Report and Advice on the Ontario Drinking Water Quality Standard for Tritium

Prepared for the Honourable John Gerretsen
Ontario Minister of the Environment

By the Ontario Drinking Water Advisory Council

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ODWAC
Ontario Drinking Water Advisory Council

The Ontario Drinking Water Advisory Council, known formally as the Advisory Council on Drinking Water Quality and Testing Standards, is an Agency of the Government of Ontario

Ontario

Advisory Council on Drinking Water Quality and Testing Standards

Le Conseil consultatif sur les normes de qualité et d'analyse de l'eau potable

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1.0 Executive Summary and Conclusion(s):

As part of its role, the Ontario Drinking Water Advisory Council provides advice on drinking water quality standards as a result of direct requests by the Minister of the Environment, and can also undertake consultations to facilitate transparency in process and provide for stakeholder and public participation. The Council's advice is directed to the Minister.

In the case of tritium, the Minister formally requested the Council to provide advice on the Ontario Drinking Water Quality Standard on February 21, 2007, as a result of the issue being raised by the Medical Officer of Health for the City of Toronto. As part of its review, the Council was requested to take into consideration the 1994 recommendations on tritium made by the former Advisory Committee on Environmental Standards (ACES) in their report entitled: "A Standard for Tritium: A recommendation to the Minister of the Environment and Energy".

On June 12, 2007, the Minister made an additional request for the Council to also take into consideration a Greenpeace Canada report, authored by Dr. Ian Fairlie entitled "Tritium Hazards Report: Pollution and Radiation Risks from Canadian Nuclear Facilities".

In undertaking its review, the Council established a working group comprised of members with knowledge of the issue and experience in radionuclide risk and regulation to assist the Council as a whole. A multi-step approach was developed including:

- obtaining and reviewing all pertinent documentation for review;
- undertaking an inter-jurisdictional comparison;
- meeting with key stakeholder groups and individuals;
- holding a public consultation to hear directly from interested parties; and
- developing recommendations for the full Council's consensus.

The preliminary conclusions, reached by the working group and presented to the full Council for discussion and subsequent Council consensus on a proposed Standard, as well as a number of measures related to implementation, include the following:

- there is a natural background level of tritium in water in Ontario, in the range of 2 to 3 Bq/L; any levels above this range imply man-made sources;

- in setting a drinking water Standard in Ontario we are in fact saying that it is acceptable or 'safe' to allow that water to be consumed each day over a lifetime of 70 years;

- the Council agrees with the conclusions of the BEIR VII report that there is linear dose-response relationship and no threshold for the induction of cancers by radionuclides;

- the target derived risk level should be 1 in a million or 10^{-6} (meaning 1 new excess cancer occurrence over existing background cancer rates in 1,000,000 people);

- the target derived risk level should be over a lifetime of exposure of 70 years, and based on cancer incidences above background (occurrences) rather than mortality (deaths);

- tritium is the most common point source radionuclide found in drinking water in Ontario and represents an on-going, active source of radioactivity above background levels, resulting in lifetime exposure to large populations. As such, the approach taken for regulating tritium in drinking water should not imply that it is appropriate for other radiologically-regulated activities or radionuclides;

- current sampling programs conducted by The Ministry of Labour's Nuclear Reactor Surveillance Program, The Ministry of the Environment's Drinking Water Surveillance Program, and the nuclear power industry should continue;

- urgent action to protect the public from more immediate exposure to tritium should be based on monitoring and reporting discharges from their source; not the drinking water treatment plant. As such, short-term exposure to drinking water that exceeds the Standard should not trigger inappropriate responses by agencies or the public rather such exceedances should be used to set in motion a series of corrective actions at the emission source of the tritium to the environment; and

- all tritium data and information should be made available by the nuclear power industry and the Ministry of Labour, to the public, the Ministry of the Environment, and local public health offices, as soon as practicably possible.

In an effort to arrive at a proposed Standard, several numerical variations that use the models of other jurisdictions and authorities were evaluated and revised using the Council's own conclusions. The technical challenge was how to best utilize the available radiological research and information to arrive at a risk as close to 1 in a million (10^{-6}) as possible, while maintaining practicability and achievability.

These variations resulted in a range for a possible proposed Standard of approximately 7 Bq/L to 109 Bq/L, but the Council concluded that these variations, based on current science and risk assessment practices, would not lead to consensus on a single number.

Since the Council could not unequivocally select one variation over another, given that the uncertainties in the scientific methods do not confirm any one particular value over another from within the range, the following question was considered:

> *Taking into account all the research and documentation, meeting with experts, stakeholders, and the general public, and Council deliberations, is there a tritium Standard (value or level) that a reasonable and informed person would feel safe drinking the water every day over a lifetime of 70 years at or below that Standard?*

To answer this question, the Council went back to address some of the basic principles or criteria used by Health Canada for setting Canadian Drinking Water Quality Guidelines for non-threshold chemical carcinogens.

This would mean that the maximum acceptable concentration should be established at a level which represents an estimated lifetime (70 years) risk of cancer falling within the range that is considered to be “essentially negligible” or as close to “essentially negligible” as reasonably practicable. "Essentially negligible" risk is generally interpreted by most world-wide regulatory bodies, including Health Canada, as a range of risk of between 10^{-5} and 10^{-6}.

However, the Council concluded that the target derived risk level for tritium in drinking water in Ontario should be 1 in a million or 10^{-6}.

The next step was to determine what limit would be considered to be “reasonably practicable”. To address this, the Council turned to two documents received as part of consultation process:

- The Canadian Nuclear Association noted in a letter to the Council that 20 Bq/L on an annual average basis is achievable in drinking water, without significant cost to the industry; and

- The Toronto Medical Officer of Health noted in a letter to the Council that the concern with tritium is chronic exposure, and that an annual average of 20 Bq/L would not be exceeded if Ontario Power Generation did not exceed its current discharge limit of 4,000 Bq/L.

Based on these two documents, the Council concluded that an Ontario Drinking Water Quality Standard for tritium of 20 Bq/L, applied as a running annual average, would meet the requirements for an appropriate level of risk and public safety, while remaining practicable and achievable by the nuclear power industry.

The Council further noted that, in applying a test of practicability to this proposed Ontario Drinking Water Quality Standard for tritium, it should not be necessary for the nuclear power industry to alter any of the applicable regulations for occupational or other radiological criteria.

Tritium is the most common point-source radionuclide found in drinking water in Ontario and represents an on-going, active source of radioactivity above background levels, capable of exposing large populations to levels above background. As such, the approach taken for regulating tritium in drinking water should not imply that it is appropriate for other radiologically-regulated activities or radionuclides.

The Council made 6 recommendations in all, as follows:

1. The Ontario Drinking Water Quality Standard for tritium should be revised to 20 Bq/L, recognizing that:

   - 20 Bq/L relates to heath effects from long-term, chronic exposure over a life time of exposure of 70 years;

   - 20 Bq/L is within the range of variations considered by the Council (7 Bq/L to 109 Bq/L), for a 10^{-6} risk level; and

   - 20 Bq/L, based on a running annual average, is achievable in drinking water, without significant cost to the nuclear power industry, according to the Canadian Nuclear Association.

2. The Standard of 20 Bq/L should be applied as the running average of the preceding 52 weekly composite samples. This running annual average is consistent with the current weekly sampling and reporting programs, and should also be used to generate monthly averages and identify trends.

3. The current sampling and monitoring programs, as conducted by the Ministry of Labour and the industry, are appropriate, and should continue. Sampling and reporting should only be required for those drinking water treatment plants that are in the proximity of or under the influence of sources of tritium. As well, the Ministry of the Environment should continue to monitor tritium at drinking water systems as part of the Drinking Water Surveillance Program (DWSP).

4. Monthly reports of weekly test results and running annual averages should be sent to regulatory bodies, local municipalities and health units, local public interest groups, and should also be made available to the general public.

5. It is equally important to monitor trends in the monthly data and if there is an indication of increases (even if they are below the Standard), the province should require the discharger to take appropriate corrective actions, in collaboration with other appropriate authorities.

6. Monitoring and reporting at the point of discharge should be the focus for emergency response in that monitoring at drinking water treatment plants is not an appropriate approach for alerting authorities and the public of significant and / or elevated discharges of tritium. The current program should be enhanced to require the dischargers to report monthly to regulatory authorities and other public bodies on the levels of tritium discharges and immediately in each case where discharges exceed designated notification level(s).

2.0 Introduction

The broad mandate of the Ontario Drinking Water Advisory Council (formally known as the Advisory Council on Drinking Water Quality and Testing Standards) is to provide advice and make recommendations to the Minister of the Environment (Minister) on drinking water quality and testing standards, as well as other drinking water matters deemed appropriate.

As part of its role, the Council provides advice on drinking water quality standards as a result of direct requests by the Minister, and can also undertake consultations to facilitate transparency in process and provide for stakeholder and public participation.

In the case of tritium, the Minister formally requested the Council to provide advice on the Ontario Drinking Water Quality Standard, as detailed in the letter to the Chair dated February 21, 2007 *(See Appendix 1*). The Minister noted that the issue had been raised by the Medical Officer of Health for the City of Toronto, in a letter dated September 27, 2006, which also referenced a related City of Toronto Council Resolution adopted on June 27, 28 and 29, 2006 *(See Appendix 2*). As part of its review, the Council was requested to take into consideration the 1994 recommendations of tritium made by the former Advisory Committee on Environmental Standards (ACES) in their report entitled: “A Standard for Tritium: A recommendation to the Minister of the Environment and Energy” [ACES, 1994].

On June 12, 2007 the Minister made an additional request *(See Appendix 3)* for the Council to also take into consideration a Greenpeace Canada report, authored by Dr. Ian Fairlie entitled “Tritium Hazards Report: Pollution and Radiation Risks from Canadian Nuclear Facilities” [Greenpeace, 2007].

In undertaking its review on tritium, the Council established a working group comprised of members with knowledge of the issue and experience in radionuclide risk and regulation to assist the Council as a whole. A multi-step approach was developed including: obtaining and reviewing all pertinent documentation for review; undertaking an inter-jurisdictional comparison; meeting with key stakeholder groups and individuals; holding a public consultation to hear directly from interested parties; and developing recommendations for the full Council’s consensus.

The preliminary conclusions reached by the working group were presented to the full Council for discussion and subsequent Council consensus on a proposed Standard, as well as a number of measures related to implementation.

It should be noted that the Council reviewed many references during the course of its deliberations on tritium. Many of the references are highlighted in this report, but for full details, the original reference should be consulted. Furthermore, the Council has provided only an abbreviated overview of the scientific background covering concepts related to radiation and has highlighted only those necessary to this report.

Part I

1.0 Background

The current Ontario Drinking Water Quality Standard (ODWQS) for tritium is 7,000 becquerels per litre (Bq/L). This is consistent with the current 1995 Canadian Drinking Water Quality Guidelines for Radiological Characteristics [Health Canada, 1995a], and the revised Radiological Characteristics of Drinking Water Document for Public Comment [Health Canada, 2006]. 7,000 Bq/L was originally proposed in a November 1993 report entitled: "Rationale Document for the Development of an Interim Ontario Drinking Water Objective for Tritium" as prepared by the Ontario Ministry of Environment and Energy (MOEE) [MOEE, 1993]. At that time, the Ontario Drinking Water Objective (ODWO) was 40,000 Bq/L.

The Minister then requested the Advisory Committee on Environmental Standards (ACES) to conduct a public consultation on the MOEE's proposed interim Objective. In May 1994, ACES issued its report to the Minister, recommending that the Objective be immediately set at 100 Bq/L and that this limit be further reduced to 20 Bq/L over 5 years, with a goal of further reductions as tritium background levels decline [ACES, 1994].

The ACES report examined two different risk assessment frameworks used in the development of drinking water objectives: radiological and chemical. Since all radionuclides and some chemicals are recognized as carcinogens, ACES proposed that tritium should follow the same risk assessment framework as chemical carcinogens. As such, it was recommended that the acceptable level of risk for tritium should be the same as the acceptable level of risk for chemical carcinogens and their regulation. Reference should be made to the ACES report for full details. As well, the two approaches for risk assessment will be addressed in Part I, Section 4.0 of this report.

In December 1994, the MOEE completed a report entitled "Economic Consequences of an ODWO for Tritium [MOEE, 1994]. This report addressed the cost implications of six scenarios for a new tritium Objective proposed by ACES, and concluded that there could be significant cost implications to Ontario Hydro, if the proposed Objective was adopted, depending on the value chosen and the type and frequency of monitoring and reporting of results. It should also be noted that when the ACES report was completed, the province did not have legally enforceable Ontario Drinking Water Quality Standards, as they do now. Instead, drinking water Objectives were used to guide municipalities in providing safe drinking water, but they could be made legally enforceable by including them in Certificates of Approval.

The Minister's decision to set the ODWO at 7,000 Bq/L was transmitted by letter to Ontario Hydro. No record of this letter was found. However, the letter is referenced in a response from Ontario Hydro to the Minister, as outlined below:

On December 9, 1994, the President of Ontario Hydro, Mr. O. A. Kupcis wrote to the Minister of Environment and Energy endorsing the Objective of 7,000 Bq/L *(See Appendix 4).* Ontario Hydro made an additional commitment that "concentrations of tritium in drinking water will remain less than 100 Bq/L on average". The commitment was based on applying "the principle that all exposures to radiation are kept As Low As Reasonably Achievable (ALARA)", in keeping with the operational practices employed by Ontario Hydro at is nuclear power plants.

2.0 Tritium

What is tritium, and what are its properties?

This section of the report provides only a brief summary about tritium and its physical, chemical, and radiological properties. Several of the references provide more complete details.

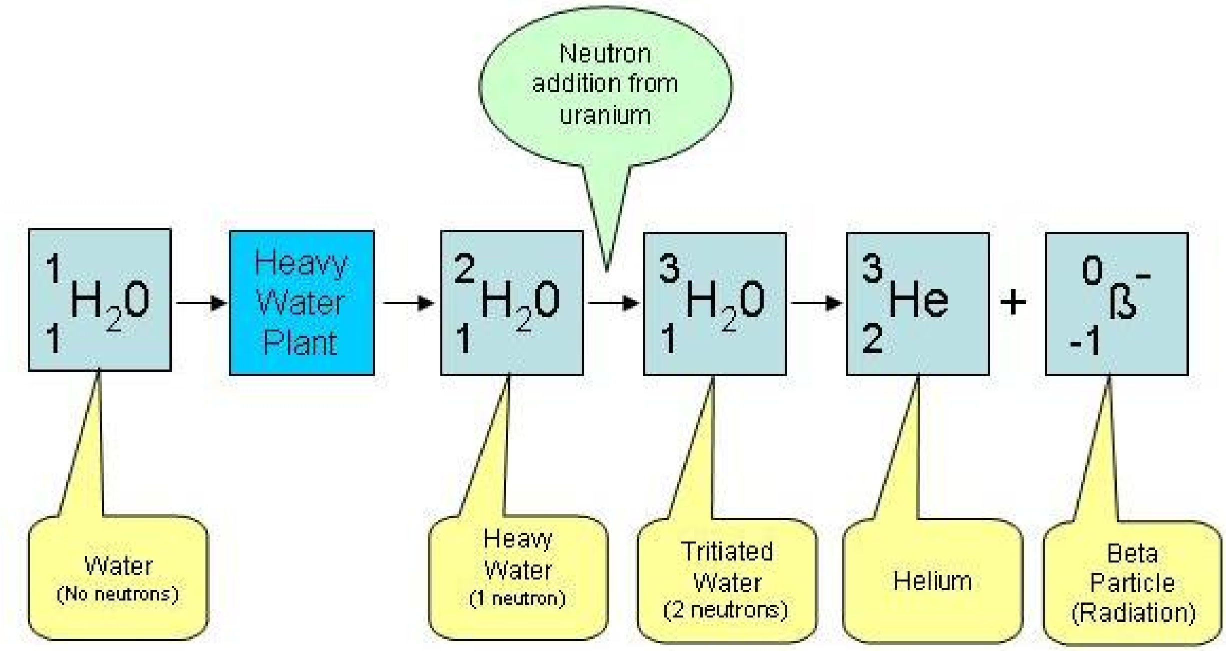
The common hydrogen atom has one proton and no neutrons. Two hydrogen atoms combine with oxygen to form water (H_2O). Tritium is a hydrogen atom that has incorporated into its nucleus two neutrons (added to the existing proton). Although tritium can be a gas (HT), the tritium molecule is preferentially found as a component of the water molecule - tritiated water (HTO), because elemental tritium readily reacts with oxygen to form water, by replacing one of the hydrogen atoms in the water molecule *(See Diagram 1)*.

Tritiated water has the same physical properties as regular water. It is colorless, odourless, and behaves the same as regular water in the environment. Tritium in water exchanges with hydrogen from other water molecules but can also become incorporated into complex organic molecules, such as proteins inside and outside cells in the body.

As with all radionuclides, tritium is unstable. This instability is called radioactive decay. As it decays, tritium emits ionizing radiation in the form of low energy Beta particles. Beta particles have the same properties (mass and charge) as electrons, and have the greatest biological impact at very short distances, as they can travel in the air for only a distance of a few feet. Through this process of radioactive decay, tritium (with a half-life of 4,500 days, or approximately 12 years) slowly breaks down into helium. This relatively short half-life (years vs. thousands of years) results in more frequent beta emissions from tritium than in a substance with a longer half-life.

In addition to radioactive half-life, there is a process known as biological half-life. This is the time it takes for one half of a given substance to be eliminated from the body. Tritiated water (HTO) has a biological half-life of approximately 10 days. Organically bound tritium (OBT), with a biologic half-life of approximately 40 days, stays in the body longer by becoming part of complex molecules. However, once tritium becomes incorporated into cellular structures, molecules, or DNA, its biological half-life extends to almost a year.

Diagram 1: Tritiated Water Decay



What is radioactivity and how is it measured?

In simple terms, radioactivity is the spontaneous nuclear transformation of unstable atoms, leading to the formation of new atoms, and the emission of radiation.

Radiation describes any process by which energy emitted by one body travels through a medium or through space, ultimately to be absorbed by another body. It can be classified as ionizing or non-ionizing radiation, depending on its effect on other atoms, molecules, or biological tissue. The most common use of the word "radiation" refers to ionizing radiation, which has enough energy to ionize atoms or molecules. There are three principal types of ionizing radiation, listed here in their relative order of severity, from low to high as follows: alpha, beta, and gamma.

Geiger counters and scintillation counters are capable of detecting radiation by directly measuring the disintegration rate of ionizing radiation. The unit of measurement for ionizing radiation is the becquerel (Bq), which is defined as the activity of a quantity of radioactive material in which one nucleus decays per second. In terms of measuring ionizing radiation in drinking water, the units are becquerels/litre (Bq/L), which can quantitatively described as the number of disintegrations taking place in a litre of water, per second.

How does tritium get into the environment and into drinking water?

There are both natural and man-made sources of tritium.

When cosmic rays strike nitrogen in the upper atmosphere, tritium is naturally produced and reaches the earth's surface via rainfall, causing elevated levels in both surface water and ground water.

Tritium was also produced during above-ground nuclear weapons testing, causing elevated levels in both surface water and ground water, on a global scale.

On a local scale, tritium is produced as a result of reactions that take place within nuclear reactors using deuterium or "heavy water". During these nuclear reactions, neutrons from the uranium fuel change some of the reactor's heavy water into tritiated water. Tritium builds up in the heavy water until it is physically removed at a Tritium Removal Facility (TRF), such as the one operated by OPG at Darlington, but it is also released into the environment with the heavy water, as a result of leaks and spills. This is the predominant route by which tritium reaches surface water, and subsequently drinking water *(See Diagram 1)*.

Surface Water

Tritium levels from atmospheric nuclear weapons testing fallout appear to be continuously declining from a peak of just under 25 Bq/L in the mid 1960's to approximately 1 Bq/L in 2007. The combination of the natural source and this source results in an overall surface water background level of 2.13 Bq/L in Lake Huron [Bruce Power, 2008a], and 1.6 Bq/L in Lake Ontario [OPG, 2008].

Tritium levels in surface water can also be influenced by precipitation and groundwater sources.

The median concentrations of tritium in surface water at sites adjacent to the Bruce, Darlington, and Pickering reactor facilities for 2007 are shown below in Table 1 [MOL, 2008].

Table 1: 2007 Surface Water Monitoring Results

Surveillance Area	Number of Samples	Tritium (Bq/L)
Bruce	10	30
Darlington	8	<5*
Pickering	8	14

**Minimum Detectable Concentration*

The average tritium concentrations in the Great Lakes from 1997-1998 are presented below in Table 2. The ascending levels of tritium in surface water are a result of discharges from nuclear power plants [Greenpeace, 2007].

Table 2: Average Tritium Concentration (in Bq/L) in the Great Lakes in 1997-1998

Lake Superior	2
Lake Michigan	3
Lake Huron	7
Lake Erie	5.5
Lake Ontario	7.1

Tritium Discharges

Tritium is discharged into the natural environment through routine leaks of heavy water, but it appears that there are no specific records of such small leaks. Both OPG and Bruce Power have programs in place to continue to reduce the frequency and volume of these leaks [OPG/Bruce Power, 2006; OPG, 2008; Bruce Power, 2008a].

Notification Levels for Waterborne Tritium Emissions from OPG:

Tritium notification levels for waterborne emissions from OPG are summarized below in Table 3 [OPG, 2007], and form part of the Coordination of the Response to a Liquid Emission at OPG and Bruce Power [OPG/Bruce Power, 2006].

Table 3: Tritium Levels for Waterborne Emissions

Description	Level (total activity)	Level (concentration)*
Derived Release Limit (CNSC licence – emission limit)	Pickering – 5.1 x 10^{17} Bq/year	3.0 x 10^{5} Bq/L
	Darlington – 4.3 x 10^{15} Bq/year	1.6 x 10^{5} Bq/L
Action Level (CNSC licence – reporting level)	Pickering – 4.1 x 10^{15} Bq/month	2.9 x 10^{4} Bq/L
	Darlington – 3.5 x 10^{16} Bq/month	1.5 x 10^{4} Bq/L
Ontario Standard for Drinking Water Quality for Tritium	na	7000 Bq/L (at WSP)
OPG Abnormal Waterborne Tritium Emission Notification Level (notification provided to Durham Region, Toronto, MOE and CNSC)	na	4,000 Bq/L at Station Discharge

* Where the limit is specified in terms of activity, this is the equivalent concentration that would have to be maintained all year long to reach the limit (with all cooling water pumps running).

According to OPG, over the past 17 years, there have been 2 releases of tritium that exceeded the 4,000 Bq/L reporting requirement at OPG [OPG, 2007]. Both occurred at Pickering and both were the result of mechanical problems resulting in a heat exchanger leak. Table 4 below summarizes information about those releases.

Table 4: OPG Tritium Release Event Data Summary

Data	Pickering Moderator Heat Exchanger	Pickering Unit 4 Shutdown Cooler Heat Exchanger
Release date	August 2, 1992	April 15, 1996
Peak outfall concentration	3×10^6 Bq/L	1.7×10^5 Bq/L
Time to Peak Impact (at Ajax WSP)	4 days (Aug 6, 1992)	30 hours
Duration of elevated tritium (at Ajax WSP)	8 days	na
Peak concentration (at Ajax WSP)	1,300 Bq/L	831 Bq/L
Highest daily average concentration (Ajax WSP)	587 Bq/L	na
Maximum calculated dose from event	0.00012 mSv	0.00010 mSv
CNSC dose limit	1 mSv/y	1 mSv/y
Natural background radiation dose	2 mSv/y	2 mSv/y

Notification of Tritium Emissions from Bruce Power:

Tritium notification levels for waterborne emissions from Bruce Power are summarized below in Table 5, and also form part of the Coordination of the Response to a Liquid Emission at OPG and Bruce Power [OPG/Bruce Power, 2006].

Table 5: Tritium notification levels for waterborne emissions from Bruce

Source	Description	Notification Level
Coordination of the Response to a Liquid Emission at OPG and Bruce Power [OPG/Bruce Power, 2006]	Initial notification from Bruce Power	Tritium levels in the cooling water outfall >30,000 Bq/L, corresponding to approximately 2,000 Bq/L at the Port Elgin water supply plant
Bruce Power's Derived Release Limits and Environmental Action Levels [Bruce Power, 2008b]	Derived Release Limit for tritium in water	2.27E+18 Bq/year
	Action Level for tritium releases to water	1.21E+16 Bq/month
Notification/Action Protocols for Abnormal Tritium Releases at BNPD (Bruce Nuclear Power Development [Bruce Power, 1996]	Action Level 1	Tritium in CCW Discharge >30,000 Bq/L and <50,000 Bq/L
	Action Level 2	Tritium in CCW Discharge >50,000 Bq/L and <90,000 Bq/L
	Action Level 3	Tritium in CCW Discharge >90,000 Bq/L

Bruce Power has noted that there has been "an increasing trend in tritium in drinking water since 2004. This trend can be attributed to a number of activities at the Bruce Power site including the return to service of Units 3 & 4, refurbishment activities surrounding Units 1 & 2, a sample cooler heat exchanger leak at Bruce A in 2006 (leak has been isolated and scheduled for repair in 2008) and a boiler tube leak at Bruce B in 2007 (leak has been repaired)." [Bruce Power, 2008a].

Greenpeace Canada provided a list of discharges in their report [Greenpeace, 2007], stating that" "In addition to routine releases to surface waters, significant groundwater and lake contamination has occurred at Canadian nuclear facilities in the past.

- In 1979, tritium groundwater concentration reached 2.15 MBq/L following a release of 666 TBq at Pickering;
- In August 1983, a pressure tube at Pickering-2 ruptured, dumping an unspecified amount of coolant into the reactor building;
- In September 1983, a leak of 222 TBq of tritium occurred from the Douglas Point reactor on Lake Huron. The prevailing counter-clockwise circulation pattern in the lake carried the tritium plume northeast to Port Elgin, where drinking water levels reached 1,600 Bq/L during a 2-day period;

- In January 1990, a loss-of-coolant accident at Bruce-4 resulted in a 12,000 kg leak of heavy water into Lake Huron;
- In June 1991, following a leak from Chalk River Nuclear Laboratories into the Ottawa River, the tritium concentration in drinking water at Petawawa was about 400 Bq/L. At Ottawa (200 km downstream), the tritium level was ~150 Bq/L;
- In August 1992, a tube break at Pickering-1 caused the release of 2,300 TBq of tritium into Lake Ontario. A nearby drinking water plant was shut down and elevated levels of tritium (up to 195 Bq/L) were found in Toronto drinking water;
- In May 1994, Ontario Hydro found a tritium groundwater concentration of 0.7 MBq/L following a leak at Pickering;
- In December 1994, a valve failure at Pickering-2 led to 140 tonnes of heavy water being discharged into Lake Ontario;
- In May 1995, a valve failure at Bruce-5 caused a 25-tonne leak of radioactive heavy water;
- In April 1996, a heavy water leak at Pickering-4 released 50 GBq of tritium into Lake Ontario; tritium levels in local drinking water reached 100 times background levels; and
- In July 1997, it was revealed that Ontario Hydro (the predecessor to OPG) had failed to report tritium contamination of groundwater on the Pickering site for a period of 20 years."

