BWXT Nuclear Energy Canada Inc.

Environmental Risk Assessment

Nuclear Fuel Pellet Operation

July 2023

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Environmental Risk Assessment Report

Nuclear Fuel Pellet Operation

July 2023

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Revision History

Revision		Details of Revision	Author	Reviewer
No.	Date			
0	March 2023	New	John Peters	Arnon Ho
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Executive Summary

The Nuclear Fuel Pellet Operation (NFPO) is a Class IB nuclear facility operated by BWXT Nuclear Energy Canada Inc. (BWXT NEC) in Toronto. The NFPO processes ceramic grade uranium dioxide (UO_2) powder to industry-grade natural uranium fuel pellets for use primarily in CANDU (Canadian Deuterium Uranium) reactor fuel bundles with a smaller quantity of pellets shipped to a plant in Wilmington North Carolina for use in Boiling Water Reactors (BWR). The facility is located on the east side of Lansdowne Avenue, north of Dupont Street in Toronto, Ontario.

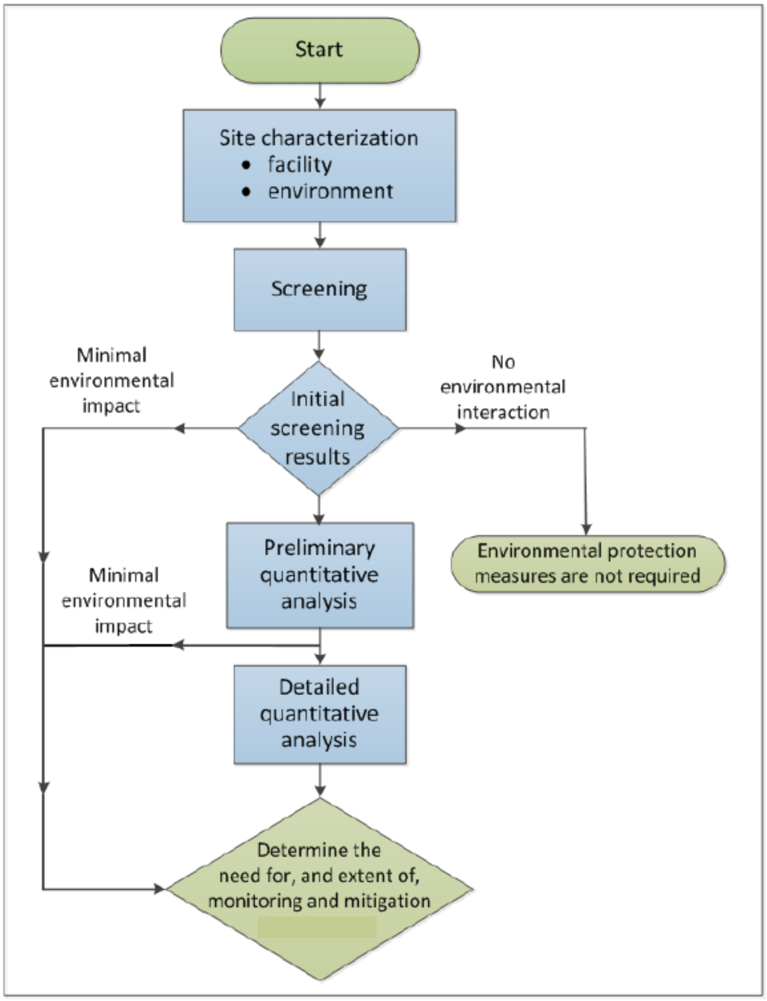
This report summarizes the Environmental Risk Assessment (ERA) for the facility required by the Canadian Nuclear Safety Commission (CNSC) *REGDOC-2.9.1: Environmental Protection: Environmental Principles, Assessments and Protection Measures* (CNSC 2020).

REGDOC-2.9.1 outlines the requirements for a Class IB nuclear facility to conduct and update its ERA in accordance with CSA *N288.6:22, Environmental risk assessment at Class I nuclear facilities and uranium mines and mills* (CSA 2022). CSA N288.6:22 requires an update to the ERA at least every five years and whenever significant change occurs in either the facility or activity. This ERA updates previous ERAs with current information, consistent with the CSA N288.6:22 requirement to review the ERA at least every five years to verify its applicability and update it, if the review indicates that an update is necessary.

An ERA is a systematic process that identifies, quantifies and characterizes the risk posed by contaminants (nuclear or hazardous substances) and physical stressors in the environment associated with a facility (CSA 2022). An ERA provides science-based information to support decision-making and to prioritize the implementation of mitigation measures. An ERA and its associated performance predictions serve as the basis for control and monitoring of releases, environmental monitoring, and any supplementary studies (CNSC 2020).

Effectively, the ERA evaluates the contaminants that are released to the air and water from the facility to determine whether there is any potential for health effects to humans through a Human Health Risk Assessment (HHRA) or non-human biota through an Ecological Risk Assessment (EcoRA). The general methodology followed for both the human health and ecological risk assessments are defined by CSA *N288.6:22*. The iterative methodology outlined in CSA N288:.6:22 and used in this ERA allows for the risk assessment to be refined in each iteration (or Tier) by removing conservatism. This methodology is illustrated in Figure ES-1.

Integral to this assessment is to understand how the contaminants from the NFPO enter the natural environment and interact with the Human and Ecological Receptors. Figure ES-2 and Figure ES-3 illustrate the potential pathways of contaminant exposure to humans and ecological receptors, respectively.



Source: (CNSC 2020)

Figure ES-1 ERA Methodology

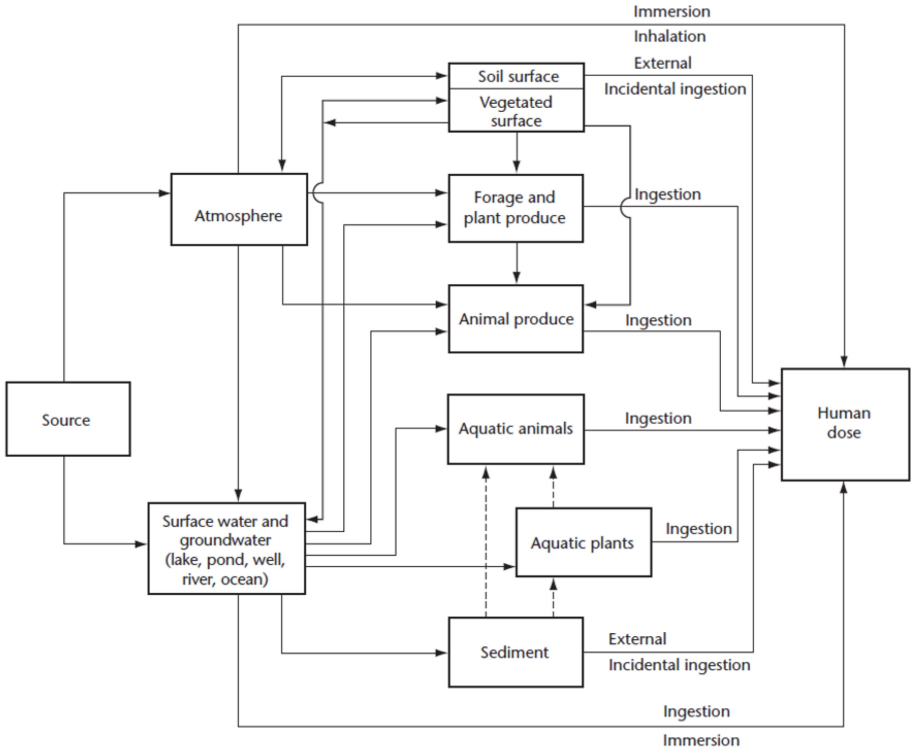


Figure ES-2 Sample Human Pathway Model (CSA 2022)

