ONTARIO POWER GENERATION

Environmental Emissions Data for Nuclear Sustainability Services - Western

Q4 2021

OVERVIEW

This report summarizes the environmental emissions data for Q4 2021 for OPG's Nuclear Waste Management operations located at the Bruce Nuclear Power Development site in Bruce County. OPG's Nuclear Sustainability Services - Western stores low and intermediate level radioactive waste from the operation of OPG and Bruce Power nuclear reactors. The low level waste is stored as is, compacted or incinerated. The facility also provides used fuel dry storage for the Bruce Power reactors. OPG's Radioactive Waste Operations Site 1 stores low and intermediate level radioactive waste.

This report includes:

- Radioactive Effluents: Releases to air and water remained well below the regulatory limits.
- Perimeter Dose Rate Monitoring: Results demonstrate radiation exposures were within the regulatory limit.
- Groundwater Monitoring: OPG continued to analyze groundwater results to examine trends.
- Waste Incinerator: Emissions testing results confirmed compliance with air quality standards.
- Spills to the Environment: There were no spills to the environment that were reportable to a regulatory authority.

Note: The contents of this report are consistent with environmental data OPG is required to provide to the Canadian Nuclear Safety Commission (CNSC) on a quarterly basis. These reporting requirements are periodically revised.

ENVIRONMENTAL EMISSIONS MANAGEMENT

OPG has an environmental management program to ensure its activities are conducted in a manner that minimizes any adverse impact on the public and the environment. OPG's environmental program conforms to CNSC requirements for environmental protection and the International Organization for Standardization (ISO) standard for environmental management systems. The quality assurance programs for OPG's chemistry and health physics laboratories conform to the requirements of national and international standards.

As part of OPG's environmental management program, OPG has established an effluent monitoring and control program that is based on the "ALARA" principle. That is, measures are in place to ensure emissions to the environment are kept As Low As Reasonably Achievable while taking social and economic factors into account.

Public Radiation Dose Data

Annual assessments of environmental radiological data for the Bruce Nuclear Power Development site, including OPG's waste facilities, are available at: www.brucepower.com/resources-and-publications/reports

MONITORING OF RADIOACTIVE EFFLUENTS

Release Limits & Action Levels

OPG uses radiation dose limits specified in federal legislation to derive Release Limits for the radionuclides that may be released to air and water from its nuclear facilities. OPG's Nuclear Sustainability Services - Western must maintain its radiological emissions well below these limits to meet the terms of its operating licence.

OPG also sets Action Levels that are much lower than the Release Limits to identify and control emissions before a limit can be reached.

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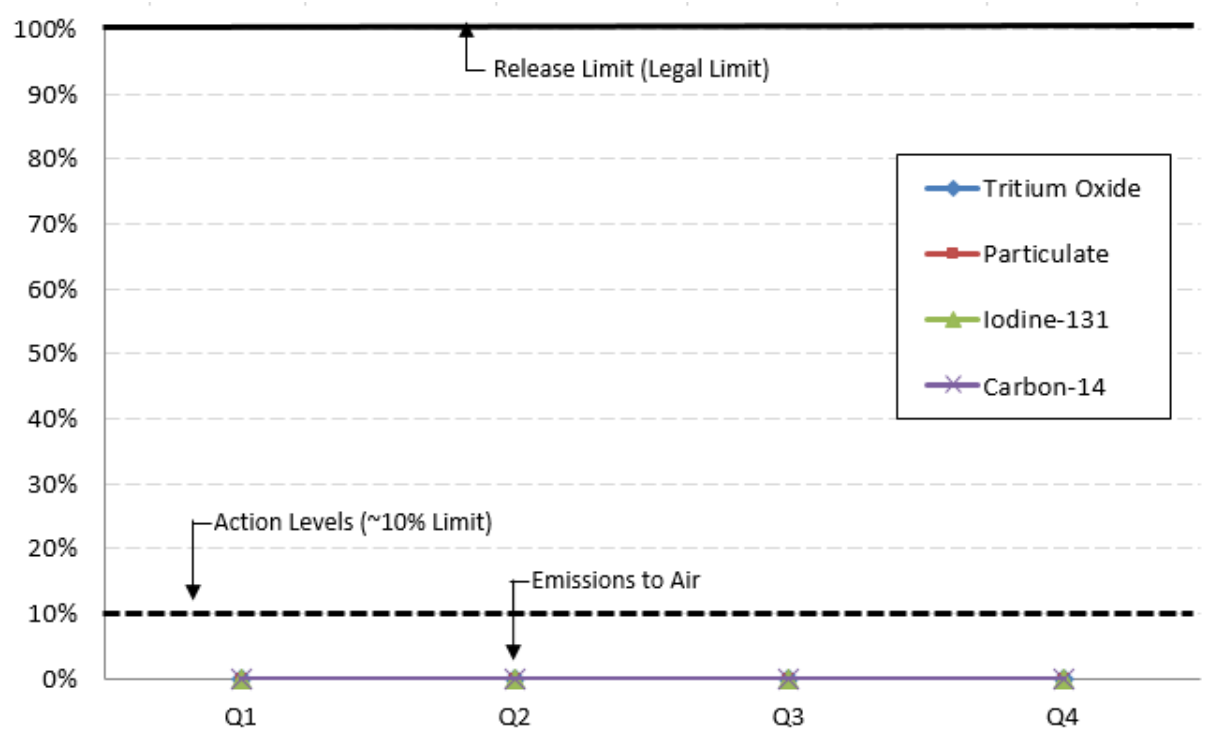
Performance Results