Drinking Water

Levels of tritium in drinking water are monitored by the nuclear industry and the Ontario Ministry of Labour's Nuclear Reactor Surveillance Program.

Reference can be made to the 2007 annual reports of Ontario Power Generation [OPG, 2008], and Bruce Power [Bruce Power, 2008a]. Table 6 below presents a summary of the 2007 levels of tritium found at drinking water treatment plants in Ontario [MOL, 2008].

Table 6: 2007 Drinking Water Monitoring - Tritium Analysis

Surveillance Area	Number of Samples	Median Value (Bq/L)
Bruce	154	8.9
Darlington	260	7.1
Essex	47	4.9
Ottawa	36	6.7
Toronto	203	6.3
Toronto-West	36	5.9

In addition, Table 7 below summarizes 5 years (2003-2007) of tritium in drinking water results from the three surveillance areas that have adjacent nuclear power generation facilities [MOL, 2008].

Table 7: 5-year Results – Tritium in Drinking Water

	Bruce Surveillance Area		**Darlington Surveillance Area**		**Pickering Surveillance Area**	
Year	# of Samples	Concentration (Bq/L)	# of Samples	Concentration (Bq/L)	# of Samples	Concentration (Bq/L)
2003	148	7.31	255	6.38	154	6.43
2004	152	8.47	258	6.23	157	6.17
2005	153	8.99	260	5.86	202	5.98
2006	154	11.92	260	6.63	203	4.81
2007	154	8.87	260	7.08	203	6.29

Concentrations of tritium at specific drinking water treatment plants for 2007 are presented below in Table 8, according to the Ministry of Labour's Radiation Protection Monitoring Service.

Table 8: 2007 Tritium Concentrations at Drinking Water Treatment Plants (Bq/L)

		Maximum	**Median**
Nuclear Facility: Pickering			
Water Treatment Plant:	Ajax	14	7.2
	Horgan	10	7.0
	R.C. Harris	14	6.9
Nuclear Facility: Darlington			
Water Treatment Plant:	Newcastle	16	6.5
	Bowmanville	13	6.8
	Oshawa	16	7.9
	Whitby	14	7.0
Nuclear Facility: Bruce			
Water Treatment Plant:	Port Elgin	44	16.1
	Southampton	28	5.0
	Kincardine	22	5.5
Nuclear Facility: Chalk River			
Water Treatment Plant:	Deep River	5.9	-
	Pembroke	12	7.3
	Petawawa	12	7.6

The City of Ottawa performs independent tritium monitoring of its drinking water treatment plant intakes, and the analyses are performed by Health Canada's Radiation Protection Bureau laboratory. Results for 2008 are seen below in Table 9.

Table 9: City of Ottawa Drinking Water Treatment Plant Tritium Concentrations (Bq/L)

	2008	Maximum	Average
City of Ottawa			
Water Treatment Plant:	Britannia	22.8	5.2
	Lemieux	11.5	5.0

Groundwater

Monitoring records show that precipitation in the proximity of nuclear facilities contains elevated levels of tritium resulting in elevated tritium concentrations in groundwater. In the Darlington and Pickering survey areas, well levels ranged from 23.5 Bq/L to 86.1 Bq/L in 2007, while in the Bruce survey area, well levels ranged from less than 6 Bq/L to over 70 Bq/L in 2007 [OPG, 2008; Bruce Power, 2008a].

Also, in the vicinity of SRB Technologies in Pembroke, a well used for drinking water at a business showed a concentration of 1,293 Bq/L in December of 2008 [SRB, 2009].

ROLES AND RESPONSILITIES

The following summarizes the roles and responsibilities of various agencies and organizations with respect to tritium and drinking water:

Federal Government:

Canadian Nuclear Safety Commission (CNSC):
The CNSC regulates nuclear fuel production and power generation in Canada. Licensees and organizations applying for licences are subject to many rules and regulations, including Derived Release Limits (DRLs), which represent release rates of all radionuclides from a facility, that correspond to critical group exposure at the public dose limit of 1 mSv per year.

Health Canada (HC):
Health Canada's mandate is to reduce the health and safety risks associated with different types of substances, and radiation by:

- conducting research into the biological effects of environmental and occupational radiation;
- developing better methods for internal radiation dosimetry and its measurement;
- providing radiation safety inspections of federally regulated facilities containing radiation-emitting devices, the devices themselves, as well as training on the proper operation of the devices;
- developing regulations, guidelines, standards and safety codes pertaining to radiation-emitting devices;
- providing radiation advice and collaborating with other government departments and agencies, industry, and the general public; and
- developing guidelines for microbiological and chemical contaminants, and radiological characteristics, in collaboration with the Federal / Provincial / Territorial Committee on Drinking Water (CDW).

Specifically, Health Canada's Radiation Protection Bureau has a mandate is to promote and protect the health of Canadians by assessing and managing the risks posed by radiation exposure in living, working and recreational environments by:

- supporting Canada's role in the Comprehensive Nuclear-Test-Ban Treaty by operating the Canadian portion of the International Monitoring System for radionuclides and providing one of 16 national radionuclide laboratories specified under the Treaty;
- conducting assessments under the Canadian Environmental Assessment Act;
- leading the coordination of federal nuclear emergency preparedness and providing Health Canada's technical support to the Federal Nuclear Emergency Plan (FNEP);
- developing guidance to protect Canadians from the effects of nuclear accidents, radioactivity in water and food, radon in indoor air, and naturally occurring radioactive materials from non-nuclear industries;

- operating the Canadian Radioactivity Monitoring Network and laboratory to provide health assessments regarding existing levels of radioactivity and effects of nuclear/radiological accidents from a national perspective;
- conducting research on the health effects of radionuclides in the environment, especially sensitive Arctic environments and food chains, and on global air and radionuclide movements;
- providing inter-comparison programs for internal radiation exposure measurements, internal dosimetry services and research on internal dosimetry and measurements through the National Calibration Reference Centre for Bioassay and In-Vivo Monitoring;
- managing the National Dose Registry, that contains the occupational radiation dose records of all monitored radiation workers in Canada. and conducts research on exposure trends and on the health outcomes of occupational exposures;
- conducting research on exposure trends for radiation workers and on the health outcomes of occupational exposures to radiation; and
- providing advice to federal departments and agencies, other levels of government, industry, universities, hospitals, workers and the public on health issues related to radiation exposure.

Provincial Government:

Ministry of the Environment (MOE):
The MOE regulates tritium and other radionuclides in drinking water through the over arching legislation of the Ontario *Safe Drinking Water Act, 2002*, and associated regulations, including Ontario Regulation 169/03 (Drinking Water Quality Standards), Ontario Regulation 248/03 (Drinking Water Testing Services), and Ontario Regulation 170/03 (Drinking Water Systems). There is currently a legally enforceable maximum acceptable concentration (MAC) of 7,000 Bq/L for tritium in drinking water, but monitoring is only mandated through the Certificate of Approval process, and on a site-specific basis.

Ministry of Labour (MOL):
The MOL's Radiation Protection Monitoring Service's (RPMS) main role is to carry out Ontario's Nuclear Reactor Surveillance Program, which continuously monitors the environment for radioactivity around nuclear reactors, in order to assure that public health, safety, and property are protected. The RPMS also provides radioactivity measurements of raw and treated drinking water in support of the MOE's Drinking Water Surveillance Program (DWSP).

Ministry of Health and Long-Term Care (MOHLTC):
The MOHLTC provides guidance on health issues and coordinates activities between the Chief Medical Officer of Health and the local Medical Officer of Health (MoH), as appropriate.

Emergency Measures Ontario (EMO):
EMO, a branch of the Ministry of Community Safety and Correctional Services, is responsible for promoting, developing and maintaining emergency programs throughout the province. In the case of a nuclear emergency, EMO invokes the Provincial Nuclear Emergency Response Plan, if appropriate.

Local Government:

Local Medical Officer of Health (MoH):
The local MoH is directly responsible for public health issues, and can order precautionary and / or protective measures, such as Drinking Water Advisories, or recommending the use of alternate sources of drinking water.

Local Municipalities and Water Treatment Plant Operators:
Local municipalities and water treatment plant operators are required to meet the Ontario Drinking Water Quality Standards and take corrective action as described in detail in the *Safe Drinking Water Act, 2002*, and associated regulations. They are only required to monitor and report results for tritium if required by their site-specific Certificates of Approval. Drinking water treatment plant operators currently work with the Ministry of Labour, and the local nuclear power plants, to collect water samples on a daily basis.

Owners / Operators:

Ontario Power Generation (OPG) and Bruce Power:
OPG and Bruce Power both monitor their discharges as required under their operating licences regulations as set out by the CNSC. For OPG, a notification limit for tritium is set at 4,000 Bq/L. Exceedance of this limit requires notification to the regulatory agencies and action to reduce the discharge levels. Bruce Power's notification limit is 30,000 Bq/L. OPG also collects water samples taken by local water treatment plant staff and analyzes them for tritium, for both OPG and Bruce Power facilities.

Atomic Energy of Canada Limited (AECL):
AECL is the overseeing body for nuclear facilities, such as Chalk River, and is considered the owner / operator of such. AECL retains ownership of the CANDU technology and licenses its use to both OPG and Bruce Power, under an agreement.

3.0 Monitoring and Reporting

The province undertakes an independent monitoring program as part of its surveillance of nuclear reactors and reports the results annually [MOL, 2008]. Testing is done by the Ministry of Labour laboratory. For tritium, a number of locations are monitored, covering sources of human exposure to tritium such as drinking water, surface water, and well water. Drinking water samples are generally collected by drinking water treatment plant staff for plants in the vicinity of nuclear power plants and are sent to the Ministry of Labour's Radiation Protection Laboratory for analysis. This laboratory is one of only a few that is capable of, and certified for, analysis of tritium at the level of detection that is expected in water. The Ministry of Labour publishes an annual report summarizing all test results for the previous year.

The Ministry of Environment operates the Drinking Water Surveillance Program (DWSP) which monitors a wide range of contaminants at many drinking water treatment plants, on an annual basis, across the province. Tritium is included in DWSP, and the analyses are performed by the Ministry of Labour laboratory.

It should be noted that there are certain practical limitations to the tests conducted by the Ministry of Labour, such as equipment limits and the time needed to complete each test. The test involves allowing the sample of water to remain in a counting chamber for a period of time. The longer the sample remains in the counting chamber, the more sensitive or lower the detection limit (i.e. the precision of the test is higher). For practical reasons, a routine tritium test is allowed to remain in the chamber for 100 minutes, which allows the laboratory to handle the current number of samples. With respect to tritium in drinking water, the Minimum Detection Concentration (MDC) for the Ministry of Labour method is 5 Bq/L [MOL, 2008].

Also, Health Canada's Radiation Protection Bureau operates the Canadian Radioactivity Monitoring Network and laboratory to provide health assessments regarding existing levels of radioactivity and effects of nuclear / radiological accidents from a national perspective.

Nuclear power plants conduct their own drinking water monitoring program in conjunction with local municipalities. Samples are taken daily by municipal staff from the water treatment plants and are combined into a weekly composite sample, which is collected and analysed by Ontario Power Generation. Their tritium detection level is 4.5 Bq/L *(See Appendix 5).* Results are reported monthly to the local municipalities and public health offices. Both OPG and Bruce Power prepare annual reports, in which drinking water results are included with all other environmental testing for a variety of radiological parameters. The results are similar to those reported by the Ministry of Labour. For detailed results, reference should be made to the various annual reports issued by the nuclear power facilities [OPG, 2008]; [Bruce Power, 2008a].

In addition, the nuclear power plants maintain an on-line system for monitoring the tritium levels in their discharge water or cooling water. In the case of Ontario Power Generation (OPG), the measurement is taken in the cooling water after mixing and the online monitors have a detection limit of approximately 3,700 Bq/L *(See Appendix 5)*. The OPG nuclear power plants use a level of 4,000 Bq/L *(See Table 3)* [OPG/Bruce Power, 2006] to notify the local Medical Officer of Health, the Ministry of the Environment, and Emergency Measures Ontario, for coordinated response and corrective actions.

This notification level has not been triggered for a number of years. Flow and dispersion models are used to predict the concentrations that may occur at the nearest drinking water treatment plant. For Pickering the models predict that for a discharge of 4,000 Bq/L the level at the Ajax drinking water plant would be 600 Bq/L and for the Darlington the level at the Bowmanville drinking water plant would be 1,100 Bq/L. Bruce Power has as similar system in place, but their notification level is 30,000 Bq/L *(See Table 5)*.

4.0 Health and Risk

This section compares and contrasts the two distinct approaches used for setting standards (the radiological and chemical carcinogen models), outlines some recent and pertinent health studies and policy directions, and numerically assesses various risk levels.

4.1 Reviews and Reports

As noted in Part I, Section 2.0, in describing the characteristics of tritium, it is the radiological activity of tritium that is of concern rather than any chemical effects or reactions. This is an important distinction as it has been the basis for two distinct approaches to setting limits: the radiological model and the chemical carcinogen model.

The approach described in the Health Canada document: "Approach to the Derivation of Drinking Water Guidelines" [Health Canada, 1995b] is similar to that used by most international regulatory bodies when setting objectives or standards for chemical contaminants in drinking water. The approach considers differences depending on whether the chemical is a carcinogen or not. In the case of carcinogenic chemicals, a linear no-threshold approach is generally accepted, unless details on the mode of action are known or adequate low dose data exist to support a linear approach with a threshold. Exposure is assumed to be over a life time of 70 years and risk is related to the incidences of new cancers above the existing background cancer rates.

The radiological paradigm, however, assumes a one-year exposure horizon that will presumably trigger actions to limit further exposure so that the allowable risk limit is not exceeded, and the risk level is based on cancer deaths (not new incidences of cancer above background).

In setting exposure limits for radiation in general, including tritium, regulators currently consider all potential exposures to humans from all radionuclide sources. This means that if one source increases, other sources may have to decrease, so that a total limit is not exceeded. This approach is described in the various references and we will not attempt to repeat it here. The Canadian Nuclear Safety Commission (CNSC), Canada's national regulatory body for radiation matters, as well as other regulatory agencies in other countries take their lead from the International Commission on Radiological Protection (ICRP). The ICRP sets out a risk framework that national organizations may use to establish safety limits and practices for their nuclear industries. ICRP's work is based on long-term experience with radiation events and human health effects research and monitoring, and as such, their initial and primary focus has been on the protection of workers in the nuclear field [ICRP, 2003].

There have been several attempts to reconcile the radiological model versus the chemical carcinogen model to determine if they represent similar levels of protection or precaution, and whether or not they could be harmonized [Health Canada/AECB/MOEE, 1998]; [HPA, 2007]. These efforts were not entirely successful and it was concluded that it was not fruitful to consider harmonizing the two approaches in that they provided different, but similar levels of health protection.

The divide between the radionuclide and chemical carcinogen paradigms for rule making or risk assessment was highlighted in the publication entitled: "Risky Business: Claimsmaking in the Development of an Ontario Drinking Water Objective for Tritium" [McMullan, Eyles, 1999]. This publication describes the paradigms and related public policy implications.

There have been several recent assessments or reviews of the health implications of ionizing radiation, as follows:

A 2004 United Kingdom report by the Committee Examining Radiation Risks of Internal Emitters raised a number of questions with respect to the ICRP approach and its application by national regulators [CERRIE, 2004].

The BEIR VII report concluded that, for ionizing radiation, there is a linear-dose response relationship between exposure to ionizing radiation and the development of radiation induced cancers in humans, and that there is no safe level for exposure [BEIR, 2006]. The ICRP also endorses the assumption of this linear-dose response relationship [ICRP, 2007]. It should also be noted that the "EPA classifies all radionuclides as Group A carcinogens." [USEPA, 2001a].

A recent United Kingdom report prepared for the Health Protection Agency, by the Advisory Group on Ionizing Radiation (AGIR), concluded that the ICRP approach was still appropriate but that for tritium the "Relative Biological Effectiveness" (RBE) should be increased from a factor of 1 to a factor of 2, and consideration be noted for critical groups [AGIR, 2007],

The RBE for a given radionuclide is a measure of its potency for causing biological damage, relative to some standard, usually gamma or X-rays. An RBE of greater than 1 indicates the radionuclide is more potent (i.e. effective) than the reference radiation; conversely, an RBE of less than 1 indicates that the radionuclide is not as potent as the reference radiation. The RBE is used in dose and risk calculations such as those involved in establishing regulatory standards. The RBE change for tritium would affect the exposure-cancer relationship and serve to lower the limit of exposure by 50%.

As noted in the introduction, the issue of the Ontario Drinking Water Quality Standard for tritium was brought to the attention of the Minister of the Environment by Toronto Public Health and Greenpeace Canada. Greenpeace commissioned a report by Dr. Ian Fairlie, who is an independent consultant on radioactivity in the environment, entitled "Tritium Hazard Report: Pollution and Radiation Risk from Canadian Nuclear Facilities, 2007". This report documents the extent of tritium radiation exposure in the environment in Canada and challenges a number of the assumptions of the ICRP model and the approach used in international jurisdictions, and Canada by the CNSC and the Ontario nuclear industry. It recommends that "safety factors" for tritium be increased by up to a factor of 20 [Greenpeace, 2007].

The Canadian Nuclear Association retained Dr. R. V. Osborne (a biophysicist) to review the report by Dr. Ian Fairlie. This review contains a comprehensive appraisal of the current approach taken in Canada and responds to the issues raised by Dr. Fairlie [Osborne, 2007].

In addition to these reports, CNSC held a one day public workshop on the safety issues relating to tritium. Recognized experts presented papers on various aspects on the issue and participants had a chance to ask question and debate issues [CNSC, 2008b].

It should also be noted that Recommendation 12 made to federal and state / provincial governments in the 7th Biennial Report (February, 1994) of the International Joint Commission (IJC) recommended that radionuclides, with a half-life greater than eight weeks (tritium has a half-life of approximately 12 years) be included in the definition of persistent toxic substances under the Great Lakes Water Quality Agreement, and that strategies for virtual elimination of these pollutants from waste streams be implemented [IJC, 1994].

All of the above noted sources are referenced and are available for more detailed review. This report does not attempt to describe this information in detail but rather to highlight the information that the Council members had available and considered throughout this review.

4.2 Risk Level

Traditionally, the standard setting processes employed by most environmental regulatory bodies consider 10^{-6} as the furthest bounds of an acceptable risk level. Acceptable risk levels of 10^{-6} or more stringent, are considered to be "*de minimis*" or trivial [Kelly, 1991]; [Graham, 1993].

Health Canada establishes its Canadian Drinking Water Quality Guidelines for non-threshold chemical carcinogens at a level which represents an estimated lifetime (70 years) risk of cancer falling within the range that is considered to be "essentially negligible" or as close to "essentially negligible" as reasonably practicable. "Essentially negligible" risk is generally interpreted by most world-wide regulatory bodies, including Health Canada, as a range of risk of between 10^{-5} and 10^{-6}.

The ICRP's "Principle of Optimisation Protection" states that "The likelihood of incurring exposure, the number of people exposed, and the magnitude of their individual doses should all be kept as low as reasonably achievable, taking into account economic and societal factors." [ICRP, 2007]. The ICRP notes that "For public exposure in planned situations, the Commission continues to recommend that the limit should be expressed as an effective dose of 1 mSv in a year." [ICRP, 2007]. The ICRP also notes that "The proposed values are implicitly set as a fraction of the dose limit" in that the "Dose constraint for public exposure, for prolonged component from long-lived nuclides" should be "0.1 mSv/year" [ICRP, 2006].

In addition, for carcinogens whose guideline levels have been established at a level above the health-based value (due to for example limitations in analytical and treatment technologies), Health Canada recommends the As Low As Reasonably Achievable (ALARA) principle [Health Canada, 1995b].

The Ministry of the Environment's approach to setting health-based Standards for carcinogens in drinking water considers an incremental lifetime risk of 10^{-6} to be acceptable, and uses this level as a starting point.

As well, the Ministry of the Environment sets air Standards based on values that protect against health and environmental effects, as opposed to those that consider technical or economic issues. For carcinogens, the Standards are set at the 10^{-6} risk level. An alternative standard process was developed to establish interim site-specific standards with the goal of continuous improvement toward achieving the effects-based standard over time [MOE, 2005].

The United States Environmental Protection Agency (USEPA) establishes drinking water standards for carcinogens as close to zero as possible, considering economic, technical, treatability and other factors and do not explicitly consider risk. However, the Agency's acceptable risk range is from 10^{-4} to 10^{-6} [USEPA, 2000].

The World Health Organization (WHO) establishes drinking water criteria for carcinogens based on an incremental lifetime risk of 10^{-5} [WHO, 2004].

An approach to better understand risk is the "Rofecoxib" (Vioxx) Risk Characterization Theatre, which illustrates and compares the approaches of other agencies and jurisdictions [Strauss, 2008].

Risk may also be addressed by applying precautionary measures, such as ALARA (As Low As Reasonably Achievable), or BATEA (Best Available Technology Economically Achievable).

In the case of Canada's nuclear industries, exposure and risks are mitigated by applying the concept of ALARA. For instance, OPG has set an administrative discharge limit of 4,000 Bq/L for the purpose of reporting to provincial and local authorities and taking corrective action. This is measured in the discharge water of the nuclear power plant after mixing with cooling water and other water discharges. Models are used to predict the expected level of tritium at the closest water treatment plants. OPG then applies ALARA on a voluntary basis to improve their operation and maintenance. By applying ALARA the industry has committed to limiting tritium in the discharge water such that the level at local drinking water plants will not exceed 100 Bq/L *(See Appendix 4)*.

For most other industrial discharges in Ontario, the concept of BATEA is applied. However the application of BATEA is not voluntary. When Ontario developed discharge limits under the MISA (Municipal Industrial Strategy for Abatement) program, BATEA was considered before setting the discharge limits and, as such, the final enforceable discharge limits required the application of BATEA. As well, with respect to drinking water, Justice O'Connor did not accept the concept of voluntary compliance and recommended a stronger and comprehensive regulatory framework [Walkerton, 2002].

There is general agreement that the incremental lifetime excess cancer risk for a lifetime of exposure (70 years) to 7,000 Bq/L of tritium in drinking water (approximately equal to 0.1 mSv), ranges from:

- 340 in a million [ACES, 1994]; to
- 350 in a million [Appendix 5], which references WHO; to
- 600 in a million [Health Canada, 1995b].

These risk estimates have been used to derive many of the international limits for tritium as described in Part I, Section 5.0. For Ontario and Canada the limit is 7,610 Bq/L which has been rounded down to 7,000 Bq/L.

5.0 Overview of Approaches by Other Jurisdictions

Canada

The approach used to develop Health Canada's Guideline values for radiological parameters in drinking water are based on using the dose coefficients (DCs) developed by the International Commission on Radiation Protection (ICRP). The DCs, expressed in sieverts per becquerel, only provide a quantitative means of expressing radiation dose from the inhalation and ingestion of radionuclides on the basis of the activity associated with that radionuclide. The DCs are not intended to provide risk estimates for individuals, but rather are a means by which population effects can be estimated. Moreover, the DCs are not temporally dependent, but are based on activity of the radiological parameter which has been associated with an adverse effect.

Health Canada, in keeping with the approach used by the World Health Organization (WHO) and other international agencies, has allocated the dose from radionuclides to be in the "essentially negligible" risk range of 10^{-6} to 10^{-5}, based on an annual exposure. This is a departure from the approach used for linear no-threshold chemical carcinogens where a life-time of exposure is generally considered in the setting of a guideline.

The CNSC released a report in 2008 that summarizes the approaches taken by other jurisdictions in deriving various guidelines and standards for tritium. Reference should be made to this report for specific details, but the following table (Table 8) summarizes the findings for a selection of countries / jurisdictions. The report also outlines how the limits were derived by each jurisdiction [CNSC, 2008a].

Table 8: Table of International Limits for Tritium in Drinking Water

Jurisdiction	Tritium Limit (Bq/L)	Application
Health Canada	7,000	Guideline
Ontario	7,000	Standard
Québec	7,000	Standard
United States EPA	740	MCL
California EPA	740; 14.8	MCL / PHG
European Union	100	Screening Value
Finland	30,000	Standard
Switzerland	10,000	Standard
Russia	7,700	Standard
Australia	76,103	Guideline
World Health Organization	10,000	Guideline

Not all jurisdictions apply their limits in the same fashion. The applications of the limits found above in Table 7 are described below:

Guidelines:
The *Guidelines for Canadian Drinking Water Quality* are established by the Federal-Provincial-Territorial Committee on Drinking Water (CDW) and are published by Health Canada. However, they are not legally enforceable standards unless promulgated as such by the appropriate provincial or territorial agency. These guidelines are used by the provinces and territories as a basis for setting maximum permissible levels for microbiological, chemical, and radiological parameters.

Standards:
Standards, such as the Ontario Drinking Water Quality Standards, are generally adopted from Health Canada's Guidelines for Canadian Drinking Water Quality as legally enforceable Maximum Acceptable Concentrations (MACs) in Regulation 169/03 (Ontario Drinking Water Quality Standards) [MOE, 2003], under the *Safe Drinking Water Act, 2002* [MOE, 2002].

Maximum Contaminant Levels (MCLs):
Maximum Contaminant Levels, used by the United States Environmental Protection Agency (USEPA), are legally enforceable standards that apply to public water systems. They protect drinking water quality by limiting the levels of specific contaminants that can adversely affect public health and are known or anticipated to occur in water [USEPA, 1996].

Maximum Contaminant Level Goals (MCLGs):
Maximum Contaminant Level Goals, used by the United States Environmental Protection Agency (USEPA), are set after reviewing health effects studies, at the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur, and which allows an adequate margin of safety. MCLGs are non-enforceable public health goals. Since MCLGs consider only public health and not the limits of detection and treatment technology, sometimes they are set at a level which water systems cannot meet. When determining an MCLG, the United States EPA considers the risk to sensitive sub-populations (infants, children, the elderly, and those with compromised immune systems) of experiencing a variety of adverse health effects.

If there is evidence that a chemical does or may cause cancer, and there is no dose below which the chemical is considered safe, the MCLG is set at zero. If a chemical is carcinogenic and a safe dose can be determined, the MCLG is set at a level above zero that is safe [USEPA, 1996].

Public Health Goals (PHGs):
Public Health Goals, used by the California Environmental Protection Agency (CALEPA) for example, are developed for chemical contaminants, based on the best available toxicological data in the scientific literature, and are set, with an adequate margin of safety, at levels that would pose no significant health risk to individuals consuming the water on a daily basis over a lifetime. PHGs are not regulatory and represent only non-mandatory goals. They are, however, used to establish primary drinking water standards (State Maximum Contaminant Levels, or MCLs), which consider economic factors and technical feasibility. Each primary drinking water standard is set at a level that is as close as feasible to the corresponding PHG, placing emphasis on the protection of public health [CALEPA, 2006].

Screening Values:
Screening Values, used by the European Union for example, are used as an indicator of the presence of other, potentially more harmful radionuclides in drinking water. For instance, if tritium levels exceed 100 Bq/L, or the Total Indicative Dose (TID) exceeds 0.1 mSv/year, then further investigation is warranted and action may be required, even though these criteria are not considered limits.