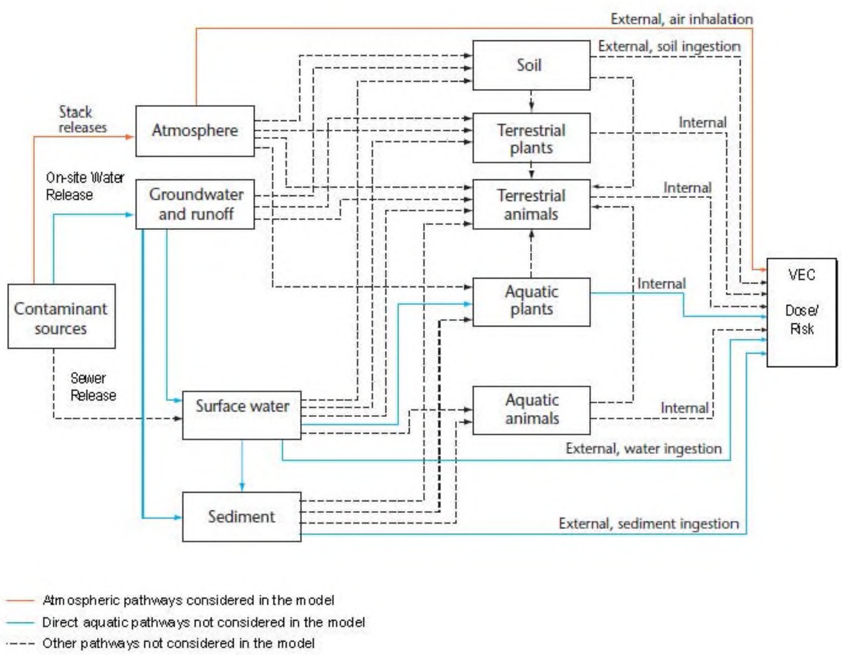


Figure ES-3 Sample Ecological Exposure Pathway Model (CSA 2022)

Once these pathways are understood, the Contaminants of Potential Concern (COPCs) need to be determined. COPCs is a list of all radiological and non-radiological contaminants released to air and water from facility operations. When contaminants are released in very small quantities, they are removed from further consideration. Also, if it is determined that the contaminants are not a concern from a human or ecological health perspective, they are removed from further consideration.

Emissions to Air

The principle radiological contaminant emissions of BWXT NEC NFPO operations is uranium.

Airborne non-radiological contaminant emissions for the NFPO operations have modelled air concentrations well below the screening criteria in all cases. Furthermore, all non-radiological substances are currently and will continue to be below CNSC licence limits, BWXT NEC *Action Levels,* BWXT NEC *Internal Control Levels* and Ontario Ministry of the Environment, Conservation and Parks (MECP) Benchmarks limits, and are therefore expected to be negligible.

Emissions to Water

There are no surface water bodies present in the vicinity of consolidated operations and limited liquid effluent from the facility, therefore no measurable effects on surface water and sediment components are expected. For discharges to sewer, after passing through the municipal wastewater treatment plant, concentrations of uranium are well below surface and drinking water quality guidelines and standards.

Human Health Risk Assessment

Since airborne contaminant emissions are well below applicable guidelines and limits, and environmental air and soil monitoring data show concentrations around the NFPO within the range of natural background, no non-radiological airborne substances have been identified as COPCs for further assessment in the HHRA. Similarly, because contaminant emissions are well below applicable guidelines and criteria, no non-radiological waterborne substances have been identified as COPCs for further assessment.

The estimated annual effective dose as a result of air releases and direct gamma exposure radiation from the NFPO operation is expected to be on the order of 0.4 to 23.5 µSv/year. This dose represents between 0 and 2% of the 1 mSv (1,000 µSv) per year effective dose limit to a member of the public and 0.2% to 12% of the 0.2 mSv (200 µSv) per year effective dose screening criterion for radiological exposures. Therefore, it can be concluded that there will be no radiological effects to human health due to the operation of te NFPO, and no further assessment is required.

Noise was identified as a potential physical stressor for human health. The NFPO operations comply with the Ministry of the Environment, Conservation and Parks (MECP) *Environmental Noise Guideline - Stationary and Transportation Sources - Approval and Planning* (NPC-300) noise criteria, therefore, it is expected that noise levels from the facility pose no adverse effects to human health.

Ecological Risk Assessment

As for human health, because airborne and waterborne contaminant emissions are well below applicable guidelines and limits, no non-radiological substances have been identified as COPCs for further assessment in the EcoRA.

Radiation (external and internal) exposure due to uranium emissions are trivial as only between 6.3 to 8.2 g of uranium per year have been emitted to air from the NFPO over the 2017 to 2020 period and exposure via water pathways are trivial. As a result, direct external exposure to gamma radiation is the only pathway for radiation exposure to Valued Components (VCs). The resulting HQ of approximately 0.0015 (assuming continuous exposure at the maximum gamma radiation level measured, inclusive of background) is well below one, the value at which no adverse effects are likely as levels are below those that are known to cause adverse effects. Therefore, it can be concluded that there are no radiological effects to VCs due to the NFPO and no further assessment is required.

The NFPO is located in a highly urbanized area which limits the site-specific potential for physical stressors (heat, wildlife-vehicle/bird-structure mortalities, artificial night lighting or noise) to impact on VCs. As such, none of these stressors are particularly relevant to the NFPO and no further assessment is required.

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1 Introduction

1.1 Background

An Environmental Risk Assessment (ERA) is a systematic process that identifies, quantifies and characterizes the risk posed by contaminants (nuclear or hazardous substances) and physical stressors (e.g., noise, artificial light) in the environment associated with a facility (CSA 2022). An ERA provides science-based information to support decision-making and to prioritize the implementation of mitigation measures. An ERA and its associated performance predictions serve as the basis for control and monitoring of releases, environmental monitoring, and any supplementary studies (CNSC 2020).

