological studies which were remarkably consistent with their own data, which increased the likelihood of a causal relationship between suspected radioactive contamination near nuclear installations and excess childhood cancer cases.

The panel cited other investigations of cancer clusters near nuclear installations, including in Germany (Krümmel), in France (La Hague), in the United Kingdom (Sellafield) and in the US (Pilgrim plant, MA), which suggest that these clusters are radiogenic.

Its final conclusion was that:

*Epidemiological causality criteria as applied to the data of the KiKK study do suggest a causal relationship between the emissions from nuclear power plants and the shown increases of childhood cancer cases with decreasing distance from these plants.*



Although the KiKK researchers irrefutably established an association between frequency of excess cases of childhood malignancies and proximity to nuclear reactors, they rejected the possibility of a causal relationship between these cancers and radioactive emissions, and declared that their findings “remain unexplained”. They did not question the population dose estimates provided by the operators of the nuclear plants, or the highly questionable radiation risk factors at those doses promulgated by radiation regulating bodies with strong ties to government and industry.

This study, which was meant to dispel public fears of detrimental health effects from emissions around nuclear power plants, actually corroborates a causal relationship. In the words of the independent scientific review commission:

*“There exists no plausible alternative hypothesis.”*

## **D. Community Health Study Proposal**

### **Health Concerns**

Over the many decades of operations of the nuclear plants and the ancillary operations, radionuclides and numerous other hazardous substances have been and continue to be released into the air, water and soil. Spikes in emissions of these substances are not uncommon and could result in releases of toxic chemicals well in excess of routine emissions.

Residents living in the vicinity of the Bruce station have expressed concern about the hazardous substances being emitted from this facility and question how or to what degree their health, the health of their children, and of vulnerable or sensitive populations (pregnant women, the elderly, immune-compromised, etc.) and their social and economic environment is being affected by its operations.

We live by a large industrial complex and it is understandable that accidents will occur. A caring and responsible industry will acknowledge its accidents and seek to avoid future incidents. As we were to learn over the years, OPG simply continued to assert its denial of harmful incidents, just as today it will seek to deny that the industry itself has caused harmful health impacts to local and area residents from its operations.

OPG, as well as Bruce Power, is able to make this assertion only because we, the community, lack the available health data this survey will be designed to collect. On the basis of a lack of evidentiary data, OPG, with the Grey-Bruce Health Unit, is able to claim that the population base is too small to allow for epidemiological analysis.

### **Need for a Community Health Study**

The DGR being proposed by OPG lies by the shores of Lake Huron. This proposal has further heightened the concerns of the community as to the potential adverse health and environmental effects, short term and very long term, of the DGR, in all its phases, from its construction, operation and closure, and the cumulative impacts that this project could have in conjunction with the operations of the nuclear power plants and other facilities on the Bruce site.

Currently, there is neither a methodology nor an evidence-based approach that has been used to determine, in an objective and scientific manner, whether any of the health impacts that have been suffered by residents in the region of the BNGS are attributable to the operations of Bruce Power's nuclear operations. To date, no health survey has been conducted to identify the state of health of residents in these communities.

If the DGR is approved, the existing and future residents and seasonal populations will be exposed to added health risks without any means of determining the extent to which these site operations at the Bruce station are linked to any such illnesses.

A health survey provides the baseline data that will help overcome the limitations noted by the Grey-Bruce Health Unit by widening significantly the types and nature of illnesses to be considered and that may be likely to exist in the community.

## **Proposal of Health Study Design**

The health study that we are proposing is for those communities in the vicinity of the Bruce site. The design is based on a community-based participatory approach that is led by members of the community, builds on its concerns, takes a holistic perspective of health, and places focus on the individual's well-being and that of their community. The central focus of this study is a health survey of members of the community.

This community-based approach for the health survey is proposed for a number of reasons. For example:

The community is in charge of conducting the health survey. It determines the objectives and goals, its design, how it is administered, and how the results are presented.

The survey can be customized to the community and the region. It will include the diversity of residents, and will cover a broad range of illnesses. It will incorporate several factors that affect the health and well-being of the community.

It does not involve the complexity or the economic costs of a traditional epidemiology study. It can be done basically through a strong community involvement and commitment to the project.

The survey will provide new detailed health data that has never been collected and will provide a unique community health profile of the community.

The findings of the survey can lead to an understanding of the amount and types of illnesses within the community, and assist the community in assessing and improving its health.

In addition to collecting health data via a survey, the community health study will include an environmental component that would gather information on the contaminants that are routinely emitted from the facilities at the Bruce site, and the potential health effects that these contaminants have on human health, and a monitoring program to determine levels of specific contaminants of concern on habitat (e.g., fish) and vegetation.

When completed, this study will provide baseline data that will assist the community in assessing any future impacts that this nuclear facility might cause on human health and the environment on which life depends. Without this baseline information, it is impossible to do this.