Emissions from the Nuclear Sustainability Services - Western are monitored to track performance. For Q4 2021, radiological emissions to air remained well below the Release Limits and no Action Levels were exceeded. (Appendix A, Tables A.1) The following graphs show radiological emissions for the year to date as a percentage of the Release Limits.

Air Emissions as a

Percent of Release Limits



WATER EMISSIONS

Starting January 2021, previously reported waterborne emissions are now captured in groundwater monitoring and environmental risk assessment programs.

PERIMETER DOSE RATE MONITORING

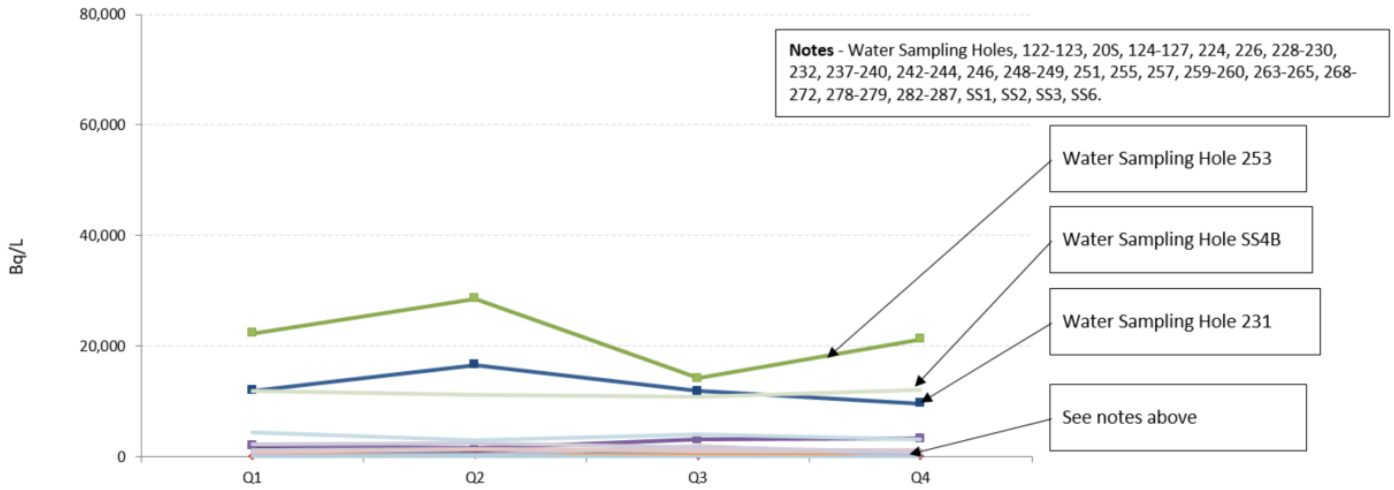
Average ambient dose rates are measured at perimeter fences by Thermoluminescent Dosimeters to demonstrate that radiation exposures to non-Nuclear Energy Workers and members of the public are as low as reasonably achievable. (Appendix A, Table A.2)

