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Supplementary Information
Oral intervention

Presentation from
Ellen E Dailey

In the Matter of

Ontario Power Generation Inc.

Proposed Environmental Impact Statement for OPG's Deep Geological Repository (DGR) Project for Low and Intermediate Level Waste

Joint Review Panel

September 16 to October 12, 2013

Renseignements supplémentaires
Intervention orale

Présentation de
Ellen E Dailey

À l'égard de

Ontario Power Generation Inc.

Étude proposée pour l'énoncé des incidences environnementales pour l'Installation de stockage de déchets radioactifs à faible et moyenne activité dans des couches géologiques profondes

Commission d'examen conjoint

Du 16 septembre au 12 octobre 2013

Canada

In the Matter of Ontario Power Generation Inc.
Proposed Environmental Impact Statement
For OPG's Deep Geological Repository (DGR) Project for
Low and Intermediate Level Waste (L&ILW)
Kincardine, Ontario

To the Joint Review Panel
September 27, 2013

Oral intervention by: Ellen E. Dailey, MD, FACOG

The Project

"The Nuclear Waste Management Organization (NWMO) is assisting Ontario Power Generation (OPG) in seeking regulatory approval for construction of a proposed Deep Geologic Repository (DGR) for the long-term management of low and intermediate level waste (L&ILW) from OPG-owned or operated reactors. The DGR is planned adjacent to OPG's Western Waste Management Facility (WWMF) on the Bruce nuclear site in the Municipality of Kincardine."

http://www.nwmo.ca/home?language=en_CA

Relevant Environmental Impact Statement Guidelines

- Section 2.5 Precautionary Approach
- Section 2.6 Study Strategy and Methodology
- Section 2.7 Use of Existing Information
- Section 6.3 Stakeholders
- Section 6.4 Other Public Participation
- Section 8.1 General Information and Design Description

Relevant Environmental Impact Statement Guidelines

- Section 9.3 Valued Ecosystem Components
- Section 10 Existing Environment
- Section 10.2.6 Human Health
- Section 11.5.6 Human Health
- Section 14 Cumulative Effects
- Section 16 Follow-Up Program

Ionizing Radiation, Human Health Conditions, and Informed Consent

Why the proponent fails to meet the EIS guidelines.

Flaws in the DGR process

- Flawed consent process
- Inadequate health data base

Certainty, risk, and uncertainty

- *Certainty* is a probability of 1 - the likelihood of the sun rising in the morning.
- *Risk* expresses the probability of an event greater than 0 but less than 1, e.g. 0.5 probability of losing a coin toss.
- *Uncertainty* cannot be expressed in terms of probabilities because of unknown and unknowable variables.

An untested hypothesis

- Hypothesis: “Low and intermediate radioactive waste can be safely stored underground indefinitely.”
- Potentially exposes the public to known and unknown health risks.
- Essentially, a open-ended, human biologic and socioeconomic experiment or clinical trial.

Elements of informed consent

- Competence (a legal determination that addresses societal interest in restricting a person's right to make decisions or do acts because of incapacity)
- Disclosure
- Understanding
- Voluntariness
- Consent

Free Prior and Informed Consent (FPIC)

A community has the right to give or withhold its consent to proposed projects that may affect the lands they customarily own, occupy or otherwise use.

Principles supporting FPIC

- The right to meaningful participation in environmental decision making
- The right to control access to their lands and resources
- Contemporary standards of public participation is a hallmark of legitimate governance.
- Basic principles of equity and justice.

- Rio Declaration on Environment and Development, Principle 10, 31 I.L.M. 874 (1992).
- Moiwana Village v. Suriname, Inter-American Court of Human Rights, Judgment of June 15, 2005, pp. 54_55.

Community consent

Are OPG's disclosures adequate?

WHAT IS LOW LEVEL RADIOACTIVE WASTE?

- Low level waste consists of common industrial items that have become contaminated with low levels of radioactivity during routine clean-up and maintenance at the nuclear generating stations
- It includes mops, rags, paper towels, temporary floor coverings, floor sweepings, protective clothing and hardware items such as tools
- It consists of paper, plastics, metal, rubber, cotton and other miscellaneous materials
- Its radiation levels are such that it can be safely handled using normal industrial practices and equipment without any special radiation protection

What is Intermediate Level Nuclear Waste?

Intermediate level nuclear waste is inserted into in-ground storage containers at the WWMF

- Intermediate level nuclear waste requires shielding to protect workers during handling
- Intermediate level nuclear waste typically includes ion exchange resins, filters and irradiated core components associated with refurbishment waste
- Approximately 290 m^3 of intermediate level nuclear waste is received each year at the WWMF
- Approximately five per cent of all waste (excluding used fuel) received at the WWMF is intermediate level nuclear waste

What is Refurbishment Nuclear Waste?

A steam generator is transported to the WWMF for interim management

- Refurbishment nuclear waste consists of low and intermediate nuclear waste generated from the refurbishment of reactors
- Intermediate refurbishment nuclear waste consists of irradiated core components such as pressure tubes, calandria tubes and end fittings that are safely managed in shielded containers inside a concrete refurbishment waste building
- Low level refurbishment nuclear waste consists of steam generators that are safely managed in a concrete refurbishment waste building

Keeping You Informed Booklet

EIS VOL 2-2 Appendix D

Table 2.4: Estimated Operational Low-Level Waste Radionuclide Inventory at 2018

		Decay Corrected Radionuclide Inventory (Bq)										
		Bottom Ash	Baghouse Ash	Compact Bales	Box Compacted	Non-pro	Feeder Pipes	Non-pro Other	Non-pro Drummed	LL/ALW Resin	ALW Sludge	Total
Net Volume (m^3)		1,352	291	2,268	10,328	36,202	2,101	3,071	6,760	1,384	1,722	65,479
Nuclide	T-1/2 (yrs)											
Ag-108m	1.3E+02	6.2E+05	6.6E+05	6.3E+05	3.7E+06	1.5E+07	2.7E+06	1.3E+06	2.9E+06	1.4E+05	1.3E+05	2.8E+07
Am-241	4.3E+02	1.1E+09	5.2E+07	2.2E+08	1.8E+09	1.6E+10	2.0E+10	6.5E+07	1.5E+05	1.9E+08	9.5E+06	3.9E+10
Am-242m	1.5E+02						3.4E+07					3.4E+07
Am-243	7.4E+03	1.1E+06	4.6E+04	3.4E+05	2.5E+06	1.2E+06	3.9E+07	8.5E+04	2.5E+02	2.6E+04	1.4E+04	4.4E+07
Ba-133	1.1E+01					2.4E+09						2.4E+09
C-14	5.7E+03	2.5E+10	4.6E+08	1.3E+10	6.9E+10	6.0E+10	6.9E+11	3.3E+09	1.0E+11	8.7E+09	3.8E+09	9.7E+11
Cf-252	2.6E+00					3.4E+07						3.4E+07
Cl-36	3.0E+05	4.2E+05	4.8E+04	1.5E+05	8.3E+05	1.4E+06	3.5E+08	6.1E+04	3.0E+05	1.5E+04	9.1E+03	3.5E+08
Cm-244	1.8E+01	1.2E+08	3.4E+06	3.4E+07	5.3E+08	4.1E+08	7.4E+09	1.2E+07	1.2E+04	4.0E+06	2.4E+06	8.5E+09
Co-60	5.3E+00	6.0E+10	7.7E+08	3.0E+09	2.0E+11	5.3E+11	2.3E+13	1.8E+10	6.0E+10	6.1E+09	3.2E+09	2.4E+13
Cs-134	2.1E+00	8.7E+07	6.1E+07	6.5E+05	7.0E+09	1.1E+09	4.2E+10	1.3E+08	1.7E+09	2.1E+07	1.2E+09	5.3E+10
Cs-135	2.3E+06	6.9E+04	6.9E+04	7.3E+04	3.9E+05	1.7E+06	2.7E+05	1.4E+05	3.1E+05	1.4E+04	1.3E+04	3.0E+06
Cs-137+Ba-137m	3.0E+01	7.8E+10	8.4E+10	7.0E+10	5.6E+11	1.8E+13	5.2E+11	2.0E+11	4.0E+11	2.2E+10	2.0E+10	2.0E+13
Eu-152	1.3E+01	1.8E+06	0.0E+00			3.9E+06			1.3E+08			1.4E+08
Eu-154	8.8E+00	5.6E+08	8.3E+07	4.0E+08	8.9E+09	2.7E+09	1.0E+11		1.0E+08			1.1E+11
Eu-155	5.0E+00	2.1E+07		1.4E+07	1.1E+09							1.1E+09
Fe-55	2.7E+00	1.8E+12	1.3E+09	2.0E+08	2.7E+10	6.8E+11	5.4E+13	5.0E+10	6.3E+10	1.8E+10	6.1E+09	5.7E+13
H-3	1.2E+01	1.2E+10		3.9E+13	9.3E+14	4.4E+14		2.8E+13	1.7E+15	1.1E+11	3.1E+12	3.1E+15
I-129	1.6E+07	3.6E+03	1.1E+04	2.7E+02	4.1E+04	5.2E+05	7.7E+04	5.2E+02	1.0E+05	4.8E+03	4.6E+01	7.6E+05
Nb-94	2.0E+04	2.7E+09	3.5E+06	1.9E+09	1.0E+10	1.7E+07			7.4E+08		7.2E+07	1.5E+10
Ni-59	7.5E+04	2.0E+08	4.7E+06	1.0E+07	5.8E+07	2.6E+08	8.2E+08	1.6E+07	3.8E+07	2.5E+06	1.5E+06	1.4E+09
Ni-63	9.6E+01	2.4E+10	5.8E+08	1.1E+09	7.3E+09	6.1E+10	1.1E+11	2.1E+09	4.7E+09	3.3E+08	2.1E+08	2.1E+11
Np-237	2.1E+06	5.2E+04	2.3E+03	1.6E+04	1.2E+05	5.7E+04	1.8E+06	4.2E+03	1.2E+01	1.3E+03	6.9E+02	2.1E+06
Pb-210	2.2E+01					5.7E+10						5.7E+10
Pu-238	8.8E+01	3.0E+08	1.1E+07	4.1E+07	3.5E+08	4.6E+08	6.4E+09	1.2E+07	2.2E+04	4.0E+06	2.1E+06	7.6E+09
Pu-239	2.4E+04	3.4E+08	1.5E+07	1.1E+08	8.0E+08	9.3E+08	1.2E+10	2.7E+07	8.0E+04	8.4E+06	4.5E+06	1.4E+10