6.0 Impacts and Cost implications

An economic study prepared by the Ministry of Environment and Energy (MOEE) in 1994 concluded that there could be significant cost implications to Ontario Hydro if the tritium drinking water objective were to be made more stringent [MOEE, 1994]. The report noted that if an annual average was used at levels of 7,000 Bq/L or 100 Bq/L, no additional costs would be expected, however, if an annual average of 20 Bq/L was considered the costs would be in the order of $500 million to billions of dollars. If weekly averages were considered, the cost for a level of 100 Bq/L would be in the order of $650 million to billions of dollars, and for a discrete level of 20 Bq/L the costs would be in the billions of dollars.

As noted in Part I, Section 1.0, Ontario Hydro, in a letter to the Ministry of the Environment dated December 9, 1994 agreed that "concentrations of tritium in drinking water will remain less than 100 Bq/L on average". There was no indication that this would require additional costs *(Also See Appendix 4).*

More recently, as a result of the Council's public consultation on tritium, the Canadian Nuclear Association (CNA) wrote to the Council *(See Appendix 5)* noting that "nuclear power plants already achieve 20 Bq/L at water supply plants, based on an annual average, but that short term control at this level would require the adoption of significant additional technologies with significant cost implications". They also noted that if the tritium standard was revised then "this would require lowering all radionuclide limits for drinking water, and it would imply that all emission limits from nuclear power plants, both to air and water should be lowered by a similar amount…. This would have significant cost implications." If OPG were required to do daily analysis this would result in an annualized incremental cost of $1.1 million per year, for analysis only.

The Medical Officer of Health for the City of Toronto also wrote to the Council on July 28, 2008 *(See Appendix 6)*. He noted that OPG had informed Toronto Public Health that daily analysis would require substantial increases in both capital and operating costs. It was recognized that the real issue is chronic (long-term) exposure to tritium and that weekly analysis, as currently performed, would be appropriate. He recommended immediate notification of drinking water levels that exceeded 20 Bq/L, based on analysis of weekly composites, routine monthly reports of weekly composite results along with a running annual average and immediate notification of accidental releases of tritium from nuclear facilities.

The Council received no other additional information concerning costs implications of a more stringent Standard.

7.0 Stakeholder and Experts Meetings

Over the course of its review, the Council's Tritium Working Group met with knowledgeable individuals, groups, and stakeholders to inform the whole Council regarding the issues surrounding an Ontario Drinking Water Quality Standard for tritium. Meetings were held with the following:

- Ontario Power Generation (OPG)
- Bruce Power
- Canadian Nuclear Safety Commission (CNSC)
- Atomic Energy of Canada Limited (AECL)
- Radiation Protection Bureau, Health Canada (HC)
- Former Chair of the Ontario Advisory Committee on Environmental Standards (ACES)
- Former Ministry of the Environment (MOE) drinking water experts
- Greenpeace Canada
- Author of the Greenpeace Canada Report [Greenpeace, 2007]
- Toronto Public Health
- Toronto Cancer Prevention Coalition, Occupational and Environmental Carcinogens Working Group
- Ministry of Labour (MOL), Radiation Protection Monitoring Service (RPMS)

Documentation provided to the Council as a result of the above meetings has been included in both the References and Appendices.

8.0 Public Consultation

On March 26 and 27, 2008, the Council held a two-day public consultation meeting on Ontario's Drinking Water Quality Standard (ODWQS) for tritium. The purpose of the meeting was to obtain input from a broad spectrum of interested community groups and stakeholders. Consultation participants were asked for their feedback on the following three questions, as well as any other feedback they had on the ODWQS for tritium:

- Is the current Ontario Drinking Water Quality Standard for tritium acceptable?
- If not, what is the basis for finding the current Standard unacceptable?
- If you propose a different Standard, what is your rationale?

Information on the consultation has been posted on the Council's website at:

http://www.odwac.gov.on.ca/standards_review/tritium/tritium_consultation.htm

A total of 65 individuals and organizations participated in the consultation, either by presenting to the Council, submitting written comments, or both. Participants included:

- 19 individuals;
- 11 community-based groups;
- 8 health organizations (6 health non-governmental organizations and 2 professional health associations);
- 6 environmental non-governmental organizations;
- 5 industry/consulting organizations;
- 4 municipalities;
- 3 non-governmental organizations;
- 2 universities;
- 1 federal government representative; and
- 1 labour organization.

In addition, the Council received over 500 e-mails and letters from individual members of the public.

Results from the public consultation have been incorporated along with the input received from individuals, and other stakeholders to inform the Council's advice to the Minister of the Environment on the Ontario Drinking Water Quality Standard for tritium. Some of the observations, concerns, and recommendations are summarized below:

<u>Summary of rationale by those in favour of the current Standard:</u>

- Concern for implications on other radionuclide guidelines and standards;
- There is no new information that warrants a change to the current Standard;
- The methodology for assessing risk and dose for tritium and other radionuclides is internationally accepted, sufficient and prudent;
- The risk of fatal and non-fatal cancers from exposure to radionuclides in drinking water of 0.1 mSv/year is negligible (6×10^{-4} over a lifetime);
- Making the Standard more stringent would depart from international guidance and advice from organizations such as the International Commission on Radiation Protection (ICRP) and the World Health Organization (WHO); and
- Changing the Standard would create the false impression with the public that there is now a higher risk from tritium in drinking water.

Summary of rationale by those in favour of a more stringent Standard:

- There is no safe dose of or level to exposure of radiation, and even the smallest doses (e.g., background) can cause cancer and other heath effects. Tritium can also promote and accelerate cancer;
- Women are more vulnerable to tritium and are affected differently than men, particularly with respect to their reproductive systems;
- Rapidly growing cells such as fetal tissue and young girls' developing breasts, genetic materials and blood forming organs are especially sensitive to tritium;
- Tritium can damage DNA, causing a mutagenic effect resulting in cancers, miscarriages, birth defects, sterility, and hypothyroidism, among others. The effects from exposure to tritium can harm offspring and last for generations;
- Female human infants are at risk from elevated tritium levels due to genetic damage to ova exposed to tritiated hydrogen;
- Certain groups are especially vulnerable to environmental carcinogens, such as women (especially when pregnant), the unborn, and the elderly, those with compromised immune systems, children, teenagers and Aboriginal people;
- How risk and dose measurements are calculated, particularly in that the current models use the "standard man", which may not reflect dosages experienced by women and children;
- Exposure studies based on animal testing are not accurate because of the lower body fat levels found in animals;
- Many of the non-lethal cancer effects of tritium are not currently considered in the model upon which the current Standard is based on. These effects include non-fatal cancers, miscarriages, still births, birth defects, sterility, hypothyroidism, genetic mutation, respiratory failure, kidney failure, nervous system disorders, cardiovascular disease, among others;
- The current Standard does not consider organically-bound tritium, thus under-estimating the true dose;
- Cumulative exposure and combined effects are not being considered;
- The current Standard considers 340 excess fatal cancers per million as an "acceptable risk", which is equivalent to 1 in 3,000;
- Anthropogenic emissions of tritium directly impact the drinking water supplies of approximately one-quarter of the Canadian population, thereby resulting in a large population being exposed involuntarily;
- Levels of tritium are 2 to 5 times higher in Lake Ontario than in other water bodies in the Great Lakes and across Canada, and Lake Ontario is a major source of drinking water for Ontarians;
- Between 1979 and 1997, there were 11 known leaks of tritium from Canadian nuclear reactors;
- Elevated concentrations of tritium are also reported to have been found in food and well water samples in the proximity of nuclear reactors in Southern Ontario;
- The risk of exposure to tritium is higher due to the facilities proximity and their use of deuterium;

- Concern that Canada's current Guideline for tritium in drinking water (which is the same as Ontario's Standard) is unacceptable because it is high compared to other jurisdictions; and
- It was felt that the precautionary approach was not being applied with respect to tritium in drinking water and that because there is still uncertainty over the impacts of tritium (such as synergistic effects with other substances), then the precautionary principle should be applied and the Standard should be lowered.

For more details, reference should be made to the report: "Ontario Drinking Water Advisory Council: Public Consultation on the Ontario Drinking Water Quality Standard for Tritium" *(See Appendix 7)*.

Part II

1.0 Conclusions

Part I of this report summarizes the work the Council undertook to become informed on matters related to tritium in drinking water. Throughout the process of collecting information and researching and receiving information and advice from experts, stakeholders and the concerned public, Council members met regularly to critically discuss and assess the information.

Through this review process, the Council arrived at a series of specific inferences which contributed to and assisted in reaching consensus on conclusions about the nature of tritium, and its regulation in drinking water. These key conclusions are as follows:

1.1 Background and Sources

There is a natural background level of tritium in water in Ontario, which is generally less than 2 Bq/L. Tritium is naturally formed in the upper atmosphere by cosmic rays, and enters surface water and groundwater via rainfall. Tritium was also produced during above-ground nuclear weapons explosions, and is currently produced as a by-product of nuclear reactors which use deuterium or “heavy water”.

The primary man-made source of tritium and subsequently tritium in drinking water is discharges from nuclear facilities. The nuclear industry has a well established program to manage, control and limit tritium discharges under the regulation of the CNSC.

Over the last decade monitoring data from drinking water plants indicate that annual average tritium levels are well below 100 Bq/L, and in fact, in most cases, below 20 Bq/L.

There is no treatment technology available to remove tritium at drinking water treatment plants. The only approach to lower tritium levels in drinking water is to avoid contamination of the source water.

The Council noted that Ontario’s nuclear power plants apply the concept of As Low As Reasonably Achievable (ALARA) to reduce tritium discharges to levels below their regulated discharge limits and, as a result, they can achieve their commitment to keep tritium levels below 100 Bq/L at local drinking water treatment plants.

Ontario's approach to industrial discharges to water under the Municipal-Industrial Strategy for Abatement (MISA) program is to apply Best Available Technology Economically Achievable (BATEA) before assigning a discharge limit. Both these approaches reflect the Precautionary Principle; however ALARA leaves the discretion with the industry. The Council prefers the province's BATEA approach for regulating discharges to the environment and subsequently to sources of drinking water, due to its application prior to setting discharge limits.

1.2 Health Risks

The Council agrees with the conclusions of the BEIR VII report that there is linear dose-response relationship and no threshold for the induction of cancers by radionuclides [BEIR, 2006]. However, it is also acknowledged that at levels below the range where there are measured data, there is a high degree of uncertainty as to the shape of the dose-response curve.

The measures for risk should be based on cancer incidences above background (occurrences) rather than mortality (deaths).

The Council concludes that the target derived risk level should be 1 in a million or 10^{-6} (meaning 1 new excess cancer occurrence over existing background cancer rates in 1,000,000 people).

The Council also concludes that the target derived risk level should be based on a lifetime of exposure of 70 years, since this incremental risk better reflects the realities of chronic or long-term exposure to tritium in drinking water than does an annual exposure.

The target derived risk level of 1 new excess cancer occurrence over existing background cancer rates in 1,000,000 people, based on a lifetime of exposure of 70 years, is consistent with the approach used for non-threshold chemical carcinogens, but there may be practical reasons for accepting or adopting a different level of risk, such as technology, economic, and time issues.

The Council agrees that a Relative Biological Effectiveness (RBE) factor of at least 2 should be used, where appropriate, in deriving exposure limits for tritium.

The research literature and specialists in the field have made extensive references to the time tritium remains in the human body, once exposed to tritium in drinking water (referred to as the biological half-life). The Council concludes that when intake is constant, as is the case in drinking water, tritium levels in the human body will reach an equilibrium value related to the tritium level in the drinking water. This important distinction is in contrast to occupational exposures, which may vary or may exceed annual limits in shorter periods of time, thus accounting for the need to amortize the doses (exposures) on a yearly basis.

1.3 Monitoring and Reporting

From the perspective of monitoring and reporting, sampling should only be required at drinking water treatment plants that are in the vicinity of or under the influence of known or suspected sources of tritium. A province-wide sampling program by municipal water authorities is not required nor warranted.

The Ministry of Labour (MOL) should continue to conduct the water sample testing under their Nuclear Reactor Surveillance Program, and water treatment plant operators should continue to collect the samples for analysis. Sampling and reporting should be done per the current MOL practices, as these methods and procedures remain appropriate.

The Ministry of the Environment's Drinking Water Surveillance Program (DWSP) is an excellent approach for broader province-wide monitoring, aimed at assessing levels and trends, including radiological characteristics, and should continue.

The nuclear power industry should also continue with their current monitoring program in conjunction with local municipalities and drinking water authorities.

It is recognized that there are sources of tritium other than from nuclear power plants. High levels of tritium were recently found in private wells in the vicinity of an industrial operation which used tritium. Monitoring requirements should apply to water treatment plants near these other sources and regulations should be flexible enough to permit the inclusion of other locations if new sources are identified.

It was also noted that samples can be taken at any convenient location in the drinking water treatment plant, since the concentration of tritium in the water will not be changed by any of the plant's treatment processes.

All tritium data and information should be made available by the nuclear power industry and the Ministry of Labour, to the public, the Ministry of the Environment, and local public health offices, as soon as practicably possible.

1.4 Cost Issues

The nuclear power industry and its association, the CNA, have expressed a concern that if the Ontario Drinking Water Quality Standard for tritium is derived by applying a different paradigm or approach than which is currently used by the radiological sector, then a revision to their approach for the application of other regulatory requirements for other radionuclides would also be required, resulting in "significant cost implications" *(See Appendix 5)*. The Council disagrees that the principles used in the development of an Ontario Drinking Water Quality Standard for tritium should guide occupational or other standards.

Tritium is the main radionuclide found in drinking water in Ontario and represents an on-going, active source of radioactivity above background levels, resulting in lifetime exposure to large populations. There is also the potential for large populations to be exposed to acute levels. Thus, the approach taken for regulating tritium in drinking water should not imply that it is appropriate for other radiologically-regulated activities or radionuclides.

1.5 Corrective Actions

It should be stressed that the proposed Standard for tritium in drinking water is based on long-term exposure and potential health implications. As such, short-term exposure to drinking water that moderately exceeds the Standard should not trigger inappropriate responses by government agencies or the public. Such exceedances should be used to set in motion a series of corrective actions to be taken by the discharger of the tritium to the environment. Water utilities and provincial agencies should be monitoring the trends of reported test results and should seek corrective actions if the trends indicate that levels are increasing and that the Standard may be exceeded if action is not taken.

Urgent actions to protect the public from more immediate exposure to tritium should be based on monitoring sources of tritium at the point of discharge. Water treatment plants cannot remove or treat for tritium in the source water, so the only response may be to shut down the water intake and rely on storage or use alternate sources of drinking water, during emergency situations. This can only be done in an effective manner if information on source discharges and models that predict the potential for that discharge, and expected tritium levels at water treatment plants, are in place. Short-term or urgent actions to protect neighbouring communities should be based on on-going monitoring and reporting from the sources of tritium and not based on sampling and reporting by drinking water treatment plants.

2.0 Developing the Standard

In Ontario, a drinking water Standard must be acceptable or "safe" to allow that water to be consumed each day over a lifetime of 70 years at the Standard. Recommendation 18 of the Part Two Report of the Walkerton Inquiry states that "In setting drinking water quality standards, the objective should be such that, if the standards are met, a reasonable and informed person would feel safe drinking the water" [Walkerton, 2002].

The technical challenge is how to best utilize the available radiological research and information to arrive at a risk as close to 1 in a million (10^{-6}) as possible, while maintaining practicability and achievability.

In an effort to arrive at a proposed Standard, the Council evaluated several numerical variations that use the models of other jurisdictions and authorities and revised them to reflect the earlier conclusions. These variations are not independent, as they are derived using initial criteria used by Health Canada and other jurisdictions, and the ICRP. The purpose of examining these variations (*found below in Section 2.1*) is to test how the Council's earlier stated conclusions would result in differing outcomes.

2.1 Numerical Variations

Lifetime Risk from a Lifetime of Exposure Variation

- Start with *unrounded* Ontario Drinking Water Quality Standard for tritium of 7,610 Bq/L
- Divide by 70 years to represent a lifetime of exposure
- ≈ 109 Bq/L

Lifetime Risk from a Lifetime of Exposure + RBE Variation

- Start with *unrounded* Ontario Drinking Water Quality Standard for tritium of 7,610 Bq/L
- Divide by 70 years exposure to represent a lifetime of exposure
- Apply a Relative Biological Effectiveness for tritium of 2
- ≈ 54 Bq/L

Risk of 10^{-6} Variation 1

- Start with 0.1 mSv/year which is approximately equal to 7,000 Bq/L
- Apply Nominal Probability Coefficient for fatal cancer induction of 5.0×10^{-2} Sv^{-1} [ICRP, 1991]
- Multiply by 70 years to represent a lifetime
- 5.0×10^{-2} Sv^{-1} x 0.1 mSv/year x 70 years = approximately 3.4×10^{-4} incremental lifetime risk over a lifetime of exposure
- Convert to a risk of 10^{-6} (7,000 Bq/L x 10^{-6})/3.4×10^{-4}
- ≈ 20 Bq/L

Risk of 10^{-6} Variation 2

- Start with the risk of fatal and weighted non-fatal conditions at a lifetime exposure of 0.1 mSv/year of between 10^{-5} and 10^{-6}, which is approximately equal to 6×10^{-4} over a lifetime [Health Canada, 1995b]
- Multiply by 70 years to represent a lifetime
- Convert to a risk of 10^{-6} (7,000 Bq/L x 10^{-6})/6×10^{-4}
- ≈ 12 Bq/L

Risk of 10^{-6} Variation 3

- Start with the Nominal Probability Coefficient for fatal cancer induction of 5.0×10^{-2} Sv^{-1} [ICRP, 1991]
- The amount of Sv to result in a risk of 10^{-6} is $10^{-6}/5\times10^{-2} = 2\times10^{-5}$Sv
- The number of Bq that will result in a dose of 2×10^{-5}Sv is 2×10^{-5}Sv/ 1.8×10^{-11} Sv/Bq [WHO, 2004] which is = 1.1×10^{6} Bq
- Multiply 730 L per year by 70 to arrive total lifetime water consumption = 51,100 L
- Calculate amount of tritium that could be present in drinking water: 1.1×10^{6} Bq / 51,100 L
- ≈ 22 Bq/L

Chemical Carcinogen Variation

- Start with a chemical carcinogen model, using the Nominal Probability Coefficient for fatal cancer, non-fatal cancer, and severe hereditary effects induction of 7.3×10^{-2} Sv^{-1} [ICRP, 1991]
- 0.1 mSv/year = a risk of approximately 7.3×10^{-6}/year
- 0.0137 mSv/year = a risk of approximately 1×10^{-6}/year
- 0.0137 mSv/70 years = a risk of approximately 1.96×10^{-4} mSv/year
- Use 1.96×10^{-4} mSv/year as numerator in MAC Calculation (instead of 0.1 mSv/year)
- ≈ 15 Bq/L
- ≈ 7.5 Bq/L *(if Relative Biological Effectiveness for tritium of 2 applied)*

Risk Assessment Information System Variation

- Start with the Risk Assessment Information System Cancer Risk Value (Potency) for tritium of 5.07×10^{-14}/pCi [USEPA, 2001b]
- (5.07×10^{-14}/pCi) x (pCi/0.037 Bq) *(1 pCi = 0.037 Bq)*
- (1.37×10^{-12}/Bq) x (3.58×10^{8} Bq over 70 years)
- 4.9×10^{4} risk at 7,000 Bq/L
- Convert to 1×10^{-6} risk
- ≈ 14 Bq/L
- ≈7 Bq/L *(if Relative Biological Effectiveness for tritium of 2 applied)*

These variations result in a range for a possible Standard of approximately 7 Bq/L to 109 Bq/L. The Council, therefore, concludes that the appropriate proposed Standard is within the range of the variations, since the range fell within a circa 10^{-6} risk.

The Council also concludes that these variations, based on current science and risk assessment practices, will not lead to consensus on a single number.

2.2 Reaching Consensus on a Numerical Standard

Since the Council could not unequivocally select one variation over another, given that the uncertainties in the scientific methods do not confirm any one particular value over another from within the range, the following question was considered:

> *Taking into account all the research and documentation, meeting with experts, stakeholders, and the general public, and Council deliberations, is there a tritium Standard (value or level) that a reasonable and informed person would feel safe drinking the water every day over a lifetime of 70 years at or below that Standard?*

To answer this question, the Council went back to address some of the basic principles or criteria used by Health Canada for setting Canadian Drinking Water Quality Guidelines for non-threshold chemical carcinogens. This would mean that the maximum acceptable concentration should be established at a level which represents an estimated lifetime (70 years) risk of cancer falling within the range that is considered to be "essentially negligible" or as close to "essentially negligible" as reasonably practicable. "Essentially negligible" risk is generally interpreted by most world-wide regulatory bodies, including Health Canada, as a range of risk of between 10^{-5} and 10^{-6}.

However, the Council concluded that the target derived risk level for tritium in drinking water in Ontario should be 1 in a million or 10^{-6}.

In addition, for carcinogens whose guideline levels have been established at a level above the health-based value (due to for example limitations in analytical and treatment technologies), Health Canada recommends the As Low As Reasonably Achievable (ALARA) principle [Health Canada, 1995b].

Using the variations outlined above in Section 2.1, the Council demonstrated that the concentration of tritium for a risk of 10^{-6} is somewhere between 7 Bq/L and 109 Bq/L. The next step is to determine what limit would be "reasonably practicable". To address this, we turned to two documents received by the Council as part of consultation process:

- The Canadian Nuclear Association noted in a letter to the Council that 20 Bq/L on an annual average basis is achievable in drinking water, without significant cost to the industry *(See Appendix 5).*

- The Toronto Medical Officer of Health noted in a letter to the Council that the concern with tritium is chronic exposure, and that an annual average of 20 Bq/L would not be exceeded if Ontario Power Generation did not exceed its current discharge limit of 4,000 Bq/L *(at either Pickering or Darlington Nuclear Power Generating Stations) (See Appendix 6).*

Based on these two documents, the Council concluded that an Ontario Drinking Water Quality Standard for tritium of 20 Bq/L, applied as a running annual average, would meet the requirements for an appropriate level of risk and public safety, while remaining practicable and achievable by the nuclear power industry.

The current data support this conclusion, in that all of Ontario's nuclear power generators are currently capable of controlling their liquid tritium discharges, to the extent that local water treatment plants should be able to meet the new Standard. The Council expects that this high level of industry performance will continue and improve.

The Council further noted that, in applying a test of practicability to this proposed Ontario Drinking Water Quality Standard for tritium, it should not be necessary for the nuclear power industry to alter any of the applicable regulations for occupational or other radiological criteria.

The Council's approach is unique to the lifetime commitment of exposure to tritium from drinking water in Ontario, in that there are multiple, on-going sources capable of exposing large populations of people in some communities, to levels above background.

It should be noted, however, that the current level of risk for exposure to tritium in drinking water and potential health implications will not change with a more stringent Standard. That is to say, there would be no elevated risk to exposed populations as a result of a more stringent Standard. A more stringent Standard, however, will help to predict future risk by finding problems more quickly through surveillance and increased frequency of sample result reporting.

3.0 Recommendations

1. The Ontario Drinking Water Quality Standard for tritium should be revised to 20 Bq/L, recognizing that:

   - 20 Bq/L relates to heath effects from long-term, chronic exposure from drinking water over a life time of exposure of 70 years;

   - 20 Bq/L is within the range of the variations considered by the Council (7 Bq/L to 109 Bq/L), for a 10^{-6} risk level; and

   - 20 Bq/L, based on an annual average, is achievable in drinking water, without significant cost to the nuclear power industry, according to the Canadian Nuclear Association.

2. The Standard of 20 Bq/L should be applied as the running average of the preceding 52 weekly composite samples. This running annual average is consistent with the current weekly sampling and reporting programs, and should also be used to generate monthly averages and identify trends.

3. The current sampling and monitoring programs, as conducted by the Ministry of Labour and the industry, are appropriate, and should continue. Sampling and reporting should only be required for those drinking water treatment plants that are in proximity of or under the influence of sources of tritium. As well, the Ministry of the Environment should continue to monitor tritium at drinking water systems as part of the Drinking Water Surveillance Program (DWSP).

4. Monthly reports of weekly test results and running annual averages should be sent to regulatory bodies, local municipalities and health units, local public interest groups, and should also be made available to the general public.

5. It is equally important to monitor trends in the monthly data and if there is an indication of increases (even if they are below the Standard), the province should require the discharger to take appropriate corrective actions, in collaboration with other appropriate authorities.

6. Monitoring and reporting at the point of discharge should be the focus for emergency response in that monitoring at drinking water treatment plants is not an appropriate approach for alerting authorities and the public of significant and / or elevated discharges of tritium. The current program should be enhanced to require the dischargers to report monthly to regulatory authorities and other public bodies on the levels of tritium discharges and immediately in each case where discharges exceed designated notification level(s).