The Canadian Nuclear Safety Commission (CNSC) *REGDOC-2.9.1: Environmental Protection: Environmental Principles, Assessments and Protection Measures* (CNSC, 2020) outlines the requirements for a Class IB nuclear facility to complete and update an ERA. REGDOC-2.9.1 requires BWXT to conduct and update its ERA in accordance with *CSA N288.6:22, Environmental risk assessment at Class I nuclear facilities and uranium mines and mills* (CSA 2022).

In accordance with CSA N288.6:22, this ERA follows a tiered approach where risks that require more detailed consideration are identified and assessed in greater detail. CSA N288.6:22 recommends that the following tiers of assessment be conducted for the nuclear facilities, as appropriate:

- Tier 1 - Screening level risk assessment (SLRA): Within the context of a tiered approach to ERA, SLRA represents the less detailed lower tier and serves as the most conservative and broadest form of risk assessment. This first tier of assessment is broad in scope and serves to identify potential issues (receptors and stressors), using qualitative or quantitative methods (singly or in combination) that require further quantitative evaluation at a higher tier. If no such issues are identified, no further assessment is needed.
- Tier 2 - Preliminary quantitative risk assessment (PQRA): This second tier addresses the identified potential issues quantitatively, generally using available site data. A PQRA can be sufficient to eliminate some risk issues (receptors and stressors) as being of no concern, while others might require further investigation. The decision on whether to progress from a PQRA to a detailed quantitative risk assessment (DQRA) is based on the severity of estimated risks as well as the spatial and temporal extent of the risks. If minimal environmental effects have been identified through the PQRA process, refining risk further through the DQRA process is not necessary.
- Tier 3 - Detailed quantitative risk assessment (DQRA): This third tier addresses any issues that are still of concern after the PQRA. A DQRA focuses on risk issues that have been found through PQRA to require further investigation based on severity of estimated risks as well as the spatial and temporal extent of the risks. A DQRA can involve a refined (more realistic) exposure assessment and risk characterization, or can consider other lines of evidence (e.g., epidemiology or field studies of toxicity or population/community condition). It can use additional site-specific monitoring data or more sophisticated modelling to estimate more realistic exposure concentrations (CSA 2022).

This progression is illustrated at a high level in Figure 1-1. Specifically, the tasks identified in Table 1-1, as appropriate, should be performed in each tier.

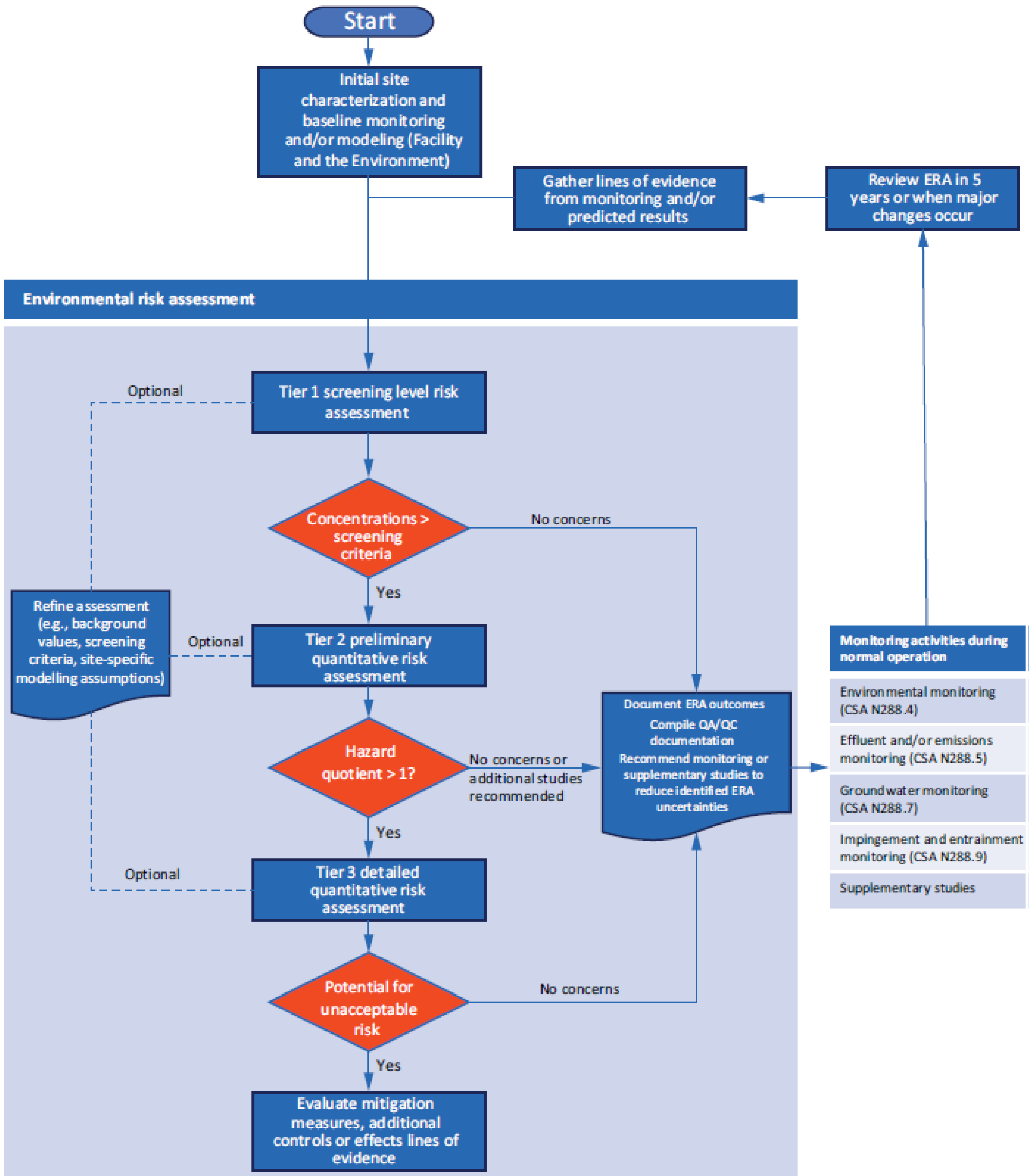


Figure 1-1 ERA Progression through Tiers of Assessment (CSA 2022)

Table 1-1 ERA Tasks by Tier

SLRA — Tier 1	PQRA — Tier 2	DQRA — Tier 3
Problem formulation • summarize site characterization results • select contaminants and physical stressors • select receptors and exposure pathways • define assessment and measurement endpoints (EcoRA) • develop conceptual model • compare screening levels to screening criteria		
Refine assessment (optional) • i.e., comparison to upper range of background values, use of alternate screening criteria	Exposure assessment • estimate exposure/dose for receptors at relevant locations for each COPC or physical stressor Toxicity/effects assessment • select TRVs/benchmarks for each receptor and COPC or physical stressor (if possible) Risk characterization • calculate HQs for each COPC or physical stressor (if possible) at relevant locations • calculate cancer risk for non-radiological carcinogens for human receptors (HHRA)	
	Refine assessment (optional) • i.e., use of more site-specific modelling assumptions • recommend additional studies, and/or continued monitoring for inclusion in next iteration of ERA	• refine exposure assessment and risk characterization • consider other available lines of evidence (e.g., epidemiology, field studies of toxicity or of population/community effects) • recommend further uncertainty reduction (e.g., supplementary studies), effects monitoring, and/or risk management (e.g., additional controls, mitigation measures) if applicable