GROUNDWATER MONITORING

Groundwater monitoring is conducted in and around the Nuclear Sustainability Services - Western and the Radioactive Waste Operations Site 1 waste storage structures to analyze water quality. (Appendix A, Tables A.3, A.4. and A.6) The following graph shows average quarterly and annual tritium concentration results for the year to date. Tritium concentrations at Water Sampling Hole (WSH) 231 remain elevated but show a decreasing trend

since 2010, with seasonal variation. Elevated tritium concentrations at WSH 253 is expected as it is located up-gradient of WSH 231 and is closer to the tritium source.

Groundwater Monitoring Tritium Concentration Results



WASTE INCINERATOR EMISSIONS TESTING

The results of annual emissions testing performed at the Waste Volume Reduction Facility in 2021 indicated the facility is in compliance with Ontario air quality standards. (Appendix A, Table A.6)

SPILLS TO THE ENVIRONMENT

OPG has extensive programs to ensure the risk of spills to the environment is effectively assessed and managed. All spills are reported by OPG to the appropriate federal, provincial and municipal authorities as required.

OPG classifies its reportable spills as Category A, B or C spills based on the actual or potential impacts. Category A spills are considered very serious due to the scale of injury or damage, health effects, or safety impairment. Category B spills are considered serious due to localized injury or impacts to property. Category C spills are all other reportable spills that are less serious than Category A and B spills.

There were no reportable spills at the Nuclear Waste Management site in Q4 2021.

APPENDIX A

ENVIRONMENTAL EMISSIONS DATA

Environmental Emissions Data for Nuclear Sustainability Services - Western

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Table A.1: Airborne Radionuclide Releases[a]

	Tritium Oxide (Bq)	Particulate (Bq)	Iodine-131 (Bq)	Carbon-14[b] (Bq)
SUMMARY: ANNUAL				
Release Limit (Bq/year)[c]	3.45×10^{17}	6.65×10^{11}	1.99×10^{12}	2.41×10^{15}
Total Releases As of Q4 2021	2.16×10^{13}	2.72×10^{3}	1.10×10^{3}	5.63×10^{9}
DETAILS: QUARTERLY[d]				
Action Level (Bq/week)[e]	6.91×10^{14}	1.33×10^{9}	3.98×10^{9}	4.82×10^{12}
Q1	1.66×10^{13}	2.72×10^{3}	0	3.00×10^{9}
Q2	5.50×10^{11}	0	0	2.37×10^{8}
Q3	1.60×10^{12}	0	0	1.40×10^{9}
Q4	2.80×10^{12}	0	1.10×10^{3}	9.80×10^{8}

(a) The Waste Volume Reduction Building radioactive waste incinerator stack and ventilation exhaust stack are monitored for tritium, particulate, and iodine-131 emissions. The incinerator stack is also monitored for carbon-14 emissions. The Transportation Package Maintenance Building ventilation stack is monitored for tritium and particulate emissions. The Used Fuel Dry Storage Facility ventilation stack is monitored for particulate emissions.

(b) Carbon-14 emissions are impacted by the in-service time of the incinerator. OPG has completed the effluent monitoring assessment project and is in the process of reviewing the impact on C-14 emission data.

(c) The derived Release Limit for a given radionuclide is the release rate of that radionuclide to air during normal operation of a nuclear facility over the period of a calendar year, which would result in an individual receiving a dose equal to the regulatory annual dose limit for a member of the public. New Release Limits have been implemented for Nuclear Sustainability Services - Western starting in 2020.

(d) Releases have been summarized by quarter for this report.

(e) Exceedances of Action Levels must be reported by OPG to the CNSC. To prevent an Action Level from being reached, OPG has set Internal Investigation Levels that require emissions to be reviewed when they reach the high end of the normal range. Corrective actions are taken if necessary. There were no CNSC Action Level exceedance events in the fourth quarter of 2021. New Action Levels have been implemented for Nuclear Sustainability Services - Western starting in 2020.

