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May 9, 2014

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Project ID: 10-60004

Dr. Stella Swanson  
Chair, Joint Review Panel  
Deep Geologic Repository Project

c/o Canadian Nuclear Safety Commission  
280 Slater Street  
Ottawa, Ontario  
K1P 5S9

Dear Dr. Swanson:

**Deep Geologic Repository Project for Low and Intermediate Level Waste –  
Submission of Response to Joint Review Panel’s Clarification Comments on  
Relative Risk Analysis of Community Acceptance in Information Request  
EIS-12-513**

The purpose of this letter is twofold, to provide further information addressing the Panel’s clarification comments on the relative risk analysis of community acceptance in Information Request EIS-12-513 (Reference 1), as committed in Reference 2, and to provide confirmation of our response to Information Request Package 12b.

For the first item, the Attachment contains the report prepared by the independent risk assessment experts retained by OPG, providing the requested clarifications. The correspondence from the Independent Expert Group to OPG is also attached.

For the second item, OPG will submit by May 30, 2014, the responses to the Panel’s follow-up clarification requests in Information Request Package 12b (Reference 3).

If you have questions on the above, please contact Mr. Allan Webster, Director, Nuclear Regulatory Affairs, at <contact information removed>

Sincerely,

<original signed by>

Laurie Swami  
Vice President, Nuclear Services  
Ontario Power Generation

Attach.

cc. Dr. J. Archibald – Joint Review Panel c/o CNSC (Ottawa)  
Dr. G. Muecke – Joint Review Panel c/o CNSC (Ottawa)  
P. Elder – CNSC (Ottawa)  
D. Wilson – NWMO (Toronto)

- References:
1. JRP letter from Dr. Stella Swanson to Laurie Swami, "Deep Geologic Repository Project for Low and Intermediate Level Waste – Submission of Independent Risk Assessment Expert Group Comments on Relative Risk Analysis of Community Acceptance in IR EIS-12-513", March 6, 2014, CD# 00216-CORR-00531-00228.
  2. OPG letter from Laurie Swami to Dr. Stella Swanson, "Deep Geologic Repository Project for Low and Intermediate Level Waste - Acknowledgement of Joint Review Panel's Clarification Comments on Relative Risk Analysis of Community Acceptance in Information Request (IR) EIS-12-513", March 28, 2014, CD# 00216-CORR-00531-00229.
  3. JRP letter from Dr. Stella Swanson to Laurie Swami, "Information Request Package #12b from the Joint Review Panel", April 15, 2014, CD# 00216-CORR-00531-00238.

## **ATTACHMENT**

Attachment to OPG letter, Ms. Laurie Swami to Dr. Stella Swanson, "Deep Geologic Repository Project for Low and Intermediate Level Waste – Submission of Response to Joint Review Panel's Clarification Comments on Relative Risk Analysis of Community Acceptance in Information Request EIS-12-513"

May 9, 2014

CD#: 00216-CORR-00531-00230

**Independent Expert Group Report and Correspondence to OPG**

# University of Ottawa

R. Samuel McLaughlin Centre for Population Health Risk Assessment  
1 Stewart Street, Ottawa, ON K1N 6N5

8 May 2014

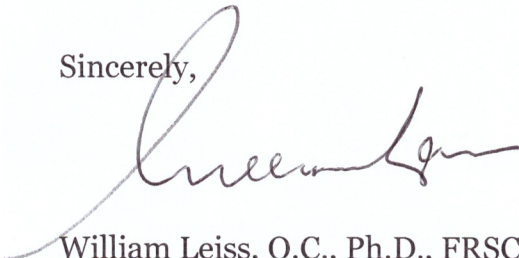
Ms. Laurie Swami  
Vice-President, Nuclear Services  
Ontario Power Generation  
889 Brock Road  
Pickering, ON L1W 3J2

Dear Ms. Swami:

On behalf of my colleagues in the Independent Expert Group – Maurice Dusseault, Tom Isaacs, and Greg Paoli – I am pleased to transmit herewith our “Report of the Independent Expert Group on Risk Perceptions of the Four Alternative Means for Managing the Storage and Disposal of Low- and Intermediate Level Radioactive Waste in Ontario.”

I would be pleased to respond to any questions that you have; to reach me by phone: 613-297-4300.

Sincerely,



William Leiss, O.C., Ph.D., FRSC  
Professor emeritus, School of Policy Studies, Queen's University  
Scientist, McLaughlin Centre for Risk Assessment, University of Ottawa  
[wleiss@uottawa.ca](mailto:wleiss@uottawa.ca)

Attachment to OPG letter, Ms. Laurie Swami to Dr. Stella Swanson, "Deep Geologic Repository Project for Low and Intermediate Level Waste – Submission of Response to Joint Review Panel's Clarification Comments on Relative Risk Analysis of Community Acceptance in Information Request EIS-12-513", CD# 00216-CORR-00531-00230

## **Report of the Independent Expert Group**

Report of the Independent Expert Group  
on  
Risk Perceptions of the Four Alternative  
Means for Managing the Storage and  
Disposal of Low and Intermediate-Level  
Radioactive Waste in Ontario

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*SUBMITTED BY:*

*MAURICE DUSSEAULT, TOM ISAACS, WILLIAM LEISS (CHAIR), GREG PAOLI*

*SUBMITTED TO:*

*THE JOINT REVIEW PANEL FOR THE DEEP GEOLOGIC REPOSITORY PROJECT FOR  
LOW AND INTERMEDIATE LEVEL RADIOACTIVE WASTE (DGR)*

May 8, 2014

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## Section I

### Introduction

This Report was prepared in response to a communication, dated 6 March 2014, from the Deep Geologic Repository Joint Review Panel (JRP).<sup>1</sup> In the excerpts from this communication quoted below, the JRP asked the Independent Expert Group (IEG) to consider the following issues:

1. "...[T]he Panel expects that there be a comparison of *risk perception* (and thus, *risk acceptability*) among the four options.... [T]he Panel suggests that the Expert Group focus on uncertainty. This is because the technical risk analysis of the four options will have a direct link with the analysis of the effects of the technical uncertainty on risk perception."
2. "Many submissions [to the JRP] presented comparative risk perceptions and risk acceptability among status quo, enhanced surface storage and deep geologic repositories. These submissions, together with information in the published literature and the Expert Group's analysis and professional judgement should be used to produce a relative risk perception/acceptability score for the four options."
3. "...[T]he Panel would encourage the Expert Group to comment on how risk perception among Aboriginal peoples might better be acknowledged and incorporated."
4. "The Panel expects that the analysis then go forward with further consideration of the *perception* of each of the four options, as influenced by the relative degree of technical uncertainty associated with the primary uncertainty issues listed above."
5. "The Panel maintains that use of a combination of evidence provided by submissions as well as published literature is sufficient to discriminate among the options if the Expert Group focusses, as is suggested above, on the effects of relative uncertainty on risk perception and risk acceptability."

In this supplementary Report the Independent Expert Group has sought to respond in detail to the issues and perspectives on risk perception and risk acceptability raised by the JRP. We have done so in the following way: First, we have commissioned a background study of the published literature on all of the general topics raised in the JRP letter (risk perception, acceptable risk, and uncertainty as a factor in risk perception). Since there is a large literature on the recent treatment of these subjects, dating back to the 1970s, the background study is extensive; therefore, we have given a short summary of the study in Section II below, and have placed the complete study in Appendix A.

Second, in Sections III and IV we have provided an overview of our understanding of risk perceptions of the four options, identified by the JRP, for managing low- and intermediate-level nuclear waste in Ontario. These risk perceptions treat separately the views of Aboriginal interveners in this discussion, on the one hand, and all other interveners, on the other. Our selection of material in our two overviews was made using a software-base search routine of all the submissions made to the JRP as well as the transcripts of hearings conducted by the Panel. Finally, in Section V we present our Observations and Conclusions with respect to the issues and perspectives raised by the JRP in its letter of 6 March 2014.

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<sup>1</sup> The complete text of the letter will be found in Appendix B of this Report.



## Section II

### **Risk Perception of Nuclear Waste Disposal: Summary of the Background Study**

#### *Risk Perception.*

Risk perception has been studied from the point of view of decision-making under conditions of uncertainty, qualitative factors associated with risk sources, demographic and psychological factors, and broader contextual factors relating to individuals' social values and their trust in risk managers. There are also findings relevant to perceptions of risk from radiation, nuclear power, and nuclear waste management and disposal.

Radiation from industrial sources is commonly thought to be a high risk by non-experts, associated with the possibility of accidents with fatal and catastrophic consequences, with little attention to the low probability that such accidents will occur. Risks from nuclear power are perceived to be unfamiliar and not observable, imposed on the public and not easily avoided or reduced. There is also a sense for some persons who are adamantly opposed to nuclear power on the grounds that it interferes with nature.

Also, nuclear power is often identified in terms of its high risk without consideration of its benefits, as individuals – experts and non-experts alike – frame an activity as predominantly a risk or a benefit and downplay the significance of the other side of the balance. The framing of nuclear power as a risk is associated with a more general negative perception of large-scale industries that impose risks on the public, while producing benefits that are diffuse and may not be experienced directly. This framing process is also seen in situations of higher risk that are tolerated because people experience, and value, benefits from the activity or use of a substance.

While commonly observed perceptions of risk from nuclear power and nuclear waste correlate strongly with a range of qualitative factors associated with the risk source, as well as demographic and psychological factors that influence individuals' judgements, the most important factors that influence perceptions of nuclear power are people's broader attitudes and values. These general attitudes and values shape more specific perceptions of risk from an activity, and the response people have to information on the activity as well as the trust they have for risk managers. Perceptions of the risk of an activity are associated with certain 'worldviews,' political values and belief systems, and are stable components of a person's general social orientation and outlook. People who hold 'ecological' values, for example, are more likely to perceive technology to be a risk and to oppose large industrial technologies such as nuclear power.

These value systems also shape the trust that individuals have in information, information sources, and risk managers. Particularly where risk perceptions relate to an issue of high value or political concern, people trust managers whose values are similar to their own, and who can be trusted to act in their best interest. Judgements about risk are complex determinations made in the context of individuals' knowledge and experience, their attitudes and values, and their social relationships. They are thus partly social phenomena, subject to interactive processes and broad social impacts. Judgements about a risk often become 'amplified'; in other words, specific risks may become the focus of heightened interest and concern through processes of information interpretation, whereby information is filtered through personal values and social interactions. One such potential effect is that of stigma, in which

negative imagery associated with a risk or activity is attributed to related activities or to an area in which a facility perceived as dangerous or undesirable is located.

Nuclear power, and by association nuclear waste disposal, are highly charged issues that engage people's values and social priorities. These attitudes and value priorities can persist when possible advantages of nuclear power are discussed, so that some people may negotiate a 'conditional' or 'reluctant' acceptance of nuclear power if, for example, it may be advantageous in preventing climate change by offsetting the use of fossil fuels in energy generation. On the other hand, many of those living in communities where these facilities are already operating, or will be operating in the future, are supportive of them on the basis of the economic benefits they provide.

#### *Perception of Risk within Aboriginal Cultures.*

The cultural values and priorities that shape risk judgements of Aboriginal peoples, while they vary among different Aboriginal cultures and communities, are distinct from mainstream Western culture. The dominant priority is the cultural value of the land, generically as a spiritual entity and principle, and specifically as traditional territory to which a community is tied through history and material practices such as traditional harvesting. The integrity of the community and its culture depend on the continuation of traditional relationships with, and practices in, its territory, placing a primary focus in risk judgements on potential effects of a nuclear waste repository on the continuing integrity of the land.

Aboriginal communities may also have a different social structure than mainstream society, with a more participatory and inclusive means of decision making that reflects high degree of respect for community elders. They often have a traditional, more experiential approach to knowledge and to understanding the world.

#### *Perceptions of Nuclear Waste.*

Nuclear waste is commonly perceived as representing a high risk, sometimes even higher than nuclear power itself. This is partly because nuclear waste remains hazardous for a very long time, requiring monitoring and management processes that are unprecedented in human history. People often frankly reject scientific claims that the risks can be assessed and managed for such a long period into the future, and that a facility can be designed to contain the wastes for that long a period. Because of this long time-frame, nuclear waste facilities appear to place an inequitable burden of risk, and responsibility for management, on future generations, who cannot consent to the facility.

Aboriginal communities in particular may consider the placing of toxic waste in the earth to be an affront to the sacred, and, in the context of the multi-generational perspective that many Aboriginal cultures assume in their actions on the environment, they may be more averse to the long-term threat posed by the wastes.

Efforts to site a nuclear waste repository have frequently been contentious and sometimes fail. More recent efforts in several countries have focused on the selection of a site through a participatory process within volunteer communities, resulting in successful attempts to site a nuclear waste facility. Financial benefits, such as stable employment opportunities and increased commercial property tax revenues, are of course available to communities which agree to host a facility. Such benefits are regarded as appropriate by those who support nuclear facilities, but may be interpreted as exerting inappropriate pressures on smaller or remote communities by those who do not.

### *Conclusions on the Concepts of Uncertainty and Acceptability.*

Experts make an effort to quantify and compare the uncertainties in various facility components and designs, and of different event scenarios, as a core consideration in a decision on the location and management of a repository that must contain nuclear wastes for thousands of years. Many non-experts, however, are not interested in quantifying uncertainties, and are more likely to refer to unknowns, asserting that many factors are simply unknowable over such long time periods. Instead of quantifiable uncertainties, non-experts are more concerned with the consequences that are possible. In addition, they are concerned about the need to delegate responsibility for designing, operating and monitoring such a facility to experts who often do not share their concerns for the risks or who do not appear to share their values with respect to the environment that is vulnerable to the risks.

The determination by a potential host community that a facility is acceptable is often seen as the desired endpoint of a participatory process. The Background Study suggests, however, that acceptability appears to represent an unrealistically simple concept entailing a generalized consent to proceed. The importance of the recognition of benefits and of the 'conditional' acceptance that has been observed among those who do not support nuclear power, suggests that agreement to host a facility is a more complex decision. The concept of tolerability has been used in other risk management contexts to express a risk that is actively managed to a level that is deemed appropriate in light of the benefits that are received from the activity. This multi-dimensional concept directs attention to the conditional or reluctant acceptance that may be granted by community members who acknowledge the value of a facility while they still have concerns about it. It reminds decision-makers and participants that ongoing attention to benefits and to risk management is an integral part of the decision-making and future management processes.

## Section III

### **Positions on the Proposed Project Expressed by Non-Aboriginal Interveners to the Joint Review Panel**

Submissions to the Joint Review Panel were made by individual members of the public, Environmental Non-Governmental Organizations (ENGOs), community associations, and others; most are based in Canada, and a few are based in the United States. Individuals and representatives of groups also made oral interventions during public hearings before the Panel. Submissions made on behalf of Aboriginal Peoples, as well as oral interventions made at public hearings by representatives of Aboriginal Peoples, are considered separately in Section IV.

The record of submissions and hearings transcripts were searched for statements and expressions of views relevant to the perceptions of risk associated with the management of low- and intermediate level (LILW) nuclear waste in Ontario in general terms. These documents were also searched for statements and expressions of views relevant to perceptions about various methods of storage and disposal of such wastes and, in particular, to the proposal to construct a Deep Geologic Repository (DGR) near the Western Waste Management Facility (WWMF) on the Bruce nuclear site.<sup>2</sup>

In this Section we present what we believe is, in an informal sense, a representative sample of these views. However, since we did not conduct a rigorous analytical examination of the documentation available to us, the generalizations that are made in the following paragraphs should be regarded as being examples rather than systematic patterns; thus individual exceptions could be found which are not encompassed in these generalizations. This snapshot, therefore, should not be taken as a complete account of the views expressed.

In general, the views expressed to the Panel in submissions and oral interventions reflected a wide spectrum of public opinion on the substantive matters under discussion. So far as the main issue – the need to provide for safe storage of nuclear low- and intermediate-level waste – was concerned, views ranged from strong support for the specific DGR proposal now under consideration, on the one hand, to a refusal to entertain storing the waste “anywhere on the planet,” on the other. So far as the subsidiary issue – what specific management option for storage and disposal of this waste is the preferred one – was concerned, views ranged across a wide variety of potentially feasible options: “as-is” at the existing WWMF; a concept of “hardened” surface storage; the proposed DGR at Bruce; and placement in a suitable facility “somewhere else” in Ontario.

It must be emphasized that our primary interest in examining these materials was not to discern the spectrum of proposal solutions for the management of nuclear LILW in Canada, as expressed by interveners to the Joint Review Panel. Rather, we have sought to understand the public perception of risks in Canada that is associated with the accumulation and management of nuclear waste, and of the four options discussed in our earlier report, in accordance with the directive in the JRP Letter. The background study we commissioned on this subject (Section II and Appendix A) was designed to provide us with some analytical tools in this regard, which we could utilize in examining the submissions and interventions by members of the public.

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<sup>2</sup> Search software using a variety of words and phrases was used to examine all of the text in the various submissions and hearings transcripts. See further the “Note on Keyword Searches” at the end of this Section.

Many of the published academic studies on public perception of risk are based on exercises using hypothetical settings or questions in order to elicit the underlying structures in people's reasoning about risk situations, structures that otherwise remain tacit and unarticulated. (Sometimes these are called "mental models.") The results, as presented in the Background Study, reveal quite stable patterns of thinking about risk across populations and countries, on the basis of which robust inferences can be made about how any random cross-section of the public might be expected to react to a new situation, presented to their communities, involving a carefully-planned technology that is intended to deal with a complex problem in risk management.