		Decay Corrected Radionuclide Inventory (Bq)										
		Bottom Ash	Baghouse Ash	Compact Bales	Box Compacted	Non-pro	Feeder Pipes	Non-pro Other	Non-pro Drummed	LL/ALW Resin	ALW Sludge	Total
Net Volume (m^3)		1,352	291	2,268	10,328	36,202	2,101	3,071	6,760	1,384	1,722	65,479
Nuclide	T-1/2 (yrs)											
Pu-240	6.5E+03	5.0E+08	2.1E+07	1.5E+08	1.1E+09	1.4E+09	1.7E+10	3.9E+07	1.1E+05	1.2E+07	6.4E+06	2.0E+10
Pu-241	1.4E+01	1.2E+10	3.0E+08	9.5E+08	1.8E+10	1.7E+10	2.4E+11	7.4E+08	1.6E+06	2.4E+08	1.3E+08	2.9E+11
Pu-242	3.8E+05	5.1E+05	2.1E+04	1.6E+05	1.1E+06	5.3E+05	1.8E+07	3.9E+04	1.1E+02	1.2E+04	6.5E+03	2.0E+07
Ra-226	1.6E+03					2.8E+09						2.8E+09
Ru-106	1.0E+00	1.2E+08	1.2E+06	1.4E+03	3.9E+10	2.1E+09	1.1E+12	2.3E+08	2.8E+08			1.1E+12
Sb-125	2.8E+00	1.6E+09	1.6E+08	1.6E+07	1.8E+10	4.1E+09	1.4E+11	4.4E+08	1.0E+09		1.0E+09	1.7E+11
Se-79	3.8E+05	2.4E+03	2.5E+03	2.5E+03	1.4E+04	5.7E+04	9.2E+05	4.9E+03	1.1E+04	5.0E+02	4.6E+02	1.0E+06
Sm-151	9.0E+01	1.9E+05	2.0E+05	2.0E+05	1.2E+06	5.0E+06	9.1E+05	4.3E+05	9.4E+05	4.5E+04	4.1E+04	9.2E+06
Sn-126	2.1E+05	3.6E+05	3.7E+05	3.9E+05	2.1E+06	8.6E+06	1.4E+06	7.3E+05	1.6E+06	7.6E+04	6.9E+04	1.6E+07
Sr-90+Y-90	2.9E+01	3.0E+10	8.0E+08	2.6E+09	2.2E+10	5.0E+11	4.8E+12	2.4E+09	7.4E+10	1.5E+09	5.2E+08	5.4E+12
Tc-99	2.1E+05	4.9E+04	1.2E+03	3.2E+04	1.7E+05	2.1E+05	3.4E+07	1.2E+04	6.0E+04	3.0E+03	1.9E+03	3.4E+07
U-232	7.2E+01						3.2E+06					3.2E+06
U-233	1.6E+05						4.3E+06					4.3E+06
U-234	2.5E+05	5.6E+05	2.3E+04	1.7E+05	1.3E+06	6.0E+05	2.0E+07	4.2E+04	1.3E+02	1.4E+04	7.2E+03	2.3E+07
U-235	7.0E+08	9.2E+03	3.8E+02	2.9E+03	2.0E+04	1.0E+04	3.2E+05	7.3E+02	2.1E+00	2.2E+02	1.2E+02	3.6E+05
U-236	2.3E+07	1.0E+05	4.4E+03	3.2E+04	2.3E+05	1.1E+05	3.7E+06	8.2E+03	2.4E+01	2.5E+03	1.3E+03	4.2E+06
U-238	4.5E+09	6.9E+05	2.9E+04	2.2E+05	1.6E+06	2.8E+09	2.5E+07	5.5E+04	1.6E+02	1.7E+04	9.0E+03	2.8E+09
Zr-93	1.5E+06	2.1E+04	1.9E+02	7.9E+03	4.2E+04	7.9E+04	9.2E+05	6.7E+03	4.9E+03		6.5E+02	1.1E+06
Totals as listed		**2.0E+12**	**8.9E+10**	**3.9E+13**	**9.3E+14**	**4.6E+14**	**8.5E+13**	**2.8E+13**	**1.7E+15**	**1.7E+11**	**3.1E+12**	**3.2E+15**
Totals with other short lived		**2.1E+12**	**8.9E+10**	**3.9E+13**	**9.3E+14**	**4.6E+14**	**9.1E+13**	**2.8E+13**	**1.7E+15**	**1.7E+11**	**3.1E+12**	**3.3E+15**

Note: Nuclides with half lives greater than 1 yr are shown, plus short-lived progeny.