A becquerel (Bq) is the standard international unit for measuring radioactive decay or radioactivity. One becquerel is the decay of one atom of a radioisotope per second, and is an extremely small amount of radioactivity. Becquerel is a measure of the rate (not energy) of radiation emission from a source.

Another unit of measuring radioactivity is the curie (Ci). 1 Ci = 3.7×10^{10} Bq.

Table A.2: Perimeter Fence Dose Rates

As per regulatory requirements, Section 4 of CNSC REGDOCS-3.1.3, *Reporting Requirements for Waste Nuclear Substance Licensees, Class II Nuclear Facilities and Users of Prescribed Equipment, Nuclear Substances and Radiation Devices,* RWOS-1 data will now be reported annually in Q4 in the Annual Compliance Monitoring Report.

		Average Air Kerma Rate (µGy/hour)[(a)]
Location		**Q4**
Radioactive Waste Operations Site 1	1	0.066
	1A	0.064
	2	0.065
	2A	0.068
	3	0.060
	4	0.062
	4A	0.061
Western Low and Intermediate Level Waste Storage Facility	5	0.066
	8	0.074
	10	0.063
	11	0.117
	12	0.071
	15	0.072
	16	0.081
	17	0.076
	18	0.075
	19	0.083
	20	0.080
	21	0.068
	22	0.069
	23	0.078
	24	0.085
	25	0.094
	26	0.093
	27	0.086
	28	0.096
	29	0.082
Western Used Fuel Dry Storage Facility	DFSN-1	0.092
	DFSN-2	0.103
	DFSN-3	0.091
	DFSN-4	0.074
	DFSS-1	0.081
	DFSS-2	0.086
	DFSS-3	0.087
	DFSS-4	0.081
	DFSE-1	0.077

Location		Average Air Kerma Rate (µGy/hour)[a] Q4
	DFSE-2	0.096
	DFSE-3	0.097
	DFSE-4	0.074
	DFSW-1	0.098
	DFSW-2	0.095
	DFSW-3	0.092
	DFSW-4	0.071

(a) Average ambient dose rates are measured at perimeter fences by Thermoluminescent Dosimeters to demonstrate that potential doses due to radiation fields from waste management facility operations are well within allowable limits and pose a negligible risk for the public, the workers and the environment. Dose rate monitoring results are compared to an internal target dose rate standard of 0.5 µGy/hour. This target is derived from the 1 mSv/year dose limit specified in federal legislation for a member of the public and assumes exposure for a working year (2,000 hours).

Table A.3: Radioactive Waste Operations Site 1 Groundwater Monitoring Results

		Tritium (Bq/L)	Gross Beta (Bq/L)	Carbon 14 (Bq/L) [a]
WSH 122	Q1	1.63×10^{2}	1.20×10^{-1}	<0.1
	Q2	1.95×10^{2}	6.90×10^{-2}	0.127
	Q3	9.92×10^{1}	5.90×10^{-2}	<0.1
	Q4	8.86×10^{1}	1.78×10^{-1}	<0.1
WSH 123	Q1	3.02×10^{2}	9.21×10^{-2}	<0.1
	Q2	7.14×10^{2}	6.50×10^{-2}	0.219
	Q3	2.94×10^{2}	7.20×10^{-2}	<0.1
	Q4	5.09×10^{2}	7.65×10^{-2}	<0.1
WSH 20S	Q1	2.10×10^{2}	7.65×10^{-2}	<0.1
	Q2	2.43×10^{2}	6.62×10^{-2}	0.192
	Q3	1.88×10^{2}	5.94×10^{-2}	1.02
	Q4	2.23×10^{2}	7.32×10^{-2}	<0.1
WSH 124	Q1	1.24×10^{2}	8.19×10^{-2}	<0.11
	Q2	1.26×10^{2}	6.84×10^{-2}	<0.1
	Q3	2.56×10^{2}	6.71×10^{-2}	<0.1
	Q4	1.55×10^{2}	6.60×10^{-2}	<0.1
WSH 125	Q1	1.25×10^{2}	1.15×10^{-1}	0.13
	Q2	1.29×10^{2}	7.41×10^{-2}	<0.1
	Q3	1.46×10^{2}	6.82×10^{-2}	<0.1
	Q4	1.26×10^{2}	1.24×10^{-1}	<0.1
WSH 126	Q1	1.12×10^{2}	8.44×10^{-2}	<0.1
	Q2	1.54×10^{2}	7.13×10^{-2}	<0.1
	Q3	1.54×10^{2}	8.27×10^{-2}	<0.1
	Q4	1.19×10^{2}	1.71×10^{-1}	<0.1