This is exactly the situation in Bruce County, where a network of small communities near the shores of Lake Huron in Ontario has been presented, for the first time in Canada, with a proposal to place hazardous radioactive materials in an engineered facility deep underground in close proximity to their homes and businesses. Few phenomena in nature are as complex as is the electromagnetic spectrum, along which are found both enormous benefits (the combination of visible light and invisible radiation from the sun, and the electromagnetic fields that make wireless technologies possible, including cellphones), as well as potentially lethal threats (damaging health effects from high-energy gamma radiation). Furthermore, the long periods of radioactive decay require carefully-planned technologies to contain those dangerous radioactive products, involving (in the DGR proposal) the combined capacities of both engineered and natural barriers.

Those responsible for designing the facility needed to respond to a particular challenge – in the present case, storing nuclear LILW – are required to use the language of formal risk assessment to make the case that they can do so safely. This language involves concepts such as hazard characterization, exposure pathways, probabilities and consequences or impacts (expressed quantitatively), risk estimations, uncertainty ranges for risk estimations, and risk mitigation options. This is the kind of language used in the technical "discourse on risk" for formal risk assessments.<sup>3</sup>

*This is not at all the language used in most of the public discourse on the risks of storing nuclear LILW.* The contrast here may be seen if we summarize the general themes found in the submissions and hearings, which are illustrated in the following paragraphs. What is important to note is what is *not* articulated, as well as what is clearly expressed. These general themes are as follows:

- A. Risks associated with handling and storing radioactive wastes are considered entirely separately from any benefits derived from nuclear power: In other words, for those opposed to the DGR proposal (for whatever reason), risks and benefits are almost never mentioned together. However, among those who support the creation of a DGR at the Bruce nuclear site, some express the belief that accepting the benefits from nuclear power generation entails a responsibility to manage its wastes.

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<sup>3</sup> The benefits associated with successfully storing radioactive waste safely are assumed in this scenario. These include the direct social and economic benefits for the host community, as well as the indirect benefits, for all Ontarians, derived from continuing to use nuclear energy to generate electricity. In this case the risks of handling radioactive materials are thought to be "outweighed" or exceeded by the associated benefits by a very substantial margin.

- B. Risks associated with handling and storing radioactive wastes are considered only as a discrete problem, and are not framed on a comparative basis with the risks of alternatives to nuclear power for electricity generation (for example, coal-fired generation stations).
- C. Opponents to the DGR proposal do not, for the most part, place their opposition in the context of a more general set of social values, but rather treat this issue in isolation (in contrast with the Aboriginal perspective, as described in Section IV).
- D. When comparing different options for managing nuclear wastes, interveners usually do not express the comparison in terms of their perception of relative risks, preferring instead to make certain general observations (for example, criticizing the DGR as exemplifying the maxim, “out of sight, out of mind”).
- E. Probability or likelihood of harm is never quantified.
- F. Consequences of adverse effects are never quantified.
- G. Uncertainty is never quantified, and is usually treated as equivalent to “unknown.”

As a generalization, and acknowledging explicitly that there are many individual exceptions to it, one is obliged to conclude that the two discourses about risk – the technical and the public – have very little in common. Although they are both referring to the same managerial issues and technologies pertinent to nuclear waste, they have fundamental differences in the way that conclusions about those issues are arrived at and the kinds of reasoning used to support those conclusions.<sup>4</sup> These differences are well-illustrated in the following extracts from the materials in submissions and hearings, which are referenced with the document number citations in the Canadian Environmental Assessment Agency (CEAA) Register for the DGR project. *No quotation marks are used, but the following extracts are all direct citations from the record.*

*Risk Perception:*

- ...[M]embers of our community, after five generations in the Hamlet of Inverhuron, will be forced to leave due to the impact of noise, pollution, a feeling of insecurity due to possible accident or malfunction of the deep repository and the lowering of property values due to stigma. (Marti McFazdean: CEAA Doc#846)
- The risk perception of those who would buy agricultural goods, visit, or purchase a cottage in the area may be shaped by the notion that Kincardine is a nuclear oasis. The research that OPG has done around stigma, because it is limited to the local study area and immediate municipalities, is unable to capture these complexities. (Huron-Grey-Bruce Citizens Committee on Nuclear Waste: CEAA Doc#1363)
- ...[T]he DGR does represent a hazard with perceptions of high risk consequences. *All the cards and letters sent to CEARIS from ordinary Canadians and Americans, from Michigan to California, from*

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<sup>4</sup> We wish to emphasize strongly the point that, in making this list, we are in no way suggesting or implying that the modes of reasoning used in the public discourse are incorrect or inappropriate, or are less compelling than those found in the technical discourse.

*service organisations like the Provincial Council of Women of Ontario, speak of the dangers of storing these wastes so close to the lake. ... (Eugene Bourgeois: CEAA Doc#944)*

#### *Risk Acceptability:*

- The radioactive threat to the Great Lakes -- 20% of the world's surface fresh water, and drinking water supply for 40 million people -- is unacceptable on its face and must be cancelled immediately. You cannot risk such an environmental and health disaster. (Kathy Babiak: CEAA Doc#524)
- I am therefore skeptical of the phrase "acceptable risk" when the likelihood of an incident is low, but the consequences if it does occur are shattering. (Voice of Women for Peace: CEAA Doc#1380)
- Lake Huron is not only one of our treasured Great Lakes, but it provides fresh water, recreational opportunities, habitat for a large diversity of eco systems and species, and living space for millions of people on both sides of the US/Canadian border, which are all at risk should containment of the proposed repository fail, due to human error, systems failure, geologic conditions, or other catastrophic events. These unacceptable risks will not be confined to the life of the waste site, but will last for many thousands of years,... (National Council of Women of Canada: CEAA Doc#75)

#### *Adverse Consequences:*

- [T]he effects of the event are unbounded: *especially with a time frame extending into the hundreds of thousands of years.* ( Eugene Bourgeois: CEAA Doc#944)
- The site fault. Did OPG also mention the fault in the area that the DGR would be built on? A small earthquake could very well widen this fault and thereby weaken or breach the integrity of the DGR. Result? Game over for 40 million people who rely on the fresh water from the Great Lakes. And possibly for the children who will be at risk for nuclear-waste induced illnesses, deformities and cancers. (Joanne Martin: CEAA Doc#1104)
- I am here today because I feel that the proposal of a Deep Geological Repository no further than 1.2 kilometres away from Lake Huron, the second-largest of the Great Lakes, is a mistake. I feel that this is an unsafe and unreliable venture in which the potential for accidents is being grossly downplayed. (Caitlin McAllister: CEAA Doc#1653)

#### *Probabilities:*

- Since radioactive waste has to be kept completely contained for such a long time that it might as well be forever, not only does Murphy's Law become inescapable, but many of the scientific tools we habitually use become useless. Probabilities no longer apply, because everything that has more than an infinitesimal probability is going to happen sooner or later. Mathematical models of the containment system no longer apply, because they can't possibly take into account everything that might happen over such a long time period accurately enough to make reliable predictions. Worst of all we cannot do scientific experiments to test and improve these models, or any proposed containment system, because such experiments would require millions of years to produce valid results. (R. Gordon Albright: CEAA Doc#1403)
- No increase in radioactivity exposure during the construction and long term operation of the proposed DGR is acceptable. OPG states in their documents that the DGR "is not likely to result in any significant residual adverse effects to human health or the environment, including Lake Huron and the Great Lakes." "Not likely" is not a reassuring answer and presents too much uncertainty.

How will a DGR for nuclear waste beside our drinking water result in a healthy outcome for ourselves and future generations? Where is the Precautionary Approach? (Jim and Brenda Preston: CEAA Doc#1373)

*Uncertainties:*

- Because of the long-term and possibly unrecoverable consequences of an accident or leak resulting from faulty or unforeseen research, no ambiguities or uncertainties should be acceptable concerning the burial of nuclear waste. Anything less than that is risk-taking. (Peter Storck: CEAA Doc#1051)
- In summary OPG's proposed DGR increases the likelihood – albeit a very tiny likelihood – that Lake Huron waters could be contaminated by radionuclides at some point over the next 60 to 1,000,000 years. OPG has advanced extensive explanations in its proposals and responses to information requests to argue that the likelihood is very small. Nevertheless, uncertainties remain that cannot be eliminated or even reduced at present. (Peter Venton: CEAA Doc#1374)
- The areas of uncertainty are around the characterization of the geology, the effectiveness of the containers (none proposed, in this case), the estimates of corrosion and gas buildup, the reliability of the computer models, etc. These are all areas of uncertainty in this case, as in others.... The preferred alternative is that which reduces these uncertainties, and retains the option of pursuing a sounder and more secure option in the future. That means continued storage at site, in engineered containers which can be monitored, performance can be measured, and the containers can be replaced or re-encapsulated if needed – as needed – at some point in the future. (Dorothy Goldin Rosenberg: CEAA Doc#1395)
- Therefore, I am deeply concerned for the danger caused by burying this low and mid-level radioactive waste because over such a long-design life, we don't know what will happen. The DGR risks the contamination of Lake Huron and all of Canada's heartland. Water from Lake Huron feeds into Lake Erie and Lake Ontario, so tens of millions of human beings downstream will also be affected. (Peter Ormond: CEAA Doc#675)
- As such, key questions include, how such material would be able to re-enter the human environment? What conduits are available, in terms of permeable rock formations, fault zones, fracture zones (which may have no fault movement along them), and deep groundwater circulation? There is further uncertainty as to how the nuclear waste will interact with the barriers (ie corrosion of the barriers, the releasing of gases), seismic or glacial activity, and how radioactive material will react in a closed environment. Again, we must ask - where is proof of safety? (Dorothy Goldin Rosenberg: CEAA Doc#1395)

*Preferred Location "far away":*

- Is it necessary to take ANY risk, when a DGR can simply be located somewhere else far away from the Bruce Nuclear Power Plant, and far away from Lake Huron or any of the Great Lakes, where these risks are not present? (Beverly Fernandez: CEAA Doc#713)
- The storage dump should be located in granite, in an area which is not subject to earthquakes, and away from our fresh water, and away from densely populated areas. (Harry Giles: CEAA Doc#985)



- Alternately, choose a site in Canada that is far above the local water table in crack free granite and hence is inherently dry. (Joanne Martin: CEAA Doc#1378)
- So the best possible scenario would be OPG abandoning the present site for a less risky site in the Canadian Shield, in order to guarantee that we keep the Great Lakes and all the interconnected waterways free of the possibility of nuclear waste contamination. This will be of ultimate benefit to the vast majority of Canadians and our American neighbours, whom also have a very great stake in the continuing good health of the Great Lakes. (Joanne Martin: CEAA Doc#1104)
- International experts agree that radioactive waste is best stored far from people, animals and water sources. Ignoring this broadly held and logical conclusion, the plan to construct the DGR in our region, the home of many picturesque small towns, an area reliant on agriculture and a vacation destination for tourists, defies responsible planning principles. (Save our Saugeen Shores: CEAA Doc#1370)

*“Out of sight, out of mind”:*

- Spend money thoughtfully and usefully, and in the next 40 to 100 years figure out a useful way to use this waste. Figure out one solution for all nuclear waste -- low, intermediate, and high level. Never in life can you bury your problems and think that they will not resurface. Nuclear waste is no different. Out of sight is not out of mind. (Paul Kluster: CEAA Doc#639)
- And therefore, we would recommend that in the absence of permanent safe solutions, society can best meet its obligations to protect the biosphere from existing nuclear waste through longer term management based on surface or near surface monitored and retrievable storage. In other words, in sight and in mind with visible institutional controls and monitoring, that in fact, the average public could take an interest and have some ownership in as well to ensure that we have adequate funding, adequate care. (Algonquin Eco Watch: CEAA Doc#1631)
- In summary, the risk of burying low- and intermediate-level nuclear waste “out of sight” and potentially “out of mind” of future generations is simply an unacceptable risk to take. It is prudent to assume, based on other precedents, that breaches of containment will occur.... Continuous surface or near-surface containment with institutional monitoring and retrieval capability is the precautionary route to take. (United Church of Canada: CEAA Doc#1273)

*Preferred Option “As Is”:*

- If it is safely stored now, as you say it is, continue to do it that way. Why rock the boat into the unknown with the concurrent risks of leaks and disaster. Fortify even further the storage currently and in the future above ground at-site. Hopefully, it can be recycled some way, without trying to bury it to eternity with all the unforeseen risks below the surface of the ground, with accompanying negligence in building materials and workmanship of the DGR over time, and old age of the structure deteriorating with time as all structures (natural and man-made) ultimately do, in addition to all the inherent transportation risks. (John Mann: CEAA Doc#1389)
- Status quo storage of low and intermediate nuclear waste – above ground and retrievable – has many advantages. There would be little need for construction as it has been in use since 1977 and

has an estimated lifespan of around 100 years. This system of management allows indefinite access, giving the researchers fifty more years to conduct further research and to develop the means to further enhance the above-ground storage systems. (Canadian Voice of Women for Peace: CEAA Doc#1377)

- So there's a few factors. If you're going to do surface or accessible, retrievable waste storage, you have to keep a population aware that this is happening. And as Dr. Harvey said, you have to have monitoring, you have to know it, you have to be able to repair it and so on. That is easier -- "easier" -- than something that is deep underground that you then have difficulties retrieving without causing more damage. (Anna Tilman: CEAA Doc#1593)
- This process is flawed and on OPG's own evidence, the status quo is the preferred option before you today. It will remain the preferred option until science can prove the same certainty as safety as the status quo has proven over the past 40 years. (Siskinds LLP: CEAA Doc#1685)

*"Abandonment":*

- The concern is institutional control and the lack of possibly institutional control in abandoning a site of this nature. How are you going to alert future generations? How are you going to avoid any intrusion if the site is not being monitored, abandoned forever, which is one of the major problems with this DGR proposal is abandonment. You cannot abandon something of this nature and ensure that if there is a problem where is the control? What if there is impairment in institutional control? What if there's no funding anymore to provide this? What if there is no memory of what this was, retained? How is this going to be looked after considering the long-lived radionuclides? So that is one of the major problems with the concept of the DGR and in this particular case, that abandonment phase. (Anna Tilman: CEAA Doc#1593)
- Nuclear waste must never be abandoned. It must be kept in engineered facilities where it will always be monitored -- forever be monitored and retrievable should containment fail. There must be zero tolerance for the escape of radiation from the storage facility. We have no right to impoverish or imperil the lives of our children and grandchildren and all future generations with any increase in exposure to ionizing radiation. (Teresa McClenaghan, CELA: CEAA Doc#1606)

*Deep Geologic Repository:*

- Imagine when an earthquake starts breaking your underground cavern apart. Who will go down there to retrieve the nuclear waste and bring it to the surface as the walls break apart, water flows in and the sealed containments crack apart? Will you? I doubt anyone will be able to stop such a calamity. The waste will go into the Great Lakes. It will flow out into the ocean. It will kill the life in the lakes, the people near the lakes, and it will stop people from enjoying the lakes, making a living from the lakes, and transportation on the lakes. (Kathy Barnes: CEAA Doc#1152)
- It only makes sense that placing medium level waste in sealed containers, far underground in structurally sound rock and monitoring them makes more sense than having it near the surface where acts of terrorism or acts of nature i.e. tornadoes, floods etc, could cause the release of the waste to more readily affect the public safety. (Barry Clemens: CEAA Doc#1361)
- In one-on-one conversations, several persons mentioned the need to support a DGR, especially after the events of the Goderich F2 tornado and, therefore, we agree with the assertion of OPG that a

DGR is more secure than the current aboveground storage for the existing waste and the waste to be generated in the future. (Neil Menage: CEAA Doc#1618)

- Nothing is immutable, not even rocks. Containers of this waste will inevitably corrode. Cracks and fissures will develop in the rock formations and widen over time. Water and gas contaminated with radionuclides will flow through the cracks and penetrate the barriers in the repository. Chemical and microbial processes and interactions will occur that could further erode the barriers. Climate change, glaciation, and earthquakes could severely destabilize the repository. And then, there is the possibility of accidental and even intentional intrusion into the repository. (Anna Tilman: CEAA Doc#1387)
- Okay, so why a Deep Geologic Repository? Well three options were studied, enhanced processing and storage, safe -- surface concrete vaults and rock vaults. And we looked at both deep and shallow. And the study trips revealed a deep rock option -- vault option was likely the most appropriate for Kincardine. We -- there was a group -- Golder was used to study the various options and they concluded that the deep rock option had the highest safety margin, also that the Kincardine geology was likely ideal for the deep rock repository. As for us, we were going to support the safest option that was available. We felt it was the only way that we could responsibly go. (Mayor Larry Kraemer: CEAA Doc#1567)

These excerpts illustrate many of the general points about risk perception that are referenced in the Background Study (Appendix A):

1. Public risk perceptions especially where risks are thought to be high, tend to be strongly influenced by the factors listed under the categories of “dread” and “unknown” risks (Appendix A, page 4, Table 1).
2. The public participants also expressed views that are consistent with risk perception respecting a complex technology and a complex hazard (Appendix A, page 6): “Risks from technology are often seen as imposed, often by large-scale industrial activities – primarily complex technologies or processes” (page 6). When faced with such complexity, some public participants express the view that it is inappropriate to situate such a facility in small communities with a rural character.
3. Many studies show that “people’s perception of the risk level of an activity is related to their trust in the authorities who manage it” (Appendix A, page 7), and this influences the judgements of some people about the risks inherent in projects that have a heavy involvement by private industry and government or public-sector organizations.
4. Risk judgements are influenced by “broader social and political attitudes and values” which are relatively stable over time and thus are not likely to change with new information (Appendix A, page 10).
5. The process whereby attention becomes focussed over protracted time-frames on particular risks, through small group interactions and media coverage, can result in an amplification of perceived risks (Appendix A, page 12).