Table 2.5: Estimated Operational Low-Level Waste Radionuclide Inventory at 2062

		Decay Corrected Radionuclide Inventory (Bq)										
		Bottom Ash	Baghouse Ash	Compact Bales	Box Compacted	Non-pro	Feeder Pipes	Non-pro Other	Non-pro Drummed	LL/ALW Resin	ALW Sludge	Total
Net Volume (m^3)		2,033	364	2,268	14,110	53,515	3,198	3,279	9,408	3,393	3,569	95,137
Nuclide	T-1/2 (yrs)											
Ag-108m	1.3E+02	6.6E+05	5.4E+05	5.0E+05	4.1E+06	1.9E+07	3.2E+06	1.2E+06	3.2E+06	3.0E+05	2.2E+05	3.3E+07
Am-241	4.3E+02	3.0E+09	5.0E+07	2.0E+08	2.7E+09	2.0E+10	2.9E+10	6.8E+07	2.0E+05	4.5E+08	1.9E+07	5.5E+10
Am-242m	1.5E+02						5.1E+07					5.1E+07
Am-243	7.4E+03	2.7E+06	4.8E+04	3.4E+05	3.9E+06	1.7E+06	5.9E+07	9.5E+04	3.4E+02	6.4E+04	3.0E+04	6.8E+07
Ba-133	1.1E+01					7.1E+08						7.1E+08
C-14	5.7E+03	6.4E+10	4.6E+08	1.3E+10	9.4E+10	7.4E+10	1.0E+12	3.7E+09	1.4E+11	2.1E+10	7.8E+09	1.4E+12
Cf-252	2.6E+00					1.2E+06						1.2E+06
Cl-36	3.0E+05	5.9E+05	4.8E+04	1.5E+05	1.1E+06	2.0E+06	5.4E+08	6.8E+04	4.0E+05	3.7E+04	1.9E+04	5.4E+08
Cm-244	1.8E+01	1.1E+08	8.1E+05	6.3E+06	2.5E+08	1.2E+08	2.2E+09	2.9E+06	4.9E+03	3.5E+06	1.7E+06	2.7E+09
Co-60	5.3E+00	6.0E+09	7.4E+06	9.0E+06	1.0E+10	1.4E+10	1.4E+11	1.1E+08	3.3E+09	9.4E+08	4.5E+08	1.7E+11
Cs-134	2.1E+00	4.5E+05	5.9E+04	2.4E-01	2.6E+07	5.9E+06	5.9E+04	5.5E+02	4.5E+06	2.9E+05	1.9E+07	5.6E+07
Cs-135	2.3E+06	8.9E+04	7.2E+04	7.3E+04	5.3E+05	2.5E+06	4.1E+05	1.6E+05	4.2E+05	3.4E+04	2.7E+04	4.3E+06
Cs-137+ Ba-137m	3.0E+01	4.8E+10	3.2E+10	2.6E+10	3.4E+11	1.2E+13	3.0E+11	8.6E+10	2.4E+11	2.8E+10	2.2E+10	1.3E+13
Eu-152	1.3E+01	1.8E+05				7.1E+05			3.6E+07			3.7E+07
Eu-154	8.8E+00	9.4E+07	2.6E+06	1.2E+07	1.2E+09	8.3E+07	5.7E+09	0.0E+00	1.5E+07			7.1E+09
Eu-155	5.0E+00	4.4E+04		2.9E+04	5.1E+07							5.1E+07
Fe-55	2.7E+00	2.9E+10	3.1E+06	2.5E+03	2.4E+07	6.2E+09	1.9E+09	3.4E+06	5.0E+08	5.7E+08	2.1E+08	3.8E+10
H-3	1.2E+01	4.5E+09		3.3E+12	2.8E+14	1.4E+14		3.2E+12	4.2E+14	6.6E+10	1.5E+12	8.5E+14
I-129	1.6E+07	1.0E+04	1.1E+04	2.7E+02	8.8E+04	7.7E+05	1.2E+05	5.8E+02	1.4E+05	1.2E+04	9.6E+01	1.2E+06
Nb-94	2.0E+04	5.2E+09	7.2E+06	1.9E+09	1.4E+10	2.1E+07			1.0E+09		1.5E+08	2.2E+10
Ni-59	7.5E+04	2.6E+08	4.8E+06	1.0E+07	8.2E+07	3.9E+08	1.3E+09	1.8E+07	5.2E+07	6.1E+06	3.2E+06	2.1E+09
Ni-63	9.6E+01	2.5E+10	4.3E+08	8.3E+08	8.0E+09	6.7E+10	1.3E+11	1.7E+09	4.9E+09	6.7E+08	3.5E+08	2.4E+11
Np-237	2.1E+06	1.3E+05	2.4E+03	1.6E+04	1.9E+05	8.5E+04	2.8E+06	4.8E+03	1.6E+01	3.2E+03	1.4E+03	3.2E+06
Pb-210	2.2E+01					3.2E+10						3.2E+10

Table 2.6: Estimated Operational Intermediate-Level Waste Radionuclide Inventory at 2018

		Decay Corrected Radionuclide Inventory (Bq)							
		Moderator IX Resin	PHT IX Resin	Misc. IX Resin	CAN-DECON Resin	IX Columns	Irradiated Core Comp.	Filters and Filter Elements	Total
Net Volume (m^3)		1,174	802	1,097	1,427	299	23	606	5,428
Nuclide	T-1/2 (yrs)								
Ag-108m	1.3E+02		4.2E+08	1.4E+08	1.7E+07	1.5E+08		8.9E+05	7.3E+08
Am-241	4.3E+02		7.9E+07	3.0E+10	9.7E+10	2.9E+07		1.3E+10	1.4E+11
Am-243	7.4E+03		9.6E+05	3.7E+06	7.4E+07	3.6E+05		1.8E+07	9.8E+07
C-14	5.7E+03	3.2E+15	7.0E+13	1.6E+13	1.4E+11	2.6E+13	1.8E+12	7.1E+12	3.3E+15
Ce-141	8.9E-02	3.5E+10	7.0E+10	6.1E+13	1.2E+12	3.7E+09			6.2E+13
Cl-36	3.0E+05	4.0E+08	2.4E+06	3.0E+07	9.7E+06	9.0E+05		4.4E+06	4.5E+08
Cm-244	1.8E+01		2.3E+09	3.4E+09	3.8E+10	6.7E+08		5.9E+10	1.0E+11
Co-60	5.3E+00	1.7E+13	6.9E+11	8.4E+12	5.5E+13	2.1E+11	6.7E+12	1.2E+12	8.9E+13
Cs-134	2.1E+00	4.8E+10	2.3E+12	4.4E+11	3.4E+11	1.0E+12			4.1E+12
Cs-135	2.3E+06		4.4E+07	1.5E+07	1.7E+06	1.6E+07		9.5E+04	7.8E+07
Cs-137 +Ba-137m	3.0E+01	3.2E+11	6.4E+13	2.2E+13	3.2E+12	2.0E+13		1.3E+11	1.1E+14
Eu-152	1.3E+01	7.8E+11	2.2E+12	6.1E+08	1.6E+10	6.1E+11			3.6E+12
Eu-154	8.8E+00	3.2E+11		4.7E+08	8.8E+11				1.2E+12
Eu-155	5.0E+00	1.5E+10		3.2E+09	2.6E+10				4.5E+10
Fe-55	2.7E+00	2.2E+12	4.0E+10	5.1E+12	1.9E+14	1.6E+10	1.8E+13	2.0E+12	2.2E+14
H-3	1.2E+01	8.8E+13	4.8E+13	2.4E+14	9.4E+13	1.3E+13	3.2E+09	0.0E+00	4.8E+14
I-129	1.6E+07	2.6E+05	5.2E+07	5.2E+06	6.4E+04	1.9E+07		2.2E+04	7.7E+07
Ir-192m	2.4E+02						4.7E+07		4.7E+07
Mo-93	3.5E+03						3.8E+08		3.8E+08
Nb-93m	1.4E+01						1.3E+11		1.3E+11
Nb-94	2.0E+04		8.8E+09	1.6E+08	2.4E+09	3.3E+09	4.8E+06	4.5E+10	5.9E+10
Ni-59	7.5E+04	1.6E+10	4.7E+07	1.8E+10	2.1E+10	1.8E+07	2.3E+11	1.7E+09	2.8E+11
Ni-63	9.6E+01	2.1E+12	6.0E+09	2.5E+12	3.1E+12	2.1E+09	3.2E+13	2.1E+11	4.0E+13
Np-237	2.1E+06		4.7E+04	1.8E+06	3.6E+06	1.8E+04		8.7E+05	6.3E+06
Pt-193	5.0E+01						4.4E+09		4.4E+09
Pu-238	8.8E+01	1.1E+06	2.0E+08	6.9E+09	9.8E+09	7.0E+07		3.8E+09	2.1E+10
Pu-239	2.4E+04	1.5E+06	3.0E+08	1.6E+10	2.3E+10	1.1E+08		5.7E+09	4.5E+10
Pu-240	6.5E+03	2.2E+06	4.4E+08	2.4E+10	3.3E+10	1.6E+08		8.3E+09	6.6E+10
Pu-241	1.4E+01	4.4E+06	5.1E+08	2.4E+12	2.7E+12	1.4E+08		1.7E+10	5.1E+12
Pu-242	3.8E+05	2.2E+03	4.5E+05	1.8E+07	3.4E+07	1.7E+05		8.3E+06	6.1E+07
Ru-106	1.0E+00	8.4E+10	5.7E+11	1.6E+08	5.0E+12	2.9E+11			5.9E+12
Sb-125	2.8E+00	1.6E+11	1.1E+11	2.9E+11	2.1E+12	4.3E+10	1.7E+13	2.6E+11	2.0E+13
Se-79	3.8E+05	1.3E+04	1.5E+06	5.4E+05	6.6E+03	5.7E+05		3.3E+03	2.6E+06
Sm-151	9.0E+01		1.4E+08	4.7E+07	5.6E+06	4.8E+07		2.9E+05	2.4E+08
Sn-121m	5.5E+01						7.9E+11		7.9E+11
Sn-126	2.1E+05		2.3E+08	8.0E+07	8.8E+06	8.7E+07		5.0E+05	4.1E+08

		Decay Corrected Radionuclide Inventory (Bq)							
		Moderator IX Resin	PHT IX Resin	Misc. IX Resin	CAN-DECON Resin	IX Columns	Irradiated Core Comp.	Filters and Filter Elements	Total
Net Volume (m^3)		1,174	802	1,097	1,427	299	23	606	5,428
Nuclide	T-1/2 (yrs)								
Sr-90+Y-90	2.9E+01	2.4E+10	3.6E+11	1.8E+12	6.8E+13	1.1E+11	5.2E+09	6.2E+10	7.0E+13
Tc-99	2.1E+05		1.7E+08	5.9E+06	2.0E+06	6.3E+07	3.6E+08	8.9E+05	6.0E+08
U-234	2.5E+05		5.0E+05	1.9E+07	3.9E+07	1.9E+05		9.2E+06	6.7E+07
U-235	7.0E+08		8.0E+03	3.2E+05	6.1E+05	3.0E+03		1.5E+05	1.1E+06
U-236	2.3E+07		9.6E+04	3.5E+06	7.0E+06	3.6E+04		1.7E+06	1.2E+07
U-238	4.5E+09	3.2E+03	6.2E+05	2.4E+07	4.7E+07	2.3E+05		1.1E+07	8.3E+07
Zr-93	1.5E+06	5.3E+05	1.5E+06	7.4E+04	6.4E+06	5.7E+05	5.7E+11	6.5E+05	5.7E+11
Totals as listed		**3.3E+15**	**1.9E+14**	**3.6E+14**	**4.3E+14**	**6.1E+13**	**7.7E+13**	**1.1E+13**	**4.4E+15**
Totals with other short lived		**3.3E+15**	**1.9E+14**	**3.6E+14**	**4.5E+14**	**6.2E+13**	**7.8E+13**	**1.2E+13**	**4.4E+15**

Note: Nuclides with half lives greater than 1 yr are shown, plus short-lived progeny.