		Tritium (Bq/L)	Gross Beta (Bq/L)	Carbon 14 (Bq/L) [a]
WSH 127	Q1	7.93×10^{1}	7.35×10^{-2}	<0.1
	Q2	8.83×10^{1}	6.62×10^{-2}	<0.1
	Q3	9.47×10^{1}	5.94×10^{-2}	<0.1
	Q4	7.72×10^{1}	1.09×10^{-1}	0.6
DD (N)[b]	October	1.99×10^{2}	1.05×10^{-1}	N/A
	November	1.17×10^{2}	1.24×10^{-1}	N/A
	December	1.69×10^{2}	9.11×10^{-2}	N/A
DD (S)[b]	October	9.38×10^{1}	1.81×10^{-1}	N/A
	November	1.17×10^{2}	1.47×10^{-1}	N/A
	December	1.27×10^{2}	6.19×10^{-2}	N/A

(a) Values prefixed by an "<" indicate that reported results were less than the minimum detectable limit.

(b) Discharge Ditches (DD) are surface water sampling points and are sampled monthly.

Table A.4: Nuclear Sustainability Services - Western Groundwater Monitoring Results

As per regulatory requirements, Section 4 of CNSC REGDOCS-3.1.3, *Reporting Requirements for Waste Nuclear Substance Licensees, Class II Nuclear Facilities and Users of Prescribed Equipment, Nuclear Substances and Radiation Devices,* RWOS-1 data will now be reported annually in Q4 in the Annual Compliance Monitoring Report.

		Tritium (Bq/L)	Gross Beta (Bq/L)	Carbon 14 (Bq/L)[a]
		Q4	Q4	Q4
WSH 226		9.75×10^{0}	1.19×10^{-1}	<0.1
WSH 228		1.56×10^{2}	6.52×10^{-2}	<0.1
WSH 229		1.15×10^{3}	9.40×10^{-2}	<0.1
WSH 230		5.98×10^{2}	5.62×10^{-2}	<0.1
WSH 231[b]	October	9.31×10^{3}	1.87×10^{-1}	N/A
	November	9.98×10^{3}	8.19×10^{-2}	N/A
	December	9.79×10^{3}	8.65×10^{-2}	N/A
WSH 240		1.67×10^{-1}	1.15×10^{-1}	<0.1
WSH 242		4.75×10^{1}	1.84×10^{-1}	N/A
WSH 243		3.41×10^{2}	1.95×10^{-1}	<0.12
WSH 253[b]		2.13×10^{4}	2.23×10^{-1}	N/A
WSH 255[b]		3.34×10^{3}	1.68×10^{-1}	N/A
WSH 264		4.70×10^{1}	1.60×10^{-1}	<0.12
WSH 265		3.04×10^{2}	1.82×10^{-1}	<0.1
WSH 269		2.65×10^{2}	2.95×10^{-1}	N/A
WSH 282		5.19×10^{2}	5.42×10^{-1}	0.18
WSH 283		9.91×10^{1}	5.48×10^{-1}	<0.1
WSH 284		3.35×10^{2}	5.03×10^{-1}	<0.1
WSH 285		3.77×10^{2}	2.44×10^{-1}	<0.1