6. Where modern technologies are concerned, risks are uppermost in most people’s minds, and quite often people are not strongly influenced by the benefits derived from those technologies. Opinion surveys in many different countries show that “people view nuclear power and nuclear waste as extremely high in risk and low in benefit to society” (Slovic 2012, cited in Appendix A, page 20).
7. Members of the public, generally speaking, overwhelmingly focus on harmful consequences that may occur, without reference of the likelihood or probability of the occurrence of the underlying event which may give rise to specific consequences (Appendix A, page 29).
8. In the context of public risk perception, “risk acceptability” – that is, a clear statement about what kind and level of risk is thought to be acceptable – is rarely articulated, if ever; nor can a concept of acceptable risk (either absolutely or relatively, in terms of alternatives) be derived from the positions of interveners (see Appendix A, pages 30-31).

#### **Note on Keyword Searches**

A specialized software program, dtSearch Desktop version 7.72, was used to perform global searches throughout all items on the CEAA Registry posted up to the end of February 2014, up to and including CEAA Doc# 1831. Items posted on the CEAA Registry with specific comments on the Environmental Impact Statement Guidelines were not included in the searches.

For each of the four options identified in IR EIS-12-513, combinations of specific keywords were used to find any references to the risk perception and/or acceptability of risk associated with the primary uncertainties specified by the Panel (in the letter dated 6 March 2014), for the public and Aboriginal groups in submissions and interventions during the public hearing/meeting sessions. Boolean searches were used to find structured groups of keywords linked by connectors such as *and*, *or*, *w/30*<sup>5</sup>. As an example, one of keyword combinations used to find references to *risk perception* and *acceptability of risk* for the *proposed DGR* with respect to *accidents* was:

*(DGR or deep geologic\* reposit\*<sup>6</sup>) w/30 (uncert\* or probab\* or risk\* or likelih\* or conseq\* or impact\* or permiss\* or communit\* or accept\*) w/30 (accid\* or incid\* or event\* or malfunc\* or fire\* or Chern\* or Three Mile\* or Fuku\*).*

Results of all searches with respect to risk perception/acceptability were grouped into:

(Public or Aboriginal Input) x (4 Options) x (9 primary uncertainties identified in the 6 March JRP letter)

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<sup>5</sup> “*apple w/30 pear*” means that “*apple*” must occur within 30 words of “*pear*”

<sup>6</sup> “*reposit\**” means “*repository*”, “*repositories*”, etc.

## Section IV

### **Positions on the Proposed Project Expressed by Aboriginal Interveners to the Joint Review Panel**

Representatives of several different Aboriginal groups made submissions to the Panel on the proposal to construct a Deep Geologic Repository (DGR) at the Bruce nuclear site. These include the Saugeen Ojibway Nation (SON), whose lands are on the shores of Lake Huron north of Kincardine); the Historic Saugeen Métis (HSM), whose territory is on the Lake Huron shoreline from Tobermory to south of Goderich); the Métis Nation of Ontario (MNO), representing Métis communities throughout Ontario; the Mnidoo Mnising First Nations (representing six First Nations in the Manitoulin Island area); and a 'global representative' for Traditional Indigenous Human Rights. While there is considerable overlap in the type of information provided by each group, they expressed a range of positions on the DGR proposal and on the decision-making process.

The transcripts and submissions to the Joint Review Panel cited here are on the public record of the review, and were collected by the Canadian Environmental Assessment Agency (CEAA), the agency responsible for managing the review. They are referenced by the document number assigned by the CEAA, and since these are often quite long documents, page numbers have been added.

#### *Identity and Assertion of Rights.*

Most of the Aboriginal submissions began with a statement of the history of their First Nation or community and an assertion of its legal right to its territory and to the pursuit of traditional hunting and harvesting activities in that territory. The SON describes itself as “an unceded First Nation” (CEAA Doc#894: page 3) that claims certain rights to their traditional territory, while the HSM asserted its rights over the lands and waters of the proposed DGR site. The MNO, HSM and the SON described the historic relationship of their Nations and communities with the Government of Canada, including the general right of Aboriginal communities to harvest foods in their traditional territories as set out in the Constitution Act (CEAA Doc#1675: 101), and more specific treaties and other agreements; there were several mentions of the Crown’s ‘duty to consult’ (CEAA Doc#1270: 3-4). The SON described the recent legal decision that permitted their communities to rebuild their commercial fishery, which had been neglected during earlier legal disputes (CEAA Doc#1461: 2-5, 7-44).

#### *Expectations for Process.*

Related to the assertion of rights over traditional territories and claims of responsibilities of the federal government, most Aboriginal interveners stated that the proponent and project reviewers have an obligation to consult with them extensively on this proposal. Many submissions referred to a 'history of exclusion,' previous failures of government to consult with them on the installation of industry on their land, including the initial construction of the Bruce nuclear power stations, and more recently the location of wind farms, which took place without their consent (CEAA Doc# 894: 6). They also recounted

the process that was followed by OPG and the Canadian Nuclear Safety Commission, which had been marked in many instances by problems, including lateness, in establishing proper notification and consultation procedures and providing capacity (CEAA Doc#894: 2-3; 1675: 106). However, some positive relationships have been developed, including a strong working relationship between the HSM and OPG and the CNSC, with good efforts by OPG to notify them of the proposal to build a nuclear waste repository, helping them understand the facility and including them in planning discussions and the review process (CEAA Doc#1675: 85, 106). Many individuals from HSM communities have been employed by the generating station and they appreciate the respectful process that OPG follows with them. Submissions by the SON noted that OPG has made a commitment that it will not begin construction on the project without support from the SON communities (CEAA Doc#1427: 98-99). MNO is working with OPG to identify a long-term agreement (CEAA Doc#1675: 114).

#### *Cultural Values.*

Most of the submissions made by Aboriginal interveners included a statement of the cultural context that shapes the perspective of the First Nation or community to the land, and to its traditional territory specifically. The HSM stated that no individual owns the land: Rather, the people are the caretakers of the land; the land provides for them, and they in turn are responsible for protecting the land. It was often stressed that the most fundamental principle is the critical relationship of the people with their territory: A SON representative stated that “who we are as a people is inextricably linked to the lands and the waters” (CEAA Doc#1741: 147).

Several submissions mentioned the importance of spiritual beliefs in the decision. One intervener said that “when we allow anyone to poison Mother Earth what we are really saying is that it is OK to poison our Children and Grandchildren and all future generations” (David Eagle, CEAA Doc#1156: 1). MNO stated that “... while the fish or the animals or vegetation may not be directly affected, people's use of that specie or their attitudes of using those things can change. Whether it's perceived safety issues or increased activity or just the way people feel about experiencing their traditional activities on the land” (CEAA Doc #1675: 134). The Mnidoo Mnising Elders Circle (CEAA Doc#1383: 2) stated that the care and protection of mother earth are part of Anishinaabe sacred teachings and are their ‘foremost priority.’

Another SON intervener (CEAA Doc#1704: 38) argued that it is “offensive” that scientists could assert that there are “no tangible reasons for Aboriginal people to change how they value plants and animals they harvest for traditional purposes.” This statement, it was said, overlooks the incompatibility of waste with the rock, which is the first order of Creation: “If our people come to believe that it is no longer right to consume the plants, fish or animals for food or spiritual reasons, this cannot be mitigated by demonstrating that there are no new radiological effects.” For example, if sweetgrass is perceived as being less ‘pure’ because of concerns that it may have been affected by radiation, it may not be viable for spiritual purposes (CEAA Doc#1704: 55). It was also noted that public hearings do not offer an appropriate context for addressing such matters (SON: CEAA Doc#1741: 153-154).

These statements illustrate Aboriginal values and the type of knowledge that is credible among Aboriginal people, which are distinct from mainstream culture and particularly from scientific

knowledge. It was mentioned by several interveners that cultural teachings are passed down from generation to generation (CEAA Doc#1741: 147). The Mnidoo Mnising Elders Circle representative (CEAA Doc#1383: 3) stated that the elders “provide the appropriate teachings that reflect our cultural[ly] sensitive manner,” and which is an essential link from the past to the future, completing the “circle of life.”

#### *Specific Concerns Related to the Proposed Repository.*

Aboriginal interveners stated that the DGR project could damage the land that they live on, which would in turn damage their rights, interests and way of life. Several Aboriginal interveners stated that they are concerned that a repository could change the relationship of the people to their territory, threatening the ability of the land to sustain them and undermining the culture and identity of the people (e.g., CEAA Doc#894: 9). A major concern is for the waters and the fisheries, both the sustenance fishery and the recovering commercial fishery. The SON (CEAA Doc#1461: 5) stated that the disposal facility “within hundreds of meters of spawning grounds” posed “a significant new threat” to the fish they rely on for food and for the commercial operation. These activities could be damaged physically by the industrial activity or by contamination from the waste, as well as by stigma effects that reduce the market value of the fish and the commercial fishery and related tourism industry; it was stated that efforts to rebuild the commercial fishery likely could not ‘withstand the blow of stigmatization’ (CEAA Doc#1704: 39).

In addition, many outlined concerns about adverse impacts that the proposed repository could have on their lands and waters. The HSM emphasized the “potential for severe impacts on the community’s constitutional rights for sustenance harvesting, in the immediate future, and for centuries into the future” (CEAA Doc#1270: 6). There were a number of comments on the need to study the potential impacts of transporting waste to the facility, as well as challenges to the determination that transportation issues were outside of the scope of the EIS. Concerns were also raised about the threat of extreme events, such as severe weather, that have not been factored into the existing facility design. Many comments referred to the events at the Fukushima reactor in Japan caused by the earthquake and tsunami, with concerns expressed that the possibility could not be ruled out that similar events could happen at the repository site over the long waste management timeframe (e.g., CEAA Doc#894: 9; 1462: 33; 1383: 2).

There were a number of criticisms of the Environmental Impact Statement (EIS), relating to the process by which elements to be assessed were determined and to the adequacy of the EIS itself. The MNO pointed out that they had been left out of the process to identify the Valued Ecosystem Components that should be studied as part of the EIS; these were “incorrectly chosen” and so the EIS does not reflect Métis values for the land. The MNO provided a complete traditional land use study, but noted that this has not been incorporated into the EIS; they argued that they should be able to sit down with the proponent and explain their land use study and the way the information in it can be used (CEAA Doc#1675: 152).

Other submissions detailed perceived deficiencies in the EIS, such as the failure to assess an alternative site and a number of other technical aspects of the proposed facility and its design. It was also noted by

interveners that central characteristics of the project have been left to be defined in later licensing stages of the approval process, rather than being included in the formal environmental assessment. Further, the contentions were made that the EIS has an incomplete waste inventory, as well as an undefined geoscientific verification plan, insufficient alternative means assessment, and no analysis of different options for managing intermediate waste components. Concern was expressed by other interveners that decommissioning waste from Pickering could be included in the facility, which would appear to be a change in the scope of the project (CEAA Doc#1704: 22).

On the social assessment side, there are statements to the effect that the socio-economic impacts are not known, and that there is an inadequate analysis of the potential impacts of stigma, suggesting that OPG does not understand the possible effects that stigma could have on the social and economic life of the communities. It was argued that some surveys of tourists' opinions are not valid as the sample size was too small and was limited in geographic scope (CEAA Doc# 1427: 44), and that the polls conducted to determine community support of the project are not reliable, since they used a vague question and produced inconclusive results (CEAA Doc#1427: 96-97). Larger nuclear power issues were also mentioned, since low- and intermediate-level nuclear wastes are products of nuclear power generation; interveners wanted to know how the construction of a low- and intermediate- level waste repository fits in with plans to manage spent fuel from power reactors.

#### *Trust and Uncertainty.*

Varying levels of trust were expressed in the different organizations involved in the project. The HSM expressed appreciation for the positive relationship it has with OPG (CEAA Doc#1362: 5). But a fundamental lack of confidence in scientific assurances of safety was expressed by a number of interveners. The SON stated that OPG has failed to demonstrate the social or technical safety of the project: The consequences of the project "are not known and in many cases are not even considered" (CEAA Doc#1461: 4), and SON communities "do not have sufficient confidence in the completeness of scientific and technical estimates" of the project (CEAA Doc#1427: 85). The long time period over which the waste must be contained "denies any real certainty for the future reliability of containment" (CEAA Doc#1675: 102).

There was a basic lack of trust that the project will have no impacts on the water or the environment, the people's health or their means of making a living. A Chief asked (CEAA Doc#1704: 33): "Can we trust this project? Can we accept this project and can we agree to have this project as part of our future for all times?" As noted above, Aboriginal people need to know if the DGR will be technically safe, but they also need to know that it will be done in a way that is consistent with "spiritual and cultural teachings and does not cause harm to fundamental elements of who they are as a people" (CEAA Doc#1741: 154). The HSM stated that a conclusion that there are no potential impacts would indicate a failure to understand "the potential nature of the Aboriginal rights or which rights could be engaged" (CEAA Doc#1675: 79).



### *Ongoing Role of Aboriginal Peoples in the Repository Project.*

Both the SON and the HSM acknowledged that the ultimate goal of the assessment process is to find a way to manage nuclear wastes and that they would have a role in that management. The SON observed that the waste management problem in their territory is “not of our own design but certainly we’ve got to be part of shaping the solutions for that waste problem” (CEAA Doc#1704: 88). The HSM expressed conditional support for the project, stating that they “recognize and accept that there is a nuclear waste issue that must be addressed” (CEAA Doc#1362: 7), and acknowledged that “we are all responsible collectively to develop a safe storage option for nuclear waste created here” (CEAA Doc#1675: 104). The HSM explained that they have received economic benefits of employment at the Bruce generating station and benefits from its activities, and looks forward to continuing involvement in working with OPG on the DGR. They noted that they have been living in the area alongside the nuclear power plant and don’t have the same sense of stigma that others might (CEAA Doc#1675: 150).

Despite these statements of support for the goal of managing nuclear wastes, both the SON and the HSM noted a number of conditions that would need to be met for their clear approval of the project.

The HSM expect to be involved in monitoring the DGR ‘as the project goes forward’: given the significance of the threat posed to their constitutionally protected Aboriginal rights, they require a high degree of consultation (CEAA Doc#1270: 5). A clear and formalized understanding of the way that HSM concerns will be considered and integrated into long-term decision-making processes will need to be developed. Agreements directly with Métis communities, or conditions stipulated in regulatory approvals, could be used to ensure that “the proponent continues to be held accountable to the affected Aboriginal community” through all phases of the project, including construction, operation, monitoring and decommissioning (CEAA Doc#1270: 7).

The SON stated that people will need the opportunity to decide their support for the project, which they believe will pose a ‘permanent’ risk to their land, water and people “regardless of how small we may now predict” the impact to be (CEAA Doc#1704: 36); under these circumstances there must be conditions for the acceptance of the project by the people. The people must “be asked for their agreement” and the project should proceed only “when the people most affected fully understand the project and when they are supportive of it moving ahead” (CEAA Doc#1704: 39-40). The SON stated that some concerns regarding the transportation of nuclear waste through its territory must be addressed or the assessment will be ‘fundamentally incomplete’ (CEAA Doc#1463: 56). “[R]egardless of what the Panel decides, our people know that the work is not complete, and SON leadership will work tirelessly to make sure that the work is completed and to the satisfaction of our people” (CEAA Doc#1704: 45). Projects in their territory that are acceptable would be those that do not subject their territory or people to undue risks or harms; that contribute to the long-term sustainability of the territory by improving the environmental, social, cultural and economic well-being of the people; and that ensure that the wastes are managed, monitored and regulated effectively with their appropriate participation (CEAA Doc#894: 10).

MNO have been engaging with OPG with discussions towards an agreement for the period of the construction phase with a desire and interest to reach a long-term agreement for the operations of the project. The specific details of that agreement are not yet completed. MNO's presentation at the JRP hearing provided information to OPG on the level of commitment required in order to proceed in good faith with OPG (CEAA Doc#1675: 90-91).

## Summary and Conclusions: Aboriginal Peoples' Perspectives on a Nuclear Waste Repository

The positions expressed by Aboriginal participants in the review process echo the cultural values and perspectives on risk that are expressed in published literature on Aboriginal attitudes to technological risks, as described in the Background Study. This enlarges an understanding of the importance of culture, social relations and political dynamics as shaping risk judgements within Aboriginal cultures.

In terms of perceptions of risk, the Aboriginal interveners all stressed the primary importance of their spiritual and material ties to their traditional territory, and their concern that adverse impacts of a DGR would undermine the traditional harvesting activities that strengthen those ties to the land and give the community its sense of identity and cohesion. While the Aboriginal interventions make it clear that they are able to address more technical aspects of risk and environmental assessment, it is also clear that their perspective places a stronger emphasis on the value of specific entities that are at risk, rather than on perceptions of the risk source and of the significance of its threat to human health more generally. This suggests that reassurances that any escape of radiation from the facility will be at low levels that have no implications for physical health may miss the point; the greater concern is for the undermining, by any means, of the spiritual and social value of the land and the traditional activities that are intertwined with it.

The respect for spiritual connections with traditional territory and for traditional teachings links to a traditional way of perceiving and knowing about the environment that is very different from modern Western scientific knowledge. The Background Study describes the 'gap' between experts and non-experts, which has been used to explain the different judgements that are reached through scientific reasoning and broader contextual reasoning used by most individuals on social situations that involve risk. The traditional aboriginal perspective is, like most non-experts', largely based in cultural and social assumptions rather than scientific principles and methods; however, it is more strongly connected to a coherent alternative body of knowledge, principles of reasoning, and respect for the traditional teachings of elders. Aboriginal people may explain an attitude to a 'risk' in terms of a cultural value that is unrelated to the conventional scientific explanation. There may therefore be a greater need for scientists and other risk managers to understand traditional Aboriginal values and knowledge in an effort to communicate effectively and with mutual respect.