Table 3.2: Estimated Reactor Refurbishment Radionuclide Inventory at 2018

		Decay Corrected Radionuclide Inventory (Bq)					
Nuclide	T-1/2 (yrs)	Retube Waste Pressure Tubes	Retube Waste End Fittings	Retube Waste Calandria Tubes	Retube Waste Calandria Tube Inserts	Steam Generators	Total
Net Volume (m^3)		49	600	34	9	8,387	9,079
Ag-108m	1.3E+02	3.6E+12	6.8E+10	2.2E+12	8.1E+08	3.7E+05	5.9E+12
Am-241	4.3E+02	3.5E+09		5.8E+08	8.7E+04	4.8E+11	4.8E+11
Am-242m	1.5E+02	5.8E+06		1.1E+06	2.2E+03	2.3E+09	2.3E+09
Am-243	7.4E+03			2.6E+08	9.5E+01	5.6E+08	8.2E+08
C-14	5.7E+03	1.4E+14	4.2E+12	1.0E+13	1.1E+11	2.2E+11	1.5E+14
Cl-36	3.0E+05	3.5E+11	4.2E+08	2.6E+10	5.6E+06	1.2E+07	3.8E+11
Cm-243	2.9E+01	6.8E+06		8.3E+06	7.2E+01	2.7E+09	2.7E+09
Cm-244	1.8E+01			1.6E+11	1.4E+03	1.8E+11	3.4E+11
Co-60	5.3E+00	2.3E+14	4.2E+15	1.5E+14	6.7E+13	3.5E+12	4.7E+15
Cs-134	2.1E+00	6.9E+10	4.0E+10	1.7E+09	4.7E+08	1.5E+08	1.1E+11
Cs-135	2.3E+06	3.2E+07	1.5E+04	5.7E+06	3.9E+02	3.6E+04	3.8E+07
Cs-137/Ba-137m	3.0E+01	2.0E+09	8.8E+01	1.2E+12	1.4E+07	5.8E+10	1.3E+12
Eu-152	1.3E+01	8.8E+02		1.7E+06	5.4E+03	1.8E+09	1.8E+09
Eu-154	8.8E+00	9.1E+06		7.2E+09	3.5E+04	1.3E+10	2.0E+10
Eu-155	5.0E+00	1.7E+06		4.0E+08	4.1E+03	1.3E+10	1.3E+10
Fe-55	2.7E+00	7.9E+14	4.2E+16	3.9E+14	6.7E+14	3.1E+12	5.3E+16
H-3	1.2E+01	8.0E+11	3.0E+12	3.2E+11	5.7E+10	8.5E+11	5.0E+12
I-129	1.6E+07	1.0E+05	4.6E+03	5.0E+05	4.9E+01	1.3E+04	6.2E+05
Ir-192m	2.4E+02	2.2E+09	2.4E+04	7.4E+07	3.8E+02		2.3E+09
Mn-54	8.6E-01	6.9E+11	1.7E+14	2.2E+11	1.7E+12	4.0E+08	1.7E+14
Mo-93	3.5E+03	8.5E+09	8.0E+10	5.4E+09	8.4E+08		9.5E+10
Nb-93m	1.4E+01	1.4E+13	2.4E+10	6.6E+12	2.7E+08		2.1E+13
Nb-94	2.0E+04	1.2E+15	6.4E+10	7.3E+10	6.9E+08	4.9E+08	1.2E+15
Ni-59	7.5E+04	6.9E+10	2.4E+12	6.4E+11	3.1E+10	1.0E+10	3.2E+12
Ni-63	9.6E+01	2.4E+13	2.4E+14	2.3E+14	3.3E+12	1.4E+12	5.0E+14
Np-237	2.1E+06	1.7E+04		5.4E+04	2.1E+06	2.7E+07	2.9E+07
Pt-193	5.0E+01	3.4E+12	9.6E+09	9.7E-85	1.1E+08		3.4E+12
Pu-238	8.8E+01	1.2E+09		6.6E+08	4.2E+04	1.3E+11	1.3E+11
Pu-239	2.4E+04	2.1E+09		8.7E+07	5.5E+04	1.7E+11	1.7E+11
Pu-240	6.5E+03	2.9E+09		7.2E+08	4.8E+04	2.5E+11	2.5E+11
Pu-241	1.4E+01	4.7E+10		1.7E+10		3.9E+12	3.96E+12
Pu-242	3.8E+05	3.2E+06		1.0E+07		2.5E+08	2.6E+08
Sb-125	2.8E+00	2.2E+12	7.4E+12	7.5E+14	8.0E+10	3.3E+09	7.6E+14
Se-79	3.8E+05	5.6E+08	3.0E+07	1.7E+09	3.3E+05	1.3E+03	2.3E+09

Table 3.3: Estimated Reactor Refurbishment Radionuclide Inventory at 2062

		Estimated Radionuclide Inventory (Bq)					
		Retube Waste Pressure Tubes	Retube Waste End Fittings	Retube Waste Calandria Tubes	Retube Waste Cal. Tube Inserts	Steam Generators	Total
Net Volume (m^3)		193	2,429	133	36	8,387	11,178
Nuclide	T-1/2 (yrs)						
Ag-108m	1.3E+02	1.2E+13	7.2E+11	6.9E+12	2.9E+10	1.4E+06	2.0E+13
Am-241	4.3E+02	1.4E+10		5.4E+08	8.1E+04	2.1E+12	2.1E+12
Am-242m	1.5E+02	2.3E+07		9.0E+05	1.8E+03	2.3E+09	2.3E+09
Am-243	7.4E+03			2.6E+08	9.5E+01	2.6E+09	2.9E+09
C-14	5.7E+03	5.5E+14	6.6E+13	3.6E+13	3.5E+12	1.0E+12	6.6E+14
Cl-36	3.0E+05	1.3E+12	6.2E+09	1.1E+11	2.9E+08	5.7E+07	1.4E+12
Cm-243	2.9E+01	2.7E+07		2.8E+06	2.5E+01	2.7E+09	2.7E+09
Cm-244	1.8E+01			2.9E+10	2.5E+02	1.9E+11	2.2E+11
Co-60	5.3E+00	9.3E+12	8.6E+14	5.3E+12	2.3E+13	1.2E+11	9.0E+14
Cs-134	2.1E+00	1.5E+06	1.5E+06	1.9E+04	4.1E+04	2.5E+03	3.1E+06
Cs-135	2.3E+06	2.2E+08	8.2E+05	8.2E+06	7.7E+04	1.7E+05	2.3E+08
Cs-137+Ba-137m	3.0E+01	6.6E+09	1.1E+05	4.2E+11	5.0E+06	1.1E+11	5.4E+11
Eu-152	1.3E+01	9.8E+01	8.8E-03	1.7E+05	5.4E+02	1.2E+09	1.2E+09
Eu-154	8.8E+00	3.5E+05	7.0E-01	2.2E+08	1.1E+03	3.0E+09	3.2E+09
Eu-155	5.0E+00	6.9E+03		8.5E+05	8.7E+00	3.3E+08	3.3E+08
Fe-55	2.7E+00	3.2E+11	5.2E+13	1.5E+11	2.8E+12	1.0E+09	5.5E+13
H-3	1.2E+01	2.4E+11	4.0E+12	6.4E+10	5.5E+10	4.8E+11	4.8E+12
I-129	1.6E+07	3.6E+05	5.4E+04	5.4E+05	1.9E+03	6.0E+04	1.0E+06
Ir-192m	2.4E+02	1.1E+10	1.2E+07	3.6E+08	1.5E+06		1.1E+10
Mn-54	8.6E-01	3.6E-01	2.6E+02	1.3E-01	1.2E+01	1.8E-04	2.7E+02
Mo-93	3.5E+03	3.2E+10	9.2E+11	1.9E+10	3.3E+10		1.0E+12
Nb-93m	1.4E+01	6.5E+12	3.4E+10	2.7E+12	1.2E+09		9.2E+12
Nb-94	2.0E+04	4.6E+15	7.4E+11	2.8E+11	2.6E+10	2.3E+09	4.6E+15
Ni-59	7.5E+04	2.7E+11	3.2E+13	2.5E+12	1.2E+12	4.8E+10	3.6E+13
Ni-63	9.6E+01	7.5E+13	3.0E+15	7.0E+14	1.4E+14	4.8E+12	3.9E+15
Np-237	2.1E+06			5.4E+04		1.2E+08	1.2E+08
Pt-193	5.0E+01	1.1E+13	7.4E+10	3.8E+11	3.0E+09		1.1E+13
Pu-238	8.8E+01	4.6E+09		4.7E+08	3.0E+04	4.6E+11	4.6E+11
Pu-239	2.4E+04	8.3E+09		8.7E+07	5.5E+04	8.1E+11	8.2E+11
Pu-240	6.5E+03	1.1E+10		7.2E+08	4.7E+04	1.2E+12	1.2E+12
Pu-241	1.4E+01	1.9E+11		2.0E+09		2.8E+12	3.0E+12
Pu-242	3.8E+05	1.3E+07		1.0E+07		1.2E+09	1.2E+09
Sb-125	2.8E+00	1.2E+09	7.6E+09	3.8E+11	2.6E+08	1.4E+06	3.9E+11
Se-79	3.8E+05	3.2E+09	5.8E+08	8.7E+09	5.5E+07	6.1E+03	1.3E+10