## **Overview of a Community Health Study**

### **A. Determinants of Public Health**

The key elements of public health include physiological integrity, well-being and quality of life. The World Health Organization (WHO) captures the essence of these elements in its definition of health formulated in 1948, which states that: "Health is a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity."<sup>159</sup>

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<sup>159</sup> Report of the Public Health Coalition: Ontario Public Health Association/International Institute of Concern for Public Health Respecting the Health Effects of Ontario Hydro's Demand/Supply Plan (Health Effects Report), Martin Campbell 1993: [EA 1993] p. 4, 8-11

The approach that we are taking in designing a community-centred health study is one that builds on the WHO definition and applies not only to the health of an individual but also the health and well-being of families and their community.

The basic principles underlying our proposed community-based health study are as follows:

1. Health is a positive state of well-being, not just the absence of disease and disability.
2. Health is determined by a wide array of social, environmental, cultural, political, economic, and behavioural factors. This leads to a holistic model of health.
3. Public health is concerned with preventing disease, disability and premature death, and promoting health and well-being.
4. A diminution in an individual's capacity for normal functioning is a health problem.
5. Public health is a collective, publicly funded and controlled societal undertaking.
6. Collective rights may supersede individual rights, while insuring the confidentiality and privacy of all individual information that is collected.
7. Where evidence exists to suggest that the public's health may be placed at risk, a precautionary approach is needed, that is, to err on the side of safety in making decisions, and to take actions that best protect the public's health.

## **B. Overview of Health Issues**

Exposure to hazardous substances affects the health and well-being of humans and wildlife. Many such substances are known carcinogens. They can also harm the reproductive, developmental and neurological systems, cause respiratory and cardiovascular disease, result in hormonal disruption, depress the immune system, and lead to long-term generational impacts.

But rarely is one exposed to just one contaminant. The combined effect of exposure to a number of hazardous substances may simply be the sum of their individual effects, but it may also be synergistic, causing a far worse health effect than if exposure were limited to a single substance or the simple sum of the effects of individual substances.

Genetic errors or anomalies caused by exposure to radiation are persistent because they are passed on by heredity to the next generation. If radiation sources continue to act on succeeding generations of offspring, they are also cumulative.

There is no "average" response to the effects of exposure to pollutants. Children are particularly susceptible to harm from such contaminants. In utero, babies exposed to chemical and radioactive toxins are most vulnerable to environmental indicators of environmental health. Visible birth defects, developmental and hormonal irregularities, and low birth weights are strongly associated with the mother's exposure to contaminants. While many of these contaminants may cause changes that are not noticeable at birth, adverse health effects can manifest themselves later in childhood or young adulthood.

Those populations who are particularly vulnerable to exposure to radiation and other toxic pollutants include women, especially pregnant women, children, the elderly, people that are immune-compromised, have an existing health condition, or have specific genetic susceptibilities, and workers in various industrial settings.

### **C. Community Health Issues - Identifying a problem** <sup>160</sup>

Residents living in the vicinity of a particular industrial facility are duly concerned about the hazardous substances that are emitted from this facility and how their own health and well-being and their social and economic environment, and that of their children, the elderly, and the community as a whole are being affected by the operations of this facility. These concerns give rise to several questions. For instance:

What hazardous substances are being emitted by this facility, and in what quantity?

Do these substances result in the deterioration of air or water quality? Do they cause illness, harmful birthing experiences, respiratory diseases, childhood asthma, and elevated cancer risks in the community?

How does proximity to the facility, lifestyle, occupation, gender, age, and genetic traits factor into the health of the community?

What is the level of exposure to which they are subjected from air, water, land and food? Are existing health problems exacerbated by continuing exposures to these substances?

To what extent do sudden spikes in emissions, or long-term low level exposure, lead to health hazards?

Is there a pattern or cluster of disease in the community?

Are there indications of social, neurological issues (e.g., stress, depression) that impact on health and well-being in the community?

How will proposed changes, such as additional projects at the facility site, impact on their health?

How can the overall health and well-being of the community be improved?

The right-to-know is essential to civil society. The questions and concerns of the community need to be addressed. They want to know whether the operations of a particular facility, or, any additional proposed facilities, are harmful to their health, and if so, how. But in many cases, no detailed or even a limited health study or community health survey has ever been done.

A well-designed comprehensive health study specific to each community will provide some answers to questions and concerns. Such a study would document health data about individuals and their families, the children and the elderly, the long-time and seasonal residents, and workers at the facility of concern. It would include a wide range of health effects, from diseases, deaths and psychosocial factors to accidents and injuries at the facility, and also a list of the pollutants to which they are likely exposed.

Once such a study is carried out, and the results analyzed, the community will be better informed as to whether there is an unusual pattern of illness in their community. If so, it may be in a better position to assess whether there is an association between the operations of a specific facility and the pattern of illness and be better prepared to examine what actions are needed to improve over-all health and well-being of its members.

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<sup>160</sup> "A Guide for the Community Seeking to Undertake a Health Survey" [Health 2000, Rosalie Bertell].