The social traditions of many Aboriginal communities place an emphasis on the necessity to establish relationships based on respect and recognition of rights and responsibilities. Process considerations are very important for all societies studied by risk perception and technology acceptability researchers, but the expectation for a respectful approach to an Aboriginal community and the development of trusting relationships may be more particular within those cultures. Especially where a First Nation or community has experienced marginalization and threats to the continuation of its traditional activities, respect and support for those communities' efforts to protect their relationships of stewardship with their territories will be critical to the development of trusting relationships.

## Section V

### Observations and Conclusions

#### *Observations:*

As the Background Study shows, earlier perspectives that appeared to find strong underlying differences between expert and “lay” perceptions of risk have been modified, suggesting that those differences were exaggerated. However, this does not affect the reality that, in countries such as Canada today, two very different *discourses* about risk will be heard during formal decision-making processes, such as environmental review public hearings carried out under the terms of legislation and regulation.

One discourse will be a technical, expert-based discussion of risk. Project proponents in these circumstances have an obligation to make a “safety case” using the technical terminology of risk assessment, and regulators expect that they will use a highly technical discourse competently. (One good example is the requirement to demonstrate that existing radiation dose limits, for both workers and the public, will not be exceeded.) Interveners at public hearings who are individual citizens or members of public-interest groups are not obliged to use a technical discourse about risk, although some may do so, and some have done so in the present case. The public discourse on risk focusses largely on the hazardous consequences, without consideration of likelihood, associated more broadly with nuclear undertakings. Thus in any environmental review process using public hearings, two quite different discourses will be heard and, for the most part, will have little in common.

Our earlier Report on comparing four options for managing low- and intermediate level nuclear waste, using the techniques of qualitative risk assessment, necessarily embodies a technical discourse. We were asked to use highly technical parameters such as advective gas and water flow, structural and mechanical impairments, waste container integrity, and radiological dose for workers. We made our expert judgements about these parameters on the basis that there are very extensive and reliable bodies of accumulated knowledge which could justify such judgements. We find no comparable parameters in the public discourses on risk that allow for focused comparison of options. However, with respect to other parameters relevant to risk in this case, such as, for example, the possibility of seismic events or future glaciation in the region, there is an element of commonality between the two discourses; but for the most part the public discourse lacks the degree of elaboration necessary to estimate, even qualitatively, the *magnitude* of the risks that are referred to.

The frequent reference in the public discourse to the proximity of the waste storage and disposal site to Lake Huron provides an excellent example of this point. When confronted with the possible Bruce DGR within visible proximity to the Lake, there is for many people almost an automatic assumption that the chain of events leading to the possibility of a breach of containment and thus uncontrolled emission of radionuclides is a very short chain indeed: After all, the physical distance to the water is on the order of one kilometer (700m deep, 1000m to the lake shore). In the technical discourse, on the other hand, the key determinants of the risk of human and environmental exposure to the stored radionuclides are not a function of proximity to the lake, but rather of the geological characteristics of the various types of

rock surrounding the underground cavern at different levels: These characteristics give rise to the expert view that any movement (advective flow) of radionuclides dissolved in water and gas through the rock would occur at an extremely slow rate, passing through hundreds of meters of rock mass over a time-span that would render the radioactivity harmless. *Both perspectives* are reasonable when considered in their own terms – but they are incommensurable with respect to the quite different conceptual framework within which each perspective is operating.

Finally, note that we are trying to be precise on an important point: There are indeed “patterns” in the some of the intervener responses; for example, see the collection of statements in Section III, pages 11-13 above, under the following headings: Preferred Option “As-Is,” “Abandonment,” and Deep Geologic Repository. However, it is not obvious that these statements, taken as a whole, reflect different patterns in the perception of risk. As this collection of statements illustrates, the public discourse is heavily dependent on the concept of safety, rather than risk. The concept of “safety” is inherently oriented around consequences, and the essential difference between safety and risk has to do with probabilistic reasoning, which is downplayed in safety but is essential to risk.

#### *Conclusions:*

We can now apply the results of both our background study on risk perception, and our examination of materials from the submissions and public hearings, to the issues and perspectives posed by the letter from the Joint Review Panel dated 6 March 2014:

- “...[T]he Panel expects that there be a comparison of *risk perception* (and thus, *risk acceptability*) among the four options.... [T]he Panel suggests that the Expert Group focus on uncertainty. This is because the technical risk analysis of the four options will have a direct link with the analysis of the effects of the technical uncertainty on risk perception.”
- “Many submissions [to the JRP] presented comparative risk perceptions and risk acceptability among status quo, enhanced surface storage and deep geologic repositories. These submissions, together with information in the published literature and the Expert Group’s analysis and professional judgement should be used to produce a relative risk perception/acceptability score for the four options.”
- “...[T]he Panel would encourage the Expert Group to comment on how risk perception among Aboriginal peoples might better be acknowledged and incorporated.”
- “The Panel expects that the analysis then go forward with further consideration of the *perception* of each of the four options, as influenced by the relative degree of technical uncertainty associated with the primary uncertainty issues listed above.”
- “The Panel maintains that use of a combination of evidence provided by submissions as well as published literature is sufficient to discriminate among the options if the Expert Group focusses, as is suggested above, on the effects of relative uncertainty on risk perception and risk acceptability.”

## Responses from the Independent Expert Group:

1. After examining the relevant published literature, and a substantial body of material from the submissions and hearings transcripts, we do not find that risk perceptions, risk acceptability, or perceptions of uncertainties are systematically and coherently structured according to the different management options that have been considered by interveners. In other words, across the range of public views as a whole, we find no discernible *pattern* within those views in which preferences among the four management options are directly or even indirectly related to the perception of risks associated with the storage and disposal of nuclear waste.
2. Since in the public discourse uncertainty is almost never provided in terms of magnitude (i.e., how much uncertainty, expressed qualitatively), there is no way to estimate relative uncertainty, and thus no possibility to discriminate among the options in this respect.
3. With regard to the concept of risk acceptability, we find in the record of the public discourse few statements about what constitutes acceptable risk in the storage of nuclear waste (as opposed to statements about what risks are unacceptable), and thus no basis to discriminate among the four options using this concept.
4. The Independent Expert Group finds that it cannot provide the Panel with a score reflecting public perception or acceptance of the risk of the four options.
5. Both the literature and the evidence provided at the hearing suggest that, in part, the public perception of the risk of the proposed facility is related to the degree of trust in the organizations that have responsibility for the safe management of the nuclear waste (i.e., the proponent, the regulatory authorities, etc.). As noted in the Background Study, public trust requires that the public have “evidence that facility proponents, designers and managers share their concerns about the hazards and their valuation of the environment that may be at risk and plan and manage the facility with those values in mind. Continued tolerance of a nuclear waste facility will require that management facilitate public scrutiny of the facility and its management through being open, with stakeholder participation, provision of relevant information, and reliable notification of any problems that occur.”
6. Aboriginal perceptions of the risks associated with the storage of nuclear waste have been articulated within a comprehensive worldview. In terms of perceptions of risk, the Aboriginal interveners all stressed the primary importance of their spiritual and material ties to their traditional territory. While the Aboriginal interventions make it clear that they are able to address more technical aspects of risk and environmental assessment, it is also clear that their perspective places a stronger emphasis on the value of specific entities that are at risk, rather than on perceptions of the risk source and of the significance of its threat to human health more generally.

7. Interveners on behalf of Aboriginal peoples indicated that conditional support for the project in these communities depends on their ability to participate in decisions and monitor the progress of the plans and the operation of the facility if it is built. Respect and support for those communities' efforts to protect their relationships of stewardship with their territories will be critical to the development of trusting relationships.

## **APPENDIX A**

### **Risk Perception Background Study**





## REPORT

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# **Risk Perception of Nuclear Waste Disposal**

A background study

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**Submitted by:**

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**Submitted to:**

The Independent Expert Group

*April 23 2014*

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## Introduction

This report presents an overview of research on the perception of risk from nuclear waste, with the aim of also providing insight into the conditions that may lead to community support for hosting a nuclear waste disposal facility. It has been prepared in response to a request made to the Independent Expert Group by the Joint Review Panel (JRP) for the Deep Geologic Repository Project for Low and Intermediate Radioactive Waste for a review of research on risk perception and community acceptance of a nuclear waste repository. This background study is in support of the JRP's review of a proposal by Ontario Power Generation (OPG) for a repository at the Bruce Nuclear Generating Station in Ontario.

The report describes research on the psychological and social contextual factors that shape individuals' judgements on the significance of a risk, and its acceptability in light of other considerations about the risk source. As the proposed facility will affect several Aboriginal communities whose traditional territories are in the region of the Bruce Nuclear Generating Station, the report discusses research on risk perception among Aboriginals in Canada as influenced by their cultural frameworks. It reviews research on perception of risk from nuclear power, and nuclear waste in particular, as a specific instance of risk perception and context for judgements on risk. It draws some conclusions from these research fields on two key concerns related to perception of risk from nuclear waste disposal, uncertainty and acceptability.

## Risk Perception: Summary of key findings and themes from literature

### Risk

Risk is a complex concept that is defined in different ways, according to the way in which the concept is to be used. However there are several essential aspects incorporated in most uses of the concept, both casual and technical. The essential characteristic is uncertainty, referring to the chance or likelihood that an outcome of concern will occur. When used casually, risk has the sense of an unspecified chance of loss or harm from exposure to a danger; in the financial world the focus is on uncertainty, with the outcome being either positive or negative. Risks can be avoided, managed, actively taken, or carefully optimized.

When applied to the professional management of adverse risks, risk is a calculated quantity that incorporates several key factors:

- Hazard: a source of harm, inherent in a substance or activity
- Exposure: measured by type, duration and dose
- Consequence: a specific outcome that results from exposure to a hazard
- Probability: the likelihood that the specified consequence will occur, perhaps expressed as the likelihood with which it may occur (in time) or the incidence with which it occurs (in a population).

In many technical applications, risk is defined as probability times consequence, or simply  $P \times C$ . It is the (generally) quantitative expression of the probability of occurrence, within a given timeframe, of a specified outcome of concern.

### **Risk Perception Research**

Research on the perceptions of risk by non-experts is conducted within several academic disciplines, each with a particular interest in an aspect of perception, and a related scale of focus and research methodology. These factors are in turn aligned with particular perspectives on risk as a concept and as an individual understanding, social concern and political debate. Each approach assumes a particular concept of risk and model of its function within society; and though risk research is increasingly multidisciplinary and appears more as a spectrum than as separate and discrete types, there are many debates about the appropriate scale, context and methods of research. To some extent the different scales used by the disciplines involved may be seen as complementary, partial perspectives that can be 'nested' to produce a comprehensive picture. However they are also expressions of differences of opinion on the scale on which risk actually 'exists', the contextual factors that are relevant to an understanding of the concept, and the way it is apprehended by members of society.

In almost all risk perception research a primary distinction is made between 'expert' and 'non-expert', 'lay', or 'public' approaches to risk, though the analysis of the differences and the relationships between them varies. The disciplines are generally within the social sciences, and range from cognitive psychology, with an interest in the ways in which individuals use information to estimate probabilities; through social psychology, with an interest in personality and relational factors that contribute to individuals' judgements of the risks of hazards and social activities; to sociology, with an analytical and critical interest in the collective definition and negotiation of phenomena and relationships that are constructed as risks.

The understanding of risk perception in this paper that has been developed through dedicated research from the early 1970s is presented in three sections. The first outlines findings on individuals' cognitive judgements of risks and the factors that influence them; the second discusses research on judgements by individuals within a particular social and cultural context; and the third looks at the social impacts and broader implications of attitudes to risks and risk sources within the population.

## **Perception of risk**

### **Cognitive processes and knowledge of risks**

Research carried out on risk perception by cognitive psychologists was founded on a concern with the processes people use in making judgements under conditions of uncertainty. Risk was interpreted as a probabilistic phenomenon, with uncertainty the most relevant consideration; assessing the probability of an event is a formal means of reducing uncertainty, in order to provide a basis for decision-making and risk management. The most appropriate means of making judgements under such conditions is through the correct interpretation of the information and application of the rules of probability.

An early finding was that non-experts deal with uncertainty not by systematically considering statistics, but by applying a set of mental shortcuts called heuristics. Heuristics are rules of thumb that enable people to use known information to evaluate a situation that appears to be similar. These heuristics lead to systematic biases in estimating probabilities and values (Tversky and Kahneman, 1974). The most common of these heuristics are representativeness, availability, and anchoring. The representativeness heuristic is the evaluation of a probability according to the degree to which it is considered to resemble, or be representative of, another risk that is better understood. The availability heuristic is the ease with which a type of event is brought to mind. This may be due to media coverage, for example, or to familiarity due to a recent similar event or combination of events, which may be a useful guide to a risk judgement, but can also bias the evaluation of a risk. In anchoring, people base an initial judgement on a value, which they then apply to other situations (Taylor-Gooby, 2004).

An important outcome of research on non-experts' perceptions of risks to health and safety is the psychometric paradigm. Using questionnaires to elicit individuals' ratings of a wide range of hazards of different types, researchers found that non-experts' perceptions were generally higher than experts', and were related to qualitative characteristics associated by respondents with those hazards. Non-experts' risk judgements are more contextual, and are more concerned with the consequences of a risk than with the probabilities of their occurrence. Furthermore, the notion of 'risk' is broader, and the consequences of concern are not limited to death or injury, but extend to harm to something that is valued, or a value or principle in itself. A key finding (Slovic, 1992: 120) was that:

When experts judged risk, their responses correlated highly with technical estimates of annual fatalities. Laypeople could assess annual fatalities if they were asked to (and they produced estimates somewhat like the technical estimates). However, their judgments of 'risk' were sensitive to other factors as well (eg, catastrophic potential, controllability, threat to future generations) and, as a result, differed considerably from their own (and experts') estimates of annual fatalities.

A major finding from this research was that hazards showed 'personality profiles' that are related to their perceived risk. These characteristics were correlated with each other 'across a wide range of hazards' (Slovic 1992: 121), and were found to cluster into two factors that were termed 'dread' risk and 'unknown risk'. Laypersons' perceptions of the risk of a hazard – but not those of 'experts' – have been found to be related to the position of the hazard within the factor space. The characteristics that make

up the dread risk and unknown risk factors are shown below; hazards that are high on the ‘dread risk’ factor are perceived as particularly high risk.

Dread Risk	Unknown Risk
uncontrollable dread global catastrophic potential consequences fatal not equitable, high risk to future generations catastrophic not easily reduced risk increasing involuntary	not observable unknown to those exposed effects delayed new risk risk unknown to science

**Table 1 Qualitative factors in risk perception.** Adapted from Slovic, 1987.

**Demographic factors** have also been found to influence perception of risk, although findings on these factors vary. Many risks, particularly environmental and technological risks (Siegrist et al., 2005) are rated as higher by women and by minority ethnic groups (Finucane et al. 2000). There are also differences among age groups and levels of education, with those with higher levels of education typically perceiving lower levels of risk. Other factors, notably social marginalization and poverty, were found to be predictive of higher risk perceptions (Boholm, 1998).

Psychometric studies have been conducted in many countries, and have found more similarities than differences among nationalities in the ‘cognitive map’ described by the two-factor space (Siegrist et al., 2005); “On an aggregated level, the patterns produced by the psychometric paradigm are very stable.” The psychometric paradigm does not describe individual variability as well, however; several factors have been put forward to explain individual variations in risk perceptions, including confidence and trust (Siegrist et al., 2005) and a range of personality factors such as levels of anxiety, desire for control, and experience with risks (Barnett and Breakwell, 2001; see Chauvin et al. 2008 for a list of references for studies on a wide range of variables).

**Perceptions of different risk sources**

Certain types of risk are consistently judged to be higher, or lower, than actual rates of harm from those sources. Figure 1, below, shows the risk rankings in a recent survey of Canadians’ perceptions of a range of risks to health.

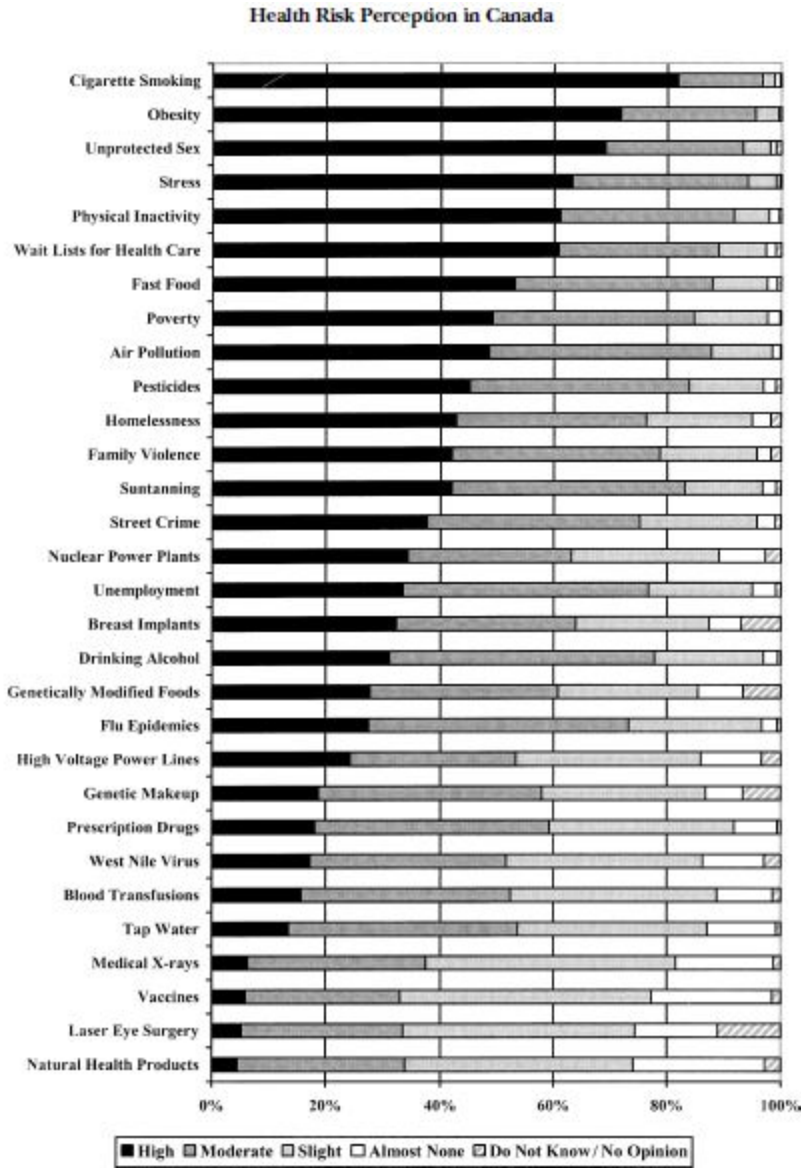


Figure 1 Perceived health risk of thirty hazards to the Canadian public. Krewski et al., 2006.