Note: *Only issues (receptors or stressors) that remain of concern at the end of each assessment tier need to be considered further in the next assessment tier. Progression from Tier 2 to Tier 3 should be based on severity of estimated risks as well as the spatial and temporal extent of the risks.*

Source (CSA 2022)

1.2 Goals, Objectives, and Scope

As per CNSC's REGDOC-2.9.1, every Class IB nuclear facility applicant or licensee must have an ERA, commensurate with the scale and complexity of the environmental risks associated with the facility or activity. REGDOC-2.9.1 requires a licensee to review and revise the ERA in accordance with CSA N288.6:22, taking into consideration whether there has been:

- a significant change in the facility or activity that could alter the nature (type or magnitude) of the interactions with the environment (such as modification, expansion or refurbishment of the facility) within the ERA predictions; and
- any transition to a new phase in the lifecycle (such as a transition to licence to operate, decommission or abandon) where the application for the new licensing phase includes any interactions with the environment that were not previously captured in the ERA (CNSC 2020).

CSA N288.6:22 require an update to the ERA at least every five years and whenever significant change occurs in either the facility or activity.

This five year update to the 2018 ERA is being completed to update the ERA with current information, consistent with the CSA N288.6:22 requirement to review the ERA at least every five years to verify its applicability and update it, if the review indicates that an update it is necessary.

As per CSA N3288.6:22, the objectives of the ERA are to:

- evaluate the risk to relevant human and non-human biota receptors resulting from exposure to contaminants and stressors related to a site and its activities, and
- to recommend further action or assessment based on the results.

The scope of the ERA covers both human health risk assessment and ecological risk assessment. Human receptors are addressed through a human health risk assessment (HHRA) and non-human biota are addressed through an ecological risk assessment (EcoRA).

CSA N288.6:22, clause 0.2 notes that the nature and complexity of ERAs will vary according to the nature and complexity of the subject (site, scenario, magnitude, facility, etc.) and provides for a tiered approach to ERA. Where concerns are below a screening criteria, a Screening Level Risk Assessment (SLRA) is deemed adequate. Where concerns are noted, a Preliminary Quantitative Risk Assessment (PQRA) is required. If the PQRA identifies a hazard quotient[1], as defined in the Standard, greater than 1 a Detailed Quantitative Risk Assessment (DQRA) is required. Within the context of this tiered approach, compared to other nuclear fuel cycles facilities, the NFPO presents a relatively low human health and environmental risk profile.

[1] Hazard Quotient (HQ) is a numerical representation of the potential for effects due to exposure to a non-carcinogenic (threshold acting) contaminant or stressor. To calculate an HQ, some estimated exposure value (EV, usually a concentration or dose) is divided by a toxicological reference value (TRV) or benchmark value (BV) in the same units (CSA 2022).

1.3 Organization of Report

The ERA has been structured for consistency with Appendix A of CSA N288.6:22. The report is structured as follows:

- Section 2.0: Site Characterization;
- Section 3.0: Human Health Risk Assessment;
- Section 4.0: Ecological Risk Assessment;
- Section 5.0: Conclusions and Recommendations;
- Section 6.0: Quality Assurance; and,
- Section 7.0: References.

2 Site Characterization

2.1 Engineered Site Facilities

The BWXT NEC NFPO in Toronto processes ceramic grade uranium dioxide (UO_2) powder to industry-grade natural uranium fuel pellets for use primarily in CANDU (Canadian Deuterium Uranium) reactor fuel bundles and has shipped pellets to the USA for use in Boiling Water Reactors (BWR). The facility is located on the east side of Lansdowne Avenue, north of Dupont Street in Toronto, Ontario (See Figure 2-1 and Figure 2-2). The business address for the NFPO is 1025 Lansdowne Avenue. Toronto, Ontario M6H 3Z6. The Toronto facility consists of a plot of land, registered in the land titles office of Toronto, April 30, 1903, as Lot Number 1, Plan M-216 being a plan of re–division of Block H, Plan M-58, and two separate buildings located thereon.

2.1.1 NFPO Buildings

There are two buildings on the site, referred to as Buildings 7 and 9 (see Figure 2-1).

Building 7 is a four-storey concrete structure which is partially below grade located at the south end of the property. This building contains the manufacturing operations for the production of uranium fuel pellets, which is performed on the first, second, and third floor levels. The fourth-floor level provides space for administrative offices.

Building 9 is a single storey masonry structure located at the north side of the property. This building is primarily used to store contaminated substances, including contaminated filters, wastewater, contaminated waste (e.g., gloves, coveralls, combustible and non-combustible), and contaminated zirconium tubes.

2.1.2 Process Description

The BWXT NEC NFPO operates under Nuclear Fuel Facility Operating Licence FFOL-3621.00/2030 to process natural and depleted UO_2 powder into fuel pellets. Specifically, UO_2 powder is received in standard steel drums and the powder is compressed into "slugs" and granulated to a free-flowing powder. This powder is pressed into a pellet shape and the sintered pellets are ground to the required diameter, inspected and wrapped for shipment to the Peterborough facility. BWXT NEC also may periodically ship natural uranium pellets to the United States of America for use in Boiling Water (BWR) commercial power reactors. In Peterborough, the pellets are loaded into zirconium sheaths and assembled into bundles (See Figure 2-3).

The facility is intended to operate over three, eight-hour shifts, five days per week, 47 weeks per year at a maximum monthly processing rate of 150 Megagrams (150 tonnes) of uranium.

2.1.3 Uncertainties in Site Engineered Facilities

There are no substantive uncertainties in the understanding of the site engineered facilities. The processing of natural uranium dioxide powder (UO_2) into fuel pellets and associated emissions are well established and understood.