		Tritium (Bq/L)	Gross Beta (Bq/L)	Carbon 14 (Bq/L)[a]
		Q4	Q4	Q4
WSH 286		2.82×10^{2}	3.90×10^{-1}	<0.1
WSH 287		2.84×10^{2}	3.54×10^{-1}	<0.1
WWMF SS1[b]	October	7.99×10^{2}	2.60×10^{-1}	N/A
	November	7.45×10^{2}	4.96×10^{-1}	
	December	1.39×10^{3}	4.24×10^{-1}	
WWMF SS2[b]	October	1.25×10^{3}	1.80×10^{0}	N/A
	November	1.16×10^{3}	1.98×10^{0}	
	December	1.10×10^{3}	1.74×10^{0}	
WWMF SS3 - [b]	October	5.84×10^{2}	7.87×10^{-2}	N/A
	November	8.90×10^{2}	6.25×10^{-2}	
	December	1.13×10^{3}	7.75×10^{-2}	
WWMF SS4B[b]	October	1.25×10^{4}	4.95×10^{-1}	N/A
	November	1.25×10^{4}	4.09×10^{-1}	
	December	1.13×10^{4}	2.48×10^{-1}	
WWMF SS6[b]	October	1.37×10^{3}	3.28×10^{-1}	N/A
	November	3.71×10^{3}	7.69×10^{-1}	
	December	4.40×10^{3}	5.19×10^{-1}	

(a) Values prefixed by an "<" indicate that reported results were less than the minimum detectable limit.
(b) Water Sampling Holes are sampled on a quarterly basis, except for WSH 231 and Sample Stations SS1, SS2, SS3, SS4B, SS6 which are sampled monthly. It has been determined the source of the tritium at WSH 231 is evaporated water from waste in the Low Level Storage Buildings, which has likely migrated as condensate via underground electrical infrastructure. Various mitigating measures have been taken and the tritium concentration at WSH 231 shows a decreasing trend, with seasonal variations. WSH 253 and WSH 255 were incorporated into the groundwater monitoring program in 2017 and are used to monitor the extent of the tritium migration.

Table A.5: Nuclear Sustainability Services - Western Annual Groundwater Monitoring Results[a]

	Tritium (Bq/L)	Gross Beta (Bq/L)	Carbon 14 (Bq/L)[b]
WSH 224	5.34×10^{1}	6.73×10^{-2}	<0.1
WSH 232	4.94×10^{0}	7.64×10^{-2}	<0.1
WSH 237	9.47×10^{0}	3.73×10^{-1}	<0.1
WSH 238	9.29×10^{0}	1.08×10^{0}	<0.1
WSH 239	9.20×10^{0}	6.14×10^{-1}	<0.1
WSH 244	6.09×10^{1}	7.18×10^{-2}	N/A
WSH 246	9.66×10^{0}	1.55×10^{-1}	N/A
WSH 248	9.80×10^{0}	2.28×10^{-1}	N/A
WSH 249	1.83×10^{1}	2.80×10^{-1}	N/A
WSH 251	1.70×10^{3}	6.70×10^{-2}	N/A

	Tritium (Bq/L)	Gross Beta (Bq/L)	Carbon 14 (Bq/L)[(b)]
WSH 257	2.51×10^{3}	1.85×10^{-1}	N/A
WSH 259	8.97×10^{2}	2.19×10^{0}	N/A
WSH 260	1.09×10^{1}	8.70×10^{-2}	N/A
WSH 263	6.59×10^{1}	8.49×10^{-2}	N/A
WSH 268	9.81×10^{0}	4.80×10^{-2}	N/A
WSH 270	8.33×10^{0}	6.63×10^{-2}	N/A
WSH 271	8.39×10^{1}	1.38×10^{-1}	N/A
WSH 272	2.45×10^{2}	6.65×10^{-2}	N/A
WSH 278	6.99×10^{1}	4.94×10^{-1}	N/A
WSH 279	1.06×10^{2}	4.11×10^{-1}	N/A

(a) Annual samples were taken in Q3 of 2021.
(b) Values prefixed by an "<" indicate that reported results were less than the minimum detectable limit.

Table A.6: Nuclear Sustainability Services - Western Incinerator Facility Point of Impingement (POI) Assessment Summary [(a)]