Some of the risk sources that are associated with raised or lower perceptions of risk have characteristics known to influence risk judgements, such as voluntariness or lack of control.

A major factor that has been observed is that people perceive risks from natural sources as being lower than risks from technological sources, such as industrial chemicals or processes. This bias may lead people generally to be unconcerned about the risks of some natural substances, such as natural radon (Golding et al., 1992; Slovic et al., 1995). Sjöberg (2000) has described an influential factor that he calls “unnatural risk” or “tampering with nature,” which expresses the sense that an activity interferes with nature, and incorporates a moral judgement about the activity.

People consistently perceive risks from technology as being greater than those from nature and have elevated perceptions of the risks of chemicals and industrial technologies and processes. In many cases perceptions of a technology differ with the application: for example, medical applications of biotechnology are perceived as lower risk than uses in food crops (Gaskell et al., 1999).

People rate a risk they undertake themselves, or are exposed to voluntarily, as being lower than one that is imposed on them. People 'discount' their vulnerability to lifestyle risks, over which they feel a sense of personal control (Sjöberg, 2000), but do not do so with so-called "societal" risks, the risks that are imposed and cannot be avoided by any personal competence.

### **Framing – benefit-risk dynamic**

Many of these qualitative perceptual factors that are inconsistent with actual rates of harm are explained through an understanding of the relationship of the individual with the risks and with the benefits of the risk source. Instead of perceiving and balancing separate judgements of the risk and the benefits of an activity or hazard, people integrate the two factors into a single coherent attitude to the risk.

Research within the psychometric paradigm found "an inverse correlation between perceived risk and perceived benefit across diverse hazards" (Alhakami and Slovic, 1994): perceived risk declines as perceived benefit increases. People construct comprehensive judgements or 'framings' of activities in to which 'risk perception' factors are integrated, to arrive at an overall 'risk-dominated' or 'benefit-dominated' perspective on an activity or other risk agent (Alhakami and Slovic, 1994). When people focus on the benefits of an activity they tend to downplay the risks. On the other hand, when people do not have personal experience with the benefits of an activity and perceive themselves to be susceptible to imposed risks, they are likely to frame that activity as a risk (Leiss, 1989; Leiss and Chociolko, 1994). Researchers related this framing dynamic to "intuitive and experiential thinking, guided by emotional and affective processes" (Alhakami and Slovic, 1994; Finucane et al., 2000); this was termed the 'affect heuristic' (discussed in more detail below), in which the dominant perspective is 'liked' and results in the downplaying of the other (Alhakami et al., 1994; Finucane et al, 2000).

Risk-benefit framing helps us understand some degree of the high perceptions of risk from many technologies. Risks from technology are often seen as imposed, often by large-scale industrial activities - primarily complex technologies or processes. These may produce diffuse benefits that may not be experienced directly by individuals, but carry risks to which individuals feel vulnerable, such as air pollution or chemical spills. People cannot control their exposure to these hazards and are dependent on remote social systems of control for protection from them. The downplaying of the benefits of these technologies is related to the 'feeling of powerlessness' in relation to them (Alhakami et al., 1994). In addition, many of these technologies are complex and not well understood by non-experts, adding an additional concern factor.



On the other hand, most people tolerate high risks from substances or activities that they benefit from, such as medications and driving, as they focus on the benefits that they experience from these activities and downplay the risks. Many people actively pursue risky activities, again focussing on the experience of benefits from the activity, and in many cases also valuing the personal control that they can exercise in the activity.

### **Trust**

Many studies have found that people's perception of the risk level of an activity is related to their trust in the authorities who manage it (Siegrist et al. 2000). This suggests that the public's disapproval of major technologies is associated with a lack of faith in government and industry (Slovic, 1993): "Public fears and opposition to nuclear-waste disposal plans can be seen as a 'crisis in confidence', a profound breakdown of trust in the scientific, governmental and industrial managers of nuclear technologies." This has been explained in part by the greater visibility of 'trust-destroying' events and the fact that they carry more weight than positive events; and to the American style of democracy that gives individuals and groups the right to intervene in proceedings, challenge government agencies, and pursue policy changes through litigation (Slovic, 1993: 680). Trust has emerged recently as a dominant consideration in the public acceptance of or aversion to a technology.

General social surveys have shown declining levels of trust in government and industry, as well as for the set of social and political values they represent and advocate.

### **Uncertainty**

Relatively little research has focussed on the public understanding of uncertainty (Frewer et al., 2003). Research focussed on eliciting the effect of uncertainty on the perception of a risk concluded that "uncertainty information had very little effect on perceptions of concern"; instead the qualitative factors described in the psychometric paradigm, such as natural or man-made, seemed to determine the risk perceived.

However, as noted above, research conducted within the psychometric paradigm has found that an unfamiliar risk, that is, one that is unobservable, or not understood, is associated with higher perceived risk. Similarly, people will often seek to reduce the uncertainty in an unfamiliar situation by likening it to one or another characteristic of a familiar one.

Risk perception research has often linked uncertainty with trust in risk managers, regulators and government. Based on a theoretical perspective that social or 'system' trust reduces complexity by delegating certain tasks to others (Bradbury et al., 1999), risk perception research has often observed that trust in managers of complex tasks or decisions helps reduce uncertainty to a more manageable level: "the less we know about an activity, the more we need to rely on others to make decisions and the more our judgements become a matter of trust" (Savadori et al., 2004; 1290).

The relationship of risk perception, uncertainty and trust is complex, and is discussed in more detail below.

## Experts and non-experts

As noted, a fundamental focus of attention from the beginning of risk perception research has been the ‘gap’ between experts’ and non-experts’ risk judgements; experts’ judgements (of the same risk ranking tasks as non-expert study participants) are closer to ‘actual’ rates of harm, and are consistently lower than those of non-experts. The inference from this observation was that experts were applying a systematic and rational analysis to the risk estimation task, whereas non-experts applied heuristic strategies, or considered qualitative or emotional associations with the hazard, leading to systematic errors. Only when experts make judgements outside of their field of expertise are they thought to rely on perceptual factors commonly employed by non-experts (Beyer et al., 2012). It should be noted that the basis on which these conclusions about the relative accuracy of the experts were based would now be considered weak: the experts included in these early studies were a group of 15 individuals described as professional risk assessors, including a geographer, and environmental policy analyst, and economist, a lawyer and a government hazardous materials regulator (Wright et al., 2002). The hazards that were to be ranked spanned a wide range of technologies and activities that applied to no single field of expertise.

More recent studies using experts qualified in the field of the study have generally concluded that expert risk assessors also use a set of heuristics in formal risk assessment; heuristics are not simply “error-prone rules of thumb” used by non-experts, but function as a “series of rules for bounding problems, collecting data and making sense out of it” (MacGillivray, 2014: 785).

Research on risk perception finds that the difference between experts’ and non-experts’ risk perceptions is a function of the level of risk – that is, across many different risks, experts’ judgements are lower than non-experts.’ Experts make systematic errors in estimates of risk frequencies that are similar to those made by non-experts, and also use similar decision-making strategies and qualitative associations, within the context of the same psychological factors, as non-experts. For example professional underwriters were “a little better in their risk judgements [of annual frequencies of deaths from a range of causes] than the lay persons . . . but the differences in performance between experts and lay persons were small in magnitude, and the nature of the biases . . . were common to both groups.” (Wright et al., 2002).

A study that asked a group of professional medical assessors to evaluate a portfolio of prescription drugs (Beyer et al. 2012) found that, while all assessors applied relevant technical risk assessment considerations, their assessments varied according to their degrees of worry for safety, consideration of product benefit, and emphasis on ethical issues. There were also differences attributed to differences among assessors: senior assessors were more risk averse than more junior assessors, and female assessors appeared to be less risk averse as a consequence of greater sensitivity to benefit considerations (Beyer et al. 2012). However an earlier study found that young female professional toxicologists had higher perceptions of risks than their older, male colleagues (Mertz et al., 1998).

Experts’ attitudes to technologies are similar to those observed in non-experts’ (Sjöberg, 2003); experts’ opinions were often biased towards their own fields, with some ‘acting as promoters of a technology’,

considering that the risks within their field had been exaggerated but that others had been neglected (Sjöberg, 2003). Experts in the same field may differ in their risk judgements. Some of this is related to professional orientation and affiliation; for example, toxicologists working for industry see chemicals as less dangerous than do toxicologists working in government and universities (Kraus et al. 1992; Barke and Jenkins-Smith, 1993). Members of disciplinary groups differed among themselves on key issues of scientific assessment and decision-making such as the value of animal studies for predicting health effects in humans, and the existence of a safe level of exposure to a carcinogen (Rizak and Hrudehy, 2005).

One researcher (Sjöberg, 2002: 455) states that “there is no ground . . . for stating that experts’ risk perception has a radically different basis than that of non-experts. On the contrary, the psychological dynamics appear to be similar when it comes to structural properties of risk judgements.”

### **Broader attitudes, political values, social relations**

The findings of experimental psychology on individual cognitions and perceptions of risks continue to have relevance to understanding public judgements of certain types of activities; however the analysis of these factors needs to take a broader perspective in order to capture the dynamic that is operating with risk issues. In 1992 a leader in this research field (Slovic, 1992: 120) claimed that the psychometric paradigm had come to “encompass a theoretical framework that assumes that risk is subjectively defined by individuals who may be influenced by a wide array of psychological, social, institutional, and cultural factors.” However, he noted that “although the psychometric paradigm has been oriented toward cognitive psychology and behavioral decision theory, I believe that societal response to hazards is multidetermined and thus needs to be studied in a multidisciplinary way” (ibid: 149).

Research that takes a broader analytical perspective on the findings produced by psychometric research on the cognitive strategies that non-experts use in judging risks gives more useful insight into the formation and function of risk judgements in society. The integration of cognitive strategies used by non-experts to judge risks into broader attitudes and values reveals the logic that relates the risk associations and cognitive strategies into a coherent and rational approach to individuals’ decision-making in complex society. Risk perceptions are stable attitudes that are shaped by prior and more fundamental social values.

Instead of piecemeal judgements on risks, and on benefits, based on cognitive shortcuts to reduce the complexity of probabilities and technical assessments, non-experts form judgements on risks based on their prior knowledge of, and experience with, the risk sources, such that the risk judgements are consistent with their attitudes. This view of risk judgements suggests not only that perceptions of risk involve broader considerations such as benefits of the activity, but also that the overall judgement is shaped by underlying and more general attitudes (Poortinga and Pidgeon, 2005). Risk attitudes are ‘embedded in a system of general attitudes and values’ that guide the derivation of more specific attitudes in a way that preserves the evaluative tendency of the higher-order attitudes” (Grunert et al., 2003: 439).

It has been found numerous times that people's risk judgements are influenced by, and are consistent with, their broader social and political attitudes and values, and that these are stable and do not shift with new information. For example, people's beliefs about and values for nature influence the risks they will perceive in technology. Those who hold "ecological" values are more likely to consider technology to be a risk (Axelrod, et al., 1999). Research on the perceptions of health risk among Canadians has found a correlation between respondent's judgements of risks and their broader attitudes; perceived risk from environmental and social factors correlated with "belief statements reflecting environmental and social concern" (Krewski et al. 2008: 175). Broader social and ideological orientations are influential, as are specific attitudes to a hazard or technology (Sjöberg, 2000).

This principle applies to experts' risk judgements as well as non-experts'. Professional ecologists, and university scientists in several plant biology disciplines, opposed genetic engineering of crops, stressing the unpredictable environmental effects of the crops but having little opinion on the benefits that are claimed for the crops. Scientists who supported the use of GM crops, on the other hand, tended to be employed in the biotechnology industry and to be confident in industry research; they believed that GM crops are not fundamentally different from their conventional counterparts and that there are benefits to be gained from their use (Kvakkestad et al., 2007).

When psychometric research variables are expanded to include broader attitudes and values, many judgements about risks are seen to be driven by social attitudes and assumptions. The "white male effect" describes the finding that a cluster of well-educated white men in a survey sample rated risks as lower than other participants of both sexes and other races. The researchers suggest that "white males see less risk in the world because they create, manage, control, and benefit from so much of it" (Flynn et al. 1994). It has also been found that lower than average perceptions of environmental risk are held by white males with conservative political views (McCright and Dunlap, 2011).

Researchers have expanded on this observation to explain the prevalence of 'climate change denial' among white males holding traditional conservative values in the United States (McCright and Dunlap, 2011). They suggest that this position is held as part of an effort to protect an elite identity against "charges of societal danger . . . levelled at activities integral to social roles constructed by their cultural commitments" and to defend the predominant social and economic system."

The incorporation of stable attitudes and values into judgements about risk has been explored through the lens of the affect heuristic. 'Affect' is described as a general positive or negative feeling that is linked, through experience and learning, with an activity (Finucane et al., 2000; Poortinga and Pidgeon, 2005). The affect heuristic is the decision-making process by which "images, marked by positive or negative affective feelings, guide judgement and decision making" (Finucane et al., 2000). The affect heuristic suggests that general affective images of an activity are prior to, and direct, judgements of risk and benefit. This reverses the model that cognitions or beliefs build evaluations or general preferences, asserting that instead broader attitudes guide the formation of more specific beliefs. Psychologists now are considering that risk perceptions combine analysis and feelings in a 'risk-as-value' approach that "motivates individuals and groups to achieve a particular way of life" (Finucane and Holup, 2006: 144).

Summarizing the importance of understanding the role of affect and of values in risk perception, Finucane and Holup (2006: 145) observe: “research suggests that analytic and affective processes work in partnership to identify and prioritize experiences that are valued positively (and thus pursued) and experiences that are valued negatively (and thus avoided). Together, dual processes comprehensively govern the valuation of risk information in order to maintain a particular way of life.”

A similar elaboration of the influence of trust on risk judgements gives insights into the political nature of trust relationships on risk management issues. Analysis of early findings that trust in risk managers is related to lower perceptions of risk suggested that increasing trust might reduce perceived risk (Slovic, 1991). Some researchers suggested that trust consists of characteristics, or ‘dimensions of trust’ including expertise, reliability, competence and care, and honesty and fairness, which are assumed to be universal, apparent to all observers, and thus generally considered ‘trustworthy’ (Cvetkovich and Nakayachi, 2007). This approach has led to risk communicators and risk managers to aim to increase trust in institutional sources of information and thus to reduce perceived risk, by conveying these qualities in risk communication and building trust through participation (Kasperson et al. 1999).

Other researchers argue that trust in risk information and managers and risk perceptions are reflections of more general attitudes towards a technology or risk management situation. Instead of a constellation of psychological attributes of a trusted risk manager, trust is characterized as a complex judgement of a risk context and the relationships among the stakeholders involved. The type of trust involved is ‘social trust’ (rather than personal trust), or a willingness to cooperate based on two “context-specific judgements” (Cvetkovich and Nakayachi, 2007). The first judgement assesses the saliency of values that apply to the problem at hand; the second assesses the “perceived agreement or similarity between self and the other person about what is important, that is, salient value similarity.” This trust is context-specific; in situations of high concern people tend to trust risk managers with values similar to their own, and whom they perceive to be acting in their best interest.

In the light of this value-based understanding of risk, risk perception appears as a broad, contextual consideration of the important aspects of a technology or activity, such as the benefits of the activity and their distribution; risk and technology issues are seen as intrinsically political and social relational. Members of the public are “less concerned with making choices about which risks they are willing to tolerate than they are with grasping which political interests lie behind the promotion of particular choices” (Priest et al., 2013).

### **Social impacts and implications of risk judgements**

Judgements about risks are complex determinations made by individuals in the context of their knowledge and understanding, their attitudes and values, and their social relationships. As such, risk judgements often become collective judgements and social phenomena, subject to many interactive processes of information dissemination and interpretation that themselves occur within broader social and institutional contexts. It is through some of these processes that a risk can become a ‘risk issue’; that is, a matter related to a risk that is highly salient within the public, or within a particular group of

stakeholders (Leiss, 2001). This may develop from factors inherent in the risk itself (such as a risk source of particular concern or the involvement of a vulnerable group), or it may relate to broader factors such as concerns about risk management practices, or wider debates about a technology.

### *The Social Amplification of Risk*

Kasperson et al. (1988) noted that apparently minor risk or risk events, as assessed by technical experts, sometimes produce massive public reactions, accompanied by substantial social and economic impacts.