Acronyms

ACES	Advisory Committee on Environmental Standards
AECL	Atomic Energy of Canada Limited
AECB	Atomic Energy Control Board
AGIR	Advisory Group on Ionising Radiation
ALARA	as low as reasonable achievable
BATEA	best available technology economically achievable
BEIR	Biological Effects of Ionizing Radiation
Bq	becquerel
Bq/L	becquerel per litre
CALEPA	California Environmental Protection Agency
CANDU	Canadian Deuterium Uranium class of fission reactor
CDWQG	Canadian Drinking Water Quality Guideline
CERRIE	Committee Examining Radiation Risks of Internal Emitters
CNA	Canadian Nuclear Association
CNSC	Canadian Nuclear Safety Commission
DC	dose coefficient
DNA	deoxyribonucleic acid
DRL	derived release limit
DWSP	Drinking Water Surveillance Network
EMO	Emergency Measures Ontario
HC	Health Canada
HT	tritium gas
HTO	tritiated water
ICRP	International Commission on Radiological Protection
IJC	International Joint Commission
L	litre
MAC	maximum acceptable concentration
MBq	megabecquerel
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MDC	minimum detectable concentration
MOE	Ministry of the Environment
MOEE	Ministry of Environment and Energy
MoH	Medical Officer of Health
MOHLTC	Ministry of Health and Long-Term Care
MOL	Ministry of Labour
MISA	Municipal Industrial Strategy for Abatement
mSv	millisievert
NAS	National Academy of Sciences
NRC	National Research Council
ODWAC	Ontario Drinking Water Advisory Council

ODWO	Ontario Drinking Water Objective
ODWQS	Ontario Drinking Water Quality Standard
OBT	organically bound tritium
OPG	Ontario Power Generation
PHG	public health goal
RBE	relative biological effectiveness
RPMS	Radiation Protection Monitoring Service
TBq	terabecquerel
TID	total indicative dose
USEPA	United States Environmental Protection Agency
WHO	World Health Organization

References

ACES, 1994. Ontario Advisory Committee on Environmental Standards. A Standard for Tritium: A recommendation to the Minister of the Environment and Energy. Report 94-01. Ontario, Canada.
http://www.odwac.gov.on.ca/standards_review/tritium/1994_ACES_Report_Tritium.pdf

AECL, 2007. Atomic Energy of Canada Limited. Annual Performance Report. AECL Annual Environmental Performance Report for 2006. CW-509241-REPT-003 Revision 0. December, 2007. Mississauga, Ontario.
http://www.aecl.ca/Assets/Publications/Reports/CW-509241-REPT-003.pdf

AGIR, 2007. Advisory Group on Ionising Radiation. Review of Risks from Tritium. Report of the independent Advisory Group on Ionising Radiation (RCE-4), on behalf of the Health Protection Agency. United Kingdom.
http://www.hpa.org.uk/webw/HPAweb&HPAwebStandard/HPAweb_C/1197382220012?p=1199451989432

BEIR, 2006. Advisory Committee on the Biological Effects of Ionizing Radiation. Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII – Phase 2. Board on Radiation Effects Research, Division of Earth and Life Studies, National Research Council of the National Academies, The National Academies Press, Washington, D.C.
http://www.nap.edu/catalog.php?record_id=11340

Bruce Power, 1996. Notification/Action Protocols for Abnormal Releases at BNPD. B-CORR-00548-0002. March 4, 1996.
http://www.odwac.gov.on.ca/standards_review/tritium/BNPD_Tritium_Release_Protocol_1996.pdf

Bruce Power, 2008a. Annual Summary & Assessment of Environmental Radiological Data for 2007. B-REP-03419-00008 R000. April 23, 2008. Ontario, Canada.
http://www.brucepower.com/uc/GetDocument.aspx?docid=2608

Bruce Power, 2008b. Bruce Power's Derived Release Limits and Environmental Action Levels.
http://www.odwac.gov.on.ca/standards_review/tritium/Bruce_B_DRL.pdf

CALEPA, 2006. California Environmental Protection Agency. Public Health Goals for Chemicals in Drinking Water: Tritium.
http://oehha.ca.gov/water/phg/pdf/PHGtritium030306.pdf

CERRIE, 2004. Report of the Committee Examining Radiation Risks of Internal Emitters. October 2004. London, England.
http://www.cerrie.org/pdfs/cerrie_report_e-book.pdf

CNSC, 2008a. Canadian Nuclear Safety Commission. Standards and Guidelines for Tritium in Drinking Water. INFO-0766. January, 2008. Ottawa, Canada.
http://www.nuclearsafety.gc.ca/eng/readingroom/healthstudies/tritium/

CNSC, 2008b. Canadian Nuclear Safety Commission. Draft Tritium Workshop Report. January, 2008. Ottawa, Canada.
http://www.nuclearsafety.gc.ca/eng/getinvolved/sessionworkshop/past/workshop_20080118/Wkshop_2008018_summary.cfm

Fairlie, 2007. Dr. Ian Fairlie. RBE and WR values of Auger emitters and low-range beta emitters with particular reference to tritium. Ian Fairlie. Journal of Radiological Protection 27 (2007) 157-168.
http://www.iop.org/EJ/article/0952-4746/27/2/003/jrp7_2_003.pdf

Fairlie, 2008. Dr. Ian Fairlie. Radiation Risks of Tritium: Additional Note for ODWAC. January 31, 2008. London, England.
http://www.odwac.gov.on.ca/standards_review/tritium/Tritium_Radiation_Risks_Additional_Note_for_ODWAC_Fairlie.pdf

Graham, 1993. John D. Graham. The Legacy of one in a million. Harvard Center for Risk Analysis. Risk in Perspective. March 1993. Volume 1, Number 1.
http://www.hcra.harvard.edu/rip/rip_Mar_1993.pdf

Greenpeace, 2007. Greenpeace Canada. Tritium Hazards Report: Pollution and Radiation Risks from Canadian Nuclear Facilities. June, 2007. Authored by Dr. Ian Fairlie. London, England.
http://www.greenpeace.org/raw/content/canada/en/documents-and-links/publications/tritium-hazard-report-pollu.pdf

Health Canada, 1994. Human Health Risk Assessment for Priority Substances (approach used under the *Canadian Environmental Protection Act*). 1994. ISBN 0-662-22126-5. Ottawa, Canada.
http://www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/approach/index-eng.php

Health Canada, 1995a. Radiological characteristics. February, 1995. Edited April, 1995. Health Canada, Ottawa, Canada.
http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/radiological_characteristics/index-eng.php

Health Canada, 1995b. Part I. Approach to the Derivation of Drinking Water Guidelines. February, 1995. Health Canada, Ottawa, Canada.
www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/part_i-partie_i/index-eng.php

Health Canada/AECB/MOEE, 1998. Health Canada, Atomic Energy Control Board, and Ontario Ministry of Environment and Energy Joint Working Group. Assessment and Management of Cancer Risks from Radiological and Chemical Hazards. Ontario, Canada. http://www.hc-sc.gc.ca/ewh-semt/pubs/radiation/98ehd-dhm216/index-eng.php

Health Canada, 2006. Radiological characteristics of Drinking Water. July, 2006. Document for Public Comment. Health Canada, Ottawa, Canada. http://www.odwac.gov.on.ca/standards_review/tritium/2006_HC_Radiologicals_Public_Comment_Document.pdf

Health Canada, 2008. Guidelines for Canadian Drinking Water Quality Summary Table. May, 2008. Health Canada. Ottawa, Canada. http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/sum_guide-res_recom/index-eng.php

HPA, 2007. Health Protection Agency. Comparison of Processes and Procedures for Deriving Exposure Criteria for the Protection of Human Health: Chemicals, Ionising Radiation and Non-ionising Radiation (RCE-3). J R Cooper, R Fielder, R Jefferson, J R Meara, K R Smith and J W Stather. July, 2007. United Kingdom. http://www.hpa.org.uk/webw/HPAweb&HPAwebStandard/HPAweb_C/1200055665320?p=1199451989432

ICRP, 1991. International Commission on Radiological Protection. 1990 Recommendations of the International Commission on Radiological Protection. Annals of the ICRP, 21(1.3). Oxford, Pergamon Press (Publication 60). http://www.elsevier.com/wps/find/bookdescription.cws_home/29083/description#description

ICRP, 2003. International Commission on Radiological Protection. International Commission on Radiological Protection: History, Policies, Procedures. Bo Lindell, H John Dunster, and Jack Valentin. 2003. Stockholm, Sweden. http://www.icrp.org/prod03.asp

ICRP, 2006. International Commission on Radiological Protection. ICRP Supporting Guidance 5. Analysis of the Criteria Used by the International Commission on Radiological Protection to justify the Setting of Numerical Protection Level Values. Annals of the ICRP, Vol. 36 No. 4. Published by Elsevier. http://www.elsevier.com/wps/find/bookdescription.cws_home/711542/description#description

ICRP, 2007. International Commission on Radiological Protection. ICRP Publication 103: Recommendations of the International Commission on Radiological Protection. Annals of the ICRP, Volume 37, Nos. 2-4, 2007. Published by Elsevier. http://www.elsevier.com/wps/find/bookdescription.cws_home/713998/description#description

IJC, 1994. International Joint Commission. Seventh Biennial Report Under the Great Lakes Water Quality Agreement of 1978.
http://www.ijc.org/php/publications/html/7bre.html

JRP, 2008. Journal of Radiological Protection. Internal dosimetry and tritium – the ICRP position. Roger Cox et al 2008. J. Radiol. Prot. 28 131-135. doi: 10.1088/0952-4746/28/2/E02J.
http://www.iop.org/EJ/abstract/0952-4746/28/2/E02

Kelly, 1991. Kathryn Kelly. The Myth of 10^{-6} as a Definition of Acceptable Risk. Kathryn Kelly, Delta Toxicology, Inc.
http://www.heartland.org/custom/semod_policybot/pdf/17603.pdf

Little/Lambert, 2007. M. P. Little and B. E. Lambert. Systematic review of experimental studies on the relative biological effectiveness of tritium. M. P. Little and B. E. Lambert, Radiation Environmental Biophysics (2007) 47:71-93
http://www.springerlink.com/content/262x706282774807/fulltext.pdf

McMullan, Eyles, 1999. Risky Business: An Analysis of Claimsmaking in the Development of an Ontario Drinking Water Objective for Tritium. Published by the University of California Press for the Society for the Study of Social Problems, Vol. 46, No. 2 (May, 1999) pages 294-311, Colin McMullin, John Eyles.
http://www.jstor.org/stable/3097257

MOE, 2002. Ontario Ministry of the Environment. Safe Drinking Water Act, 2002.
http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_02s32_e.htm

MOE, 2003. Ontario Ministry of the Environment. Ontario Regulation 169/03. Ontario Drinking Water Quality Standards. (As amended to O. Reg. 327/08).
http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_030169_e.htm

MOE, 2005. Ministry of the Environment. Guideline for the Implementation of Air Standards in Ontario. July, 2005. PIBS # 5166e.
http://www.ene.gov.on.ca/envision/gp//5166e.pdf

MOEE, 1993. Ontario Ministry of Environment and Energy. Rationale Document for the Development of an Interim Ontario Drinking Water Objective for Tritium. November, 1993. Standards Development Branch.
http://www.odwac.gov.on.ca/standards_review/tritium/1993_MOEE_Rationale_Doc_Tritium.pdf

MOEE, 1994. Ontario Ministry of Environment and Energy. Economic Consequences of an ODWO for Tritium. Economic Services Branch. December, 1994. Ontario, Canada. http://www.odwac.gov.on.ca/standards_review/tritium/1994_Economic_Consequences_of_an_ODWO_for_Tritium.pdf

MOL, 2008. Ontario Ministry of Labour. Radiation Protection Monitoring Service. Nuclear Reactor Surveillance Program 2007 Report to the Radiation Monitoring Working Group. October 31, 2008. Ontario, Canada. http://www.odwac.gov.on.ca/standards_review/tritium/MOL_RPS_Annual_Report_2007.pdf

OPG, 2007. Ontario Power Generation. Attachment to email of August 10, 2007, I. Benovich to S. Barrett, "Types and Levels of 'Spills' " http://www.odwac.gov.on.ca/standards_review/tritium/OPG_Types_and_Levels_of_Spills.pdf

OPG, 2008. Ontario Power Generation. 2007 Results of Radiological Environmental Monitoring Programs. N-REP-03481-10006-R000. April 23, 2008. Ontario, Canada. http://www.ontariopowergeneration.com/pdf/Nuclear%20Reports%20and%20Publications/2007%20Radiological%20Environmental%20Monitoring%20Program%20(REMP)%20Report.pdf

OPG/Bruce Power, 2006. Ontario Power Generation / Bruce Power. Coordination of the Response to a Liquid Emission at OPG and Bruce Power. http://www.odwac.gov.on.ca/standards_review/tritium/OPG_BRUCE_Liquid_Emission_Response_Procedure.pdf

Osborne, 2002a. R. V. Osborne, 2002. Tritium in the Canadian Environment: Levels and Health Effects. RSP-0153-1. Prepared for the Canadian Nuclear Association. March 22, 2002. Ranasara Consultants Inc., Deep River, Ontario. http://www.odwac.gov.on.ca/standards_review/tritium/Osborne_CNSC-RSP-0153-1.pdf

Osborne, 2002b. R. V. Osborne, 2002. Tritium in the Canadian Environment: Questions and Answers. RSP-0153-2. Prepared for the Canadian Nuclear Association. June 26, 2002. Ranasara Consultants Inc., Deep River, Ontario. http://www.odwac.gov.on.ca/standards_review/tritium/Osborne_CNSC-RSP-0153-2.pdf

Osborne, 2007. R. V. Osborne, 2007. Review of the Greenpeace report: "Tritium Hazard Report: Pollution and Radiation Risk from Canadian Nuclear Facilities" I. Fairlie, 2007 June. Prepared for the Canadian Nuclear Association. August 13, 2007. Ranasara Consultants Inc., Deep River, Ontario. http://www.cna.ca/english/pdf/Studies/ReviewofGreenpeacereport_Final.pdf#search="Osborne"

SRB, 2009. SRB Technologies (Canada) Inc. 2008 Annual Compliance Report. March 31, 2009. Pembroke, Ontario. http://www.betalight.com/pip/compliance-2008.pdf

Strauss, 2008. Stephen Strauss. Picture this: a new way of seeing risk. Salon: Canadian Medical Association Journal. May 20, 2008; 178 (11).
http://www.cmaj.ca/cgi/reprint/178/11/1512

UNSCEAR, 2000a. United Nations Scientific Committee on the Effects of Atomic Radiation. Sources and Effects of Ionizing Radiation. Volume I: Sources. UNSCEAR 2000 Report to the General Assembly, with Scientific Annexes (New York: United Nations).
http://www.unscear.org/unscear/en/publications/2000_1.html

UNSCEAR, 2000b. United Nations Scientific Committee on the Effects of Atomic Radiation. Sources and Effects of Ionizing Radiation. Volume II: Effects. UNSCEAR 2000 Report to the General Assembly, with Scientific Annexes (New York: United Nations).
http://www.unscear.org/unscear/en/publications/2000_2.html

UNSCEAR, 2001. United Nations Scientific Committee on the Effects of Atomic Radiation. Sources and Effects of Ionizing Radiation. Hereditary Effects of Radiation. UNSCEAR 2001 Report to the General Assembly, with Scientific Annex (New York: United Nations).
http://www.unscear.org/unscear/en/publications/2001.html

UNSCEAR, 2006. United Nations Scientific Committee on the Effects of Atomic Radiation. Sources and Effects of Ionizing Radiation. UNSCEAR 2006 Report Vol. I. Effects of Ionizing Radiation. UNSCEAR 2006 Report Vol. I. Report to the General Assembly, with scientific annexes A and B.
http://www.unscear.org/unscear/en/publications/2006_1.html

USEPA, 1996. United States Environmental Protection Agency. Setting Standards for Safe Drinking Water.
http://www.epa.gov/safewater/standard/setting.html

USEPA, 2000. United States Environmental Protection Agency. Radionuclides Notice of Data Availability, Technical Support Document. Prepared by: USEPA Office of Ground Water and Drinking Water in collaboration with USEPA Office of Indoor Air and Radiation United States Geological Survey. March, 2000.
http://yosemite.epa.gov/water/owrccatalog.nsf/e673c95b11602f2385256ae1007279fe/3a339e30164b47a485256d83004fd9ac!OpenDocument

USEPA, 2001a. United States Environmental Protection Agency. User's Guide: Radionuclide Carcinogenicity. 2001.
http://www.epa.gov/radiation/heast/userguid.html#intended_users

USEPA, 2001b. United States Environmental Protection Agency. Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors (Federal Guidance Report No. 13 Morbidity Risk Coefficients, in Units of Picocuries). 2001.
http://www.epa.gov/radiation/heast/docs/heast2_table_4-d2_0401.pdf

Walkerton, 2002. Part Two Report of the Walkerton Inquiry: A strategy for Safe Drinking Water. The Honourable Dennis R. O'Connor.
http://www.attorneygeneral.jus.gov.on.ca/english/about/pubs/walkerton/part2/

WHO, 2004. World Health Organisation. Guidelines for Drinking-Water Quality. Vol. 1. Third Edition. Geneva, Switzerland.
http://www.who.int/water_sanitation_health/dwq/GDWQ2004web.pdf

Appendices

1. 1st Request for ODWAC Advice from the Minister of the Environment, February 21, 2007.

2. Request for Tritium Review from Toronto Medical Officer of Health, September 27, 2006.

3. 2nd Request for ODWAC Advice from the Minister of the Environment, June 12, 2007.

4. Ontario Hydro letter to Minister Wildman, December 9, 1994.

5. Canadian Nuclear Association letter dated April 23, 2008.

6. Toronto Public Health letter dated July 28, 2008.

7. Ontario Drinking Water Advisory Council - Public Consultation on the Ontario Drinking Water Quality Standard for Tritium - March 26 and 27, 2008 Toronto, Ontario – Summary Report – Prepared for the Ontario Drinking Water Advisory Council By Lura Consulting – June 5, 2008.

Appendix 1:

1st Request for ODWAC Advice from the Minister of the Environment, February 21, 2007

Ministry of the Environment

Office of the Minister

135 St. Clair Ave. West
12th Floor
Toronto ON M4V 1P5
Tel (416) 314-6790
Fax (416) 314-6748

Ministère de l'Environnement

Bureau de la ministre

135, avenue St. Clair ouest
12e étage
Toronto ON M4V 1P5
Tél (416) 314-6790
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Ontario

ENV1283MC-2006-4181b

FEB 21 2007

Mr. Jim Merritt
Chair
Advisory Council on Drinking Water
Quality and Testing Standards
40 St. Clair Avenue West, 3rd Floor
Toronto ON M4V 1M2

Dear Mr. Merritt:

This letter is to formally request your assistance in responding to a letter, dated September 27, 2006, from Dr. David McKeown, Medical Officer of Health, City of Toronto, which was sent on behalf of Toronto City Council and the Toronto Board of Health. The letter outlines their concerns about the Ontario Drinking Water Quality Standard for tritium.

In follow up to this letter, my staff and staff of the Standards Development Branch met with Dr. McKeown and his colleagues on January 16, 2007 to further discuss their concerns. As a result, I am requesting advice from the Advisory Council on Drinking Water Quality and Testing Standards (Advisory Council) on the current Ontario Drinking Water Quality Standard for tritium, in consideration of the 1994 recommendations made by the former Ontario Advisory Committee on Environmental Standards (ACES).

I am hoping that you can raise this matter with your colleagues. Attached is a copy of Dr. McKeown's letter for the Advisory Council's review. I have also instructed Standards Development Branch staff to provide the ACES report referenced in Dr. McKeown's letter as well as any related documents to the Advisory Council.

As I would like to obtain the Advisory Council's advice before I respond to the concerns raised by the City of Toronto, I would appreciate an estimate of the timelines associated with the execution of the Advisory Council's review at your earliest convenience.

Thank you in advance for your assistance and please accept my best wishes. I look forward to hearing from you.

Yours truly,

<original signed by>

Laurel C. Broten
Minister of the Environment

Attachment

ENV1283MC-2006-4181

TORONTO

Dr. David McKeown
Medical Officer of Health

Public Health
277 Victoria Street
5th Floor
Toronto, Ontario M5B 1W2

Tel: 416-338-7820
Fax: 416-392-0713
dmckeown@toronto.ca
www.toronto.ca/health
Reply: Sarah Gingrich
Tel: 416-338-3513
Fax: 416-392-7418
sgingri@toronto.ca

September 27, 2006

The Honourable Laurel Broten
Minister of the Environment
12th Floor, 135 St. Clair Avenue West
Toronto, Ontario M4V1P5

Subject: Request for review of Ontario Drinking-water Quality Standard for Tritium

Dear Ms. Broten:

At the present time, the Government of Ontario is developing Ontario's energy strategy and has expressed its intention to rely on nuclear energy. Therefore, it is timely to ensure that drinking water standards for tritium and other radionuclides are protective of health.

On behalf of Toronto City Council and the Toronto Board of Health, I am requesting that the Government of Ontario review the Ontario Drinking-Water Quality Standards for tritium and other radionuclides. Specifically, the City of Toronto asks the Province of Ontario to adopt more health-protective standards, and to give further consideration and weight to the 1994 recommendations of the Ontario Advisory Committee on Environmental Standards (ACES). City Council's decision on this issue is attached for your reference.

The current Ontario Drinking-water Quality Standard for tritium is 7,000 becquerels per litre (bq/L), (O. Reg. 169/03, as amended to O. Reg. 248/06). The 1994 ACES report recommended immediate adoption of a 100 bq/L standard, reduced to 20 bq/L within five years. Had Ontario adopted these recommendations, the standard would already be at the more protective level of 20 bq/L.

I look forward to further discussion on this matter.

Sincerely,

<original signed by>

David McKeown, MDCM, MHSc, FRCPC
Medical Officer of Health

Attach: Decision by Toronto City Council at its meeting June 27, 28 and 29, 2006

Cc: The Honourable Dalton McGuinty, Premier
The Honourable Dwight Duncan, Minister of Energy
The Honourable George Smitherman, Minister of Health and Long-Term Care
Chair and Members, Toronto Board of Health
Ruth Grier, Co-Chair, Toronto Cancer Prevention Coalition, Occupational and Environmental Carcinogens Working Group

TORONTO CITY CLERK

Consolidated Clause in Board of Health Report 4, which was considered by City Council on June 27, 28 and 29, 2006.

4

Ionizing Radiation and Public Health in the City of Toronto (GTA) in Relation to the Refurbishment and Expansion of Nuclear Power Reactors and Facilities on Lake Ontario

City Council on June 27, 28 and 29, 2006, adopted this Clause without amendment.

The Board of Health recommends that City Council adopt the recommendations in the communication (May 10, 2004) from Ruth Grier, Co-Chair, Toronto Cancer Prevention Coalition, Occupational and Environmental Carcinogens Working Group, as follows:

(1) that the City of Toronto test and report information on tritium and other radionuclides both in the raw water of Lake Ontario and in Toronto's drinking water and include these results in the annual report on drinking water required by the Ontario Drinking Water Standards; and

(2) that the City of Toronto request the current Ontario Government to revisit the recommendations of the Ontario Advisory Committee on Environmental Standards Committee and consider the more healtb protective standard be required.

Action taken by the Board:

The Board of Health endorsed the following recommendations in the communication (May 10, 2004) from Ruth Grier, Co-Chair, Toronto Cancer Prevention Coalition, Occupational and Environmental Carcinogens Working Group:

(i) that the City of Toronto test and report information on tritium and other radionuclides both in the raw water of Lake Ontario and in Toronto's drinking water and include these results in your annual report on drinking water required by the Ontario Drinking Water Standards; and

(ii) that the City of Toronto request that the current Ontario Government revisit the recommendations of the Ontario Advisory Committee on Environmental Standards Committee and consider the more health protective standard be required.

The Board of Health submits the following communication (May 10, 2004) from Ruth Grier, Co-Chair, Toronto Cancer Prevention Coalition, Occupational and Environmental Carcinogens Working Group:

Occupational and Environmental Carcinogens Working Group of the Toronto Cancer Prevention Coalition

May 10, 2004
To: the Toronto Board of Health, Chair John Filion

Re: Ionizing Radiation and Public Health in the City of Toronto (GTA) in relation to the refurbishment and expansion of nuclear power reactors and facilities on Lake Ontario

The Occupational and Environmental Carcinogens Working Group of the Toronto Cancer Prevention Coalition is writing to you to express our concerns regarding the public health implications of the -Ontario Power Authority recommendation to expand nuclear power generation in Ontario. This decision is premature. The risks to health and safety from routine releases, accidents, transport and radioactive waste make the pursuit of-energy alternatives imperative. Yet the Province has barely begun to explore these alternatives.

The Toronto Cancer Prevention Coalition states that although we are exposed to a wide variety of cancer causing substances in the workplace and-the environment, this is not inevitable. By combining scientific approach grounded in the precautionary principle with smart public policies designed to prevent pollution, we can promote health and prevent cancer in a comprehensive, integrated and sustainable way (Preventing Occupational and Environmental Cancer: A Strategy for Toronto, May 2001).

Our working group fully -endorses the principles and recommendations of the letter by Dr. David McKeown, MDCM, MHSc, FRCPC, Toronto Medial Officer of Health to Premier Dalton McGuinty regarding the Ontario Power Authority's Supply Mix Advice report, December 2005 EBR #PO05E0001 (Feb 3 2006). Dr. McKeown calls for a sustainable energy strategy for the province composed of a combination of measures, in the following order of priority: demand management (energy efficiency and conservation) approaches and supply from low-impact ecologically sustainable renewable sources rather than by nuclear energy.

As well we endorse, Dr. McKeown's recommendations that the Province of Ontario undertake a full health assessment of all energy options including the lifecycle of nuclear by products and nuclear waste as well as catastrophic nuclear accidents. Health care cost avoidance should be considered for all alternatives in such a review.

Consideration of these issues raises the specter of the safety of our current use of nuclear energy which includes routine emissions to the environment, and the transportation and storage of radioactive materials throughout the region. These uses add to the burden of the radionuclide use in many medical and scientific endeavors in our local environment. (1) We need to ensure the prevention of -exposure to these hazardous and cancer causing substances

We concur with recommendations 'Contained in the Pembina/CELA Report, Power for the Future Towards a Sustainable Electricity System for Ontario, that nuclear power plants be phased out by 2020 stopping all such releases {www.cela.ca, www.pembina.org)

There are a few further steps which we feel that the City could take to further our understanding of the impacts of nuclear power and, increase protection from tritium and other radionuclides from routinely-entering the drinking water of the GT A from-existing nuclear facilities on Lake Ontario (one quarter of Canadians depend on the Great Lakes for their drinking water).

1. The City of Toronto should test and report information on tritium and other radionuclides both in the raw water of Lake Ontario and in Toronto's drinking and include these results in your annual report on drinking water required by the Ontario Drinking Water Standards.

There has been considerable concern over the setting of standards in Ontario for tritium at or near to background levels. Our current standards are far more permissive that those of other jurisdictions. In 1994 an extensive review of these standards was done by the Ontario Advisory Committee on Environmental Standards (ACES). The recommendations of this expert Committee was that the level of 7,000 Bq/L be reduced initially to 100 Bq/L and progress to 20 Bq/L within five years. Those recommendations were rejected by the Ontario Government at the time.

2. The City of Toronto should request that the current Ontario Government revisit the recommendations of the ACES committee and consider the more health protective standard be required (2).

In combination, these two actions would go a long way to addressing the reality of our cities proximity to nuclear reactors and act as a deterrent for future nuclear expansion.

We have appended further background information to this letter to reinforce our concerns about the impacts of Ontario's proposals for reliance on nuclear power for the future on public health of Torontonians (3).

Thank you for your attention and we look forward to your response to our recommendations.

Sincerely

Ruth Grier
Co Chair Toronto Cancer Prevention Coalition, Occupational and Environmental Carcinogens Working Group

Cc to:

Dr. David McKeown Medical Officer of Health City of Toronto Public Health

The Honourable Dalton McGuinty Premier of Ontario

The Honourable Dwight Duncan Minister of Energy

The Honourable Donna Cansfield, Minister of Energy (former) Minister's Office

The Honourable Laurel Broten, Minister of Environment

The Honourable George Smitherman Minister of Health and Long-Term Care

Dr. Sheila Basur
Chief Medical Officer of Health

Mr. Ian Carr Chief Executive Officer Ontario Power Authority

Dr. Peter Love
Chief Energy Conservation Officer Ontario Power Authority

Appendix:

(1). Along with the problem of solid nuclear waste is the question of the regular emissions of radioisotopes from nuclear power plants into air and water. Human beings-can receive exposure to organically bound tritium through the ingestion of plants and animals exposed in an effluent pathway in addition to direct uptake through inhalation, absorption and drinking contaminated water. The CANDU reactor emits tritium as well as carbon 14 and other radioisotopes. Tritium is a radioactive isotope of hydrogen that combines readily with oxygen to form radioactive water. It binds easily with organic molecules including DNA.

The International Agency for Research on Cancer (IARC) lists a number of radionuclides as proven causes of cancer including ones produced from the mining, milling manufacturing and use of uranium fission in nuclear power plants. Recent research on the effects of even very low levels of ionizing radiation shows that no level is safe to health. In July, 2005, the U.S. National Academies of Science released a major report on the health effects of ionizing radiation, Biological Effects of Ionizing: Radiation (BEIR) VII http://www.nuclearactive.orginews/070605.htmJ.This document reconfirmed that there is no safe level of exposure to radiation and that low levels can cause cancer. Even exposures to background radiation cause some 'Cancers. Additional exposure causes additional risk. The BEIR VIJ report also found that the risk of cancer was greater to women and children, the younger the children, the 'greater the risk, females being at greater risk.