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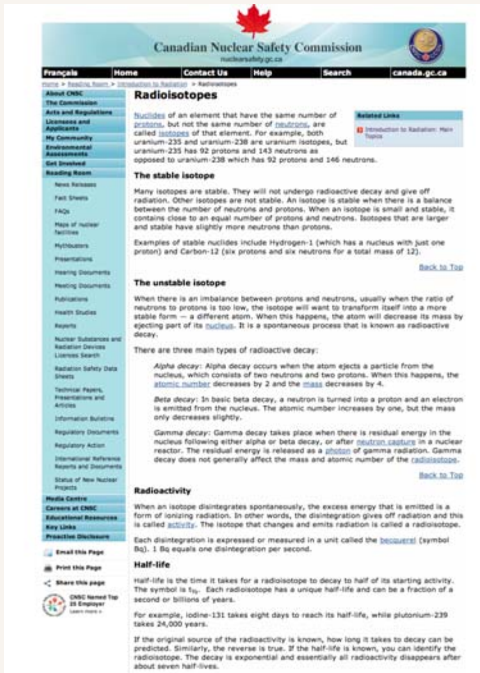
Title: REFERENCE LOW- AND INTERMEDIATE-LEVEL WASTE INVENTORY FOR THE DEEP GEOLOGIC REPOSITORY

		Estimated Radionuclide Inventory (Bq)					
		Retube Waste Pressure Tubes	Retube Waste End Fittings	Retube Waste Calandria Tubes	Retube Waste Cal. Tube Inserts	Steam Generators	Total
Net Volume (m^3)		193	2,429	133	36	8,387	11,178
Nuclide	T-1/2 (yrs)						
Sm-151	9.0E+01	3.4E+05	1.6E+00	1.7E+09	9.6E+04	4.1E+05	1.7E+09
Sn-119m	8.0E-01	1.2E-01	4.6E-01	2.3E+01	1.6E-02		2.4E+01
Sn-121m	5.5E+01	2.1E+11	7.4E+11	7.6E+13	2.7E+10		7.7E+13
Sn-126	2.1E+05			1.1E+07	1.3E+02	9.1E+05	1.2E+07
Sr-90+Y-90	2.9E+01	2.4E+12	3.2E+05	9.2E+11	4.4E+06	6.0E+12	9.3E+12
Tc-99	2.1E+05	2.4E+10	2.6E+10	9.4E+09	7.5E+08	1.1E+07	6.0E+10
U-232	7.2E+01	2.2E+06		5.5E+06	5.5E+03	2.2E+08	2.3E+08
U-233	1.6E+05	2.9E+06		5.9E+06	8.1E+04	3.0E+08	3.1E+08
U-234	2.5E+05	1.4E+07		2.1E+06		1.3E+09	1.3E+09
U-235	7.0E+08	2.1E+05		1.6E+02		2.1E+07	2.1E+07
U-236	2.3E+07	2.6E+06		4.5E+04	9.1E+00	2.5E+08	2.5E+08
U-238	4.5E+09	1.7E+07		2.4E+05		1.7E+09	1.7E+09
Zr-93	1.5E+06	1.5E+14	1.9E+08	6.2E+13	8.3E+06	2.9E+06	2.1E+14
Totals as listed		**5.4E+15**	**4.0E+15**	**8.9E+14**	**1.7E+14**	**1.7E+13**	**1.1E+16**
Totals with other short lived		**5.4E+15**	**4.0E+15**	**9.0E+14**	**1.7E+14**	**1.7E+13**	**1.1E+16**

What does CNSC and Health Canada say about ionizing radiation?



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Radioisotopes

Nuclides of an element that have the same number of protons, but not the same number of neutrons, are called isotopes of that element. For example, both uranium-235 and uranium-238 are uranium isotopes, but uranium-235 has 92 protons and 143 neutrons as opposed to uranium-238 which has 92 protons and 146 neutrons.

Related Links

Introduction to Radiation: Main Topics

The stable isotope

Many isotopes are stable. They will not undergo radioactive decay and give off radiation. Other isotopes are not stable. An isotope is stable when there is a balance between the number of neutrons and protons. When an isotope is small and stable, it contains close to an equal number of protons and neutrons. Isotopes that are larger and stable have slightly more neutrons than protons.

Examples of stable nuclides include Hydrogen-1 (which has a nucleus with just one proton) and Carbon-12 (six protons and six neutrons for a total mass of 12).

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The unstable isotope

When there is an imbalance between protons and neutrons, usually when the ratio of neutrons to protons is too low, the isotope will want to transform itself into a more stable form — a different atom. When this happens, the atom will decrease its mass by ejecting part of its nucleus. It is a spontaneous process that is known as radioactive decay.

There are three main types of radioactive decay:

Alpha decay: Alpha decay occurs when the atom ejects a particle from the nucleus, which consists of two neutrons and two protons. When this happens, the atomic number decreases by 2 and the mass decreases by 4.

Beta decay: In basic beta decay, a neutron is turned into a proton and an electron is emitted from the nucleus. The atomic number increases by one, but the mass only decreases slightly.

Gamma decay: Gamma decay takes place when there is residual energy in the nucleus following either alpha or beta decay, or after neutron capture in a nuclear reactor. The residual energy is released as a photon of gamma radiation. Gamma decay does not generally affect the mass and atomic number of the radioisotope.

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Radioactivity

When an isotope disintegrates spontaneously, the excess energy that is emitted is a form of ionizing radiation. In other words, the disintegration gives off radiation and this is called activity. The isotope that changes and emits radiation is called a radioisotope.

Each disintegration is expressed or measured in a unit called the becquerel (symbol Bq). 1 Bq equals one disintegration per second.

Half-life

Half-life is the time it takes for a radioisotope to decay to half of its starting activity. The symbol is $t_{1/2}$. Each radioisotope has a unique half-life and can be a fraction of a second or billions of years.

For example, iodine-131 takes eight days to reach its half-life, while plutonium-239 takes 24,000 years.

If the original source of the radioactivity is known, how long it takes to decay can be predicted. Similarly, the reverse is true. If the half-life is known, you can identify the radioisotope. The decay is exponential and essentially all radioactivity disappears after about seven half-lives.

http://www.nuclearsafety.gc.ca/eng/readingroom/radiation/radioisotopes.cfm

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Health Concerns

ARCHIVED - How would radiation affect my body?

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Cellular effects of radiation

Ionizing radiation affects living tissue on a cellular level by breaking chemical bonds and altering the structure of the molecules. Three things can happen to a cell as a result of irradiation:

1. The cell may repair itself;
2. The cell may mutate;
3. The cell may die.

Cellular repair

If the damage resulting from irradiation is such that the cells are able to repair themselves, then there is no effect to the organism from the radiation.

Cellular mutation

Irradiation may cause mutations in cells; that is, the radiation may affect the cell's genetic coding, or DNA. This can result in abnormalities when the cell divides and multiplies. In this case, there are three possible results:

1. The cell may be destroyed by the immune system;
2. The cell may survive but will lose some function;
3. The cell may survive but is dysfunctional.

In the first two circumstances, there is no effect to the organism. In the third possibility, the cell dysfunction may result in cancers, reproductive failures, or genetic effects.

Cellular death

There are three things that can happen when cells are killed by radiation:

1. If few cells are killed, the organism will heal itself and survive;
2. If more cells are killed, the organism may survive with prolonged symptoms;
3. If many cells are killed, the organism will die.