Figure 2-1 NFPO Facility

Figure 2-2 NFPO Surrounding Environment

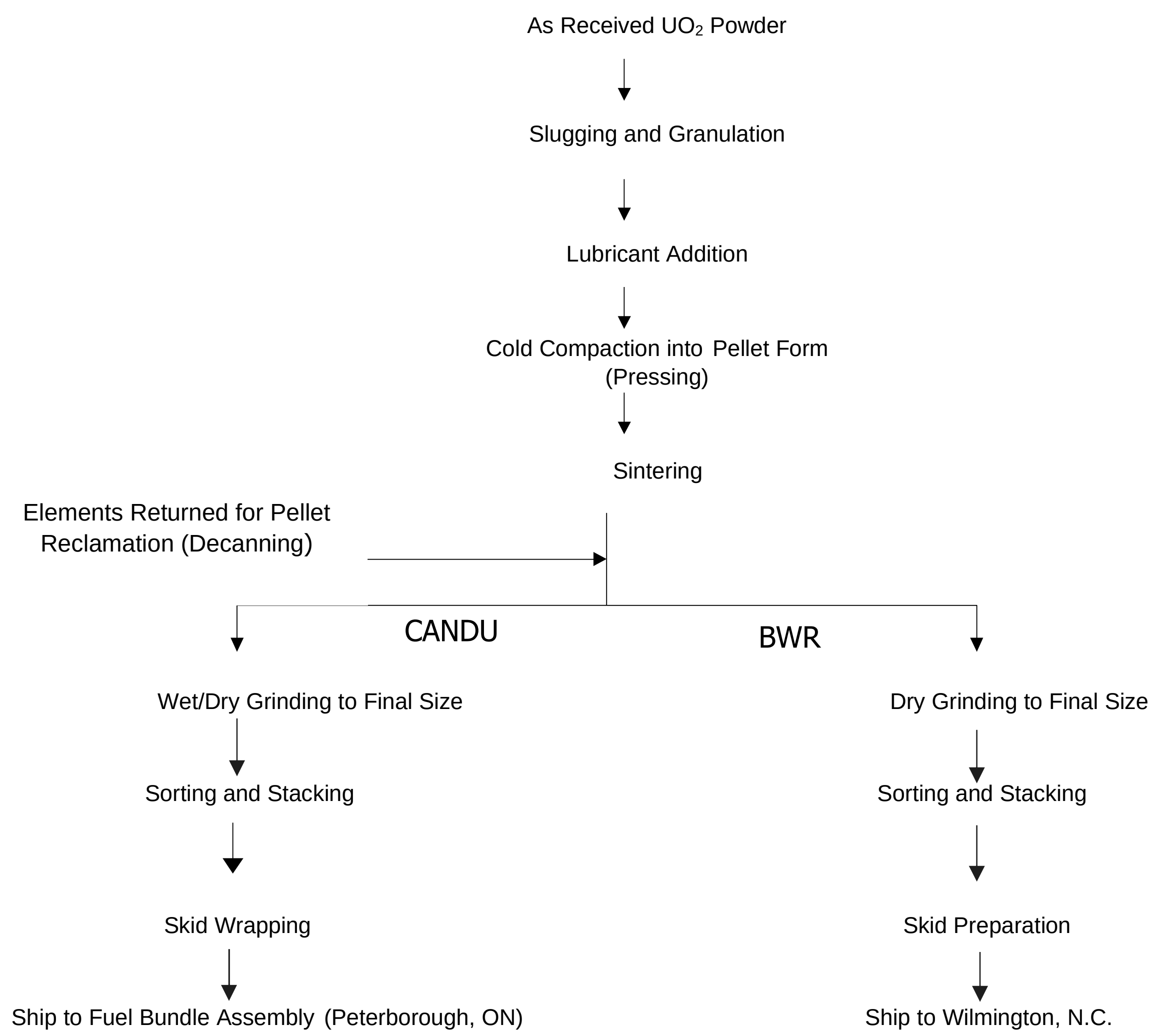


Figure 2-3 Natural Uranium Fuel Pelleting Manufacturing Process

2.2 Description of the Natural and Physical Environment

The natural and physical environment of the NFPO and the surrounding area is described in this section.

2.2.1 General Description of Surrounding Area

The NFPO is located in an area that is comprised primarily of residential and commercial properties, as well as a Canadian National (CN) rail corridor and a Canadian Pacific (CP) rail corridor.

2.2.2 Climate and Meteorology

Climatic and meteorological conditions are the main forces of contaminant dispersion, transformation and eventual removal from the atmosphere. This section summarizes the climatic parameters in the study area and provides an overview of the most recent local meteorological conditions.

Toronto has a humid continental climate (according to the Köppen classification (Ontario Ministry of Agriculture, Food and Rural Affairs 2011). Toronto's climate is modified by its location on the shores of Lake Ontario (i.e., it is warmer in winter and cooler in summer than in the rest of Ontario). This climate is characterized by four different season. Summers bring warm to hot and humid days and nights, and convective precipitation events are common. Cool days and cool to cold nights and periods of dry, sunny weather that alternate with periods of rain are typical of the fall season. Winters are characterized by dry, cold days alternating with periods of precipitation (usually snow) and common winter storms. The spring season has periods of cool, dry and sunny weather, while low pressure systems bring precipitation (SENES 2011).

Toronto climate is affected by common winter low pressure systems and typical storm tracks in Canada and the U.S. (SENES 2011). Low pressure systems, and their associated stormy weather along their warm and cold fronts, typically move along North America's major storm tracks. Winter storms often pass by, bringing milder air and sometimes large amounts of snow. Tropical storms have the potential to impact weather in Toronto, but rarely reach as far inland as Ontario.

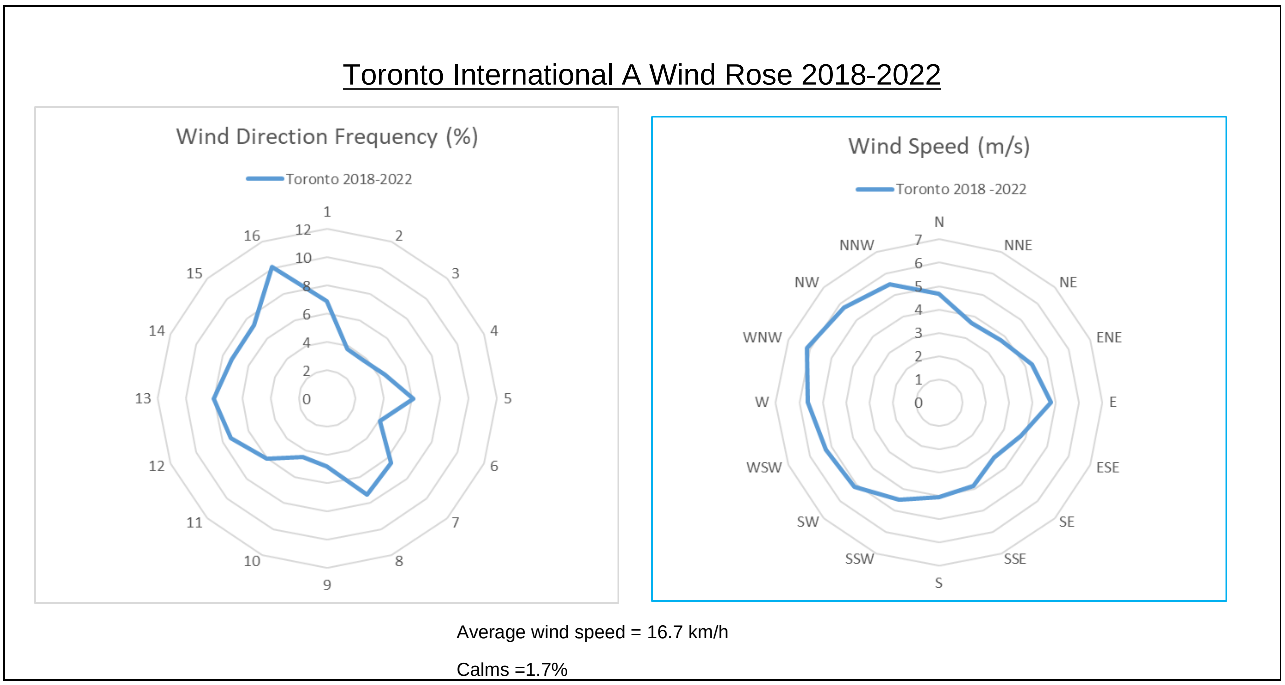
The local meteorology near the NFPO is characterized by the surface meteorological data collected from the Toronto Pearson International Airport climate station. The long-term climate conditions in the region are described by the Environment Canada and Climate Change (ECCC) 30-year climate data normals from the Toronto Pearson International Airport station for the period from 1981 to 2010 (the most recent data available) (ECCC 2022a). In June 2013, the Toronto Pearson International Airport changed equipment which resulted in a change in climate ID and station name (Toronto Int'l A), but the data sets from both instruments were confirmed (by Ontario Climate Center and NAV Canada) to be consistent. The local meteorology near the NFPO, as described below, is characterized by the surface meteorological data collected from the ECCC Toronto Int'l A climate station, for the period from 2018 to 2022.