The social amplification of risk framework (Kasperson et al, 1988; Pidgeon et al., 2003) draws on communications theory to map out factors that contribute to people's interpretation of a risk and the movement through society of beliefs about risks and risk events. The basic principle is that "hazards interact with psychological, social, institutional and cultural processes in ways that may amplify or attenuate public responses to the risk or risk event" (Kasperson et al, 1988:178). Social amplification itself is "the phenomenon by which information processes, institutional structures, social-group behavior, and individual responses shape the social experience of risk, thereby contributing to risk consequences" (Kasperson et al, 1988: 181). Amplification occurs when these processes combine to heighten awareness and response to a risk, as is often seen with technological activities or chemical risk events; attenuation is seen with such well-documented health risks as indoor radon or aflatoxin (a carcinogen) in peanut butter, about which people are generally unconcerned. The steps of amplification include filtering of signals for attention; processing of risk information and attaching social values to it; interacting with cultural and peer groups to interpret and validate signals; formulating behavioural intentions to tolerate or take action against the risk or risk manager; and engaging in group behaviour to accept, ignore, tolerate, or change the risk.

Individuals may attend to certain sources of information on a risk that they trust, which may have the effect of reducing uncertainty for the individual and of polarizing opinion in society into separate and often conflicting camps (Eiser, 2004). In the case of amplification, one possible outcome of increased concern and salience about an issue is stigmatization.

### *Stigma*

One characteristic that emerged was that of stigma, defined as "a mark placed upon a person, place, technology or product, associated with a particular attribute that identifies it as different and deviant, flawed, or undesirable (Kasperson et al. quoted in Peters et al. 2004). Stigma is intensely negative imagery that is strongly associated with something that is socially disapproved; it can generate fear and anger, and is associated with both affective and cognitive responses (Peters et al. 2004). Stigma can be associated with substances or products. Negative imagery is associated with chemicals; the word 'chemical' is interpreted as a synthetic substance, rather than as a fundamental component of nature, and associations with it are mostly negative, eliciting responses like 'dangerous, poison, or toxic'. Stigma is often associated with technologies, or with places or communities in which technologies perceived as dangerous or unacceptable are located (Gregory and Satterfield, 2002; Miller and Sinclair, 2012).

Stigmatization often occurs as a result of media coverage, and associated risk amplification (Slovic, 2000), in many cases following an accident or critical event that serves as a ‘signal’ that the technology involved holds “abnormal risk” (Gregory and Satterfield, 2002).

### ***Aboriginal perception of risk***

Aboriginals make risk judgements according to the same basic principles as any other social group or community; that is, they rely largely on qualitative factors about a risk, and interpret these through the lens of their knowledge of and relationship with the risk source and their social and cultural values. As has been observed in many risk perception studies in many countries, overall attitudes about an activity are driven by judgements of its value and benefits.

However, Aboriginals’ perceptions of risk, and judgements of risk sources, often differ from mainstream risk judgements, because many Aboriginal cultural assumptions and values, as well as material conditions and interactions with the environment, are different from those of the mainstream Canadian society. In order to understand the perceptions of risk by Aboriginal individuals and communities, it is necessary to be familiar with the cultural context that shapes those perceptions.

It is important to note that there are many Aboriginal groups in Canada, including the Inuit, Métis and many First Nations, which include communities both on and off-reserve from British Columbia to the Maritimes, as well as the Territories and Nunavut. These societies, nations and communities have long histories grounded in the way the communities lived in their traditional lands within these very diverse geographical regions; there is therefore no single ‘Aboriginal’ perspective.

Despite the diversity of Aboriginal culture in Canada, many North American Aboriginal cultures share a set of general assumptions and values that differ from key characteristics of Western culture. There are a number of cultural and social factors that form the context within which risks and risk sources are perceived and judged.

#### *Relation to the land*

Land – nature as a spirit, the environment as providing foods and other material that communities use to survive, and territories that are traditional for individual communities – is central to Aboriginal activities, culture and identity. Nature, and the earth, is sacred; people and communities are part of Creation generally, and nations and communities are tied to specific traditional territories in which they carry out traditional hunting and other cultural practices.

Nature, physically and literally, embodies the sacred; the whole of creation, the land itself, is alive. ‘Mother Earth’ is meant literally as humans’ mother; water is Earth’s blood, rocks and minerals her bones, and plants her hair (Paper, 1990). Sharing a creator, humans are related to all other forms of life and can communicate with them; humans can take animal form, and animals can change into human form. Other species were regarded as ‘people’ with their own qualities and purpose within creation, and with whom humans relate as kin (Deloria, 1992). For Aboriginal cultures, humans are part of creation

and are not superior to the rest of life, but were placed on earth “to be caretakers of all that is here’ (Clarkson et al. 1992). This is closely tied to the traditional use of the land, which imparts a sense of the sacred into community relations with the land: “Every location within [a tribe’s] original homeland has a multitude of stories that recount the migrations, revelations, and particular historical incidents that cumulatively produced the tribe” (Deloria, 1992: 122). While there is “great unanimity” among Aboriginal nations about the natural world and humans’ behaviour in it, they are also distinct because they live in different local ecosystems; knowledge and values are not seen as universal (Henderson, 2000: 259 - 264).

Beyond the spiritual meaning of Nature, the land matters to Aboriginals in very material ways. Traditional uses of land maintain culture and strengthen communities, as many Aboriginal communities still hunt, fish, and harvest local plants which have been used by the people for many years. Carrying out traditional practices on ancestral lands and sacred places is fundamental to their identity and their survival as a people. Traditional foods “are those culturally accepted foods available from local natural resources that constitute the food systems of Aboriginal peoples. The concept of food system includes sociocultural meanings, acquisition and processing techniques, use, composition and nutritional consequences for the people using the food. Of importance to understanding the role that culture plays in determining food choice in Aboriginal communities is that the activities required to procure traditional food are not merely a way of obtaining food but, rather, a mode of production that sustains social relationships and distinctive cultural characteristics. These practices are vital for the maintenance of traditions and cultural cohesion” (Willows, 2005).

As Simpson (2003) notes,

From a social perspective, being out on the land strengthens our relationship to our extended families and deepens our spiritual understanding of life and our place in it. Consuming traditional foods revitalizes our cultures, our languages and our ceremonies and it reinforces our sovereignty within our families, communities and Nations. Gathering rice, berries, and plants requires our people to remember or seek out Traditional Knowledge in order to understand how to harvest these items in a respectful and traditional way.

#### *Social order*

Many traditional Aboriginal cultures have a different social organization and decision-making tradition than Western Culture. Decision-making is often community-based, inclusive and more collaborative than Western expert and specialist-driven processes. Elders are highly respected, in part for their deep knowledge of the environment and of the traditional territories (Friendship and Furgal, 2012).

#### *Knowledge*

Knowledge within traditional Aboriginal cultures is more observational and experiential than analytical and technological, as Western knowledge is. Members of Aboriginal communities are likely to rely on sensory methods to judge the state or quality of elements in the environment. Much traditional knowledge is historical and transmitted orally, passed on by Elders (Friendship and Furgal, 2012).



### *Marginalization*

For a complex set of reasons related to social and political factors, including the colonial histories of Aboriginal people in Canada, the health status of Aboriginal communities in general is lower than the general population (Driedger et al., 2013). Housing on many reserves is below the standard expected in the rest of the country; many Aboriginal communities do not have reliable safe drinking water supplies (Patrick, 2011); and “access to and legitimacy of health services has been, and continues to be, a real issue” (Driedger et al. 2013). Many Aboriginals feel their health is a lower priority than is that of the mainstream population, and that their lives ‘are less valued’ than are those of other Canadians.

Differences in worldviews and values, knowledge and decision-making traditions, combine with social and political factors to create a lack of trust in Canadian authorities, experts and expertise. The combination of social marginalization and the use of traditional knowledge results in a lack of understanding of, and trust in scientific knowledge and dominant Western governance and decision-making. This lack of understanding is mutual, as scientists and authorities often do not understand Aboriginal values and perspectives, and consequently do not recognize that their own styles of knowledge and communication are not in accordance with those they are attempting to reach.

### **Perception of risk in Aboriginal culture and communities**

These cultural assumptions, values and priorities shape the perception of risks by Aboriginal individuals and communities. Several dimensions of risk perception can be recognized as particular to Aboriginal cultures; risks appear as events or circumstances that threaten key values or the viability of important cultural activities. Because of the centrality of nature, and of the use of traditional lands, to the maintenance of culture and community, an event that reduces the ability of the people to carry out their traditional activities on the land is a serious risk. Such threats could be changes in the environment, the wildlife or plants that live in it, access to traditional areas, or contamination that makes the use of traditional foods unsafe. The ability to continue to use the local natural environment is so central to Aboriginal cultural survival that risk to the environment is often simply perceived directly as a threat to culture and to the maintenance of the traditional way of life.

The deep connection between the land and the people leads to a belief that risks to the environment cannot be kept separate from the people: with humans and the rest of nature are united in a single system; “whatever happens to the animal life . . . will also happen to the Anishnawbe” (Morrisseau, 1991: 40). “Elders all over North America know that when the earth is sick, the people will also be sick and this rings true in Indigenous Territories throughout Canada” (Simpson, 2003).

There is a strong interaction between cultural perceptions of the benefits and risks of using or consuming foods and water, as well as with impacts on health and on the community of exposure to risks in the environment.

First, the contamination of traditional foods or water sources leads to complex situations of competing risks and benefits. As there are health and cultural benefits to eating ‘country foods’ - wild foods hunted or gathered in the traditional way - contamination of these foods causes health risks if they are

consumed, and cultural risks if they must be avoided. Reducing consumption has a greater impact than it might in mainstream society; substitutions are less viable, because the hunting itself is integral to the process, and because healthy and affordable alternatives may not be available in remote communities. When people fear that traditional foods are contaminated, they lose confidence in the environment and in the traditional activities involved in gathering them (Indian Affairs and Northern Development, 2003: 74).

This situation has been observed with the discovery of high levels of mercury in some fish species in the North (El-Hayek, 2007), where the risks of mercury in fish must be balanced against the nutritional value of the fish, particularly in a population that relies heavily on fishing and hunting for food, as well as against the cultural values of fishing and eating traditional foods.

In some instances the cultural benefits of using certain traditional foods or water may override risks, particularly if the risks are not readily apparent. The 'values and benefits of the connections with elements of the natural world outside of nutritive contributions' (Friendship and Furgal, 2012) can lead to the consumption of food or water that is not safe. Many individuals, particularly elders "who have spent a large part of their lives outdoors" (Martin et al., 2007) prefer to drink water from creeks, lakes or rivers rather than bottled water or treated tap water: despite the presence of bacterial contaminants, 'raw' water was considered to be "clearer and less contaminated' than water from household tanks, and tastes better, because it does not taste of chlorine (Martin et al. 2007).

Second, the means of identifying and perceiving a risk is different within Aboriginal culture than by scientific methods. Aboriginals may rely on historical knowledge, personal experience and observation, and sensory methods to detect contaminants in food or water, for example. Chemical or bacterial contaminants may be detectable only with technological sampling and testing, and not be apparent to the senses. There is concern about health risks from environmental contaminants, and anxiety is increased by the lack of familiarity with many contaminants and by the uncertainty of receiving information from scientists that does not accord with sensory perceptions or with traditional means of assessing the environment. Many residents of reserves are concerned about the safety of drinking water in their communities. Women on reserves were found in one study to be more concerned about the safety of drinking water than men. The researchers "suspect that this is partly a reflection of the culture, given First Nations women are viewed as guardians of water, possessing greater traditional learning and knowledge of the natural resource"; women with children under 15 were also more concerned (Spence and Walters, 2012).

Uncertainty about the safety of traditional foods and water – "not being aware of whether water has ever been contaminated during the year" (Spence and Walters, 2012) - increased concern about the safety of the water. Many contaminants are not only invisible but are the products of a technological society with which remote Aboriginal communities are not familiar, leading to misunderstandings, uncertainty and anxiety (Indian Affairs and Northern Development, 2003). There may be a 'resistance' to information about invisible contaminants that cannot be tasted or smelled, which increases uncertainty in interpreting the safety of food and the possible presence of contaminants, and creates conflicts between different sources of information and modes of understanding. People may not 'go

against the knowledge of Elders when choosing between science and traditional knowledge' (Friendship and Furgal, 2012). Incidents of contamination may require consultation with technical experts who refer to a different system of knowledge: "They must rely on individuals using different modes of understanding, communication and inquiry, and there are often competing messages about the nature and extent of the risks by different experts" (Indian Affairs and Northern Development, 2003).

These complex factors make communicating about risks difficult with Aboriginal communities. Trust is further eroded with the awareness that much of the contamination of the environment, and traditional foods and water, is the result of Western industrial activities. As Simpson (2003) notes, "Colonization, genocide and colonial policies aimed at destroying Indigenous Nations and disrupting our physical and intellectual connections to the land brought tremendous tragedy, sickness and dependency to our peoples. Industrial activities such as mining, deforestation, road building, hydro -electric development, and the contamination of the environment with toxic chemicals continue to threaten the ability of Indigenous communities to rely on our traditional foods systems for our health and well-being and the health and well-being of our families."

## **Perceptions of Risk from Nuclear technology and Nuclear Waste**

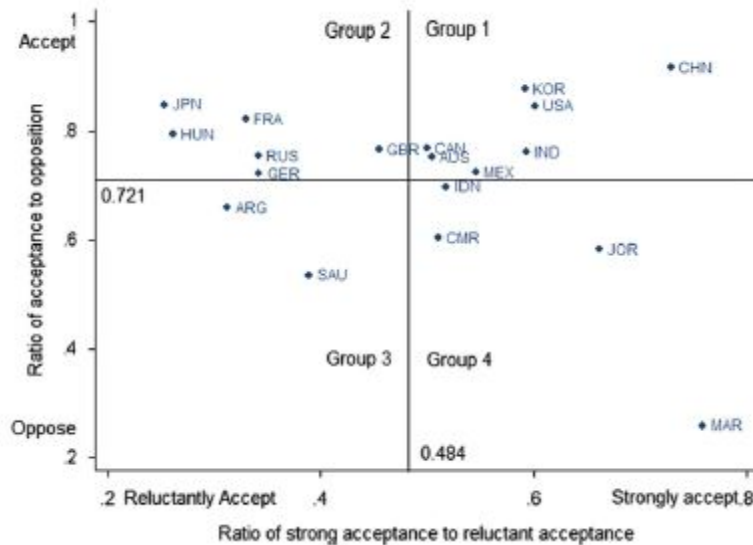
### **General levels of support: survey research**

Many surveys provide information on general attitudes to nuclear technologies and applications; some of these are general risk perception studies (Krewski et al., 2006); others include questions on nuclear technologies in general public opinion surveys (for example the Eurobarometer surveys discussed by Greenberg, 2012); while others are dedicated studies of levels of opinion on nuclear technologies (Kim et al., 2014). These offer a broad, high-level picture of public opinion on nuclear technologies over time, and relative to other issues, social concerns, and risk sources. However, the general surveys provide little depth on any issue and do not offer interpretation and explanation of findings. It is also difficult to compare information from several surveys as the questions asked and the analyses performed on the data are specific to each study.

In the United States, there is fairly stable support for the use of nuclear energy, with benefits perceived as greater than risks (Jenkins-Smith, 2011). Support for the increased use of nuclear power in the U.S. fluctuated between 44% and 52% from 2005 to 2010 (Greenberg, 2012). The Eurobarometer survey of 2005 found an average of 37% of the populations of the EU countries favoured nuclear power and 55% were opposed; however there was a wide range in approval among countries. Several surveys reported a steady increase in positive opinion in Europe and the United States up to 2010, with the populations evenly split between support and opposition. An international opinion survey found that an average of 38% favoured the use of nuclear energy, with a majority of respondents supporting the technology in India and the US. While only 34% of respondents to this survey approved of the construction of new nuclear power plants, approval was higher in the US (44%) and the UK (43%). It has been found in a number of studies that nuclear waste is perceived as a higher risk than nuclear power (Sjöberg, 2004; Whitfield et al., 2009).

The events at the Fukushima plant in Japan caused levels of support to drop in many countries (Greenberg, 2012). The international survey found that those who opposed nuclear power were most influenced, with 26% of those opposed to nuclear power strongly influenced by the Fukushima events in the US and 20% in the UK. As is discussed in more detail below, the effect of these events on individuals' perceptions of the risks of the technology depended on their pre-existing broader attitudes (Yeo et al., 2104).

Many studies ask respondents about the level of their support or opposition to nuclear technologies; one study of data collected in 2005 by the International Atomic Energy Agency (IAEA) distinguished between strong and reluctant acceptance of nuclear power, and opposition to the technology. 'Reluctant acceptance' was defined as "acceptance of the use of nuclear energy without a friendly attitude towards it because of a high level of dependence on nuclear energy, and a lack of alternative energy sources within that country" (Kim et al., 2014). Researchers were able to classify the 19 countries involved in the survey into four groups according to the levels of support and opposition. Group 1 countries had a high level of acceptance and a high level of strong acceptance; Canada is in this group, along with Australia, China, India, South Korea, Mexico and the US (Kim et al., 2014).



**Figure 2. Classification of public acceptance of nuclear power over 19 countries. Kim et al., 2014.**

There have been a number of findings on attitudes towards different aspects and applications of nuclear technologies: even when there is general support for the use of nuclear energy, there is commonly opposition to the local siting of a plant (Whitfield et al., 2009). Advocates of nuclear energy have anticipated that since nuclear power is a sustainable means of generating electricity that does not emit carbon dioxide, concern about climate change might change attitudes and revive the technology; however that appears not to be occurring (Whitfield et al., 2009; Bickerstaff et al., 2008).

Finally, Krewski et al. (2006) included nuclear power plants in a list of hazards that were ranked by respondents to the survey. One-third of the participants in this survey considered that nuclear power poses a high health risk, compared to 6 % who considered medical x-rays as being a high risk (Slovic, 2012).