Compound of Concern	Emission Rate	Calculated POI Concentration	Applicable POI Standard	Compliance Assessment
		24 hour basis (except where noted)	24 hour basis (except where noted)	% of Limit
	g/s	µg/m³	µg/m³	
PM	5.36E-04	0.031	120	0.026
Mercury	1.90E-07	1.11E-05	2	5.57E-04
Arsenic	1.60E-07	9.39E-06	*0.3*	*3.13E-03*
Barium	2.66E-06	1.56E-04	*10*	*1.56E-03*
Beryllium	3.60E-08	2.11E-06	0.01	0.021
Cadmium	2.20E-07	1.29E-05	0.025	0.052
Chromium	1.15E-06	6.77E-05	0.5	0.014
Copper	6.62E-06	3.89E-04	50	7.77E-04
Lead	3.40E-06	2.00E-04	0.5	0.040
Manganese	1.64E-06	9.63E-05	0.4	0.024
Nickel	1.96E-06	2.05E-05 (annual)	0.04 (annual)	0.051 (annual)
Silver	6.71E-08	3.94E-06	1	3.49E-04
Zinc	5.47E-06	3.21E-04	120	2.67E-04
D&F (TEQ)	1.27E-11	2.28E-09 (1/2-hour)	**15 (1/2-hour)**	1.52E-08 (1/2-hour)
		7.47E-10	1.00E-07	0.75
Total PCB's	1.81E-09	1.06E-07	*0.15*	*7.10E-05*
HCB	5.04E-08	2.96E-06	0.011	*0.027*
Naphthalene	2.07E-07	3.70E-05 (1/2 -hr)	**36 (1/2 – hour)**	1.03E-04 (1/2 – hr)
		1.21E-05	22.5	5.39E-05
Benzo(a)pyrene	*5.04E-08*	*9.03E-06 (1/2-hour)*	0.015 (1/2-hour)	0.060 (1/2-hour)
		2.96E-06	0.005	0.059
		5.28E-07 (annual)	0.00001 (annual)	5.28 (annual)

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Compound of Concern	Emission Rate	Calculated POI Concentration	Applicable POI Standard	Compliance Assessment
		24 hour basis (except where noted)	24 hour basis (except where noted)	% of Limit
	g/s	µg/m³	µg/m³	
HCl	4.81E-03	0.28	20	1.41
Phenol	*5.50E-03*	*0.323*	30	1.08
Acetaldehyde	*7.62E-05*	*0.014* (1/2-hour)	500 (1/2-hour)	2.73E-03 (1/2-hour)
		4.47E-03	500	8.94E-04
Formaldehyde	2.04E-04	0.012	65	0.018
Acrolein	*7.62E-05*	0.011 (1 – hour)	4.5 (1-hour)	0.25 (1-hour)
		4.47E-03	0.4	1.12
Benzene	2.41E-05	*2.52E-04* (annual)	0.45 (annual)	0.056
Ethylbenzene	*1.76E-06*	*1.04E-04*	1,000	1.04E-05
Methyl Ethyl Ketone (2-Butanone)	*1.76E-06*	*1.04E-04*	1,000	1.04E-05
Styrene	*1.76E-06*	*1.04E-04*	400	2.59E-05
Tetrachloro-Ethylene	*1.76E-06*	*1.04E-04*	360	2.88E-05
Toluene	*1.76E-06*	*1.04E-04*	*2,000*	*5.18E-06*
Trichloroethane, 1,1,1	1.76E-06	*1.04E-04*	115,000	9.00E-08
Vinyl Chloride (chloroethene)	*1.76E-06*	*1.04E-04*	1	0.010
Xylene, m&p	*3.53E-06*	*2.07E-04*	730 (sum of all xylenes)	4.26E-05
Xylene,o	*1.76E-06*	*1.04E-04*		
Carbon Monoxide	9.49E-05	0.017 (1/2-hour)	6,000 (1/2-hour)	2.83E-04 (1/2-hour)
Nitrogen Oxides	0.072	10.73 (1-hour)	400 (1-hour)	2.68 (1-hour)
		4.22	200	2.11
Sulphur Dioxide	2.51E-04	0.038 (1-hour)	690 (1-hour)	5.44E-03 (1-hour)
		0.015	275	5.36E-03

***Bold text indicates ECA prescribed limits*.**

Underlined italics indicate compound emissions less than reporting limits.

Shaded italics indicate **Guideline** POI concentrations.

(a) The results of an emission testing program performed in October 2021 indicated the Nuclear Sustainability Services - Western Waste Volume Reduction Facility was operating well within compliance for all Ontario Environmental Protection Act, Ontario Regulation 419/05 standards and point of impingement guidelines based on ground level point of impingement concentrations. This testing is required annually to meet Ontario Ministry of the Environment, Conservation and Parks Environmental Compliance Approval requirements.