2.2.2.1 Wind

Wind speed and direction are meteorological parameters that dictate the location and distance from the source that a contaminant may travel. If wind doesn't blow toward a receptor, human or environmental, there will be no air quality impact on that receptor. Ambient contaminant concentrations typically decrease with increasing wind speed as a result of dilution.

Table 2-1 summarizes the wind speed and wind direction for the 30-year period from 1981 to 2010 at the Toronto Pearson International Airport station. Wind direction is reported as the direction from which the wind blows and is based on surface (i.e., 10 m) observations. The most frequent wind recorded at Toronto Pearson Int'l A in the period 1981 to 2010 was from the west, with average annual wind speed of 15 km/h. The maximum hourly wind speed was in the range from 61 km/h (from the west recorded in July) to 97 km/h (from the north recorded in March).

Figure 2-4 presents the frequency distribution of hourly surface wind speed and direction at the Toronto Int'l Airport station in the period from 2018 to 2022 in the form of a wind rose. The prevailing annual wind direction was from the norh-north-west and north occurring at 10.1% of the time. The average wind speed was 16.7 km/h. Calm wind conditions were observed 1.7% of the time.



Note: Wind directions shown are winds "blowing from"

Figure 2-4 Wind Rose

2.2.2.2 Temperature

Thirty-year temperature normals, which are updated by ECCC every ten years, are provided in Table 2-2 for the period 1981 to 2010, for the Toronto Pearson International Airport station (ECCC 2022a). Mean daily temperatures were below 0ºC from December through February and ranged from 21.5ºC in July to -5.5ºC in January. The mean daily temperature was 8.2ºC. The mean daily maximum temperature was in the range from a high of 27.1ºC in July to a low of -1.5ºC in January for the 1981 to 2010 period. The mean daily minimum temperature ranged from 15.8ºC in July to -9.4ºC in January between 1981 and 2010. For this 30-year period, the extreme temperature ranged from a maximum of 38.3ºC in August to a low of –31.3ºC in January.

The combination of low temperature and wind can produce a chilling effect experienced by the human body that is much greater than the actual measured temperature. Based on the Climate Normals (1981 to 2010) the lowest wind chill in Toronto was calculated to be -44.7°C in January (see Table 2-3).

The local temperature data for the most recent 5-year period of 2018 to 2022 were collected from the ECCC meteorological station at Toronto Pearson International Airport (ECCC 2022b) and are summarized in Table 2-4. Mean daily temperatures were below 0ºC from December through March and ranged from 25.0ºC in July to -3.1ºC in February. The mean daily temperature was 9.7ºC. The mean daily maximum temperature ranged from a high of 30.4ºC in July to a low of 0.5ºC in February. The mean daily minimum temperature ranged from 19.5ºC in July to -6.7ºC in February. For this 5-year period, the extreme temperature ranged from a maximum of 35.5ºC in July to a low of –20.6ºC in January. Figure 2-5 presents the mean, maximum and minimum monthly temperatures for the period 2018 to 2022. For a comparison, average daily temperature climate normal was presented in the same figure. The temperature data from the recent 5-year period are generally consistent with the temperature climate normals.

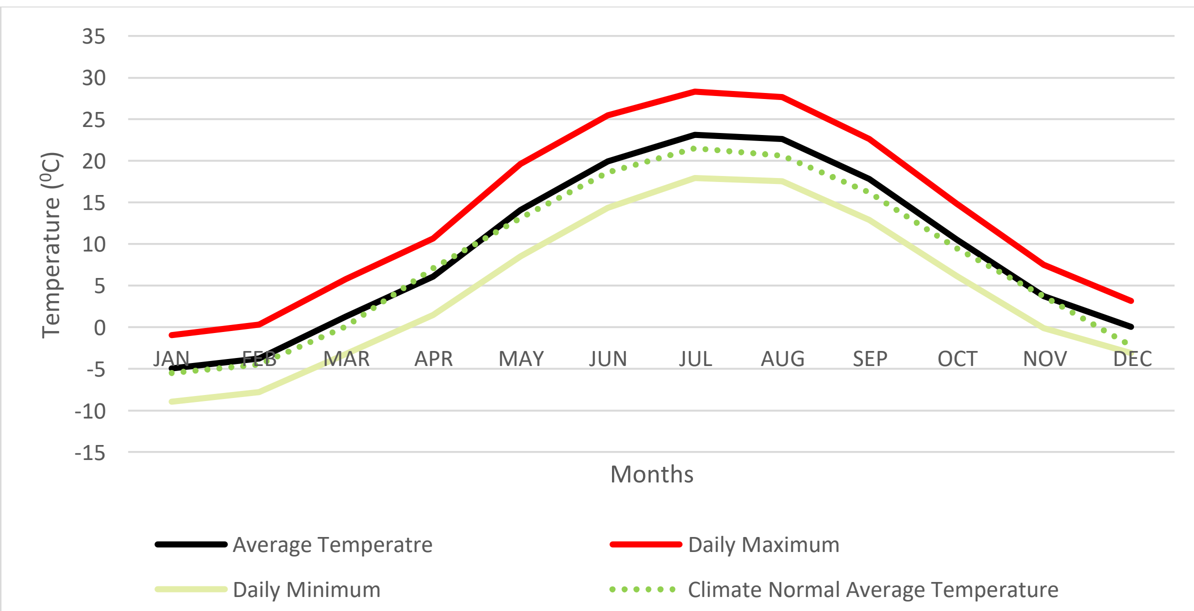


Figure 2-5 Average Monthly Temperatures at the Toronto International Airport Meteorological Station (2018-2022)