### Factors in attitudes to nuclear technologies

#### *Qualitative factors related to radiation*

As noted above, studies within the psychometric paradigm have described a number of qualitative factors that are associated with risk perceptions. Many of these factors apply to public perceptions of radiation and nuclear power, which differ from experts in fields related to radiation and nuclear technologies (Hardeman et al., 2004).

It is useful to understand the 'risk profile' that is presented by radiation and nuclear technologies; however it should also be noted this perspective leaves out contextual factors such as social dynamics and personal and political values, which are the most influential factors shaping attitudes to risk and acceptability.

Perceptions of the risks of radiation follow the pattern of qualitative associations (Ramana, 2011). The following are the key factors that are associated with non-experts' perceptions of the risks of radiation from various sources.

*Risk of different sources of radiation: industrial, medical and natural*

Radiation from nuclear power, and particularly nuclear waste, is perceived as high risk; nuclear technologies ranked very high on the 'dread' and 'unknown' scales created by Slovic (1987). Nuclear waste and nuclear weapons were considered to be the most serious of five nuclear and environmental hazards presented (Whitfield et al., 2009). MacGregor et al. (2002) consider that the perceptions of risk from radiation from all sources are disproportionate to the exposures that actually occur; these perceptions are related rather to concerns about the consequences of exposure to radiation and about risk management.

Other man-made sources of radiation, including medical x-rays, are seen as low risk. It is also a common finding that people are not concerned about radiation from natural sources, even when it may pose a relatively high health risk, such as radon gas in people's homes (Slovic, 2012; Hardeman, et al., 2004).

*Risk-benefit relationship*

Slovic (2012) attributes some of the reason for the high perceived risk of nuclear power and nuclear waste to the perception that they do not offer social benefits; this same balance explains the lower overall risks perceived from other technologies that use radiation.

Representative surveys of the general public in the United States, Sweden, Canada, Norway, Belgium, and Hungary have consistently shown that people view nuclear power and nuclear waste as extremely high in risk and low in benefit to society, whereas medical x-rays are seen as very beneficial and low in risk.

*Radiation is 'unknown'; invisible and complex to detect*

Most members of the public "have a modest understanding of facts related to nuclear energy" (Jenkins-Smith, 2011); conclusions differ on the impact of that level of knowledge on risk perceptions. Jenkins-Smith (2011) found that the more inaccuracies a respondent provided the greater was the perceived risk and opposition to nuclear power. On the other hand, efforts to provide information on nuclear power did not change attitudes to the technology (Ramana, 2011) or changed them slightly (Slovic, 2012).

In terms of the characteristics of radiation and nuclear power as hazards, radiation is invisible and undetectable by the senses; special instruments are required to detect the type and amount of radiation that may be present. This means that it is not possible to be certain that there is no radiation present, or that one is not exposed, and that individuals must rely on experts to measure the radiation and interpret the significance of the risk.

*Involuntary exposure*

As with many large scale industrial facilities, nuclear power plants may expose those in the vicinity to emissions from routine operations, as well as from spills, leaks and other accidents; there is little possibility for people to reduce or avoid this exposure.

*Effects delayed and long-term; may affect future generations*

The health effects of exposure to radiation, except at very high levels, are expected to be in cancer that appears years, or decades, after the exposure; cancer is itself a highly feared health impact. Genetic damage from some exposures may also result in adverse impacts on offspring, thus resulting in effects on children and on future generations.

*Catastrophic potential*

As seen in several severe accidents and disasters, the impact of an incident at a nuclear power reactor is catastrophic; the concern for potential consequences outweighs the consideration that such events are infrequent and have a very low probability of occurring.

These effects include both severe impacts on human health and devastation of the environment for large areas around an accident site. The Chernobyl disaster resulted in a number of immediate deaths and the more or less permanent evacuation of an entire region, displacing many residents and resulting in concerns for heightened frequencies of thyroid cancer in children. The events at the Fukushima plant in Japan following the tsunami in 2011 also illustrated the potential for impacts that are severe, wide-spread, and long-term.

*Uncontrollable*

When accidents occur with nuclear technologies, the impacts are not easily managed or mitigated, even by experts. The damaged reactor at Chernobyl must be encased in concrete to contain the radiation that it continues to emit, decades after the accident; and international experts were not able to bring the situation at the Fukushima reactor under control after it was damaged by the Tsunami.

*Tampering with nature*

A later elaboration of the psychometric paradigm has been found to improve the explanation of risk perceptions. Tampering with nature includes 'interference with nature' and 'human arrogance and immorality' (Sjöberg, 2000). When included in a study of perceptions of risk from nuclear power this factor was also associated with a fear of long-term consequences and 'a warning of worse things to come' (Sjöberg, 2000).

*Trust in Management*

As has been found in general risk perception research, trust in those managing nuclear technologies is a strong factor in support for the technology (Whitfield et al., . . .) MacGregor et al; (2002) found that a majority in the US do not think the risks of radiation are regulated adequately. They do not believe that

the government has done all it could to protect them, and do not think that decisions about health risks should be left to experts.

In addition to these qualitative factors that have been associated with the perception of various hazards, it can be seen that the broader effects of stigma and social amplification apply to nuclear issues.

### *Imagery*

Nuclear power originated in military applications and was strongly associated with nuclear weapons through the 1980s. This negative imagery has persisted, and is more recently combined with images of the effects of the accidents and Chernobyl and Fukushima, evoking associations of 'disaster' and 'bad' (Slovic, 2012).

Associated with the factors of invisibility and tampering with nature, nuclear accidents and the emission of radiation appear more as 'contamination' than damage; they 'penetrate human tissue indirectly rather than wound the surface . . . invisible contaminants remain a part of the surroundings – absorbed into the grain of the landscape and the tissues of the body" (Slovic, 2012 quoting Erikson, 1990). These images are associated with industrial applications of radiation, but not with natural sources or medical applications.

### *Signal value and amplification*

Nuclear power and related technologies are highly salient, and incidents and other events receive a great deal of media coverage and commentary. Yeo et al., (2014) suggest that perceptions are strongly influenced by media coverage of risk issues.

As evidenced by the increased concern reported following the Chernobyl and Fukushima events, nuclear plant accidents are subject to social amplification, and generate broader social impacts. The Fukushima events resulted in large public demonstrations calling for the closure of another nuclear power plant located close to a fault line (Ramana, 2011).

### *Stigma*

A large amount of research has been conducted on the potential for nuclear technologies, particularly nuclear waste facilities, to stigmatize a region (Ramana, 2011). Much of this was related to impacts that a proposed nuclear waste facility located at Yucca Mountain in Nevada could have on broader social and economic conditions in the state (Slovic, et al. 1991). This phenomenon has been observed in the Fukushima prefecture in Japan; produce from the affected region is avoided, tourism to the region has dropped, and school children from the area have been bullied by classmates (Slovic, 2012; Ramana, 2011).

### *Demographic characteristics*

The effect of demographic factors on risk perceptions has been considered in many studies of perceptions of nuclear technology, and results are variable. They are generally found to have little



explanatory power on perceptions of risk directly, though they do on a number of factors that influence the perception of risk (Whitfield et al. 2009). Others have found however that women are less supportive than men of the use of nuclear power (Stoutenborough et al., 2013), and to be more likely to perceive very high risks (Sjöberg, 2004).

General levels of education have been associated with higher perceptions of risk (Sjöberg, 2004) and with lower levels of perceived risk (Whitfield et al., 2009). However, while it is generally acknowledged that members of the public are not well informed on radiation or nuclear power (Ramana, 2011; Stoutenborough et al., 2013), it is not clear that this factor affects the perception of risk from nuclear technologies or support for their use.

### **Worldviews, values and political attitudes**

Most researchers of attitudes to nuclear power and nuclear waste disposal advise that the focus of attention should not be on the psychological aspects of perceptions or cognitions about risk, or about emotions, but on the broader attitudes that members of society hold in the context of political systems and processes and of their worldviews and values (2004; Yim and Vaganov, 2003; Kim et al., 2014; Sjöberg, 2003). Broader attitudes shape beliefs (Sjöberg 2000) and influence the interpretation of information (Yeo et al., 2014; Yim et al., 2013) rather than the other way around. Whitfield et al. (2009), in their study on the values-beliefs-norms model of attitude structure, conclude that:

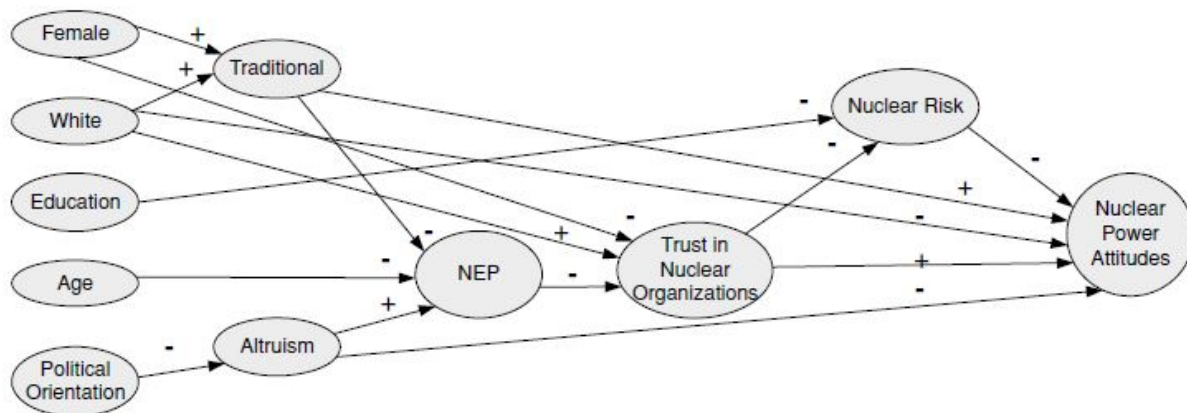
[T]he individual decisionmaker is neither an isolated, cold, calculating maximizer of the rational actor paradigm, nor is the “cognitive cripple” ruled by incoherent thinking once believed in the psychology of risk. Instead, the decisionmaker exhibits a rich combination of cognitive insight, social and emotional intelligence and cultural awareness, all anchored by fundamental values showing concern for others and the environment.

Within various theoretical frameworks and disciplinary methodologies, researchers are describing the values and beliefs that underlie, and shape, individuals’ attitudes to nuclear power (Whitfield et al., 2009 . . . .). Certain values and attitudes are associated with approval of nuclear power, and lower perceptions of risk from nuclear power, while others are associated with opposition to nuclear power and a higher perception of risk.

Whitfield et al. (2009) argue that “attitudes towards nuclear power are driven directly by the perceived risk of the technology and the levels of trust in the institutions responsible for managing it.” As has been noted in research focussing on social trust, people show greater trust in those organizations with which they identify, and that share core values.

However, there are other direct and indirect links that explain this association. The perception of risk is affected by both education and by trust in organizations that manage the risk; and this trust is “a function of generalized beliefs or worldview about human impacts on the environment.” The following are the important influences on attitudes to nuclear power:

- Individuals with more traditional beliefs have greater support for nuclear power:
  - Traditional beliefs include importance of family, patriotism, and stability, and are associated with less concern for the environment
- Those with more altruistic values are more opposed:
  - Altruism is "a concern for the welfare of other humans and other species" and is associated with higher levels of environmental concern and perceptions of ecological risk
  - Belief that nuclear technology 'interferes with natural processes' is predictive of opposition to nuclear power. 'Tampering with nature' associates a moral judgement of human arrogance with the technology (Sjöberg, 2000).
- Trust in those responsible for managing nuclear power is a major driver of support for nuclear power:
  - Those showing greater trust in nuclear organizations are those with "less concern for the biosphere"
  - Those who are more altruistic and have greater concern for the environment (with higher New Environmental Paradigm scores have less trust in nuclear organizations.
  - Trust in 'inspection authorities' (in this case the IAEA inspections) is important for those who are 'reluctant supporters' of nuclear power (Kim et al. 2014), but this trust does not inspire strong support.
  - Trust in science – a belief that science has solved the problem of nuclear waste disposal - was found to correlate with perceived risk (Sjöberg 2004).



**Figure 3. Whitfield et al., 2009.** Stern-Dietz (S-D) values-beliefs-norms model of environmental decision making applied to nuclear attitudes. The direction of the association is shown as positive (+) or negative (-).

These attitudes and values have often been represented as basic political orientations, and associated with attitudes towards nuclear power. Yeo et al. (2014), for example, observe that conservatives are more supportive of nuclear power than liberals.

#### *Decision making on nuclear issues*

While studies interested in attitude formation focus on psychological and cognitive processes, it is clear that people use a number of conscious and deliberate strategies in pulling together information and personal values and priorities in making decisions. This is closer to a policy analysis approach to understanding differences of opinion and in political priorities; Whitfield et al. (2009) describe the decision process employed by the public as ‘social and deliberative’. People’s attitudes to a technology are related to their valuing of the benefits they perceive from a particular application of the technology, in relation to its risks, in the context of their confidence in the motivations and competence of those who are responsible for managing it.

Sjöberg (2003) argues that people weigh a range of contextual factors when deciding on an issue of the use of technology. ‘Substitutability’ of technology was the predominant factor he found in a study of support or opposition to the continuation of nuclear power. Sjöberg argues that in Sweden, where nuclear power generates half of the country’s electricity, people will become more accepting of the technology as they realize that there are currently no viable substitutes for the technology. Similarly, people in Japan are ‘anxious about nuclear power’ but also recognize that it is necessary (Tanaka, 2004; note that this study was conducted before the Fukushima events).

Pidgeon et al (2008) found that there was some support in the UK for increasing the use of nuclear power if it would help address the adverse impacts of climate change – but they emphasize that this response was highly conditional on the provision that the technology “would help”; and that the majority of the population remains opposed to the technology. Bickerstaff et al. (2008) similarly positioned nuclear power as a response to the impacts of climate change and found that the proposition was interpreted as a risk-risk scenario, in which people felt they could ‘reluctantly’ accept nuclear power if it would help offset the effects of climate change. Pidgeon et al. (2008) and Bickerstaff et al. (2008) caution that attempts to reframe nuclear power as an environmentally advantageous technology relative to fossil-fuel energy sources appears opportunistic and manipulative and will likely fail.

#### **Nuclear Waste**

The risks of nuclear wastes are commonly perceived to be even greater than those of nuclear power generation (Bickerstaff et al., 2008). In fact the problem of nuclear waste is often cited as a source of the concern about nuclear power, and members of the public state that they would give greater support to nuclear energy if the high-level waste storage and disposal issues were resolved (Jenkins-Smith, 2011). Because of this it is more difficult to find a location and construct a nuclear waste repository than a nuclear power plant (Tanaka, 2004). There is long history of opposition to attempts to site a nuclear waste facility in many countries, in most cases related to political contexts with the approval and use of nuclear power, with a number of failed efforts to site repositories and to change public opinion on them (Solomon, 2010).

Less research has been conducted on public judgements of nuclear waste than of nuclear power (Jenkins-Smith, 2011), although the studies on stigma carried out in the 1980s and '90s focussed on the potential impacts of a nuclear waste repository on the society and economy of the state of Nevada. Nuclear waste is perceived to be highly stigmatizing, in terms of psychological effects, moral objections to nuclear power and water, and economic consequences (Marshall, 2005).

An early study of attitudes to a high-level nuclear waste repository in the US (Flynn et al., 1993) shows large differences between the public and members of the American Nuclear Society. A majority of the public believed there would likely be risks associated with the facility (such as earthquakes, accidents during operations, or sabotage or terrorist attacks); the strongest beliefs were that the buried waste would not be contained to prevent underground water supplies, and that regulators “can [not] be trusted to provide prompt and full disclosure of any accidents or serious problems.” Imagery about nuclear waste was very negative, evoking thoughts of death and destruction.

Opinions of members of the American Nuclear Society were almost the inverse of the public opinions; however both groups agreed that there would be accidents associated with the transport of wastes to the disposal site (Flynn et al., 1993).

Research on initiatives to manage nuclear waste in many countries has described a fairly consistent range of social and ethical concerns that have made siting a nuclear waste facility a very contentious and usually unsuccessful undertaking. People are concerned that there will be an accident, or that spills or leaks will contaminate surrounding land; accidents associated with the transportation of wastes to the facility are also a major concern (Marshall, 2005). Although the siting process in many countries involves inviting communities to volunteer to host a facility, through local political processes and plebiscites, many have questioned the objectivity of the information provided to the community and, particularly when financial compensation is offered, whether the consent is genuine or is a result of political or financial pressure. This concern is underscored by the fact that communities that are considered as potential waste facility sites are often remote and economically disadvantaged, so that residents may feel unable to reject a facility that they would otherwise oppose because of the promise of compensation and employment (Marshall, 2005).

In addition to these concerns about regional or social inequities in siting a nuclear waste facility, the very long time that the wastes remain hazardous and will require monitoring or management raises issues of intergenerational justice (Marshall, 2005). The consent for a facility that is expected in a democratic society can only be obtained from the present generation, yet many future generations who cannot give, or refuse, consent will also be affected by, and perhaps at risk from, the facility.

There is frequently some skepticism about the public participation in siting processes, partly as a result of the legacy of secrecy associated with historical nuclear technology decision-making, and partly due to challenges in mutual lack of comprehension between public and technical perspectives. There is often “public unease” about experts’ claims of knowledge about long-term safety (Marshall, 2005), and a lack of trust in the nuclear industry and other risk management authorities.

A contrasting perspective is offered by the example of the successful process to agree to the development of a low-level nuclear waste facility in Port Hope, Ontario, which was driven by collaborative processes between the community, governments and the owners of the uranium refinery that had produced the wastes in activities from the 1930s to the 1970s (porthope.ca). Other factors that contributed to the success of the process were the familiarity with local people with refinery operations, the conviction that existing wastes should be dealt with, and the attention paid to the development of a 'comprehensive solution' that protected property values (NEA, 2003).