Especially sensitive to the effects of tritium are rapidly growing cells such as fetal tissue and young girls' developing breasts, genetic materials and blood forming organs. Tritium can affect protein precursors that will make up the chromosomal strands in the DNA which can damage the DNA creating a mutational effect. The results of all these processes can result in cancers, miscarriages, birth defects, sterility, hypothyroid, etc., not only in those directly affected but also in their offspring and theirs. A connection to heart disease and stroke, possible genetic damage was also discussed.

(2) Since the Walkerton water tragedy, there has been a major focus on water quality in Ontario and in Canada as a whole. Environment Canada describes good drinking water as being devoid of disease causing organisms, harmful chemicals and radioactive matter such as radionuclides. The Ontario Ministry of the Environment {Drinking Water Systems Regulation O. Reg. 170/03, 2003, June 2003 p7), says that the ingestion of radionuclides in drinking water may cause cancer

in individuals exposed and hereditary damage in their children ...It is assumed that no threshold exists below which the probability of induced effects is zero.

Ontario's drinking water standard is 7,000 Bq per litre, a level that is far more lax than the European Union's standard of 100 Bq per litre or the U."S. figure of 740 Bq per Htre. (California last year issued a report calling for an even tougher health protection 'Standard of 15 Bq per litre.) The Ontario government rejected an advisory panel (the Advisory Council on Environmental Standards (ACES) recommendation in 1994 to adopt 100 Bq per litre as the standard. Tritium, like all radioactive substances, is considered a health risk because it can cause cancer. While there is still-considerable regulatory uncertainty about what constitutes an unsafe exposure in Ontario, the BEIR VB. National Academv of Sciences 2005 report clearly illustrates that there is no safe dose.

@) Further References:
Tritium, Properties, Metabolism, Dosimetry http://www.cerrie.org/commjttee papers/Paper 9- 01.doc

Health and Environmental Issues Linked to the Nuclear Fuel Chain, Gordon Edwards, Ph.D., for the Canadian Environmental Advisory Council http://www.ccnr.onyceacB.htm]

Environmental and Occupational Causes of Cancer: A Review of Recent Scientific Literature, Richard Clapp, Genevieve Howe, Molly Jacobs, Boston University, School of Public Health and Environmental Health Initiative, University of Massachusetts, Lowell, September, 2005. (This study lists the various 1:ancers and the chemicals/radiation they are related to (p 10) "The State of the Science by Cancer", the relationship of ionizing radiation to bladder, bone, brain, breast, colon, leukemia, liver, lung, multiple myeloma, nasal and nasopharynx, stomach and thyroid cancers)

Recommendations of the European Commjttee on Radiation Risk (ECRR), Health Effects of Ionizing Radiation Exposure at Low Dose for Radiation Protection Purposes, Regulators Edition, Brussels, 2003

Meeting Note #4181

Meeting: Dr. David McKeown

Date: Thursday January 11, 2007

Time: 3:00 P.M.

Location: Minister's Boardroom, 12th Floor

Internal Attendee: Minister Broten and Theresa McClenaghan
External Attendees: Dr. David McKeown

Agenda: Request for review of Ontario Drinking-water Quality Standard for Tritium

Background:

Canadian Drinking Water Quality Guidelines (CDWQG) for Radionuclides

- The existing federal Canadian Drinking Water Quality Guidelines (CDWQG) for 78 radiological parameters were developed in 1995.

- The Federal-Provincial-Territorial Committee on Drinking Water (CDW), in collaboration with Health Canada, has recently reassessed the CDWQGs for natural and artificial (man-made) radiological parameters of drinking water based on new information. The term "radiological parameters" refers to the levels of the individual radionuclides in drinking water.

- The reassessment resulted in changes to the CDWQGs of natural and artificial radiological parameters which are detailed in Appendix 1. **See attached Briefing Note.**

Tritium

- Tritium is a form of hydrogen that is radioactive and reacts with oxygen to form water.

- Tritium is produced naturally in the upper atmosphere when cosmic rays interact with atmospheric gases. Tritium then reaches the surface of the planet via rainfall. The amount of tritium found in rain water has ranged from below 0.05 Bq/L to 9 Bq/L in studies conducted in North America. Activities higher than this value would indicate a human-made source.

Human-made sources of tritium include nuclear weapon explosions and nuclear reactors used for producing electricity. Tritium is also released by facilities producing glow-in-the-dark signs who obtain tritiated gas from nuclear facilities.

MINISTRY OF ENVIRONMENT

FEB 2 6 2007

STANDARDS DEVELOPMENT
BRANCH

See attached Briefing Note.

Previous Meetings: N/A

Recent Correspondence: N/A

Date: January 9, 2007.

Appendix 2:

Request for Tritium Review from Toronto Medical Officer of Health, September 27, 2006

ENV1283MC-2006-4181

TORONTO

Dr. David McKeown
Medical Officer of Health

Public Health
277 Victoria Street
5th Floor
Toronto, Ontario M5B 1W2

Tel: 416-338-7820
Fax: 416-392-0713
dmckeown@toronto.ca
www.toronto.ca/health
Reply: Sarah Gingrich
Tel: 416-338-3513
Fax: 416-392-7418
sgingri@toronto.ca

September 27, 2006

The Honourable Laurel Broten
Minister of the Environment
12th Floor, 135 St. Clair Avenue West
Toronto, Ontario M4V1P5

Subject: Request for review of Ontario Drinking-water Quality Standard for Tritium

Dear Ms. Broten:

At the present time, the Government of Ontario is developing Ontario's energy strategy and has expressed its intention to rely on nuclear energy. Therefore, it is timely to ensure that drinking water standards for tritium and other radionuclides are protective of health.

On behalf of Toronto City Council and the Toronto Board of Health, I am requesting that the Government of Ontario review the Ontario Drinking-Water Quality Standards for tritium and other radionuclides. Specifically, the City of Toronto asks the Province of Ontario to adopt more health-protective standards, and to give further consideration and weight to the 1994 recommendations of the Ontario Advisory Committee on Environmental Standards (ACES). City Council's decision on this issue is attached for your reference.

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I look forward to further discussion on this matter.

Sincerely,

<original signed by>

David McKeown, MDCM, MHSc, FRCPC
Medical Officer of Health

Attach: Decision by Toronto City Council at its meeting June 27, 28 and 29, 2006

Cc: The Honourable Dalton McGuinty, Premier
The Honourable Dwight Duncan, Minister of Energy
The Honourable George Smitherman, Minister of Health and Long-Term Care
Chair and Members, Toronto Board of Health
Ruth Grier, Co-Chair, Toronto Cancer Prevention Coalition, Occupational and Environmental Carcinogens Working Group

Occupational and Environmental Carcinogens Working Group of the Toronto Cancer Prevention Coalition

May 10, 2004
To: the Toronto Board of Health, Chair John Filion

Re: Ionizing Radiation and Public Health in the City of Toronto (GTA) in relation to the refurbishment and expansion of nuclear power reactors and facilities on Lake Ontario

The Occupational and Environmental Carcinogens Working Group of the Toronto Cancer Prevention Coalition is writing to you to express our concerns regarding the public health implications of the -Ontario Power Authority recommendation to expand nuclear power generation in Ontario. This decision is premature. The risks to health and safety from routine releases, accidents, transport and radioactive waste make the pursuit of-energy alternatives imperative. Yet the Province has barely begun to explore these alternatives.

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As well we endorse, Dr. McKeown's recommendations that the Province of Ontario undertake a full health assessment of all energy options including the lifecycle of nuclear by products and nuclear waste as well as catastrophic nuclear accidents. Health care cost avoidance should be considered for all alternatives in such a review.

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We concur with recommendations 'Contained in the Pembina/CELA Report, Power for the Future Towards a Sustainable Electricity System for Ontario, that nuclear power plants be phased out by 2020 stopping all such releases {www.cela.ca, www.pembina.org)

TORONTO CITY CLERK

Consolidated Clause in Board of Health Report 4, which was considered by City Council on June 27, 28 and 29, 2006.

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Action taken by the Board:

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In combination, these two actions would go a long way to addressing the reality of our cities proximity to nuclear reactors and act as a deterrent for future nuclear expansion.

We have appended further background information to this letter to reinforce our concerns about the impacts of Ontario's proposals for reliance on nuclear power for the future on public health of Torontonians (3).

Thank you for your attention and we look forward to your response to our recommendations.

Sincerely

Ruth Grier
Co Chair Toronto Cancer Prevention Coalition, Occupational and Environmental Carcinogens Working Group

Cc to:

Dr. David McKeown Medical Officer of Health City of Toronto Public Health

The Honourable Dalton McGuinty Premier of Ontario

The Honourable Dwight Duncan Minister of Energy

The Honourable Donna Cansfield, Minister of Energy (former) Minister's Office

The Honourable Laurel Broten, Minister of Environment

The Honourable George Smitherman Minister of Health and Long-Term Care

Dr. Sheila Basur
Chief Medical Officer of Health

Mr. Ian Carr Chief Executive Officer Ontario Power Authority

Dr. Peter Love
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Appendix:

(1). Along with the problem of solid nuclear waste is the question of the regular emissions of radioisotopes from nuclear power plants into air and water. Human beings-can receive exposure to organically bound tritium through the ingestion of plants and animals exposed in an effluent pathway in addition to direct uptake through inhalation, absorption and drinking contaminated water. The CANDU reactor emits tritium as well as carbon 14 and other radioisotopes. Tritium is a radioactive isotope of hydrogen that combines readily with oxygen to form radioactive water. It binds easily with organic molecules including DNA.

The International Agency for Research on Cancer (IARC) lists a number of radionuclides as proven causes of cancer including ones produced from the mining, milling manufacturing and use of uranium fission in nuclear power plants. Recent research on the effects of even very low levels of ionizing radiation shows that no level is safe to health. In July, 2005, the U.S. National Academies of Science released a major report on the health effects of ionizing radiation, Biological Effects of Ionizing: Radiation (BEIR) VII http://www.nuclearactive.orginews/070605.htrnJ.This document reconfirmed that there is no safe level of exposure to radiation and that low levels can cause cancer. Even exposures to background radiation cause some 'Cancers. Additional exposure causes additional risk. The BEIR VIJ report also found that the risk of cancer was greater to women and children, the younger the children, the 'greater the risk, females being at greater risk.

Especially sensitive to the effects of tritium are rapidly growing cells such as fetal tissue and young girls' developing breasts, genetic materials and blood forming organs. Tritium can affect protein precursors that will make up the chromosomal strands in the DNA which can damage the DNA creating a mutational effect. The results of all these processes can result in cancers, miscarriages, birth defects, sterility, hypothyroid, etc., not only in those directly affected but also in their offspring and theirs. A connection to heart disease and stroke, possible genetic damage was also discussed.

(2) Since the Walkerton water tragedy, there has been a major focus on water quality in Ontario and in Canada as a whole. Environment Canada describes good drinking water as being devoid of disease causing organisms, harmful chemicals and radioactive matter such as radionuclides. The Ontario Ministry of the Environment {Drinking Water Systems Regulation O. Reg. 170/03, 2003, June 2003 p7), says that the ingestion of radionuclides in drinking water may cause cancer

in individuals exposed and hereditary damage in their children ...It is assumed that no threshold exists below which the probability of induced effects is zero.

Ontario's drinking water standard is 7,000 Bq per litre, a level that is far more lax than the European Union's standard of 100 Bq per litre or the U."S. figure of 740 Bq per Htre. (California last year issued a report calling for an even tougher health protection 'Standard of 15 Bq per litre.) The Ontario government rejected an advisory panel (the Advisory Council on Environmental Standards (ACES) recommendation in 1994 to adopt 100 Bq per litre as the standard. Tritium, like all radioactive substances, is considered a health risk because it can cause cancer. While there is still-considerable regulatory uncertainty about what constitutes an unsafe exposure in Ontario, the BEIR VB. National Academv of Sciences 2005 report clearly illustrates that there is no safe dose.

@) Further References:
Tritium, Properties, Metabolism, Dosimetry http://www.cerrie.org/commjttee papers/Paper 9- 01.doc

Health and Environmental Issues Linked to the Nuclear Fuel Chain, Gordon Edwards, Ph.D., for the Canadian Environmental Advisory Council http://www.ccnr.onyceacB.htm]

Environmental and Occupational Causes of Cancer: A Review of Recent Scientific Literature, Richard Clapp, Genevieve Howe, Molly Jacobs, Boston University, School of Public Health and Environmental Health Initiative, University of Massachusetts, Lowell, September, 2005. (This study lists the various 1:ancers and the chemicals/radiation they are related to (p 10) "The State of the Science by Cancer", the relationship of ionizing radiation to bladder, bone, brain, breast, colon, leukemia, liver, lung, multiple myeloma, nasal and nasopharynx, stomach and thyroid cancers)

Recommendations of the European Commjttee on Radiation Risk (ECRR), Health Effects of Ionizing Radiation Exposure at Low Dose for Radiation Protection Purposes, Regulators Edition, Brussels, 2003

Appendix 3:

2nd Request for ODWAC Advice from the Minister of the Environment, June 12, 2007

Ministry of the Environment

Office of the Minister

135 St. Clair Ave. West
12th Floor
Toronto ON M4V 1P5
Tel (416) 314-6790
Fax (416) 314-6748

Ministère de l'Environnement

Bureau de la ministre

135, avenue St. Clair ouest
12^e étage
Toronto ON M4V 1P5
Tél (416) 314-6790
Téléc (416) 314-6748

MINISTRY OF ENVIRONMENT
JUN 1 2 2007
STANDARDS DEVELOPMENT
BRANCH

Ontario

JUN 1 2 2007

ENV1283MC-2007-2563

Mr. Jim Merritt
Chair, Advisory Council on Drinking Water
Quality and Testing Standards
40 St. Clair Avenue West, 3rd Floor
Toronto, ON M4V 1M2

Dear Mr. Merritt:

First, let me extend my thanks to you and the other members of the Drinking Water Advisory Council for your thoughtful and timely advice on Health Canada's Corrosion Control document. As you are aware, on June 7th, we announced an action plan to protect Ontario's most vulnerable from the effects of lead in drinking water. Your report was the foundation for our plan.

Today, I am writing with regard to tritium and drinking water. On February 21, 2007, I requested advice from your committee on the current Ontario Drinking Water Quality Standard for tritium. This request was made after staff from my Standards Development Branch met with Dr. David McKeown, Medical Officer of Health for the City of Toronto.

I also asked you to consider the 1994 recommendations made by the former Ontario Advisory Committee on Environmental Standards. As you know, the government of the day in 1994 considered many of these issues around tritium and set the current standard.

This morning, I had the opportunity to meet with Shawn-Patrick Stensil of Greenpeace Canada and Dr. Ian Fairlie. They presented me with the Dr. Fairlie's report entitled, "Tritium Hazard Report: Pollution and Radiation Risk from Canadian Nuclear Facilities." You will find a copy attached. I am urging the Advisory Council to review this report alongside the ACES report that was forwarded to you earlier by staff in our Standards Development Branch.

Thank you for your assistance and please accept my thanks for all of the important work the Advisory Council undertakes. I look forward to hearing from you.

Yours truly,

<original signed by>

Laurel C. Broten
Minister of the Environment

Attachment

Appendix 4:

Ontario Hydro letter to Minister Wildman, December 9, 1994

Ontario Hydro
700 University Avenue
Toronto, Ontario
M5G 1X6

O. Allan Kupcis, President

RECEIVED
45402
DEC 13 1994
GENERAL MANAGER
NUCLEAR

bc: J. Runnalls
D. Anderson
N. Simon
B. Kelly

December 9, 1994

The Honourable C.J. Wildman
Minister
Ministry of Environment and Energy
12th Floor
135 St. Clair Avenue West
Toronto, Ontario
M4V 1P5

Dear Minister:

Thank you for your letter outlining your recommendations regarding the Ontario Drinking Water Objective for tritium. Let me first state Ontario Hydro's commitment to comply with the final decision on this objective.

Establishing an interim objective at 7,000 Bq/L represents a substantial reduction in the existing Ontario Drinking Water Objective of 40,000 Bq/L. However, this is in keeping with the recommendations of the World Health Organization. We would be prepared to accept your recommendation and are committed to assist the federal government in its review.

It is important to note that Ontario Hydro operates under the principle that all exposures to radiation are kept as low as reasonably achievable (ALARA). Our past performance, which is based on this principle, demonstrates that concentrations of tritium in drinking water will remain less than 100 Bq/L on average. Ontario Hydro is committed to maintaining that standard and publicly reporting our performance in this regard.

I believe we share the commitment to public safety. This has always been the prime concern of Ontario Hydro.

Sincerely,

<original signed by>

O.A. Kupcis

cc - Mr. M. Strong

Appendix 5:

Canadian Nuclear Association letter dated April 23, 2008

Canadian Nuclear Association
Association nucléaire canadienne

April 23, 2008

Mr. Scott Barrett
Executive Assistant
Ontario Drinking Water Advisory Council
40 St. Clair Avenue West, 3rd Floor
Toronto, ON M4V 1M2

Dear Mr. Barrett:

RE: Review of the Ontario drinking water standard for tritium

On behalf of the CNA, I am submitting the attached information which includes written responses requested by council members at the March 27 public consultation as well as supplementary information and clarification for some of the other questions asked.

I reiterate our position that any change to the current standard should be made for well supported scientific reasons. During the consultation, the issue of what the acceptable lifetime risk level should be for setting the tritium limit was discussed, but not fully addressed. Our attachment points out that both the US and the WHO have ranges of acceptable risk rather than a single level, and they assign chemicals to the lower end while radiation is assigned to the higher end. A valid scientific rationale is provided for this treatment. Thus, rather than a "double standard" there is a justified difference.

There was much interest in the control of tritium "spikes" and the implications of adopting a 20 Bq/L limit for tritium. In summary, there are 2 types of implications.

The first implication is related to the basis for the change, assumed to be the adoption of a 10^{-6} lifetime risk as the basis for the limit. This would require lowering all radionuclide limits for drinking water, and it would imply that all emission limits from nuclear power plants, both to air and to water should be lowered by a similar amount in order to meet a new level of acceptable public risk for exposure to radiation. This would have significant cost implications.

The second implication is related to the request by many participants to control tritium in drinking water to below 20 Bq/L on a short term basis, e.g. daily. Although nuclear power plants already achieve 20 Bq/L at water supply plants on an annual average basis, short term control at this level would require the adoption of significant additional control technologies with significant cost implications. Additional resources for daily analysis rather than weekly composites would also result in additional costs. We believe there is no scientific reason for a daily monitoring requirement.

130 Albert Street, Suite 1610 / 130, rue Albert, pièce 1610, Ottawa ON K1P 5G4
Tel./tél. (613) 237-4262 Fax/téléc. (613) 237-0989 Website/site Web www.cna.ca

We trust that the attached information is of use to the council, and we would be happy to meet with the council to provide any additional information or clarification.

Yours truly,

<original signed by>

Steve Coupland
Director, Environmental Affairs

Attachment

CNA Supplementary Submission to the Ontario Drinking Water Advisory Council on the Review of the Limit for Tritium in Drinking Water – April 23, 2008

The responses and clarifications below are provided to the Ontario Drinking Water Advisory Council (ODWAC) as a follow up to the Canadian Nuclear Association (CNA) presentation during the public consultation of March 26 and 27. Some of the verbal responses provided by Mr. Coupland and Dr. Hart of CNA were requested in writing by ODWAC members. Clarifications and additional information that CNA believes will assist the council in their deliberations are also provided.

The questions that were posed by council members are paraphrased as:

1 a. Can you explain the differences between the chemical and radiological paradigms for setting limits for contaminants in drinking water?
1 b. Can you provide a scientific reason for why the council should not recommend the use of a lifetime risk criterion of 10^{-6} to derive the drinking water standard for tritium?
1 c. Can you provide the basis for the U.S. EPA dose criterion of 0.04 mSv/y for tritium in drinking water?
1 d. In countries where there exist two different standards for chemical and radiological contaminants in drinking water, was the decision to have 2 different standards a scientific one or a policy decision?

Before providing responses to these questions, a review of some background material is required.

BACKGROUND

These questions deal with the same fundamental issue that was raised by the Advisory Council on Environmental Standards (ACES) report (ACES 1994), i.e. Should the methods for setting regulatory limits for chemical and radiological contaminants in drinking water be harmonized?

The harmonization issue was raised by the Science Advisory Board and the Radiation Advisory Committee of U.S. Environmental Protection Agency (EPA) in the form of a commentary and a request to EPA's Administrator in 1992 (EPA 1992) to address the issue in some way. Although they could not advise on how to achieve harmonization, they did state that “Harmonization does not necessarily imply identical treatment, but it does imply that any differences in treatment are clearly explained and justified.”

In 1995, Overy and Richardson, both from EPA, published an article in the Environmental Law Reporter (Overy 1995) on “current steps toward risk harmonization” between radiological and chemical carcinogens. They concluded that “EPA's radiation standards, which in many cases were derived under policies applicable to chemical carcinogens, are, for the most part, consistent with the International Commission on Radiological Protection's (ICRP's) recommendations.”

In 1998 Health Canada and the Atomic Energy Control Board (AECB, now the Canadian Nuclear Safety Commission or CNSC) issued their report on the Assessment and Management of Cancer Risks from Radiological and Chemical Hazards, an effort that was requested by the Ontario Minister of Environment and Energy to help resolve the issue that ACES raised (HC 1998). This report was developed by a joint working group of staff from Health Canada, AECB, AECB's Advisory Committee on Radiological Protection, AECB'S Group of Medical Advisors and a representative of the Ontario ministry of Environment and Energy. They identified the similarities and differences in risk assessment and risk management for radionuclides and for chemicals as well as the strengths and weaknesses of each approach. They concluded that the risk management strategies of both methods are well-developed and produce a high degree of health protection with actual exposures well below legal limits. They agreed harmonization of the two methods could be desirable, but would not be practical at that time. They recommended that future opportunities for harmonization should be considered, but in doing so, "consideration must be given as to whether public health benefits would be derived from harmonization."

Duggan and Lambert, from the United Kingdom, published a paper in 1998 (Duggan 1998) comparing the approaches used for radiation and chemicals for environmental standards. They cover basically the same similarities and differences as the publications mentioned above, and suggest possible pathways to some degree of harmonization, but conclude that the possibility of achievement of an integrated approach remains remote.

In 1976, EPA established a dose-based drinking water standard for combined beta and gamma emitting radionuclides (includes tritium) of 4 mrem per year (0.04 mSv/y). The U.S. Safe Drinking Water Act was amended in 1986 and in 1996, The U.S. National Primary Drinking Water Regulations (NPDWR) of 1977 were reviewed starting in 1991 with a final revision issued in 2000 (EPA 2000c). This included considerations of harmonizing how genotoxic chemicals and radiological hazards are regulated. Other than the article by Overy and Richardson mentioned above, there is no overt record of a formal evaluation of harmonization by the EPA, although considerable insight into EPA's direction in this respect can be obtained from the points raised by Overy and Richardson, the Technical Support Document for radionuclide standards for the NPDWR revision of 2000 (EPA 2000a), the Proposed Rule document (EPA 2000b) and the Final Rule (EPA 2000c). It appears that EPA has already harmonized how it regulates genotoxic chemicals and radionuclides. The following derivation of radionuclide standards is very similar to how chemical standards are derived. EPA clearly states that there is a range of acceptable lifetime risk for contaminants in drinking water from 10^{-6} to 10^{-4}, and that it considers as appropriate a lifetime risk level of about 10^{-4} from radiological contaminants mainly because of the precision of the risk data, but also because of the small fraction of the population that actually is exposed to risks greater than 10^{-6} through the application of emission controls. Thus it is starting from a lifetime acceptable risk criterion (which happens to be different from the one used for some chemicals – more on the rationale later). EPA determined the tritium standard using a risk value that takes into account age, gender and sensitive populations:

The U.S. EPA set the target risk level for beta and gamma emitting radionuclides at about 10^{-4} lifetime risk, and this falls within EPA's acceptable risk range of about 10^{-6} to 10^{-4}. The tritium drinking water risk coefficient was calculated taking into account lifelong ingestion of water (70 years), adjusted for age differences over a lifetime (e.g. intake rates, physiological changes and sensitivities), and gender (EPA 1999). The associated annual radiation dose (effective dose equivalent) is 0.04 mSv/y, assuming a constant exposure concentration over a lifetime (EPA 2000a). Although a 1991 EPA determination of the associated concentration limit (Maximum Contaminant Level, MCL) gave a value of 2,253 Bq/L, the 1996 Safe Drinking Water Act Amendments do not allow raising the limit above the previous 1976 value of 740 Bq/L, so this value remained as the tritium standard in the 2000 regulations . The value determined in 1976 used the ICRP 2 (ICRP 1959)/NBS 69 (NBS 1963) dosimetry system, while the 1991 value was determined using the current ICRP 60 dosimetry system (ICRP 1990).

Derivation of the tritium MCL in terms of activity concentration (i.e., pCi/L) corresponding to a specified target risk level:

MCL (pCi/L) = TR/[(RF * 0.037) * 2 * 365 * 70)] = 60,900 pCi/L (or 2253 Bq/L)

where:
TR = target risk level ($1.09\text{x}10^{-4}$ for beta and gamma emitters, including tritium, EPA 2000).
RF = tritium drinking water risk coefficient from *Federal Guidance Report No. 13(EPA 1999)* = $9.44\text{x}10^{-13}$ Bq^{-1} in risk per Becquerel (Bq).
0.037 = factor to convert from Bq to pCi/L.
2* 365*70 = Litres of water consumed over a lifetime.

Although EPA used its own adjusted lifetime risk levels from Federal Guidance Report No. 13, the basic radiological risk data is taken from ICRP/UNSCEAR sources. UNSCEAR, the United Nations Scientific Committee on the Effects of Atomic Radiation is an authoritative international body of experts on radiation effects.

The World Health Organization (WHO) approach for radiological contaminants in drinking water (WHO 2006) is similar to the EPA approach, whereby it states that its dose criterion of 0.1 mSv/y corresponds to a lifetime risk of about 10^{-4} (actually $3.5 \text{ x } 10^{-4}$ for fatal cancers). The WHO uses a risk criterion of 10^{-5} for non-threshold (genotoxic) chemicals, but allows that individual national authorities may choose to use an alternative value between 10^{-6} and 10^{-4}. Thus the WHO recommended regulation of radionuclides is similar to that of the US EPA and to the regulation of genotoxic chemical carcinogens in both the U.S. EPA and the WHO.

The main differences between the regulation of radiological and genotoxic chemicals appear to be (1) the placement within the range of acceptable risk, and (2) the presence or lack of a combined risk criterion for multiple contaminants.