Effects of radiation on a cell

This is a diagram of the various effects that radiation can have on a cell:

http://www.hc-sc.gc.ca/hc-ps/ed-ud/event-incident/radiolog/info/body-corps-eng.php

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Radiation Health Effects

What is safe?

The word "safe" means different things to different people. For many, the idea of being safe is the absence of risk or harm. However, the reality is that there is a level of risk in almost everything we do.

For example, speed limits on roads are set to maximize safety. Nevertheless, accidents occur even when drivers are obeying the speed limit. Despite the risks, we make a conscious decision to drive.

Similar conscious decisions are made when radiation is used. Radiation exposure carries a health risk. Knowing what the risks are helps the CNSC and other regulatory bodies set dose limits and regulations that limit exposure to an acceptable or tolerable risk (some may even say a safe limit).

One significant advantage with radiation is that more is known about the health risks associated with it than with any other chemical or otherwise toxic agent. Since the early twentieth century, radiation effects have been studied in depth in both the laboratory and among human populations. Since the establishment of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) in 1955, the mandate of the Committee has been to undertake broad assessments of the sources of ionizing radiation and its effects on human health and the environment. Those assessments provide the scientific foundation used in formulating international standards for the protection of the general public and workers against ionizing radiation. The UNSCEAR 2010 Report (PDF, source: UNSCEAR Web site) consolidates and summarizes, in simple terms, the Committee's detailed understanding of the low-dose radiation effects on health.

How radiation affects cells

The primary way radiation affects our health is through breakage of DNA molecules. DNA is a long chain of amino acids whose pattern forms the blueprint on how the cell lives and functions. Radiation is able to break that chain. When it does, three things can happen:

1) The DNA is repaired properly

In this case, the cell is repaired properly and it continues to function normally. DNA breakage occurs normally every second of the day and cells have a natural ability to repair that damage.

2) The DNA damage is so severe that the cell dies (*deterministic effects*)

When the DNA or other critical parts of a cell receive a large dose of radiation, the cell may either die or be damaged beyond repair. If this happens to a large number of cells in a tissue or organ, early radiation effects may occur. These are called deterministic effects and the severity of the effects varies according to the radiation dose received. They can include burns, cataracts, and in extreme cases, death.

A strand of DNA

The first evidence of deterministic effects became apparent with early experimenters and users of radiation. They suffered severe skin and hand damage due to excessive radiation dose. More recently, this relationship was observed at the 1986 Chernobyl nuclear plant accident where more than 130 workers and firefighters received high radiation doses (800 to 16,000 mSv), and suffered severe radiation sickness. Two of the people exposed died within days of exposure. Close to 30 more workers and firefighters died within the first three months.

Radiation damage to cells

- Ionizing radiation affects living tissue at the cell level by breaking chemical bonds and altering the structure of the DNA molecules.

Radiation damage to cells

- Cellular repair
- Mutation
- Cell Death

Radiation damage to cells

- Deterministic effects
- “High doses of radiation can damage or destroy many cells, resulting in serious damage, or even death, to an organism. The severity of the effects increases with the radiation dose received. These are known as early, or deterministic, effects because they can be determined to be a direct result of radiation exposure. Deterministic effects in persons can include burns, radiation sickness, cataracts, sterility, and in extreme cases, death.”
- http://www.hc-sc.gc.ca/hc-ps/ed-ud/event-incident/radiolog/info/body-corps-eng.php

Radiation Effects

- Stochastic effects
- “Sometimes the effects of a radiation dose are not immediately observable. In these cases, there is no direct connection that can be made between the radiation dose and its possible effects. In other words, it is the probability rather than the severity of the effects that is increased. These are referred to as late, or stochastic, effects. Stochastic effects of low radiation doses can include an increased incidence of cancer in exposed persons and the possibility of genetic effects in their children.”

http://www.hc-sc.gc.ca/hc-ps/ed-ud/event-incident/radiolog/info/body-corps-eng.php


Canadian Nuclear Safety Commission
nuclearsafety.gc.ca

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Linear-Non-Threshold Model

April 2013

Fact Sheet: Linear-Non-Threshold Model (PDF)

The Canadian Nuclear Safety Commission (CNSC) regulates the use of nuclear energy and materials to protect the health, safety and security of Canadians and the environment. One of the ways the CNSC ensures health and safety is through setting regulations, including dose limits for workers and members of the public. To help set these limits, the CNSC joins the international community in relying on a radiation protection risk model known as the Linear-Non-Threshold (LNT) model.

The LNT model assumes a direct and proportional relationship between radiation exposure and cancer risk with all radiation doses. It provides an understanding of radiation health risks that informs the setting of dose limits and regulations that limit exposure to an acceptable level. Radiation doses at or below these limits are considered "safe" in that there is no direct medical or scientific evidence to show that they cause harm.

The risks from radiation have been largely derived from atomic bomb survivor studies, where the incidence of disease (principally cancer) was plotted against radiation dose. Where there was data, the dose response was linear, meaning that as dose increased, so did cancer risk. However, below the lowest data point, the natural incidence of the disease masked any effects that may have been caused by radiation. Because of this, the LNT model assumes that cancer incidence as it relates to radiation dose behaves in the same way as at higher doses; that is, in a linear manner.

Reports by the International Commission on Radiological Protection (ICRP 99, 2006) and the U.S. National Research Council of the National Academies (BEIR VII, 2006) state that while evidence supports other models, the LNT model provides the best overall fit for radiation protection purposes.

http://www.nuclearsafety.gc.ca/eng/readingroom/healthstudies/linear-non-threshold.cfm

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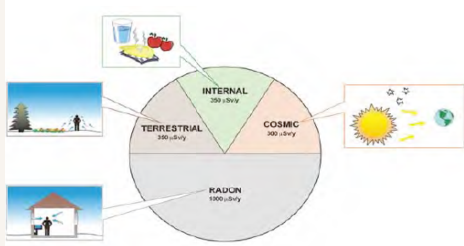
Radiation Safety Background

- Sievert is a unit of measure used to describe the effective dose of ionizing radiation received by people. Dose is often expressed in millionths of a Sievert, or microSievert (µSv)
- Natural background radiation averages about 2,000 µSv per year. This represents the amount of radiation dose that the average person in Canada receives each year from all natural sources
- The radiation received from a chest x-ray is 60 µSv
- Dose rate to the public, living at the site boundary, from the Bruce site activities is less than 3 µSv per year. Dose rate to the public, living at the site boundary, from the WWMF is less than 0.1 µSv per year



This diagram shows the range of sources of natural background radiation in Ontario. People are exposed to radiation from a number of natural sources such as the sun and the bedrock, and human activities such as medical examinations and power generation.

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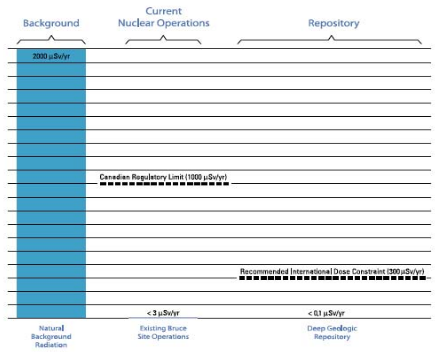
Preliminary Safety Assessment

- The safety assessment of the DGR is being completed by a team led by Quintessa Limited, a consulting firm based in the United Kingdom, which specializes in safety assessment of waste management facilities
- This chart shows the dose rate estimates for the Deep Geologic Repository. Maximum estimated doses to humans are well below the international standards and natural background levels
- A detailed safety assessment is well underway, using the latest scientific information from the Bruce site and design information



Keeping You Informed Booklet
EIS Vol. 2-2 Appendix D

Did OPG select the appropriate “receptors”?

Linear No-Threshold Risk Model

The Linear No-Threshold (LNT) risk model assumes there is a direct relationship between radiation exposure and cancer rates.

http://www.unscear.org/docs/reports/2010/UNSCEAR_2010_Report_M.pdf

Radiation dose limits and susceptible groups

- Age
- Gender
- Pregnant
- Breast feeding
- Genetic predisposition
- Immunocompromised

Cancer linked to genes

- Breast
- Colon
- Pancreatic
- Prostate
- Ovarian
- Retinoblastoma
- Li-Fraumeni Syndrome
- Other multiple neoplasia syndromes

"Receptors"

Table C2.3.3-1: General Characteristics of Potential Critical Groups

Group Name	General Characteristics and Location of Group
BR1	Non-farm resident, Lakeshore Scott Point, located north of the Bruce nuclear site
BR11	Non-farm resident, Inland Baie du Doré, located to the northeast of the Bruce nuclear site
BR32	Non-farm resident, Lakeshore Inverhuron Bay, south-southeast of Bruce B
BR22	Non-farm resident, Inland Northeast of Inverhuron, located to the south of the Bruce nuclear site
BR27	Non-farm resident, Trailer Park Northeast of Inverhuron, located to the south of the Bruce nuclear site
BF1	Agricultural, Non-dairy farm resident located to the northeast of the Bruce nuclear site
BF14	Agricultural, Non-dairy farm resident located to the southeast of the Bruce nuclear site
BDF11	Agricultural, Dairy farm resident located to the southeast of the Bruce nuclear site near Tiverton.
BEC	Worker in Bruce Energy Centre located to the east of the Bruce nuclear site

Source: [C14]

Radiation and health effects

According to the websites of CNSC, Health Canada, the World Health Organization, the American Cancer Society and the Nuclear Regulatory Commission, exposure to ionizing radiation carries health risks.