Attitudes of the general public to a proposed facility may not be easy to determine through a participatory siting process. This is because those who are more active in such processes – described in one study (Sjöberg, 2003a) as stakeholders – have stronger views and more extreme positions than members of the general public who are less active in such processes. Although stakeholders in a siting process in Sweden were not generally more risk-averse than others, they did have stronger concerns and more extreme views about the issue of nuclear waste disposal (Sjöberg, 2003a). Active stakeholders, both supporters and opponents of the project, had stronger opinions on risks and on benefits than the general public. Opponents perceived greater personal risk, expressed as a perception of damage to nature and new and unknown risk, and expected lower benefits from new business and government economic support associated with a facility. Supporters agreed that there would be benefits from the project and did not agree with the negative, risk statements. Stakeholders who were opposed perceived more risk, and less economic benefit, than non-stakeholders; stakeholders who supported a facility perceived less risk and more economic benefit than non-stakeholders (Sjöberg, 2003a).

More recent research has found that people generally prefer the centralized storage of nuclear wastes and are not comfortable with indefinite storage on the reactor site. The public expects very high levels of monitoring and environmental surveillance of interim storage, and is concerned about transportation of the wastes (Greenberg, 2012). Concerns about uncertainty, and skepticism about the adequacy with which it can be addressed through technical calculations and design, pertain to the uncertainty about future social and political conditions that will affect the way that the facility continues to be monitored or operated. Significant changes in social and political structures and conditions are inevitable but their nature is impossible to predict, and it is impossible even to be assured that facility warning information and symbols will be understood by people living in the area in hundreds or thousands of years (Marshall, 2005).

Opinions are also shaped by perceptions of benefits, and by policy and facility design factors. For example, a design that permits retrieval of the waste is generally preferred; and many people who had been opposed or neutral to the siting of a facility would support it if it were co-located with a research laboratory, which would both study improved ways to manage nuclear wastes and also reduce the stigma of the repository (Jenkins-Smith, 2011). Compensation to a community may increase support for hosting a facility – but only among those who were not previously opposed; such an offer actually decreased support among those who already opposed the project, to whom it appeared to be a bribe.

Some siting processes and related studies have found that communities that are close to a site appreciate the benefits of improved roads that the construction and operation of a facility would bring, and that communities that are closer to a site have higher approval (Jenkins-Smith, 2011). A positive siting process can reduce opposition and build support, as shown with the process to establish a repository in New Mexico (Jenkins-Smith et al., 2011). Greater success has been had in Scandinavia, with successful participatory processes and waste management (Solomon, 2010); Solomon recommends a greater role for social scientists and considerations of ethics and public policy processes in future research and siting processes.

### ***Aboriginal perceptions of nuclear waste disposal***

Farrugia-Uhalde noted in 2003 that there was very little research on Aboriginal attitudes to nuclear waste disposal (despite the fact that territory claimed and used by Aboriginal communities has been a major focus for the location of nuclear waste repositories that have been evaluated in Canada). In one of the few studies of Aboriginal perspectives on nuclear waste disposal, Hine et al. (1997) found that Aboriginal survey respondents were significantly more strongly opposed to a repository than the non-Aboriginal respondents. Aboriginals expressed lower levels of trust in the regulators of the technology, and in science and technology than non-Aboriginals, and associated greater costs with the repository than others. Hine et al. (1997) suggest that the Aboriginals' "commitment to future generations" and to their responsibilities of stewardship of the earth explain much of the opposition to a nuclear waste repository, and is a major factor distinguishing Aboriginals' perspectives on the facility from non-Aboriginals'. This study also found that financial benefits that may be offered as a tradeoff against the risk of a repository did not offset the opposition to the project among Aboriginals; this may be due to the very high level of risk perceived from the repository (Hine et al., 1997).

Farrugia-Uhalde (2003) reviews Aboriginal opinion on nuclear waste disposal by North American Aboriginals through an analysis of submissions made to the Seaborn Panel reviewing the concept for the disposal of high-level nuclear wastes. She found that the major issues that Aboriginal participants noted concerned respect for treaty and Aboriginal rights, spiritual and cultural values, the Aboriginal role in decision-making, and the lack of involvement of, and communication with, Aboriginals on the disposal concept.

Aboriginals recognize the risk posed by a possible nuclear waste repository as both a grave violation of the sacred earth and a threatened degradation of a culture. The notion of building a waste repository with potential effects for 100,000 years on the usual five-year planning horizon may be unimaginable to a people accustomed to making decisions with the seventh generation in mind. Other expressions of risk allude more specifically to the violation, by some more complex technologies, of a principle of nature as a threat in itself. A Lakota Sioux elder (quoted in Gowda, 1999: 138) warned that "the atomic force that

binds the nucleus together is a sacred force; splitting the atom and transmuting matter is viewed as an intrusion in the realm of God and invites retribution.” Placing toxic substances in nature is considered an affront to the sacred.

In addition to these cultural concerns Aboriginal interveners noted their concerns with deep geological disposal as a waste management option, and preferred the option of storing the waste above ground to facilitate monitoring and risk management.

Haalboom (2014) has noted in a recent analysis of Aboriginal participation in governance arrangements of uranium mining in northern Saskatchewan that perceptions of risk are described in terms of a lack of understanding of technical matters, often addressed through the provision of technical information. Haalboom (2014: 12) argues that this risk frame is “not benign” but rather renders “the development process as controllable, calculable and predictable, and those pursuing it as environmentally and socially responsible.” Aboriginal participants counter by noting failures of technology and asserting their knowledge of local conditions, often making the dispute over ‘techno-scientific’ information central to the debate and controversy. While the governance process and provision of information are intended to engender trust with these Aboriginal communities, this dynamic does not achieve that trust.

## **Summary: Uncertainty and Acceptability**

In the light of the observations that have been made through several decades of research on risk perception, particularly on the social and political dynamics that shape complex attitudes of the public and experts to technologies, perceptions of the risks they pose and benefits they offer, and trust in managers, several concluding observations may be made. These observations relate to the role of uncertainty in the controversy over the debate on nuclear waste disposal, and to the issue of the ultimate support of local communities and the public for a nuclear waste repository.

### **Uncertainty**

The public is concerned with uncertainty in the performance and safety of proposed facility, but their interest in it is not the same as experts’. The reason for this can be found in some of the factors that influence risk perception, as well as in more social and political attitudes and priorities.

First, non-experts tend to be less concerned with the likelihood that an adverse consequence will occur than they are with the significance of the consequence itself. This is clearly true of nuclear power, with the very rare but undeniably catastrophic accidents that have occurred, notably Chernobyl and Fukushima. With respect to nuclear waste, people recognize that there are a number of very serious impacts that could occur with a technology that must keep long-lived hazardous wastes contained and ‘safe’ for hundreds or thousands of years. A large part of the concern with the attention to consequences is the value of the people or ecosystem elements that could be affected.

Second, when non-experts think of uncertainty they are likely to think of the possibility that something may occur, even of various degrees of possibility; they are less likely to be interested in calculating and comparing detailed quantitative probabilities. There will inevitably be significant uncertainty with the long-term responsibility of containing nuclear waste; this recognition, combined with the serious consequences that could affect a highly valued environment, renders redundant the quantification and comparison of uncertainties related to certain functions of the facility.

Third, uncertainty may relate to people's lack of familiarity with a very complex technology, and to concern with the prospect of deep burial, out of sight, of materials whose hazardous properties are invisible. This requires that people delegate the management and oversight of the technology to experts and professional risk managers, as non-experts have very little means of evaluating the performance of the facility themselves. However experiences with processes to assess proposed facilities often make it clear that the experts involved do not share the values of many in the public with respect to the use of nuclear power and the siting and operation of the waste disposal facility; these experts therefore do not have the trust of those groups. Furthermore, there is skepticism that science, and risk managers, are capable of predicting and preventing the adverse consequences that may occur.

Two crucial things are known about a proposed nuclear waste facility: it holds the potential for serious harm to the environment due to the toxicity of the waste material and the long time period over which it must be managed; and the combinations of events – including social and political changes – that might occur in tens or hundreds of years to cause such harm are unknowable. The uncertainties pertain to 'unknown unknowns' that may occur over such long time frames that they are essentially irreducible; efforts to quantify them suggest a focus on the wrong issue, and an investment of greater confidence in the process and results of quantification than is deserved. The presence of such 'large unknowns' and disputes over the meaning of uncertainties is characteristic of amplified risk controversies: Leiss (2003) notes that in risk controversies "incomplete hazard characterization," uncertainty over the range of adverse effects the public should be worried about" can be "compounded by the propensity of spokespersons for industry, often seconded by their governments counterparts, either to downplay or deny the scope of the hazards." Addressing risk controversies requires attention to the social and political dimensions of the controversy, or 'risk issue', as a separate managerial competence.

### **Acceptability and Tolerance**

The concept of 'acceptability' used in relation to the public attitude to the proposed facility refers to a judgement made collectively, or by a majority of the public, that the waste disposal technology can be accepted by the community at that site. It is clear that in most efforts to site a nuclear waste facility such acceptance is not achieved, and where community support has been achieved it is the result of long and carefully conducted processes of consultation with the community in which priorities for addressing risks and benefits are established.

There are a number of critical factors in the development of community support for a facility that are not reflected in the relatively simple term of 'acceptability'. Risk management principles developed by



the Health and Safety in the UK make a distinction between acceptability and tolerability that is relevant to the context of nuclear waste disposal (HSE, 1992; HSE, 2001).

In this usage, an acceptable risk is one that is deemed to be low enough that no management is required to reduce it. This is not the kind of support that has been achieved in nuclear waste facility siting processes, or indeed in most applications of complex technology.

The type of support that has been achieved is better reflected in the concept of tolerance: a tolerable risk that is one that is *managed*, and is tolerated at the managed level *in light of the benefits received*. This concept may be more appropriate to the evaluation of public support for a nuclear waste disposal facility, as it retains the notion of negotiated trade-offs and ongoing relationships and responsibility. As the desired outcome of a community siting process, it directs decision-makers' attention to the important relationship between risks and benefits, and to the responsibility of risk managers to attend to that dynamic, ensuring that benefits are received and valued, by those bearing the risks, and that risks are managed to an appropriate level.

The toleration of a risk is conditional – as is the 'reluctant acceptance' of nuclear power as a response to climate change – on both the reception of benefits and on the appropriate control of the risks. The risk is not simply accepted as low enough that it is not a concern, a handing of the issue over to risk managers for them to manage as they see fit.

This conditionality means that the performance of risk managers will be scrutinized; they will not be trusted blindly to manage a nuclear waste facility. The trust that the public will place in risk managers will be "critical trust" (Walls et al., 2004), an "active trust" in which "self-confident and active citizens assess the claims of experts and institutions" (Walls et al, 2004; Taylor-Gooby, 2006). Active, or critical, social trust incorporates critical attention to, or monitoring of, activities and institutions as an essential complement to the delegation of responsibility for risk management; it functions both to manage the social complexity and to monitor the competence of those entrusted to manage the risk and ensure that they remain aligned with social values and expectations.

With this in mind, it is to be expected that achieving tolerance of the risks of a nuclear waste disposal facility will require that the public receive, and acknowledge that they receive and value, benefits from the facility; it will also require that they have evidence that facility proponents, designers and managers share their concerns about the hazards and their valuation of the environment that may be at risk and plan and manage the facility with those values in mind. Continued tolerance of a nuclear waste facility will require that management facilitate public scrutiny of the facility and its management through being open, with stakeholder participation, provision of relevant information and reliable notification of any problems that occur.

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## **APPENDIX B**

### **Letter from the Joint Review Panel**

March 6, 2014

Laurie Swami  
Vice President, Nuclear Services  
Ontario Power Generation

<contact information removed>

**Subject: Deep Geologic Repository Project for Low and Intermediate Level Waste – Submission of Independent Risk Assessment Expert Group Comments on Relative Risk Analysis of Community Acceptance in IR EIS-12-513**

Dear Ms. Swami:

The Joint Review Panel thanks the Expert Group for its letter regarding the challenges of assessing community acceptance for the four prescribed options in the local and regional study area and outside of the regional study area, as required in IR EIS 12-513. The Panel has determined that the phrase “community acceptance” requires revision and further explanation. Accordingly, the Panel provides the following clarifications to the Expert Group.

Rather than “community acceptance”, the Panel expects that there be a comparison of *risk perception* (and thus, *risk acceptability*) among the four options. Risk perception, in turn, is affected by the relative degree of uncertainty associated with each option. The Panel notes that risk perception and risk acceptability are also affected by trade-offs among social and ethical values; however, it does not expect that the Expert Group include social and ethical trade-offs in its analysis since that would go well beyond the intended scope of the IR. Rather, the Panel suggests that the Expert Group focus on uncertainty. This is because the technical risk analysis of the four options will have a direct link with the analysis of the effects of the technical uncertainty on risk perception.

The primary uncertainties associated with the management of low and intermediate-level nuclear waste were described in numerous written and oral submissions to the Panel. Many submissions presented comparative risk perceptions and risk acceptability among status quo, enhanced surface storage and deep geologic repositories. These submissions, together with information in the published literature and the Expert Group’s analysis and professional

judgement should be used to produce a relative risk perception/acceptability score for the four options.

The Panel expects that the relative risk perception scores will be related, but not necessarily confined, to the following primary uncertainties identified in submissions and reflected in the published literature:

- Accidents and terrorist threats
- Natural events (particularly seismic events and severe weather)
- Transportation risks
- Efficiency and trustworthiness of the options
- Level of confidence needed before proceeding with a given option
- Ease of monitoring
- Retrievability
- Equitable distribution of risks and benefits (theory that those who generate the waste bear more of the risk)
- Risks to future generations

The Panel also heard from Aboriginal groups with respect to the effect of spiritual and cultural factors on risk perception. The distinctive world view of the Aboriginal groups who presented at the Panel Hearing included the concept of "asking permission" of the earth before proceeding with an underground repository. This is just one example of the additional risk perception dimensions that are added when a proposed project might adversely affect potential or established Aboriginal rights, title or Treaty rights asserted in the area. The Panel refers the Expert Group to the Hearing transcripts for days with formal presentations by Aboriginal groups. Scheduled presentations were made on September 16 and 25, 2013 and October 11 and 30, 2013 by the Saugeen Ojibway Nation. Presentations were made by the Historic Saugeen Métis and the Métis Nation of Ontario on October 7, 2013. This information is in addition to the written submissions prepared by each of these Aboriginal Groups. It may not be possible to use Aboriginal risk perception values to discriminate among the four options. However, the Panel would encourage the Expert Group to comment on how risk perception among Aboriginal peoples might better be acknowledged and incorporated.

The Panel understands that many of the above uncertainties will be assessed as part of other portions of the analysis of the four options (e.g. with respect to risks

to the Safety Case). However, the Panel expects that the analysis then go forward with further consideration of the *perception* of each of the four options, as influenced by the relative degree of technical uncertainty associated with the primary uncertainty issues listed above.

The Panel did not intend that the requirement for the risk analysis to be “defensible and repeatable” would be interpreted as a requirement for “evidence based” analysis. The Panel’s intent was that the analysis be transparent. Transparency produces defensibility. If other investigators understand precisely how the risk analysis results were determined, then repeatability is also possible (although the Panel acknowledges that a different set of experts may produce different outcomes).

The Panel has also determined that the stipulation regarding study area has led to misunderstanding. The Expert Group states in its letter that “there is insufficient information directly relevant to the issue of local and regional community acceptance, based on research having to do with *discriminating* among the four specific options listed in the charge to the Expert Group.” The Panel is aware that there is no formal quantitative or qualitative evidence comparing risk perception and risk acceptability of all four options within the local and regional study areas. In fact, such data would be impossible since there are no granitic bedrock locations in the regional study area. The Panel maintains that use of a combination of evidence provided by submissions as well as published literature is sufficient to discriminate among the options if the Expert Group focusses, as is suggested above, on the effects of relative uncertainty on risk perception and risk acceptability.

The Panel acknowledges paragraph #4 in the Expert Group’s letter of February 18, 2014. While the Group members were not present throughout the public hearing process, there are extensive and varied records available. To assist the Expert Group in this regard, a description of the information sources follows. The Panel recommends accessing the Canadian Environmental Assessment Registry Internet site at [www.ceaa-acee.gc.ca](http://www.ceaa-acee.gc.ca). In the folder called “Hearing Documents”, the Expert Group will find both Daily Agenda files (example, document #1563) and daily Hearing Transcript files (example, document # 1567). These are in addition to document #1521 that provides a comprehensive preliminary agenda for the first four weeks of the hearing and document #1722 that outlines the hearing agenda for October 28-30, 2013.

The daily agendas provide a complete list of registered participants for each day and the Hearing Transcripts are a verbatim record of what was said each day. The Expert Group members then have the additional option of watching the daily webcast to obtain information. Webcasts for each day of the public hearing can be accessed at [www.nuclearsafety.gc.ca](http://www.nuclearsafety.gc.ca). If you have any questions regarding the search functions of the CEAA on- line project registry, please contact Debra Myles at (613)957-0626.

The Panel hopes that the clarifications regarding its expectations for analysis of risk perception and risk acceptability will assist the Expert Group.

Any questions that you have may be directed to the Panel Co-Managers, Kelly McGee at (613) 947-3710 or Debra Myles at (613) 957-0626.

Sincerely,

<original signed by>

Stella Swanson  
Chair  
Deep Geologic Repository Joint Review Panel

c.c.: James F. Archibald, Joint Review Panel Member  
Gunter Muecke, Joint Review Panel Member