When the linear no-threshold model is assumed for regulatory purposes, the uses of lifetime risk, annual risk and radiation dose are essentially interchangeable (with proper conversions) and do not represent any fundamental differences. EPA selected a lifetime risk level of 10^{-4} for radiation as the upper bound of acceptable risk in the process of resolving a court case in 1987 and based this conclusion on a Survey of Societal Risks and their relative "acceptability." (Overy and Richardson 1995). The lower bound of 10^{-6} did not have as direct a foundation, as it started out as zero (Delaney Clause) and worked its way up to a more practical level of 10^{-6} over time. The EPA and the WHO provide a rationale for the selection of a lifetime risk criterion of 10^{-4} as opposed to the level of 10^{-6} to 10^{-5} for genotoxic chemicals. They state that the upper level of the acceptable risk range is appropriate *because of the significantly better quality of risk-response data for radiation as compared with chemicals in general*. Data for radiation effects and risk have been derived over many years from both human epidemiological data as well as animal studies. Duggan and Lambert state "There are more and better quality human exposure risk data for radiation than for any other environmental carcinogen and this has resulted in calculated risk estimates of apparently high precision". These high quality data have been reviewed and analyzed by authoritative scientific international bodies such as UNSCEAR and ICRP and updated relatively frequently as more data become available in order to produce the radiation risk estimates currently used by most countries of the world, including Canada. Because of the much lower uncertainty in risk estimates from exposure to radiation as opposed to chemicals, the "maximum acceptable risk" does not have to be set as conservatively as for exposure to chemicals. In setting its lifetime radiation criterion of 10^{-4}, EPA also considered that the risk would not exceed 10^{-6} for the greatest number of persons reasonably achievable through the application of emission controls (source control). The same approach was taken for benzene in 1989 (Overy 1995). It should be noted that controls over (man made) sources of radionuclides in drinking water in Ontario are in the form of federal (CNSC) regulations, policies and license conditions which include the requirement to follow the ALARA principle for emissions (As Low As Reasonably Achievable, economic and social considerations being taken into account). Although the CNSC emission limits do not explicitly consider the drinking water standard for radionuclides, they have been sufficiently effective (because of the application of ALARA) to have kept drinking water exposures to the lifetime risk level of 10^{-6} or lower. Consideration of the level of natural radiation background risk of 10^{-3} to 10^{-2} (assuming the Linear No Threshold model) and its geographic variability of up to a factor of 10 as a benchmark to the acceptable maximum radiation risk level of 10^{-4} puts the risk of exposure to manmade radioactivity in drinking water in perspective, i.e. regulating to levels somewhat lower than the variability in natural background.

The second difference between the chemical and radiological approach is that limits for chemicals are set individually at a lifetime risk of 10^{-6} or higher. The presence of multiple chemicals generally means that total lifetime risk to an individual consuming the drinking water could be many times higher than 10^{-6}, although for most chemicals it is not known whether combined effects are linear, synergistic or antagonistic. The lifetime risk of 10^{-4} for radionuclides (for WHO and Canada) applies to all radionuclides collectively, such that only a portion of the calculated limit may be applied for each radionuclide if more than one radionuclide is present, so that the total lifetime risk to the individual does not exceed the risk/dose criterion. In the U.S., EPA made the dose/risk criterion for beta and gamma emitters a combined one, but provided separate limits for uranium, radium, and alpha emitters (usually of natural origin). The combined limit on radionuclides is possible because of the increased level of knowledge of radiological risks, such that a system was developed by ICRP that allows the dose/risk to various organs and tissues of the human body from exposure to different types of radiation to be combined using weighting factors derived from epidemiological data, i.e. the “effective dose” concept. There is no comparable system for most chemicals, so that the combined risk from multiple chemicals can not be determined, while it can be for multiple radionuclides.

Having presented this background material, answers to the questions posed at the start of this letter are:

a) Although the methods for setting radiological and genotoxic chemical contaminant limits in drinking water evolved separately and appear to be quite different, current limits calculated by methods recommended by the WHO and those derived by the US EPA are in fact very similar in nature for the two types of contaminants. Both types of contaminants now start with a maximum lifetime risk in the acceptable range of about 10^{-6} to 10^{-4}, apply the Linear No Threshold assumption for risk at very low environmental concentrations, and derive a maximum concentration limit based on an assumed daily intake of drinking water. Because of the much higher uncertainty in estimating risks for chemical genotoxic carcinogens, a lifetime risk level of 10^{-6} is applied for determining the limits for many chemicals, while a risk of 10^{-4} is applied for determining the limits for radionuclides. Another consideration for the higher maximum risk for radionuclides is the assurance that the greatest number of persons reasonably achievable will be exposed at a risk of about 10^{-6} through the application of source controls. The radionuclide risk criterion may also be expressed as an annual radiation dose, but this parameter is not independent of the lifetime risk and the two are interchangeable with proper conversions. Chemicals are regulated on an individual basis while radionuclides are regulated on a combined basis. Thus a mixture of chemicals in drinking water, each with a risk of 10^{-6}, will have a higher total risk than 10^{-6}, while any number of natural or man made radionuclides in the drinking water would have a maximum risk of 10^{-4}.

b) In addition to reasons given in the first answer, there appears to be no reason to select a lifetime risk of 10^{-6} as the sole criterion for drinking water limits for all contaminants. The two global leaders in setting/recommending drinking water standards, US EPA and the WHO, allow for a range of acceptable lifetime risk criteria of about 10^{-6} to 10^{-4}, and provide reasonable rationales for setting the radiation criterion at 10^{-4}, i.e. mainly the higher quality of radiation risk data, and also the very low fraction of the population that is actually exposed to risks higher than 10^{-6} as a result of emission controls. Note that in Ontario, a large fraction of the population is exposed to tritium in drinking water, but an extremely low fraction of the population may be exposed to lifetime risks greater than 10^{-6} from tritium in the drinking water as a result of the application of emission controls.

The case for tritium is the same as for any other radionuclide since the stressor is the radiation emitted from any radionuclide. There are no valid reasons to single out tritium from all other radionuclides. Most claims of this nature made in the recent non-peer-reviewed Greenpeace report on tritium hazards authored by Dr. Fairlie have been refuted by the panel of scientific experts who attended the tritium risk workshop hosted by the CNSC in January 2008 in Ottawa (please see the proceedings of this workshop), and by the response prepared by Dr. Richard Osborne, a respected Canadian and international authority on tritium (Osborne 2008a, Osborne 2008b). The only issue raised that may affect the dose and thus risk from tritium is the radiation weighting factor which could possibly result in an increase in dose/risk of about a factor of 2. Perhaps the questions to be asked are "what compelling reason would the council have to justify a departure from the well established, well thought-out, well reviewed, and still unchanged risk criterion for the regulation of radionuclides in drinking water as implemented by the US EPA, and as recommended by the WHO and implemented in most other countries that have radiological limits or investigation levels in their drinking water regulations?", and "What benefit to public health would result?"

c) As described above, the current basis for the 0.04 mSv/y dose limit used by the EPA for tritium is tied to a lifetime risk of about 10^{-4} for lifelong exposure at the concentration level associated with this dose. A concentration of 740 Bq/L of tritium was originally calculated using 1959 dosimetry models and parameters. Although a 1991 recalculation gave 2,253 Bq/L using current dosimetry models and parameters, U.S. law does not permit the lowering of the limit, so it remains at 740 Bq/L in the latest revision of the US National Primary Drinking Water Regulations. It should be noted that the total dose from radionuclides could be somewhat higher than 0.04mSv/y (or risk greater than 10^{-4}) in some situations, as the EPA combined dose limit is only for beta and gamma emitting radionuclides, and does not include separate limits for some natural radionuclides, i.e. uranium, radium and alpha emitters. (The Ontario standard has a combined limit for all radionuclides, both natural and man-made, so the dose limit of 0.1 mSv/y would not be exceeded).

d) The differences in the risk criteria for radionuclides and for chemicals in the U.S. and in those countries that base their regulations on the WHO drinking water recommendations have a scientific rationale as described above. It should be noted that the European Union (EU) countries who have adopted the EU Directive for drinking water regulation do not have a limit for tritium, only an indicator parameter level, more like an investigation level, not an action level. The EU also has an indicator parameter for "total indicative dose" (the dose from all radionuclides combined) set at 0.1 mSv/y, consistent with the WHO recommendations, but again, it appears as an investigation level in the EU directive while it is a recommended standard in the WHO document.

2a. **<u>What is the U.S. Environmental Protection Agency's (EPA) basis for the 0.04 mSv/y dose criterion for setting radiological drinking water standards?</u>**

The basis for the 0.04 mSv/y EPA dose criterion is included in some detail in the Background information above, and is summarized here.
The U.S. EPA set the target risk level for beta and gamma emitting radionuclides, including tritium, at about 10^{-4} lifetime risk. This level is within EPA's acceptable range of risk of about 10^{-6} to 10^{-4}. The risk coefficient for tritium was calculated taking into account lifelong ingestion of water (70 years), and was adjusted for age differences over a lifetime (e.g. intake rates, physiological changes and sensitivities), and gender (EPA 1999). The annual radiation dose that results from the 10^{-4} lifetime risk criterion is 0.04 mSv/y (EPA 2000a), and the associated tritium concentration limit was 740 Bq/L, based on a previous dosimetry system (ICRP 1959, NBS 1963). A 1991 EPA recalculation of the associated concentration limit based on the current dosimetry system (ICRP 1990) and 0.04 mSv/y dose gave a value of 2,253 Bq/L of tritium. However, the 1996 Safe Drinking Water Act Amendments do not allow raising the limit above the previous value of 740 Bq/L, so this value remained as the tritium standard in the 2000 regulations. The basis for the current limit is still the 10^{-4} lifetime risk.

2b. **<u>What is the basis for the 0.1 mSv/y limit on radiological contaminants in drinking water set by the World Health Organization (WHO)?</u>**

This dose/risk basis is adopted by many countries, including those of the European Community. The WHO gives the following rationale for their basis for setting limits for radiological contaminants (WHO 2006):

"The current Guidelines are based on:
—a recommended reference dose level (RDL) of the committed effective dose, equal to 0.1mSv from 1 year's consumption of drinking-water .... and

The additional risk to health from exposure to an annual dose of 0.1mSv associated with the intake of radionuclides from drinking-water is considered to be low for the following reasons:

- *The nominal probability coefficient for radiation-induced stochastic health effects,* ***which include fatal cancer, non-fatal cancer and severe hereditary effects (emphasis added)*** *for the whole population, is 7.3* x*10^{-2}/Sv (ICRP, 1991). Multiplying this by an RDL equal to 0.1mSv annual exposure via drinking-water gives an estimated upper-bound lifetime risk of stochastic health effects of approximately 10^{-4}, which can be considered small in comparison with many other health risks. This reference risk estimation for radionuclides is quite reliable due to the extensive scientific databases that have included human population exposure data. As with chemical carcinogen risk extrapolations, the lower-bound risk is zero.*
- *Background radiation exposures vary widely across the Earth, but the average is about 2.4mSv/year,with the highest local levels being up to 10 times higher without*

any detected increased health risks from population studies; 0.1mSv therefore represents a small addition to background levels."

Further details related to the statements quoted above are available in WHO 2006.

2a and 2b – In summary, both the U.S. and the WHO set drinking water limits for radionuclides (with Uranium as an exception) on the basis of an acceptable risk from exposure to the associated radioactivity, and they both use a lifetime risk of about 10^{-4}. EPA states that this falls within their range of acceptable risks of about 10^{-6} to 10^{-4}. The WHO uses a lifetime risk basis of 10^{-5} for chemical genotoxic carcinogens, so their range is 10^{-5} to 10^{-4}. The EPA provide a rationale for setting the radiological risk limit at about 10^{-4}, i.e. the much better quality of risk data for exposure to radioactivity (and thus lower uncertainty than for most genotoxic chemicals), and the estimation that most of the population would be subject to an actual exposure risk of around 10^{-6}. The WHO also provides a rationale as to why they went to the higher end of the acceptable risk range for radioactivity, i.e. a) the lower uncertainty in the value of risk per unit radiation dose which is based on a large body of data including human population exposures, and b) the observation that the limiting dose criterion (0.1 mSv/y) is a small fraction of the average background radiation level (2.4 mSv/y) and a small fraction of the variability of that background which ranges up to a factor of 10 higher than average, with no observed increases in health risk. Other than setting a different level of acceptable risk for chemicals and for radioactivity, the determination of the radionuclide limits and the genotoxic chemical carcinogen limits follow very similar methodologies.

3. Why was Dr. Osborne's critique of Dr. Fairlie's Greenpeace report not published in a journal where Dr. Fairlie could have an opportunity to respond.

A member of the panel asked whether the commentary prepared by Dr. Richard Osborne for the Canadian Nuclear Association on the report prepared for Greenpeace by Dr. Ian Fairlie had been published, so that Dr. Fairlie would have an opportunity to respond. Neither Dr. Fairlie's Greenpeace report nor Dr Osborne's review has been published in a peer-reviewed journal. The Greenpeace report was posted on their website (http://www.greenpeace.org/canada/en/documents-and-links/publications/), and Dr. Osborne's review on the CNA website (http://cna.ca/english/studies.asp).

Dr. Fairlie, however, has published a paper in a peer reviewed journal (Fairlie 2007) which deals only with the question of the appropriate radiation weighting factor, and does not mention any of the other claims and concerns about tritium risk that he mentioned in the Greenpeace Report. The w_R issue has been thoroughly discussed in the commentary by Dr. Osborne, and at the Canadian Nuclear Safety Commission (CNSC) January 2008 workshop (see proceedings of that workshop).

4. <u>Please provide the wording in OPG's ISO 14001 document about OPG's 100 Bq/L voluntary commitment on tritium in drinking water.</u>

Many presenters at the recent ODWAC public consultation on the review of the standard for tritium in drinking water claimed that OPG's ISO 14001 document contained a statement that OPG would keep tritium in drinking water less than 100 Bq/L or that OPG "could now meet the 100 Bq/L level". We are not sure how the presenters obtained such information, but their statements are not correct. Our Nuclear Program ISO 14001 document, "Environmental Management", OPG document N-PROG-OP-0006, does not contain any wording about keeping tritium in drinking water at 100 Bq/L. In 1994, the Ministry of the Environment recommended 7,000 Bq/L as the limit for tritium in drinking water, calculated by the traditional radiological method. The Advisory Council on Environmental Standards (ACES 1994) issued their own recommendation of 100 Bq/L, going down to 20 Bq/L in 5 years, calculated according to their method for chemical contaminants. The Ontario government set an interim standard for tritium in drinking water of 7,000 Bq/L, pending the outcome of a federal study that they requested to examine differences between the radiological and chemical approaches to setting drinking water standards and to recommend a value for the standard. At that time, Ontario Hydro voluntarily committed to the minister of the environment to maintain tritium releases from its nuclear power plants at or below historic levels, consistent with its ALARA operating practice, such that levels at nearby water supply plants would not exceed 100 Bq/L on an annual average basis (OH 1994). Ontario Hydro and its successors, Ontario Power Generation and Bruce Power continue to meet this commitment which is mentioned in Ontario Power Generation's and Bruce Power's annual environmental monitoring reports (e.g. OPG 2007, Bruce 2007).

5. <u>Are there practical technologies available for the removal of tritium from drinking water?</u>

The technology currently used by Ontario Power Generation in the Darlington Tritium Removal Facility (TRF) for removal of tritium from contaminated water is designed for treating relatively higher concentrations of tritium in heavy water, and is not designed for removing tritium at very low concentrations and high volumes. We are not aware of any existing practical technology that could remove tritium from drinking water at levels closer to background, or any that could operate on the scale of a water supply plant for a large population. Atomic Energy of Canada Limited and Kinectrics Inc. have looked into a conceptual design for removing lower concentration tritium from light water (e.g. groundwater), but their conceptual design is still for concentrations much higher than found in water supplies (e.g. 37,000 Bq/L), would reduce levels to the current US drinking water limit (740 Bq/L), and could handle only $1x10^6$ US Gal./year (Everatt 2006). It is possible that a system for detritiating a water supply plant could be developed, but the size and cost is likely to be prohibitive.

6a. <u>What causes tritium spikes in NPP emissions to water and what technologies are used/available to prevent/reduce these spikes,</u>

6b. <u>If the drinking water limit were dropped to 20 Bq/L, what else has to be done to ensure drinking water limits will not be exceeded, and what would the cost be, and</u>

6c. <u>If the limit drops to 20 Bq/L, what are the implications on other radionuclides or other radiological protection areas – identify and explain.</u>

The term “spikes” could mean a number of things. In the context of this public consultation, based on the comments made by presenters and the questions of council members, the term “spikes” is taken to mean any tritium emissions to a lake or river that result in short term tritium concentrations at WSPs greater than 20 Bq/L. CNA has already presented data showing that emissions from NPPs do not result in annual average tritium concentrations greater than 20 Bq/L in WSPs. OPG experience over the six year period 2000-2005 has been that at routine operational levels, with no specific sources of higher than normal tritium emissions identified, weekly emissions may reach about 15 Bq/L during the winter months when dilution in the lake is usually at its lowest. In a special study, OPG analyzed daily tritium samples from the Oshawa WSP for the month of December 2005 and found that concentrations greater than 20 Bq/L occurred on 7 days that month, reaching levels of up to 28 Bq/L. The maximum average weekly concentration in December 2005 was 16.7 Bq/L, and the average annual concentration in 2005 at the Oshawa WSP was 7.4 Bq/L.

Tritium waterborne emissions could be reduced in general by a more efficient leak detection/leak repair program or by lowering the tritium concentration of heavy water in the station systems so that the impact of any leak with respect to releases of tritium is lower.

Improvements to the leak detection/leak repair program are already made every year and are incremental, thus large reductions in emissions can not be expected from this program without a significant change in approach. One approach currently possible is the installation of tritium monitors on each reactor heat exchanger that has a capability of producing a leak containing a significant amount of tritium. This arrangement would allow detection of a slowly developing leak much sooner and could result in the reduction of the amount of tritium released to the lake. However, it would not be effective for a leak that developed quickly. The cost of installing additional monitors at Pickering was estimated to be about 10-15 M$ (and likely a similar cost at other CANDU stations).

It may be possible to develop a practical technology to remove tritium from the liquid wastes discharged through the Active Liquid Waste Management System (ALWMS), but no such process is currently available, and it would not address any leaks that result in tritium being discharged through the high volume service water pathways. This approach to remove tritium is costly. We currently have no estimate for the cost of developing and installing ALWMS tritium removal equipment.

Essentially, a significant reduction in waterborne tritium emissions would have to come from the installation at each nuclear station of a tritium removal facility (TRF) similar to the one at Darlington. This would reduce the tritium concentration in the heavy water of all station systems and equipment significantly, so that the same volume of heavy water leakage would now release less tritium to the environment. Although the Darlington TRF now treats tritiated water from Darlington, Pickering and the Bruce reactors, its capacity is not large enough to achieve the required reductions for a 20 Bq/L limit at all of these reactors. A very rough estimate of the cost of each new TRF is 350 – 450 M$.

If the drinking water standard for tritium were to be lowered to 20 Bq/L only because a lifetime risk criterion of 10^{-6} was to be applied in deriving that standard, the remainder of the radionuclide standards would have to be revised downward by a factor of 350 as well. The stressor associated with tritium is the exposure to radiation, exactly the same stressor as for all other radionuclides (except for uranium whose chemical toxicity exceeds its radiation toxicity). Tritium has no characteristics that would justify assigning it a different risk level than the other radionuclides. Since all radionuclide drinking water standards, including Ontario's are combined standards – i.e. the maximum allowable dose or risk is applied to all radionuclides concurrently present in a water supply, the associated maximum acceptable dose to the public would be 0.1 mSv/y / (7,000/20) = 2.9×10^{-4} mSv/y. This is in sharp contrast to the federal public dose limit of 1 mSv/y and could raise public concern about this discrepancy or about their radiation safety in other areas – e.g. nuclear power plant operation, incidental dose (not the diagnostic dose) while visiting a dental office or medical x-ray department, or incidental exposure while working in non-nuclear occupations such as sewage treatment plants (where low levels of radioactive material used in medical diagnostic tests are disposed.) The current performance of Ontario's nuclear power plants (NPPs) results in public doses that range from about 0.001 to 0.005 mSv/y. These doses would be 3 to 15 times higher than the allowable dose from drinking water if a standard of 20 Bq/L were set for tritium, and it would be likely that emissions from NPPs would have to be reduced significantly in order to address public concerns about this situation (No cost estimate available). It should be noted that it would take only 3 minutes of exposure to natural radiation during an airplane flight to reach the 0.00029 mSv dose that would be obtained from drinking water for a full year at a concentration of 20 Bq/L.

Another possibility is that a lower de facto public radiation dose limit, as established by a lower drinking water limit, would have an effect on radiation workers who have higher dose limits than members of the public (because their exposure is voluntary and they derive direct monetary benefit from that exposure). However, even taking that consideration into account, radiation worker dose limits have remained within a range of 10 to 20 times the public dose limits since 1959, and going to a multiple of 3,500 to 7,000 times the public limit may be a source of concern for radiation workers and their families who may demand an equivalent reduction of 350 in their dose limits. Should this occur, there would be impacts in many fields where radiation is present such that more workers would be needed to achieve the same amount of work as is done today, or very significant changes in work practices, technologies and equipment would be needed to meet much tighter radiation protection requirements. A quick review of data in the Canadian dose registry indicates that areas significantly affected would include nuclear power plants, uranium mines and mills, diagnostic nuclear medicine technicians, physicians, and industrial radiographers.

In summary, the implications of lowering the tritium drinking water standard to 20 Bq/L are expected to be significant because such an action would indicate that Ontario rejects the risk levels currently acceptable for exposure to radiation internationally, and considers that that they should be lowered by a factor of 350. The response given in item 1 above provides evidence that adoption of a risk level of 10^{-6} for radionuclides in drinking water is not appropriate, that a level of about 10^{-4} is appropriate and is used by most jurisdictions, and that the drinking water standard for tritium and all radionuclides need not be inconsistent with international radiation protection standards.

7. <u>Can you provide a summary of the analysis and data on validations/calibrations you do on your Derived Release Limits (DRL) models?</u>

DRL model predictions for OPG and Bruce Power stations were validated with field data and shown to be sufficiently accurate to be suitable for the calculation of DRLs, particularly for the radionuclides which have the largest impact on dose to the public, i.e. tritium and carbon-14. A comprehensive validation exercise was completed as part of the validation of the software which implements our conceptual environmental pathways models. Concentrations in environmental media were predicted by the models using measured emission rates from the station and compared with actual measurements of environmental media from our routine radiological environmental monitoring program. The model is designed to predict realistic concentrations in environmental media, and it then adds considerable conservatism into the calculation of radiation dose by using 95th percentile intake rates (e.g. air, water, food) and conservative exposure factors for external radiation. A summary of the results of that study for well water and surface water is given below (OPG 2003a)

Tritium in Well Water

Pickering - of 11 wells tested, the model over-predicted tritium concentrations for 8, with an average predicted to measured ratio of 18, and under-predicted 3 wells with an average predicted to measured ratio of 0.6.

Bruce – of 21 wells tested, 15 were predicted to have tritium below the detection level (3.7 Bq/L), and in all 15, tritium was not detectable. In the remaining 6 wells, the model over predicted all 6 by an average predicted to measured ratio of 5.

Tritium in Surface Water

Of 5 water supply plants (WSP) near Ontario nuclear power stations, the model over-predicted tritium concentrations for 4 of them with an average predicted to measured ratio of 1.7, while it under predicted at one WSP with an average predicted to measured ratio of 0.5.

8. What can be monitored routinely at a WSP?

OPG experience is given as an example, but experience at Bruce Power is very similar. Currently, operators at the Harris, Horgan, Ajax, Whitby, Oshawa, Bowmanville and Newcastle WSPs collect samples of raw water once per shift, and store these on site for a period of one month. OPG collects these samples once a month, creates a weekly composite for each WSP and analyzes them for tritium at its low-level environmental radiological laboratory in Whitby. Gross beta-gamma activity is analyzed on monthly composite samples. The tritium detection level is 4.5 Bq/L, and the WSP samples typically have levels around 4 to 15 Bq/L. If OPG were required to provide and report on daily analyses, it would mean adding additional building space, staff, equipment and purchased services with an incremental cost estimated at about 1.6 M$ initial capital cost and 0.9 M$/year operating costs, for an annualized incremental cost of 1.1 M$/year.

Technology for the measurement of tritium online at the levels encountered at the water supply plant is not available. OPG operates an on-line (automated frequent batch analysis) instrument for measuring tritium in its reactor building service water for the purpose of early detection and minimization of any tritium leaks. The minimum detection limit for this equipment is about 3,700 Bq/L, and we are not aware of any that is more sensitive.

9. Clarification: Sensitivity of Embryo/Fetus and Implications on spikes/monitoring frequency

The effects of ionizing radiation exposure of the embryo or fetus in utero have been well-studied, particularly because of the risks from diagnostic and therapeutic medical exposures of potentially-pregnant patients. ICRP 2003 provides a detailed recent review.

In brief, there are 4 responses of concern: failure to implant during the first ~10 days after conception; developmental abnormalities from exposure during the embryonic period to 8 weeks after conception; impairment of neurological development from exposure during the period 8-25 weeks after conception, leading to reduced mental capacity; and carcinogenic risk throughout gestation. The first 3 of these responses have well-demonstrated thresholds in dose of at least 100 mGy (=100 mSv for tritium), and below this dose no effects have been observed. This is more than 1000 times the maximum dose that could be received under the current Canadian drinking water guideline. The risk of inducing a cancer is believed to persist throughout the pregnancy, perhaps higher in the third trimester. This risk, however, is not different from that of a child, which is perhaps a few times greater than that of an adult.

The issue of protection of the female fetus during the period of development of oocytes was raised in the public consultation by many presenters in the context of the need to have the drinking water standard provide adequate protection for a sensitive segment of the population and in the context of a possible need for more frequent monitoring of tritium in drinking water. The UK Advisory Group on Ionising Radiation (AGIR) comprehensive review of the risks from tritium (AGIR 2007) examined the risks from continuous exposure of oocytes to tritium from conception to 30 years of age. It concluded that for an equilibrium body content of tritium of 175 kBq, the frequency of severe hereditary effects would be expected to be about 10^{-6}, and this may be compared to a normal incidence of 3% to 4%. Continuous intake of 2 L of drinking water per day containing tritium at 7,000 Bq/L would result in an equilibrium body content of about 200 kBq of tritium, and using the AGIR risk of 10^{-6} for 175 kBq, a risk of hereditary effects of about $1.1\text{x}10^{-6}$ would be expected. Similarly, continuous intake of drinking water with 100 Bq/L of tritium produces a risk estimate of $0.016\text{x}10^{-6}$, and for 20 Bq/L tritium, the risk estimate is $0.003\text{x}10^{-6}$. Thus continual consumption (at 2L/d) of drinking water with 7,000 Bq/L of tritium or less represents a very low lifetime risk of hereditary effects via exposure of oocytes, does not constitute a limiting case for setting the drinking water standard, and does not support any increase in the frequency of monitoring in Ontario.

At doses below the annual public dose limit (1 mSv per year), there is no difference in risk for any of these effects whether the dose is distributed evenly over the year, or received in a single day. For doses below this public dose limit, or at the Ontario Provincial Liquid Emission Response action level (7,000 Bq/L at a WSP), there is no benefit to risk management in monitoring drinking water on a daily or even a weekly basis.

10. Clarification: Renfrew high tritium levels – still produced a very low dose.

During Ole Hendrickson's presentation, he described a citizen of Pembroke whose urine reportedly contained a concentration of HTO of 2000 Bq/L. Tritium in urine accurately reflects its concentration in body water generally, and is used as the basis for monitoring HTO-exposed workers. However a concentration of 2,000 Bq/L corresponds to an annual dose, if maintained at this level throughout the year, of only ~ 0.04 mSv, a small fraction of the public dose limit, and of background.