2.2.2.3 Precipitation

Table 2-5 summarizes the thirty-year precipitation normals for the Toronto Pearson International Airport station for the 1981 to 2010 period provided by ECCC. The average annual precipitation measured within 30-year period was 785.9 mm, with approximately 87% of the total annual precipitation falling as rain. The highest mean monthly rainfall was in August (78.1 mm), while the greatest rainfall in a 24-hour period occurred in October (121.4 mm). The highest mean monthly snowfall was in January (29.5 cm), while the greatest snowfall in a 24-hour period occurred in February (39.9 cm). An extreme snow depth of 67 cm for the period from 1981 to 2010 was recorded in January.

Local precipitation data are available from daily data collected from the Toronto Pearson International Airport meteorological station in the form of rainfall, snowfall and total precipitation. Total precipitation data for the 5-year period 2018 to 2022 are summarized in Table 2-6 and presented in Figure 2-6. The mean annual total precipitation over the 5-year period 2018 to 2022 was 818.4 mm, with 81% of the total precipitation falling as a rain. Precipitation over the 5-year period 2018 to 2022 was 104% of the 30-year climactic norm. The highest mean monthly rainfall was in October (80.3 mm), while the highest mean monthly snowfall was in February (42.5 cm).

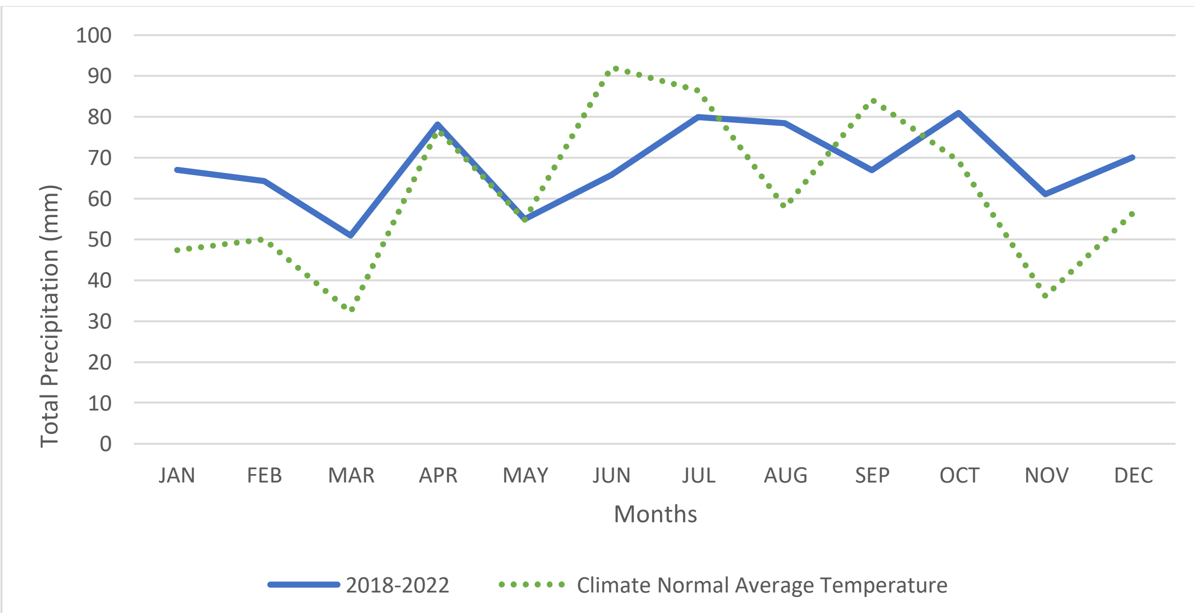


Figure 2-6 Total Monthly Precipitation at the Toronto International Airport (2018-2022)

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Table 2-1 Wind Climate Normals, Toronto Pearson Int'l A, 1981 to 2010

Wind	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Speed (km/h)	17.6	17.0	16.9	16.8	14.4	13.2	12.9	11.9	12.7	14.0	15.7	16.7	15.0
Most Frequent Direction	W	W	N	N	N	N	W	N	W	W	W	W	W
Maximum Hourly Speed (km/h)	77	77	97	81	71	63	61	71	77	92	80	76	97
Direction of Maximum Hourly Speed	W	N	SW	W	W	NW	E	W	W	W	W	W	SW
Maximum Gust Speed (km/h)	115	105	124	115	109	107	135	115	106	104	122	109	135
Direction of Maximum Gust	E	W	SW	W	W	W	NW	NE	NW	NW	SW	S	NW

Source (ECCC 2022a)

Table 2-2 Temperature Climate Normals, Toronto Pearson Int'l A, 1981 to 2010

Temperature	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Daily Average (°C)	-5.5	-4.5	0.1	7.1	13.1	18.6	21.5	20.6	16.2	9.5	3.7	-2.2	8.2
Standard Deviation	3.2	2.3	2	1.6	1.9	1.6	1.5	1.5	1.6	1.5	1.5	2.6	1.0
Daily Maximum (°C)	-1.5	-0.4	4.6	12.2	18.8	24.2	27.1	26	21.6	14.3	7.6	1.4	13.0
Daily Minimum (°C)	-9.4	-8.7	-4.5	1.9	7.4	13	15.8	15.1	10.8	4.6	-0.2	-5.8	3.3
Extreme Maximum (°C)	17.6	14.9	25.6	31.1	34.4	36.7	37.6	**38.3**	36.7	31.6	25	20	38.3
Extreme Minimum (°C)	**-31.3**	-31.1	-28.9	-17.2	-5.6	0.6	3.9	1.1	-3.9	-8.3	-18.3	-31.1	-31.3

Note: Bolded values represent the extreme temperature conditions

Source (ECCC 2022a)

Table 2-3 Wind Chill Climate Normals, Toronto Pearson Int'l A, 1981 to 2010

Wind Chill	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Extreme Wind Chill	-44.7	-38.9	-36.2	-25.4	-9.5	0	0	0	-8.0	-13.5	-25.4	-38.5	-44.7

Source (ECCC 2022a)

Table 2-4 Temperature Data, Toronto Pearson Int'l A, 2018 to 2022

Temperature	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Daily Average (°C)	-1.5	-3.1	3.2	5.9	12.1	20.5	25.0	22.1	16.8	9.3	6.6	-0.3	9.7
Daily Maximum (°C)	1.8	0.5	7.3	10.7	17.3	26.6	30.4	27.4	22.0	13.7	11.0	2.6	14.3
Daily Minimum (°C)	-4.8	-6.7	-0.9	1.1	6.8	14.3	19.5	16.6	11.5	4.8	2.2	-3.2	5.1
Extreme Maximum (°C)	11.9	9.3	18.4	14.8	31.0	32.1	**35.5**	32.7	28.6	24.7	24.3	9.6	35.5
Extreme Minimum (°C)	-15.6	**-20.6**	-10.9	-4.8	-4.7	7.9	15.3	11.0	3.1	-5.4	-6.2	-9.7	-20.6

Note: Bolded values represent the extreme temperature conditions.