Cancers associated with ionizing radiation exposure

- Breast
- Bladder
- Colon
- Liver
- Lung
- Esophagus
- Ovary
- Stomach
- Prostate
- Nasal cavity/sinus
- Pharynx
- Larynx
- Pancreas
- Thyroid
- Bone marrow (leukemia, multiple myeloma)

http://www.nrc.gov/about-nrc/radiation/health-effects/rad-exposure-cancer.html

Thyroid and bone marrow cancers

"The thyroid gland and bone marrow are particularly sensitive to radiation. As a result, leukemia, a type of cancer that arises in the bone marrow, and thyroid cancer, are among the most common radiation-induced cancers."

- http://www.cancer.org/cancer/cancercauses/othercarcinogens/medicaltreatments/radiation-exposure-and-cancer

Thyroid cancer

- According to the *Canadian Cancer Statistics 2013 Report*, the incidence rate of thyroid cancer is the most rapidly increasing incidence rate among all major cancers. There was a 6.8% per year increase in males since 1998, and a 7.0% per year increase in females since 2002.

Canadian Cancer Statistics 2013, pg.19, Canadian Cancer Society

Health risks: non-cancer conditions

- Thyroid adenomas
- Autoimmune disease
- Cardiovascular disease
- Stroke
- Cataracts
- Premature aging
- Stress
- Hereditary effects – teratogenic and genetic

Radiation: hereditary effects

- Congenital malformations
- CNS problems
- Growth restriction
- Pregnancy Loss - miscarriage, fetal death, neonatal death, infant death
- Prematurity
- Infertility

Inadequate disclosure in educational materials

NUCLEAR WASTE MANAGEMENT ORGANIZATION SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

NWMO Fact Sheet

FACT SHEET

Health Effects of Radiation and Radioactivity

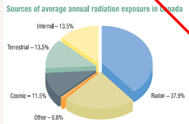
Rad meters can detect even the most minute amounts of radiation.

RADIATION AND RADIOACTIVITY

"Radiation" is simply energy moving through space. It can take the form of electro-magnetic waves such as microwaves used to cook food, x-rays for diagnostic medical purposes, and gamma rays for therapeutic medical purposes. Or it can be in the form of high-speed alpha particles and beta particles emitted by heavy metals such as uranium and radium, and neutrons produced at fission.

Substances are said to be "radioactive" when they emit radiation, either naturally or as a man-made condition. In Canada, on average, seventy-six percent of human exposure to radiation is from natural sources. These include radon gas from the earth's crust that is present in the air we breathe, terrestrial radiation from mineral soils, and cosmic radiation from space. Our bodies are also a source of radiation from potassium and carbon in the foods we eat. The remaining sources of radiation exposure are man-made. Twenty-three percent comes from medical technologies including x-rays and gamma-rays. And one percent can be categorized as "other" – created by things like the nuclear generation of electricity.

Sources of average annual radiation exposure in Canada



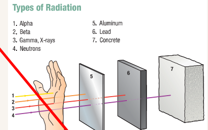
HEALTH EFFECTS OF RADIATION

Radiation can be either "ionizing" or "non-ionizing." Ionizing radiation has enough energy to change the make-up of materials at their most basic level, the atom. The forms of ionizing radiation are alpha particles, beta particles and neutrons, as well as x- and gamma-rays. Non-ionizing radiation does not have enough energy to cause atomic changes.

The form and amount of ionizing radiation determine how far it can penetrate human tissue and how much damage it can cause. Skin can stop alpha particles and low energy beta particles, while a thin aluminum sheet will stop all beta particles. Higher energy radiation – including neutrons, gamma rays and x-rays – can penetrate the human body if it is not properly shielded. That is why we wear a protective lead covering when we have our teeth x-rayed by the dentist.

Normally the human body withstands the radioactivity encountered in our daily lives because natural processes allow us to repair damaged tissue. However, if living tissue absorbs ionizing radiation, changes can occur at the atomic level. Exposure over the long term can disrupt the body's natural repair processes, permitting the uncontrolled growth of cells –

Types of Radiation



commonly called cancer. Very high-level exposure within a short time can be even more serious.

RADIATION PROTECTION PRINCIPLES

There are two important principles designed to ensure safety in the Canadian nuclear industry:

- ALARA – maintaining radiation exposure As Low As Reasonably Achievable and,
- Defence-in-Depth – creating multiple protective barriers between radiation sources and people and the environment.

ALARA is achieved by:

- Minimizing radiation and radioactive waste through efficient station operations,
- Minimizing the release of radioactive material to the environment through effective storage and ventilation systems, and
- Minimizing exposure to people and the environment by requiring workers to wear protective clothing, and by controlling emissions.

Defense-in-Depth requires each barrier to offer a unique and stand-alone level of protection so that if one level fails the next will come into play. The principle is applied in the storage of nuclear fuel waste. The first barrier consists of the ceramic material that makes up the fuel pellet. A second is the special alloy tubing in which the fuel pellets are encased. And a third is the concrete canister which houses the fuel bundles in dry storage facilities. The storage building and its ventilation systems provide additional protective barriers.

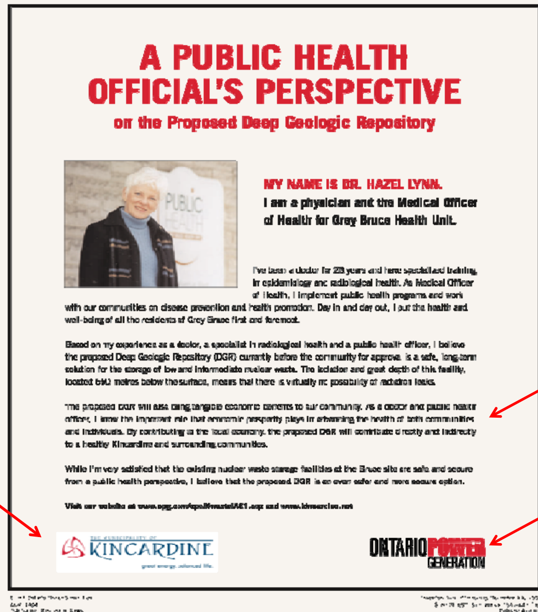
Canadian nuclear facilities implement the ALARA and Defense-In-Depth principles through radiation protection programs that include:

- Systems to monitor the radiation levels in each facility.
- Classification of work areas, as well as access control and restriction of activities to these areas based on present and anticipated radiological conditions.
- Work planning, work permit, and supervisory requirements for activities in work areas.
- Monitoring of all workers and visitors to ensure their exposure to radiation does not exceed regulatory limits. (All personnel in a nuclear facility must wear a device that provides a reading of the external dose of radiation while working on site. In addition, internal dose from ingestion or inhalation is assessed through bioassay samples.)
- Protective clothing and equipment requirements for areas with a high probability of contamination.
- Control of surface and airborne contamination through ventilation systems.
- Systems to measure and control facility emissions, as well as environmental monitoring programs.
- Employee training programs on radiological hazards within each facility.
- Emergency response plans.
- Packaging and transportation requirements for radioactive substances.

Radiation protection programs are part of the license requirements for nuclear facilities. Operating licenses are granted only if such programs are shown to be in place. For additional information visit our website: www.nwmo.ca

NUCLEAR WASTE MANAGEMENT ORGANIZATION SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Nuclear Waste Management Organization
49 Jackes Avenue First Floor
Toronto Ontario Canada M4T 1E2
Tel 416.934.9814 Fax 416.934.9526
Toll Free 1.866.249.6966
www.nwmo.ca



A PUBLIC HEALTH OFFICIAL'S PERSPECTIVE

on the Proposed Deep Geologic Repository

MY NAME IS DR. HAZEL LYNN.

I am a physician and the Medical Officer of Health for Grey Bruce Health Unit.

I've been a doctor for 20 years and have specialized training in epidemiology and radiological health. As Medical Officer of Health, I implement public health programs and work with our communities on disease prevention and health promotion. Day in and day out, I put the health and well-being of all the residents of Grey Bruce first and foremost.