11. Clarification : Misconceptions about credible evidence on Leukemia and birth defects – references of proper epidemiological studies are provided.

Birth defects in populations living near the Pickering stations, and childhood leukemias in populations living near all of the Ontario nuclear stations, have been studied by epidemiologists under contract to the CNSC (formerly the Atomic Energy Control Board), by Health Canada and the Ontario Cancer Treatment and Research Foundation, respectively. The birth defect results were reported in AECB 1991a. The leukemia results were reported in AECB 1991b. Neither found statistically-significant effects. These potential adverse health effects have also been considered by the Durham Region Health Department (Durham 2007). They reported "In conclusion, disease rates in Ajax-Pickering and Clarington did not indicate a pattern to suggest that the Pickering NGS and the Darlington NGS were causing health effects in the population."

12. <u>Provide information on HTO discharge rates, detection limit for monitoring at the plant and corresponding WSP concentrations; time to reach WSP from previous leaks, and existence of reporting agreements and LERP (Liquid Emission Response Procedures)</u>

Routine tritium discharge rates from nuclear power plants (NPPs) are monitored and controlled at source as per CNSC regulations and license conditions. Although CNSC limits are not set in terms of drinking water limits, CNSC requires its licensees to apply ALARA. This has resulted in NPP discharges that are very low, and the NPPs in Ontario have made a voluntary commitment to keep their tritium emissions low enough so as not cause tritium in water supply plants to exceed 100 Bq/L on an annual average basis.

Non-routine tritium discharges from the NPPs have occurred in the past, mainly via a heat exchanger leak (equipment failure), and have released larger than routine levels of tritium to the lake. The leaks are stopped at source generally within one shift. Transit times to the closest WSP could be as little as a few hours (for maximum lake current speeds) and as much as a few days, but elevated tritium levels persist at the WSPs for periods from about a day to a few weeks. In response to such events, NPPs have installed new or improved monitors in the discharge line of the reactor building service water so that a leak can be detected and stopped much more quickly than in the past, resulting in faster notification and lower tritium emissions. Furthermore, to fulfill the Policy on Liquid Emission Response of the Province of Ontario Nuclear Emergency Plan, nuclear power plant operators, OPG and Bruce Power, agreed to send an abnormal waterborne tritium emission notification when tritium in the station discharge would cause WSP levels to reach 600 to 2,000 Bq/L. Notification is provided to Emergency Management Ontario, the Provincial Spills Action Centre and local municipalities (e.g. for OPG, it is to Durham Region and Toronto).

13. <u>Clarification: on whether radiological dosimetry/risk takes into account additional sensitivity for women</u>

ICRP 2006 provides detail on the methods recommended for ensuring that all members of the public are adequately protected, regardless of age and sex. In short, the variations in radiation risk among these various populations are relatively well-known, and as appropriate, the characteristics of the most sensitive members are used as the basis of protection. The criterion for the representative person is generally that "the probability is less than 5% that a person drawn at random from the population will receive a greater dose".

In addition, the risk factors used by the US EPA for determining the drinking water limit are taken from U.S. Federal Guidance Report No.13 (EPA 1999) and take into account age, gender and sensitive populations adjusted over a 70 year lifetime.

REFERENCES

ACES 1994	A Standard for Tritium, A Recommendation to the Minister of the Environment and Energy, Advisory Committee on Environmental Standards, ACES report 94-01, Ontario, May 1994.
AECB 1991a	Johnson K.C. and Rouleau J., "Tritium Releases from the Pickering Nuclear Generating Station and Birth Defects and Infant Mortality in Nearby Communities 1971-1988" AECB INFO-0401 (1991).
AECB 1991b	Clarke E.A., McLaughlin J. and Anderson T.W. "Childhood Leukemia around Canadian Nuclear Facilities Phase II – Final Report" AECB INFO-0300-2 (1991).
AGIR 2007	Review of Risks from Tritium, Report of the Independent Advisory Group on Ionising Radiation, Documents of the Health Protection Agency, UK, November 2007.
Bruce 2007	Annual summary and assessment of environmental Radiological data for 2006, B-REP-03419-00007 Rev 000, N. McDougall, April 11, 2007.
Duggan 1998	Standards for Environmental, Non-threshold, Carcinogens: A comparison of the Approaches Used for Radiation and for Chemicals, M.J. Duggan and B.E. Lambert, Annals of Occupational Hygiene, v. 42, No. 5, pp. 315-328, 1998.
Durham 2007	Durham Region Health Department 2007 publication, Radiation & Health in Durham Region: http://www.iicph.org/docs/health-durham-2007.pdf .
EPA 1992	Letter from Dr. R.C.Loehr of the Science Advisory Board, and Dr. O.F. Nygaard, Radiation Advisory Board to Hon. W.K. Reilly, Administrator, U.S. Environmental Protection Agency, "Commentary on Harmonizing Chemical and Radiation Risk-Reduction Strategies", EPA-SAB-RAC-COM-92-007, May 18, 1992.
EPA 1999	US EPA Federal Guidance No. 13, "Cancer Risk Coefficients for Environmental Exposure to Radionuclides", EPA 402-R-99-001, Sep. 1999.
EPA 2000a	US EPA, "Radionuclides Notice of Data Availability, Technical Support Document", prepared by USEPA Office of Groundwater and

Drinking Water in collaboration with USEPA Office of Indoor Air and Radiation, United States Geological Survey, March 2000.

EPA 2000b National Primary Drinking Water Regulations; Radionuclides; Notice of Data Availability; Proposed Rule, Part IV, Environmental Protection Agency, Federal Register 40 CFR Parts 141 and 142, April 21, 2000.

EPA 2000c National Primary Drinking Water Regulations; Radionuclides; Final Rule, Part II, Environmental Protection Agency, Federal Register 40 CFR Parts 9, 141 and 142, December 7, 2000.

Everatt 2006 Technologies for Removal of Tritium from Water, A. Everatt, R. Sadhankar, J.R. Robins, V. Singh, J.Krasznai, presented at the EPRI 2006 International Low Level Waste Conference, New Mexico, June 27-29, 2006.

Fairlie 2007 RBE and w_R Values of Auger Emitters and Low-range Beta Emitters with Particular Reference to Tritium, Journal of Radiological Protection 27 (2007) 157-168.

HC 1998 Assessment and Management of Cancer Risks from Radiological and Chemical Hazards, prepared by a Joint Working Group assembled from AECB's Advisory Committees, AECB Staff, Health Canada Staff, and Ontario Ministry of Environment and Energy Staff, 98-EHD-216, AECB INFO-0684(E), AC-5, Canada 1998.

ICRP 1959 International Commission on Radiological Protection. *Report of Committee II on Permissible Dose for Internal Radiation (1959)*. ICRP Publication 2. New York: Pergamon, Adopted July 1959.

ICRP 1990 ICRP Publication 60: 1990 Recommendations Of The International Commission On Radiological Protection, Annals of the ICRP Volume 21/1-3, Publication April 1991.

ICRP 2003 ICRP Publication 90, "Biological Effects after Prenatal Irradiation (Embryo and Fetus)" Annals of the ICRP 331-2 (2003).

ICRP 2006 ICRP Publication 101 "Assessing Dose of the Representative Person for the Purpose of Radiation Protection of the Public and the Optimisation of Radiological Protection: Broadening the Process" (2006).

NBS 1963 U.S. National Bureau of Standards. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in* *air and in water for occupational exposure*. National Bureau of Standards handbook 69, as amended. AFP-160-6-7. Washington, DC: Govt. Print. Office; U.S. Department of Commerce, August 1963. First published in 1959, with an addendum in 1963. Also bears the series title NCRP report no. 22, of the National Committee on Radiation Protection and Measurements.

OH 1994 — Letter O.A. Kupcis of Ontario Hydro to C.J. Wildman, Minister of Environment and Energy, December 9, 1994.

OPG 2003a — IMPACT Validation Exercise Report , OPG Document N-REP-03482-10006, April 2003.

OPG 2003b — The Pickering Model Verification Report for the Updated Radiological Environmental Monitoring Program, OPG Report N-REP-03481-10001, Lamarre, J. and Polack A., Dec.2003

OPG 2007 — 2006 Results of Radiological Environmental Monitoring Programs, OPG report N-REP-03481-10005-R001, J. Borromeo, Dec. 2007.

Osborne 2008a — Review of the Greenpeace report: “Tritium Hazard Report: Pollution and Radiation Risk from Canadian Nuclear Facilities” I. Fairlie, 2007 June by R.V. Osborne, Ranasara Consultants Inc., Deep River, Ontario. Prepared for the Canadian Nuclear Association, 2007 August 13, **C**anadian Nuclear Association website at (http://www.cna.ca/english/studies.asp).

Osborne 2008b — Comments on the Ontario Drinking Water Quality Standard for Tritium, Richard V. Osborne, PO Box 1116, Deep River, Ontario K0J1P0 2008 March 7 (written submission to ODWAC)

Overy 1995	Regulation of Radiological and Chemical Carcinogens: Current Steps Toward Risk Harmonization, D.P. Overy and A.C.B. Richardson, The Environmental Law Reporter, V.XXV, No.12, pp. 10657-10670, 1995.
WHO 2006	Guidelines for Drinking-Water Quality, First Addendum To Third Edition, Volume 1, Recommendations- 3rd edition, World Health Organization, 2006.

Appendix 6:

Toronto Public Health letter dated July 28, 2008

TORONTO

125 Years
Toward a healthy city

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July 28, 2008

Ontario Drinking Water Advisory Council
40 St. Clair Avenue West, 3rd Floor
Toronto, ON M4V 1M2

Dear Esteemed Council Members:

In the recent public consultation on the Ontario drinking water standard for tritium, I submitted my recommendations to the Ontario Drinking Water Advisory Committee (ODWAC). At that time, I recommended:

- The adoption of the drinking water standard proposed by the Ontario Advisory Committee on Environmental Standards (ACES) of 100 Bq/L, to be further reduced to 20 Bq/L within five years, which is based on public exposure over a lifetime (70 year exposure) and a *de minimis* risk level of 1 in a million cancer risk.
- Mandatory reporting and notification to the affected local Medical Officer of Health (MOH) of tritium levels in drinking water and releases from nuclear power, to include the following:
    - routine monthly reports on levels of tritium in drinking water (or raw water in proximity to drinking water intake pipes);
    - immediate notification of any daily drinking water level that exceeds 20 Bq/L;
    - immediate notification of accidental releases of tritium from nuclear facilities.

Since then Toronto Public Health has received some additional information from the Ontario Power Generation (OPG) that has helped me to clarify my views.

OPG has a voluntary agreement with the City of Toronto to monitor tritium in drinking water at Harris and Horgan Water Treatment Plants. Currently Toronto Water takes three drinking water samples per day (1 per 8-hour shift). OPG picks up water samples on a monthly basis. The daily samples are composited into weekly samples and analyzed for tritium. OPG voluntarily provides monthly reports on the weekly composite samples to Toronto Water and to the Plant Managers.

OPG has informed Toronto Public Health that daily analysis would require a substantial increase in both capital investment and operating costs. Given this, and that the concern with tritium is chronic exposure, I believe that weekly analysis is acceptable if these are done every week rather than as monthly batches as is the current practice.

I also noted in my letter that it is important that peaks in tritium concentrations in Toronto's drinking water do not occur as a result of upset conditions at the nuclear power plants. Spikes in tritium drinking water concentrations can occur when there are leaks and upset conditions at nuclear power plants. OPG informed me that to fulfill the Policy on Liquid Emission Response of the Province of Ontario Nuclear Emergency Plan, OPG and local officials in the City of Toronto have developed notification protocols for tritium releases from Pickering station. OPG notes that it was agreed that OPG will notify the City of Toronto, Emergency Management Ontario (EMO) and the Ministry of the Environment Spills Action Centre when tritium concentrations in the station discharge is equal or greater than 4000 Bq/L. OPG further notes that at this concentration, the tritium concentration at the Harris or Horgan Water Treatment Plants would be approximately 400 Bq/L, based on a dilution factor of 10.

Based on calculations by Toronto Public Health, short term increases in drinking water concentrations of tritium at this level could occur for 13 to 15 days per year (or exceedances of two weekly composite samples) without exceeding an annual drinking water average of 20 Bq/L. Thus, equipped with information on the magnitude of exceedance of the drinking water standard and a rolling annual average, I would be best positioned to provide advice to the City of Toronto on risk management measures in the event of upset conditions and provide risk communication messages to the public.

Thus, I would like to re-iterate my recommendations to the ODWAC with the following modifications:

- Require routine monthly reports on levels of tritium in drinking water (or raw water in proximity to drinking water intake pipes), based on daily sampling but analyzed and reported as weekly composites, and reported in conjunction with an rolling annual average of tritium in drinking water;
- Require immediate notification of drinking water level that exceeds 20 Bq/L, based on daily sampling but analyzed as a weekly composite;
- Require immediate notification of accidental releases of tritium from nuclear facilities into source water for drinking water facilities.

In conclusion, I urge the ODWAC and the province to consider requiring mandatory reporting of tritium levels in drinking water on a regular basis and immediate notification of any accidental releases or upset conditions to affected MOHs.

I hope these comments and points of clarification are helpful. Please do not hesitate to contact Dr. Monica Campbell for further clarification at mcampbe2@toronto.ca or 416- 338-8091. I look forward to reviewing the recommendations of the Ontario Drinking Water Advisory Council.

Sincerely,

<original signed by>

David McKeown, MDCM, MHSc, FRCPC
Medical Officer of Health

Attachments: Toronto Medical Officer of Health Submission to Ontario Drinking Water Advisory Council on Drinking Water Standard for Tritium. Presented by Dr. Monica Campbell at public consultation meeting held from March 26-27, 2008 at Sutton Place Hotel

TORONTO

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April 7, 2008

Ontario Drinking Water Advisory Council
40 St. Clair Avenue West, 3rd Floor
Toronto, ON M4V 1M2

Dear Esteemed Council Members:

Re: Submission to the Ontario Drinking Water Advisory Council (ODWAC) on the Drinking Water Standard for Tritium

Thank you for the opportunity to contribute to the public consultation on the drinking water standard for tritium. I have attached a copy of the presentation that Dr. Monica Campbell made to the Council on my behalf.

During the public consultation, the panel members asked a few questions of clarification on my submission.

The panel asked for clarification on the optimal frequency of monitoring and notification of exceedances of the proposed drinking water standard of 20 Bq/L. It is my view that tritium should be treated in the same manner as other drinking water standards, therefore, subject to daily monitoring and notification of exceedances to local Medical Officers of Health (MOHs).

The council members also asked if I had concerns about the risk communication challenges of reporting short term exceedances of the drinking water standard. As with short term exceedances of standards by chemical carcinogens, risk communication of environmental hazards can be challenging. However, clear and transparent reporting of this information can result in the positive engagement of communities. Moreover, it will help governments, the nuclear industry and the public make decisions to protect health and our environment.

The Ontario Public Health Association and Dr. David L. Mowat, the Medical Officer of Health for Peel Region, have both recommended to the ODWAC that a subcommittee be set up to discuss implementation considerations for a revised tritium drinking water standard. Examples of implementation considerations include monitoring and notification to the local MOHs of exceedances of the standard. I also support this recommendation and would be pleased to participate in this work.

I trust that these comments and points of clarification are helpful. Please do not hesitate to contact Dr. Monica Campbell for further clarification at mcampbe2@toronto.ca or 416- 338-8091. I look forward to reviewing the recommendations of the Ontario Drinking Water Advisory Council.

Sincerely,

<original signed by>

David McKeown, MDCM, MHSc, FRCPC
Medical Officer of Health

Attachments: Toronto Medical Officer of Health Submission to Ontario Drinking Water Advisory Council on Drinking Water Standard for Tritium. Presented by Dr. Monica Campbell at public consultation meeting held from March 26-27, 2008 at Sutton Place Hotel.

TORONTO MEDICAL OFFICER OF HEALTH SUBMISSION TO THE ONTARIO DRINKING WATER ADVISORY COUNCIL ON THE DRINKING WATER STANDARD FOR TRITIUM

Presented by Dr. Monica Campbell at the public consultation meeting held from March 26 to March 27, 2008 at the Sutton Place Hotel.

As Toronto's MOH, I am responsible for protecting the health of Toronto's residents. Toronto Public Health, Canada's largest municipal public health agency, provides public health programs and services for 2.6 million Ontarians. I am pleased to provide comments and recommendations for the review of the Ontario's Drinking Water Standard for tritium.

Concern about tritium is linked to the provincial government's plans to meet Ontario's energy needs.

Nuclear power plants are the current major *preventable* sources of tritium releases to the environment in Ontario. Lake Ontario receives tritium discharges from nuclear power plants. Lake Ontario is the source of Toronto's drinking water. Notably, 27% of Toronto's drinking water comes from F.J. Horgan Water Treatment Plant which is in close proximity to the Pickering Nuclear Generating Station. Water treatment plants cannot treat or remove tritium from the drinking water supply.

The City of Toronto continues to express concern with the province's plan to refurbish and intensify its nuclear program. The province's plan will result in higher levels of tritium released into the environment. Therefore, it is timely to ensure that drinking water standards for tritium and other radionuclides are protective of health.

In a letter to Premier McGuinty on February 3 2006, I urged the Ontario Power Authority and the Government of Ontario to create a sustainable energy strategy that gives clear priority to conservation and demand management approaches, and supply from low-impact, renewable energy sources, rather than placing such a heavy emphasis on nuclear energy (Attachment 1).

This recommendation is consistent with the request made by City Council in July 2004 for the province to develop a strategy using, "a combination of measures, in the following order of priority: energy conservation and efficiency, ecologically sustainable renewable electricity supply sources and small scale high-efficiency natural gas-fired co-generation power plants that replace existing monogenerators and provide electricity and heat to local district heating grids, *rather than by nuclear energy*" (Attachment 2).

Toronto Public Health advocates for lowering the Ontario tritium drinking water standard.

In 2006, I was asked by the Toronto Board of Health and by City Council to write to the Minister of the Environment to request the Ontario Government to revisit the 1994 recommendations of the Ontario Advisory Committee on Environmental Standards (ACES) and consider the more health protective standard. The ACES report encourages the province to set the standard comparable to the process for chemical carcinogens, which assumes:

- public exposure over a lifetime (70 year exposure); and,
- a *de minimis* risk level of 1 in a million cancer risk.

ACES recommended immediate adoption of a 100 Bq/L drinking water standard, to be reduced to 20 Bq/L within five years.

Currently, the tritium drinking water standard assumes a lifetime risk estimate based on only **one year's** exposure to tritium. This is a departure from the typical method of establishing a drinking water standard for chemical contaminants based on a lifetime risk associated with a lifetime of exposure (assumed to be 70 years).

Moreover, the *acceptable* lifetime risk estimate is typically assumed to be 1 in a million (*de minimis* risk level or an acceptable risk level). Assuming a lifetime of exposure, the current drinking water standard for tritium represents a lifetime cancer risk of 340 in a million[1]. This constitutes an unacceptable level of *preventable* risk to Toronto's residents.

It is understood that regulatory risk *acceptance* varies considerably for ionizing radiation and chemical carcinogens. The underlying assumptions used by the two paradigms differ considerably and result in differences in risk acceptance[2]. The radiological risk assessment approach was developed in the context of public background exposure to naturally occurring radionuclides/radiation. Furthermore, the radiological approach was used to assess the risk of voluntary and beneficial exposures to radionuclides (e.g., x-rays, other radiological medical procedures, workers exposed to radiation and radionuclides). The general populations' exposure to elevated concentrations of tritium in drinking water is involuntary and caused by anthropogenic activity. Thus, I do not believe the radiological risk assessment approach is appropriate for developing a tritium drinking water quality standard. Despite the challenges associated with harmonizing the approaches, I believe that it is important for the protection of the health of Toronto residents that the standard for tritium in drinking water follows the chemical risk paradigm.

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[1] This calculation was provided by Dr. P.J. Waight of the Radiation Protection Bureau of Health Canada as part of his submission to the ACES public consultation in 1994.

[2] Health Canada, 1998. Assessment and Management of Cancer Risks form Radiological and Chemical Hazards. ISBN 0-662-26624-2.

Recent reviews of the low dose hazards of tritium further support a precautionary approach

Independent scientists and expert panels convened by government agencies have been raising the alarm that there is greater uncertainty in the risk estimates for tritium than was previously thought[3]. Scientists are challenging assumptions made in the International Commission on Radiological Protection (ICRP) calculations, upon which the drinking water standard for tritium is based[4]. The guiding principles of risk assessment direct us to provide a greater level of public protection when there is uncertainty about exposure or harm. Moreover, the principles of precaution guide us to act to prevent harm when there is a threat to human or environmental health, even if there is a lack of full scientific certainty.

Thus, I urge the provincial government to convene an expert panel to review the ICRP and WHO limits and underlying assumptions and to integrate the growing level of uncertainty into the derivation of the Ontario drinking water standard for tritium.

Every effort should be made to eliminate or reduce preventable exposures to carcinogens including tritium

The Canadian Cancer Society and the National Cancer Institute of Canada estimated that in 2007 there would be 59,500 new cases of cancer diagnosed and 26,900 deaths from cancer among residents of Ontario[5]. The International Agency for Research on Cancer classifies internalized radionuclides that emit β-particles as *carcinogenic to humans (Group 1)*[6]. Tritium is one of these radionuclides.

As with other carcinogens, it is assumed that no threshold of exposure to tritium exists below which adverse health effects do not occur. We are exposed to many different carcinogens concurrently. Thus, it is prudent public health practice to set stringent standards for each substance and minimize exposures to carcinogens to the greatest extent possible. Moreover, because harm can occur at any level, an *acceptable* level of risk must be chosen by risk managers. It is standard practice at Toronto Public Health to recommend that the level of *acceptable risk*, or what is otherwise called a *de minimis* risk level, is set at 1 in a million increased risk of developing cancer from lifelong exposure (assumed to be 70 years).

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[3] CERRIE (Committee Examining Radiation Risks of Internal Emitters), 2004. Report of the Committee Examining Radiation Risks of Internal Emitters.
CERRIE, 2004. Minority Report. ISBN 0-85951-545-1. Accessed at: www.cerrie.org
ECRR (European Committee on Radiation Risk) 2003. Recommendations of the ECRR The Health Effects of Ionising Radiation Exposure at Low Doses and Low Dose Rates for Radiation Protection Purposes: Regulators' Edition. ISBN: 1 897761 24 4.
[4] The WHO reference levels for drinking water of 0.1 mSv/year is based on the ICRP *acceptable* public dose limit.
[5] Canadian Cancer Society/National Cancer Institute of Canada: Canadian Cancer Statistics 2007, Toronto, Canada, 2007.
[6] International Agency for Research on Cancer. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Volume 78: Some internally deposited radionuclides: http://monographs.iarc.fr/ENG/Monographs/vol78/volume78.pdf

Drinking water is an important **preventable** source of exposure to tritium. Nuclear power plants are the current major preventable sources of tritium to the environment. It is estimated that the natural background concentration of tritium in Lake Ontario is 2 Bq/L[7]. Any exceedances of this level are the result of releases from nuclear power plants. Higher concentrations of tritium can be detected in air, water and food in areas near Canadian nuclear facilities when compared to Canadian background levels[8].

It is important to ensure that **average** concentrations in Toronto's drinking water do not increase as a result of an increase in Lake Ontario's tritium loading from nuclear power plants. In 2006, Toronto's drinking water concentration for tritium was at an average of 3.3 Bq/L, with a maximum value of 12 Bq/L. Across Ontario, the average tritium concentrations in drinking water are between 5 and 10 Bq/L[9]. This is a marked decrease since the mid-1960s peak in tritium concentrations in the environment. A more health protective standard would help to protect the integrity of Toronto drinking water by ensuring that measures are put in place to reduce tritium releases into the environment.

In addition, it is important that **peaks** in tritium concentrations in Toronto's drinking water do not occur as a result of upset conditions at the nuclear power plants. Data[10] demonstrate that spikes in tritium drinking water concentrations can occur when there are leaks and upset conditions at nuclear power plants. The most notable upset conditions in recent years were a tube break at Pickering-1 which caused the release of 2,300 TBq of tritium into Lake Ontario in 1992; and in 1996, Pickering-4 accidentally released 50 GBq of tritium into Lake Ontario, causing the local drinking water to reach tritium levels 100 times background levels[11].

Mandatory reporting and notification to local MOHs of tritium levels in drinking water and releases from nuclear power plants would help ensure that public health is better protected.

As a matter of protecting public health, it is prudent that risk management measures are initiated if tritium concentrations in drinking water are found to significantly increase above the current levels of tritium in raw water and drinking water supplies. It is the responsibility of the local MOH to keep informed and monitor matters relating to environmental health (R.S.O. 1990, c.H.7,s.12(1) of the Health Protection and Promotion Act). Thus, with the risk of increasing levels of tritium in the environment due to nuclear power generation, it is prudent to institute the **mandatory reporting** to local MOHs of the following:

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[7] Estimate is for Lake Superior and applied to all Great Lakes. King et al 1998. Tritium in the Great Lakes in 1997. AECL Report. Cited in Fairlie, 2007. Tritium Hazard Report: Pollution and Radiation Risk from Canadian Nuclear Facilities.

[8] Canadian Nuclear Safety Commission. 2008. FAQs and Fact Sheets. Frequently Asked Questions – Tritium Studies. Date Modified: 2008-11-02. Date Accessed: 2008-15-02. www.nuclearsafety.gc.ca/eng/resources/faq/tritium/faq.cfm

[9] Data for 2000-2006. Health Canada, 2006. Radiological Characteristics of Drinking Water.

[10] Data is for Toronto water supply plants; provided by Ontario Power Generation, Environmental Division, 2004

[11] Fairlie, 2007. Tritium Hazard Report: Pollution and Radiation Risk from Canadian Nuclear Facilities.

a. routine monthly reports on levels of tritium in drinking water (or raw water in proximity to drinking water intake pipes), may be reported as weekly averages;
b. immediate notification of any *daily* drinking water level that exceeds 20 Bq/L;
c. immediate notification of accidental releases of tritium from nuclear facilities[12].

My staff and other divisions in the City of Toronto, in consultation with the Ministry of the Environment, Ontario Power Generation, Bruce Nuclear, and Durham region have been working on a protocol to address emergency procedures in the event of an accidental release of tritium from a nuclear power plant. As part of this process, they have been exploring the tritium level which would trigger an emergency response; including which level would necessitate shutting off Toronto's drinking water intake pipes in the vicinity of the release. This is a good example of the risk management measures that can be put in place to reduce the impact of upset conditions at the nuclear power plants on local drinking water quality. This protocol should be applied to other affected municipalities.

Thus, I urge the province to consider requiring mandatory reporting of tritium levels in drinking water ***and*** *releases of tritium from nuclear power generating stations to local Medical Officers of Health on a regular basis, in addition to immediate notification in the event of any accidental releases or upset conditions. This will help to protect the integrity of Toronto drinking water by ensuring that measures are put in place to allow assessment and monitoring of tritium levels.*

A lowering of the tritium drinking water standard is <u>achievable</u>.

The Canadian Nuclear Safety Commission states that all tritium doses and releases must be **as low as can be reasonably achieved**. The *ALARA Principle* is the internationally supported principle that *acceptable* levels should be as low as reasonably achievable, taking into account the hazards and the social and economic benefits of the available technology. Drinking water monitoring for Ontario shows that we are already achieving levels of tritium that meet the ACES recommendations.

In summary, and to specifically answer the three questions posed by the Ontario Drinking Water Advisory Council:

Is the current drinking water standard for tritium acceptable?

No. At 7000 Bq/L, the tritium standard is unacceptably high for a chronic drinking water standard.

[12] This notification level may be based on a higher level of tritium than the proposed drinking water standard.

If not, what is the basis of finding it unacceptable?

A health-based drinking water standard for a carcinogen should be based on keeping the risk from exposure to tritium and other radionuclides below 1 in 1 million excess cancer risk over a lifetime of exposure.

Are you proposing a different standard? What is your rationale?

I support the recommendation made by the Advisory Committee on Environmental Standards in 1994. The ACES report recommended immediate adoption of a 100 bq/L standard, reduced to 20 Bq/L within five years.

The ACES report encourages the province to set the standard comparable to the process for chemical carcinogens. Specifically this would require an assumption of:

- public exposure over a lifetime (70 year exposure); and,
- a *de minimis* risk level of 1 in a million cancer risk.

Moreover, the guiding principles of risk assessment direct us to provide a greater level of public protection when there is uncertainty in our understanding about exposure or harm. The drinking water standard for tritium should reflect the growing level of uncertainty in the science upon which it is based.

The City of Toronto continues to express concern with the province's plan to refurbish and intensify its nuclear program. An intensification of Ontario's nuclear program will result in higher levels of tritium released into the environment. Drinking water is an important **preventable** source of exposure to tritium. A lower drinking water standard for tritium would help ensure that exposure to this carcinogen is kept to a minimum.

Thank you for the opportunity to contribute to the public consultation on the tritium drinking water standard. I look forward to reviewing the recommendations of the Ontario Drinking Water Advisory Council.

TORONTO

Dr. David McKeown
Medical Officer of Health

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February 3, 2006

The Honourable Dalton McGuinty
Premier of Ontario
Legislative Building
Queen's Park
Toronto, Ontario
M7A 1A1

Dear Premier McGuinty:

Re: Ontario Power Authority's *Supply Mix Advice Report*, December 2005
EBR# PO05E0001

I am writing to provide comments on the Ontario Power Authority's (OPA's) December 2005 *Supply Mix Advice Report* (EBR# PO05E0001). At this time, the Province of Ontario is defining its energy future. We have an opportunity to embrace sustainable energy and reap the benefits long into the future. However, the plan described in the OPA report will not help us to achieve this vision. This letter describes my key concerns about the OPA's recommendations, and provides steps that would lead us to an alternative vision, a sustainable energy strategy.

(1) Energy conservation and demand management

The OPA report recommends reliance on nuclear power, plus some renewable energy. However, the report recommends a remarkably small role for energy conservation and demand management (CDM). Of all the energy supply options available to Ontario, CDM provides the greatest environmental health benefit. By reducing energy demand and increasing energy productivity, we can prevent new sources of air pollution, greenhouse gases or radioactive waste. Embracing CDM would also reduce the need to build more expensive energy supply and transmission capacity in Ontario.

Considering these benefits, the OPA should be a great champion of CDM. The report should have a generous CDM target as its foundation and primary goal, and describe the steps Ontario will take to achieve this vision. Instead, the report indicates that OPA was not able to properly assess the potential for conservation (Volume 1, p. 16). As a result of this inability, OPA assumes that there will be little demand reduction through CDM efforts, and makes up for this by recommending more new energy supply capacity. CDM is not included in the OPA's comparison of the energy options' environmental impacts (Volume 1, p. 31), indicating that CDM was not considered on an equivalent basis as new energy supply.

At its meeting July 20, 21 and 22, 2004, Toronto City Council requested that the Government of Ontario set targets to reduce electricity demand by 40 percent by 2020, using energy efficiency and conservation. According to a study by the Pembina Institute and the Canadian Environmental Law Association (2004), it is possible for Ontario to reduce energy demand by 40 percent by the year 2020, relative to business as usual. This would be achieved through a combination of financial incentives, approaches to financing, and reducing barriers to cogeneration. The study also estimates that Ontario is capable of producing more than 55 percent of its energy supply from renewable sources by 2020, if implemented in concert with these aggressive energy conservation measures. Even if these estimates are ambitious, there is room for a much larger role for CDM than the five percent demand reduction by 2025 assumed by the OPA (Volume 1, page 5).

To achieve a sustainable energy future, the Province must explore innovative CDM approaches and best practices, with the goal of truly creating a culture of conservation. For example, the OPA should examine and expand successful techniques, such as providing local electric utilities with the resources and flexibility needed to reduce their customers' energy demand. This approach has encouraged Toronto Hydro Electric System Ltd. to commit to reducing its customers' peak energy demand by five percent by 2007. By helping utilities reduce their customers' demand on peak demand days, particularly on smog alert days, the OPA could reduce Ontario's need for expensive energy imports while improving air quality and health.

(2) Nuclear energy

While I support Ontario's decision to phase out coal-fired electricity generation by 2009, I have concerns about the potential reliance on nuclear power recommended in the OPA report. Canada is already storing 36,000 tonnes of radioactive uranium waste. The risks from radioactive waste continue for thousands of years after the fuel has been used to generate electricity, and the waste requires management over this time period. The use of nuclear energy can result in releases of radioactive material during operations, and there is a very low chance of a catastrophic release caused by natural events, accidents or foul play. Nuclear power also raises a number of questions regarding cost and reliability. Ontario's nuclear reactors have routinely incurred cost overruns for building, refurbishment and operation of facilities, and many have underperformed relative to expectations. The use of nuclear power creates risks that must be managed for many generations to come. This energy source therefore does not adhere to the key principle of sustainable development. In contrast, CDM and renewable energy do not carry these risks and impacts.

In addition to concerns about reliance on nuclear power, I also have concerns about the adequacy and completeness of the OPA's assessment of nuclear power. While the report indicates that it assesses the life-cycle impacts of energy options (Volume 1, p. 30), the main report (Volume 1) does not mention the chance of a catastrophic event occurring at a nuclear energy facility. While the probability of this type of mishap is low, the potential impacts on health are substantial, and must be considered in any meaningful discussion of nuclear power.

In addition, I do not believe that OPA's conclusion that, "the environmental indicators show that nuclear energy has lower impact over its life cycle than many other supply sources, including natural gas generation" (Volume 1, p. 25), is sufficiently well-founded. First, the assessment of nuclear power did not consider all potential adverse impacts from the energy source, including a catastrophic outcome. Second, the weighting system used to compare the environmental characteristics of the energy options (Volume 1, p. 30), was not balanced appropriately: it puts too much emphasis on impacts from greenhouse gas emissions (weight of 20), compared to impacts such as radioactivity, waste and water impacts (weight of 1 each).

(3) Recommendations

Recommendation 1:

I urge the OPA and the Government of Ontario to create a sustainable energy strategy that gives clear priority to conservation and demand management approaches, and supply from low-impact, renewable energy sources, rather than placing such a heavy emphasis on nuclear energy.

This recommendation is consistent with the request made by City Council in July 2004 for the Province to develop a strategy using, "a combination of measures, in the following order of priority: energy conservation and efficiency, ecologically sustainable renewable electricity supply sources and small scale high-efficiency natural gas-fired co-generation power plants that replace existing mono-generators and provide electricity and heat to local district heating grids, rather than by nuclear energy".

Recommendation 2:

I recommend that a comprehensive Health Impact Assessment of Ontario's energy options should be undertaken, including nuclear power and conservation and demand management. I recommend that the Province of Ontario engage an independent party to complete the HIA, with advice from the Chief Medical Officer of Health.

As described above, in my opinion, the OPA report describes Ontario's energy options without sufficiently characterizing and assessing their environmental and health impacts. Having a clear picture of the environmental and health impacts of the various energy options is key to understanding their long-term costs and suitability for Ontario. Health Impact Assessment (HIA) is the most comprehensive means available for assessing the health, social, economic and environmental impacts and benefits of our energy options. An HIA for Ontario's energy options should include quantitative estimates of all inputs required and outputs generated by the energy options, using a true lifecycle assessment. It should include an assessment of a catastrophic event at a nuclear energy facility. It should also include an assessment of any anticipated benefits to air quality and health from reduced demand for domestic and imported energy. Health care costs should also be estimated for all energy options.

With innovation and a strong will to create a sustainable energy strategy, I believe Ontario is capable of moving toward this vision over the long-term.

Sincerely,

ORIGINAL SIGNED BY

David McKeown, MDCM, MHSc, FRCPC
Medical Officer of Health

cc: The Honourable Donna Cansfield, Minister of Energy
The Honourable Laurel Broten, Minister of Environment
The Honourable George Smitherman, Minister of Health and Long-Term Care
Dr. Sheela Basrur, Chief Medical Officer of Health
Mr. Jan Carr, Chief Executive Officer, Ontario Power Authority
Mr. Peter Love, Chief Energy Conservation Officer, Ontario Power Authority
Coordinator, Energy Economics, Office of Energy Supply and Competition

Attach: Letter from MOH to the Honourable Dwight Duncan, Ontario Minister of Energy, dated August 24, 2005, *Recommendations on Ontario's Future Energy Supply Mix*

CITY CLERK

Consolidated Clause in Board of Health Report 5, which was considered by City Council on July 20, 21 and 22, 2004.

1

Air Pollution Burden of Illness in Toronto: 2004 Summary Agenda for Action on Air and Health

City Council on July 20,21 and 22,2004, amended this Clause by:

(1) deleting Recommendation (3) *of the Board of Health and inserting instead the following:*

"(3) request the Premier of Ontario to:

(a) develop a strategy to phase-out Ontario's coal-fired power plants by a combination of measures, in the following order of priority: energy conservation and efficiency, ecologically sustainable renewable electricity supply . sources and small scale high-efficiency natural gas-fired co-generation power plants that replace existing mono-generators and provide electricity and heat to local district heating grids, rather than by nuclear energy;

(b) ensure that where any new gas-fired co-generators are considered, then the plants should be subject to continuous emissions monitoring, have their emissions conform to all existing or new emissions standards, such co-generation plants to supply funding to the Toronto Atmospheric Fund or other such local initiatives and must support establishment of effective local community lia~onprograms;and

(c) ensure that no new source of emissions are considered unless there is a net gain in reduction of emissions through shut down of current sources of emissions; "; and

(2) adding the following:

"That:

(a) Council endorse a voluntary Car Free Day for September 22, 2005;

(b) Toronto Public Health, as lead, working with the City's Works and Emergency Services Department, Toronto Public Health, the ITC, the Toronto Cycling Committee, the Toronto Pedestrian Committee, Special Events and the Roundtable on the Environment, in concert with relevant stakeholders, such as the Sierra Club of Canada, establish a Working Group and take ownership of the event and build the event into each applicable department's annual work plan;

Chlorine disinfection of swimming pools:

Concerns/issues to consider:

1) Exposure to microbial contamination in swimming pools and hot tubs may cause illness from communicable diseases
2) Because of the risk of communicable disease and the need to continually disinfect pool water in which people swim, chlorine is generally the disinfection agent of choice, and provincial guidelines for public and semi-public pools require a minimum level of 0.5 mg/l of free chlorine (chlorine residual) in the pool water [Ontario Health Promotion and Protection Act: R.R.O. 1990, Reg. 565, s. 7 (7)]. (The WHO guidelines for safe recreational water environments recommend setting these levels at the local level, not to exceed 3.0 mg/l for swimming pools and 5.0 mg/l for hot tubs/whirlpools).
3) Adverse health effects of exposure to chlorine disinfection byproducts (DBPs) include reproductive outcomes and cancer.
4) Routes of exposure to DBPs include ingestion (mainly from drinking tap water), inhalation (through showering and swimming), and dermal absorption (swimming and showering/bathing). The relative contribution of swimming to the overall THM exposure appears to be potentially significant in populations with little exposure through drinking water (e.g. use bottled water or tap water not a significant source). For example, total THM exposure attributable to swimming was estimated at around 25% in pregnant women in France who drank mainly bottled water.
5) Body burdens of THMs (e.g. measurements of biomarkers) increase with the intensity of exercise (e.g. significantly higher with lap swimming vs. wading around) and the THM levels in the water and air around the pool, which in turn are increased by the amount of chlorine used, the organic matter in the pool, and the number of people using the pool.
6) The WHO guidelines refer to the potential for adverse effects from DBPs and the need to balance that risk with the benefits of swimming as exercise and the risks of microbial hazards in water that is not adequately disinfected. However, their guidelines suggest an upper limit of 3.0 mg/l for swimming pool chlorine residuals, and suggest that regulatory limits should be set locally (i.e. recommend using the 0.5 mg/l level set by the province).

Gaps/uncertainties:

1) The epidemiology around DBPs and adverse health effects is focused on municipal drinking water supplies and exposures. The specific effects of exposures through swimming have not been reported. While the outcomes would be expected to be the same, the relative exposure received through swimming, and the level of free chlorine associated with that level of exposure are not clear.
2) The levels of DBPs associated with different levels of free chlorine are not clear either, although it would seem to be the case that higher levels of chlorine residuals are associated with higher levels of DBPs (WHO).

Overall:

Need to ensure minimal risk of microbial contamination, but also need to reduce exposures to DBPs.

Chlorination of pools greatly in excess of regulatory levels does not appear to be helpful in terms of reducing risk of microbial contamination, and increases exposure to potentially harmful DBPs.

Suggest that chlorine residuals should not routinely be higher than the 3 mg/l upper limit suggested by the WHO, and that levels closer to the Ontario regulatory minimum of 0.5 mg/l are more appropriate and health protective.

There is also evidence that use of chlorine can be lessened and DBPs can be reduced by decreasing the addition of organic contaminants into the pool, in particular, what the WHO refers to as the "bather-derived" inputs (urine; sweat; dirt; and lotions (sunscreen, cosmetics, soap residues, etc.) Thus, better education of pool users and managers, and better enforcement of regulations, such as showering before entering the water, may assist with reducing these "bather-derived inputs" and hence reducing the DBPs produced in the water.

Appendix 7:

Ontario Drinking Water Advisory Council - Public Consultation on the Ontario Drinking Water Quality Standard for Tritium - March 26 and 27, 2008 Toronto, Ontario – Summary Report – Prepared for the Ontario Drinking Water Advisory Council By Lura Consulting – June 5, 2008

Ontario Drinking Water Advisory Council

Public Consultation on the Ontario Drinking Water Quality Standard for Tritium

March 26 and 27, 2008
Toronto, Ontario

Summary Report

Prepared for the
Ontario Drinking Water Advisory Council
By Lura Consulting

June 5, 2008

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Toronto, Ontario M2J 4Z2, Canada

This public consultation summary was prepared by Lura Consulting. It presents a summary of the public consultation meeting on March 26 and 27, 2008 and of received submissions. If you have any questions or comments regarding the report, please contact either:

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Table of Contents

1 Introduction

1.1 About the Public Consultation Meeting

On March 26 and 27, 2008, the Ontario Drinking Water Advisory Council (ODWAC) held a two-day public consultation meeting on Ontario's Drinking Water Quality Standard (ODWQS) for tritium. The purpose of the meeting was to obtain input from a broad spectrum of interested community groups and stakeholders. Consultation participants were asked for their feedback on the following three questions:

- Is the current Ontario Drinking Water Quality Standard for tritium acceptable?
- If not, what is the basis for finding the current Standard unacceptable?
- If you propose a different Standard, what is your rationale?

Participants were also invited to contribute any other feedback they had on the ODWQS for tritium. This feedback will be incorporated with other input received to date from other stakeholders and will inform ODWAC's advice to the Ontario Minister of the Environment on this topic.

The Minister's request for advice on this Standard was formally made to ODWAC on February 21, 2007. The request was in response to a letter from Dr. David McKeown, Medical Officer of Health, City of Toronto, which outlined concerns about the current Standard for tritium. The Minister's request asked ODWAC to consider the 1994 recommendations made by the former Ontario Advisory Committee on Environmental Standards as well as the Greenpeace report entitled "Tritium Hazard Report: Pollution and Radiation Risk from Canadian Nuclear Facilities."

The public consultation was advertised in the Toronto Star, and invitations were distributed directly to stakeholder groups. Information on the consultation was also posted on ODWAC's website at (http://www.odwac.gov.on.ca/standards_review/tritium/tritium.htm). The public was invited to make a presentation to ODWAC at the meeting, to submit comments in writing, or both. At the meeting, participants were provided with 10 minutes to make their presentation, and an additional 5 minutes for questions from ODWAC panel members.

1.2 Overview of this Report

This report provides a summary of the feedback received through the public consultation, including presentations made during the March 26-27, 2008 meeting as well as written submissions received at or following the consultation meeting.

The summary of public comments is provided in section 2 of this report and is organized based on the three questions posed by ODWAC. The agenda for the meeting is provide in Appendix A, and a summary of the questions asked by the ODWAC panel members and the answers given by the presenters is provided in Appendix B.   Copies of the presentations and written submissions are provided in Appendix C and D.

2 Summary of Public Comments

This section provides a summary of the comments made by the presenters during the two-day public consultation meeting and from the written submissions received during the consultative process. A total of 65 individuals and organizations participated in the consultation, either by making a presentation to ODWAC, submitting written comments, or both. Participants included:

- 19 individuals;
- 11 community-based groups;
- 8 health organizations (6 health non-governmental organizations and 2 professional health associations)
- 6 environmental non-governmental organizations;
- 5 industry/consulting organizations;
- 4 municipalities;
- 3 non-governmental organizations;
- 2 universities;
- 1 federal government representative; and
- 1 labour organization.

In addition, ODWAC received 532 e-mails from individual members of the public that closely followed a model submission provided on the Greenpeace website.

The paragraphs below summarize the feedback provided by the various stakeholder groups. The comments are organized according to the three key questions posed by ODWAC for this public consultation, followed by a summary of any other tritium-related concerns or issues raised. No attempt has been made to assess the scientific accuracy or basis of the feedback received.

2.1 Is the current Ontario Drinking Water Quality Standard for Tritium acceptable?

In general, most of the stakeholder groups that commented during the Council's consultation on the ODWQS for tritium believe that the current Standard is not acceptable. These groups included concerned citizens, community groups, health organizations, health non-governmental organizations and professional health associations, environmental non-governmental organizations, municipalities, non-governmental organizations, universities, and labour.

Five submissions indicated that the current standard is acceptable or that there is insufficient evidence to warrant lowering it (Health Canada, the Canadian Nuclear Association, two radiation researchers/scientists, and a health physicist.).

2.2 What is the basis for finding the current standard acceptable or unacceptable?

2.2.1 Rationale for the standard being "unacceptable"

There were a number of issues raised to support the view that the current ODWQS for tritium is unacceptable. These issues are summarized below.

Impact of Tritium on Human Health

The rationale provided by those who felt that the Standard is unacceptable was consistent across many of the participants. A key area of concern was the potential impact of tritium on human health. Key comments presented included:

- There is no safe dose of or level to exposure of radiation, and even the smallest doses (e.g., background) can cause cancer and other heath effects. Tritium can also promote and accelerate cancer.
- Women are more vulnerable to tritium and are affected differently than men, particularly with respect to their reproductive systems.
- Rapidly growing cells such as fetal tissue and young girls' developing breasts, genetic materials and blood forming organs are especially sensitive to tritium.
- Tritium can damage DNA, causing a mutagenic effect resulting in cancers, miscarriages, birth defects, sterility, and hypothyroidism, among others. The effects from exposure to tritium can harm offspring and last for generations.
- Female human infants are at risk from elevated tritium levels due to genetic damage to ova exposed to tritiated hydrogen.
- Certain groups are especially vulnerable to environmental carcinogens, such as women (especially when pregnant), the unborn, and the elderly, those with compromised immune systems, children, teenagers and Aboriginal people.

Risk and Dose Measurement Methodologies

Concerns about how risk and doses are measured and used to help set the Standard were raised by community groups, citizens, NGOs and health organizations. These concerns included:

- How risk and dose measurements are calculated, particularly in that the current models use the "standard man", which may not reflect dosages experienced by women and children. Research by Dr. Richard B. Richardson was cited as finding that the dosage of tritium to women is estimated to be 45% higher than the dose to the "standard man." Dr. Richardson's research was referenced as illustrating that the dose co-efficient for women is under-calculated.
- Additionally, exposure studies based on animal testing are not accurate because of the lower body fat levels found in animals.
- Many of the non-lethal cancer effects of tritium are not currently considered in the model upon which the current Standard is based on. These effects include non-fatal cancers, miscarriages, still births, birth defects, sterility, hypothyroidism, genetic mutation, respiratory failure, kidney failure, nervous system disorders, cardiovascular disease, among others.
- The current Standard does not consider organically-bound tritium, thus under-estimating the true dose.
- Cumulative exposure and combined effects are not being considered.
- The current Standard considers 340 excess fatal cancers per million as an "acceptable risk", which is equivalent to 1 in 3,000.

With respect to using either radiological or chemical assessment approaches in developing an ODWQS for tritium, the Public Health sector advocated using the chemical-based approach. Their reasons included:

- The Standard is being set for drinking water for the whole population.
- Tritium exposure should be considered primarily an anthropogenic contaminant emitted to the environment.
- Anthropogenic emissions of tritium directly impact the drinking water supplies of approximately one-quarter of the Canadian population, thereby resulting in a large population exposure.
- Exposure to tritium in drinking water is involuntary.

Tritium in Ontario's Environment

Concern over the amount of tritium currently found in Ontario's environment was cited as a reason for the current ODWQS for tritium being unacceptable. For example, a few NGOs and community groups noted that:

- Levels of tritium are 2 to 5 times higher in Lake Ontario than in other water bodies in the Great Lakes and across Canada. For example, concentration of tritium in Lake Ontario was reported to be 7.1 Bq/L, compared to 2 Bq/L in Lake Superior. Lake Ontario is a major source of drinking water for Ontarians.
- Between 1979 and 1997, there were 11 known leaks of tritium from Canadian nuclear reactors.

Elevated concentrations of tritium were also reported to have been found in food and well water samples. For example, water samples taken from a pond at a home in/near Millbrook in 2005 were reported to show an average concentration of 1770 Bq/L, with a maximum of 2494 Bq/L. The home was reported to be 220 metres away from an emissions stack at a tritium light manufacturing facility. Produce grown by residents in Pembrooke was reported to contain tritium levels as high as 12,000 Bq/L.

Proximity of Nuclear Reactors in Southern Ontario

A number of citizens, community groups, NGOs and health organizations, as well as the City of Pickering, noted that Ontario has a high number of nuclear reactors that use heavy water as a coolant, and therefore the risk of exposure to tritium is higher due to the facilities proximity and their use of deuterium.

How the Ontario Standard Compares to Other Standards Internationally

Community groups, concerned citizens, NGOs, health groups and university representatives believe that Canada's current Guideline for tritium in drinking water (which is the same as Ontario's Standard) is unacceptable because it is high compared to other jurisdictions. For example, while the ODWQS for tritium is 7000 Bq/L, it was reported that the drinking water standard for tritium in the United States is 740 Bq/L and the European Union has an action level of 100 Bq/L.

The Precautionary Approach

The precautionary approach was raised by many of the stakeholders who believe the current Standard is unacceptable, including community groups, citizens, health organizations, and NGOs. It was felt that the precautionary approach was not being applied with respect to tritium in drinking water and that because there is still uncertainty over the impacts of tritium (such as synergistic effects with other substances), then the precautionary principle should be applied and the Standard should be lowered.

2.2.2 Rationale for the standard being "acceptable"

While many of the consultation participants felt that the current Standard was unacceptable, there was some support not changing it. Reasons for not changing the current standard include:

- There is no new information that warrants a change to the current Standard.
- The methodology for assessing risk and dose for tritium and other radionuclides is internationally accepted, sufficient and prudent;
- The risk of fatal and non-fatal cancers from exposure to radionuclides in drinking water of 0.1 mSv/year is negligible (6×10^{-4} over a lifetime).
- Making the Standard more stringent would depart from international guidance and advice from organizations such as the International Commission on Radiation Protection (ICRP) and the World Health Organization (WHO).
- Changing the Standard would create the false impression with the public that there is now a higher risk from tritium in drinking water.

Also, regarding the question on whether to assess the risk from tritium as either ionizing radiation or as a genotoxic chemical, it was suggested that the appropriate assessment is as an ionizing radiation because it is the location of where the radiation is delivered and the nature of the radiation that is important, rather than the chemical nature of the radionuclides. It was also suggested that, for the purposes of setting standards, all radionuclides should be treated equally.

It was also noted by one submitter that while there was currently no compelling reason to reconsider the Standard at this time, it may be reasonable to adjust the radiation weighting factor from 1 to 2 and accommodate parameters more appropriate for infants, which would result in a revised Standard of 3,000 Bq/L. The submitter noted that adopting this value would be of little practical significance because tritium levels currently observed are already far below this value.

2.3 If you propose a different Standard, what is your rationale?

The majority of those who believe that the current ODWQS for tritium is unacceptable suggest that the levels proposed in the 1994 ACES report should be adopted, that the current Standard be reduced immediately to 100 Bq/L and then to 20 Bq/L within 5 years. The main reasons stated for adopting this process include:

- The ACES recommendation is more conservative than the current Standard;
- Ontario Power Generation has stated that levels below 100 Bq/L at drinking water plant intakes are currently achievable;

- It employs the precautionary approach, and encourages erring on the side of caution;
- It is based on the chemical genotoxic paradigm, rather than the radionuclide paradigm;
- It lowers the level of risk of cancer to 1 in a million, and reduces the number of premature deaths from 340 per million to 5 per million.

For similar reasons, some concerned citizens and NGOs recommended lower limits, ranging from 0 Bq/L to a range between 10 and 20 Bq/L.

2.4 Other Tritium-Related Comments

In addition to comments regarding the ODWQS for tritium, the consultation participants also provided additional comments with respect to tritium. The most common of these was the suggestion that the allowable level of tritium in discharge from nuclear reactors be zero. This comment was made by health, NGO, municipal public health representatives, concerned citizens and community groups. Other comments are summarized below.

Tritium and Human Health

- More research is needed to identify the impacts of tritium on human health.
- A study is currently underway by the CNSC regarding tritium and its health impacts.
- A committee should be established to investigate health issues related to tritium.

Tritium Monitoring

- Monitoring for tritium in drinking water should be mandatory.
- Should drinking water monitoring show levels of tritium higher than the maximum allowable, then alternate drinking water supplies should be provided.
- Daily monitoring of drinking water should be required for areas near Ontario Power Generation (OPG) plants.

Public Notification and Disclosure

- The public should be immediately notified when tritium levels in drinking water exceed 5 Bq/L.
- The public and municipalities should be notified in instances of accidental releases of tritium from nuclear facilities.
- The nuclear industry should be compelled by stricter disclosure obligations.

Nuclear Power

- Government funds and subsidies should be diverted from nuclear power to renewable energy;
- More research is needed on how to reduce emissions of radioactive material from nuclear energy production facilities.

3 Next Steps

After the public consultation meeting, participants were given until April 4, 2008 to submit additional comments for the consultation. Mr Jim Merritt, ODWAC Chair, noted that information received after that date would still be considered in their advice to the Minister of the Environment. ODWAC plans to transmit its recommendations on the ODWQS for tritium some time in the summer of 2008.