Based on my experience as a doctor, a specialist in radiological health and a public health officer, I believe the proposed Deep Geologic Repository (DGR) currently before the community for approval is a safe, long-term solution for the storage of low and intermediate nuclear waste. The isolation and great depth of this facility, located 500 metres below the surface, means that there is virtually no possibility of radiation leaks.

The proposed DGR will also bring tangible economic benefits to our community. As a doctor and public health officer, I know the important role that economic prosperity plays in advancing the health of both communities and individuals. By contributing to the local economy, the proposed DGR will contribute directly and indirectly to a healthy Kincardine and surrounding communities.

While I'm very satisfied that the existing nuclear waste storage facilities at the Bruce site are safe and secure from a public health perspective, I believe that the proposed DGR is an even safer and more secure option.

KINCARDINE

great energy. balanced life.

ONTARIO POWER GENERATION

Existing conditions

According to the EIS summary statement, “For the purposes of this EA, ‘existing conditions’ are defined as those present during the period from 2006 through 2010, unless otherwise noted.”

Health Analytics Branch

"When analyzing data it is important to assess whether the data are appropriate for the evaluation at hand"

Data gaps

Information gaps - the scope, elements, or collection techniques used are insufficient to answer the research question.

- Accuracy
- Timeliness
- Comparability
- Usability
- Relevance

Data gaps

- **Spatial gaps** - data are unavailable, incomplete, or inapplicable for the geographic scale of analysis
- **Temporal gaps**

OPG's health data

Table C2.7.2-1: Health Conditions

	Ontario		Grey Bruce PHU		Difference[a]	Ontario Aboriginal Population	
	2008	2009	2008	2009		2000/2001	2003
Overweight - males 18 years and over (%)	40.8	40.1	44.1	34.4	↔	37.2	47.5
Obese - males 18 years and over (%)	18.5	18.6	23.2	26.9	↔	22.1	25.8
Overweight - females 18 years and over (%)	28.2	27.8	34.7	31.7	↔	26.9	37
Obese - females 18 years and over (%)	15.6	16.3	24.1	20.6	^	30.8	27
Arthritis (%)	16.9	16.8	25.3	21	^	21.6	23.2
Diabetes (%)	6.2	6.4	6.3	9.2	↔	7.1	6.4
Asthma - males 12 years and over (%)	7.2	6.8	7.9	6.8	↔	11.6	13.4
Asthma - females 12 years and over (%)	9.4	9.6	11	8.1	↔	20.5	21
High blood pressure (%)	16.6	17.2	20.7	19	^	11	13.2
Injury hospitalization (age-standardized rate/100,000)[b]	431	420	611	697	^	n/a	n/a

Notes:
a Difference is indicated using symbols as follows: ^ statistically significant increase, _ statistically significant decrease, ↔ change not statistically significant, does not compare Aboriginal population results.
b Years 2007 and 2008
n/a Data not available
Source: [C5;C7;C26]

Data were obtained from Statistics Canada [C5] with the exception of those on injury hospitalization, which were obtained from Canadian Institute for Health Information [C7]. The statistical significance of the differences between the Grey Bruce PHU estimates and those from the province are also reported by Statistics Canada ($p<0.05$) and have been presented here where available [C5]. Statistics on the significance of the differences between the Aboriginal Population and provincial data and Grey Bruce PHU were not available.

Table C2.7.4-1: Life Expectancy

	Ontario		Grey Bruce PHU		Difference[a]	Ontario Aboriginal Population	
	1997	2001	1997	2001		2000/2001	2003
Infant mortality (rate per 1,000 total births)	5.3[b]	6.1[c]	6.8[b]	5.3[c]	↔	n/a	n/a
Life expectancy - males (years)	76.2	77.4	75.6	76.2	↓	n/a	n/a
Life expectancy - female (years)	81.4	82	81.2	81	↓	n/a	n/a

Notes:
a Difference is indicated using symbols as follows: ↑ statistically significant increase, ↓ statistically significant decrease, ↔ change not statistically significant, does not compare Aboriginal population results
b The infant mortality data is not based on data from 1997 and 2001. It is based on a three year average of data from 2000 to 2002
c The infant mortality data is not based on data from 1997 and 2001. It is based on a three year average of data from 2005 to 2007
n/a Data not available
Source: [C26;C33;C34]

The statistical significance of the differences between the Grey Bruce PHU estimates and those from the province are also reported by Statistics Canada ($p<0.05$) [C5]. Information regarding Ontario Aboriginal population infant mortality rates or life expectancy was unavailable from Statistics Canada.

The infant mortality rates are the three year average from 2000 to 2002 and 2005 to 2007. There was no statistical difference ($p>0.05$) between the Grey Bruce PHU and the Ontario infant mortality rates. The life expectancy for individuals in the Grey Bruce PHU was significantly lower ($p<0.05$) than those in Ontario.

C2.7.5.1 Non – Aboriginal Population

Cancer incidence rates specific to the Regional Study Area were not available. However, data was available for Ontario, the South West LHIN and Grey Bruce PHU and have been presented below in Table C2.7.5-1.

Table C2.7.5-1: Cancer Incidence Rates in the General Population

	Ontario			South West LHIN			Grey Bruce PHU		
	2001	2002	2003	2001	2002	2003	2001	2002	2003
All invasive primary cancer sites (including in situ bladder), both sexes	398	393	391.5	419.7	415.2	409.7	403.6	395.5	365.6
Colon, rectum and rectosigmoid junction cancer, both sexes	50.9	49.2	48.3	55.6	53.6	51.6	52.7	50.0	50.0
Bronchus and lung cancer, both sexes	52.7	50.4	48.9	53	50.6	49	49.9	48.8	46.0
Female breast cancer, females	100.5	99.1	98.6	102.2	103	102.4	94.2	98.1	—
Prostate cancer, males	134.2	131.2	128.4	149.3	146.3	141.8	158.3	150.9	—

Notes.
Rates are based on a three-year average. The 2001 and 2002 data are based on the July 2005 Canadian Cancer Registry (CCR) file, whereas the 2003 data are based on the June 2007 CCR file.
Data presented as age-standardized rate per 100,000 population
Source: [C35;C6]

The statistical significance of the differences between the South West LHIN and Ontario was not available. With exception of prostate cancer cancer incidence rates in the South West LHIN and Grey Bruce are within 10% of Ontario incidence rates for the same type of cancer. As such, the South West LHIN and Grey Bruce PHU cancer incidence rates are considered to be comparable to Ontario rates due to many confounding factors that require consideration including lifestyle (smoking, alcohol consumption, obesity, etc.), genetic predisposition, access to medical care, and education. Also, while incidence rates appear to fluctuate, there are no apparent increasing trends for all types of cancers including prostate cancers.

C2.7.5.2 Aboriginal Population

Cancer incidence rates for First Nations and the statistical significance of differences between these rates and those of Ontario in general are presented below in Table C2.7.5-2 [C8]. In general, cancer incidence rates are lower in First Nations communities compared to the general population; however, colorectal and lung cancer rates are reportedly increasing.

Table C2.7.5-2: Cancer Incidence Rates in First Nations in Canada

Cancer	Ontario	First Nations	Difference[a]
Males			
Colorectum cancer	55	65	↔
Prostate cancer	119	61	↓
Lung cancer	63	57	↔
Kidney cancer	16	20	↔
Lymphoma	22	15	↔
Females			
Breast cancer	114	65	↓
Lung cancer	41	36	↔
Colorectum	37	35	↔
Lymphoma	19	10	↔
Cervical cancer	9	11	↔

Notes:
a Statistical significance of the differences are indicated using symbols as follows. ↑ statistically significant increase, ↓ statistically significant decrease, ↔ change not statistically significant.
Age-standardized rate/100,000 based on the 1991 Canadian population ages 15-74.
Based on data from 1997-2001.
Source: [C8]

Public participation?

Conflict of interest?

Useful health data?

Informed consent?

EIS Guidelines

Relevant Environmental Impact Statement Guidelines

- Section 2.2 Public Participation and Aboriginal Engagement
- Section 2.5 Precautionary Approach
- Section 2.6 Study Strategy and Methodology
- Section 2.7 Use of Existing Information
- Section 6.3 Stakeholders
- Section 6.4 Other Public Participation
- Section 8.1 General Information and Design Description

Relevant Environmental Impact Statement Guidelines

- Section 9.3 Valued Ecosystem Components
- Section 10 Existing Environment
- Section 10.2.6 Human Health
- Section 11.5.6 Human Health
- Section 14 Cumulative Effects
- Section 16 Follow-Up Program

Summary

I have concluded from my review that the proponent has not only failed to meet accepted standards of informed individual and community consent, but also baseline health data necessary for monitoring of future health effects are lacking.

Summary

The Joint Review Panel should **not** recommend approval of the DGR proposal.

Thank You