Source (ECCC 2022b)

Table 2-5 Precipitation Climate Normals, Toronto Pearson Int'l A, 1981 to 2010

Precipitation	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Rainfall (mm)	25.1	24.3	32.6	63	74.3	71.5	75.7	**78.1**	74.5	60.6	68	34	681.6
Snowfall (cm)	**29.5**	24	17.7	4.5	0	0	0	0	0	0.4	7.5	24.9	108.5
Precipitation (mm)	51.8	47.7	49.8	68.5	74.3	71.5	75.7	78.1	74.5	61.1	75.1	57.9	785.9
Average Snow Depth (cm)	6	7	3	0	0	0	0	0	0	0	0	3	2
Median Snow Depth (cm)	5	5	2	0	0	0	0	0	0	0	0	2	1
Snow Depth at Month-end (cm)	8	5	0	0	0	0	0	0	0	0	0	3	1
Extreme Daily Rainfall (mm)	58.7	31.8	41.7	55.8	92.7	53.8	118.5	80.8	108.0	**121.4**	86.1	40.9	121.4
Extreme Daily Snowfall (cm)	36.8	**39.9**	32.3	26.7	2.3	0	0	0	0	7.4	33.5	28.2	39.9
Extreme Daily Precipitation (mm)	58.7	55.9	41.7	55.8	92.7	53.8	118.5	80.8	108.0	**121.4**	86.1	40.9	121.4
Extreme Snow Depth (cm)	**67**	48	30	13	0	0	0	0	0	13	18	36	67

Note: Bolded values represent the extreme precipitation conditions.

Source (ECCC 2022a)

Table 2-6 Precipitation Data, Toronto Pearson Int'l A, 2018 to 2022

Precipitation	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Rainfall (mm)	35.4	26.1	41.8	57.9	54.3	65.8	**80.0**	60.2	66.9	80.3	43.0	48.4	660.0
Snowfall (cm)	36.6	**42.5**	9.7	4.8	0.7	0.0	0.0	0.0	0.0	0.5	17.2	22.2	134.3
Precipitation (mm)	67.0	64.2	50.9	78.2	55.0	65.8	80.0	78.4	66.9	**81.0**	61.1	70.1	818.4

Note: Bolded values represent the extreme precipitation conditions.

Source (ECCC 2022b)

2.2.3 Geology

The NFPO is located near the inferred northern limits of the former Lake Iroquois shoreline, composed of shallow water silt to sand deposits. The site is situated east of inferred former Lake Iroquois coarser grained beach and bar deposits. Younger Wildfield to Halton tills of Late Wisconsinian age are located a short distance north of the site; these deposits are part of a till plain that constitutes the dominant surficial soil type across the City of Toronto (OGS Map P2204, Sharpe, D.R. 1980).

The Iroquois shoreline deposits vary from silts to sandy silts to fine to medium grained sand deposits. Locally, clayey silt to silty sand deposits can dominate, indicative of deeper and/or lower energy lacustrine environments. These deposits range from 5 to 9 m (15 to 35 ft.) in thickness to the south near Dundas and Bloor; the thickness generally increases to the north and is known to exceed 18 m (65 ft.) in thickness northwest of the subject site. The deposits can range from poorly to well drained. There can be buried bedrock valleys located both within the Lake Iroquois shoreline and surrounding till deposits, the locations of which are often poorly understood.

Recent alluvial and organic deposits are found in the numerous river valleys that cross the Greater Toronto Area; the closest valley of any significance is the Black Creek valley, located approximately 2 km northwest of the site.

Based on Ontario well records (wells 1002420766 and 1002420772) the site is characterized by gravel/fill from 0 to 0.5 m, followed by clay/silt from 0.5 to 2 m (MECP 2021a). Further characterization of the soil setting was not included in this assessment as there is not a groundwater pathway for contaminants release from the site (see Section 3.1.4). The subject site and surroundings have been developed for commercial/industrial use for over a century, therefore, agricultural soil classifications are not applicable.

Due to the commercial and industrial land uses on and in the vicinity of the subject site, soil quality may be contaminated in excess of provincial Site Condition Standards in some areas.

2.2.4 Groundwater

The does not use any groundwater, with water needs met by the City of Toronto municipal water system. There are no known or suspected groundwater contamination plumes or subsurface contamination attributable to the NFPO, either on- or off-site. As such, detailed information on subsurface utilities and infrastructure is not required for the purpose of risk assessment.

Within the Lake Iroquois shallow water deposits, the water table can range from less than 4 metres to greater than 15 metres (<12 to >50 ft.) below ground surface (mbgs), depending on the coarseness of the deposits and the drainage of the general vicinity. Water table deposits tend to be closer to surface in the finer grained lacustrine soils. Within the tills, the water table tends to be close to surface (+/- 2 mbgs), due to their fine grained, highly compacted nature. Shallow groundwater flow directions are often towards a nearby surface water course (i.e., creek, river). Regional, deeper groundwater flow directions tend to be to the south towards Lake Ontario, or towards deeper river valleys. However, in built-up areas such as the NFPO and vicinity, shallow groundwater flow can be locally influenced by the presence of infrastructure (buildings, roadways, etc.) and buried utilities.

In some locations, the coarser, granular shoreline deposits would be expected to produce significant quantities of water. However, the City of Toronto obtains its potable water from Lake Ontario. It is not expected that there are any water wells currently operating in the vicinity of the site, and water supply development is not expected in the foreseeable future.

Figure 2-7 identifies groundwater wells located within 0.25 km of the NFPO property line. Within this area, there are multiple boreholes used for geotechnical surveys and no known drinking water wells (MOECC 2021a). The NFPO does not use any groundwater, with water needs met by the City of Toronto municipal water system.

The Provincial Groundwater Monitoring Network (PGMN) assesses current groundwater conditions and provides a warning system for changes in water levels and water quality. PGMN Well ID: W0000325-1 (see Figure 2-8), located in concession 1, lot 38 of York Township is the closest representative PGMN monitoring location with on-going monitoring (MECP 2022a). Table 2-7 shows uranium sample data from 2003 to 2020 at a maximum level of 0.01 µg/L.

There are no known or suspected groundwater contamination plumes or subsurface contamination attributable to the operations, either on- or off-site. As such, detailed information on subsurface utilities and infrastructure is not required for the purpose of risk assessment.

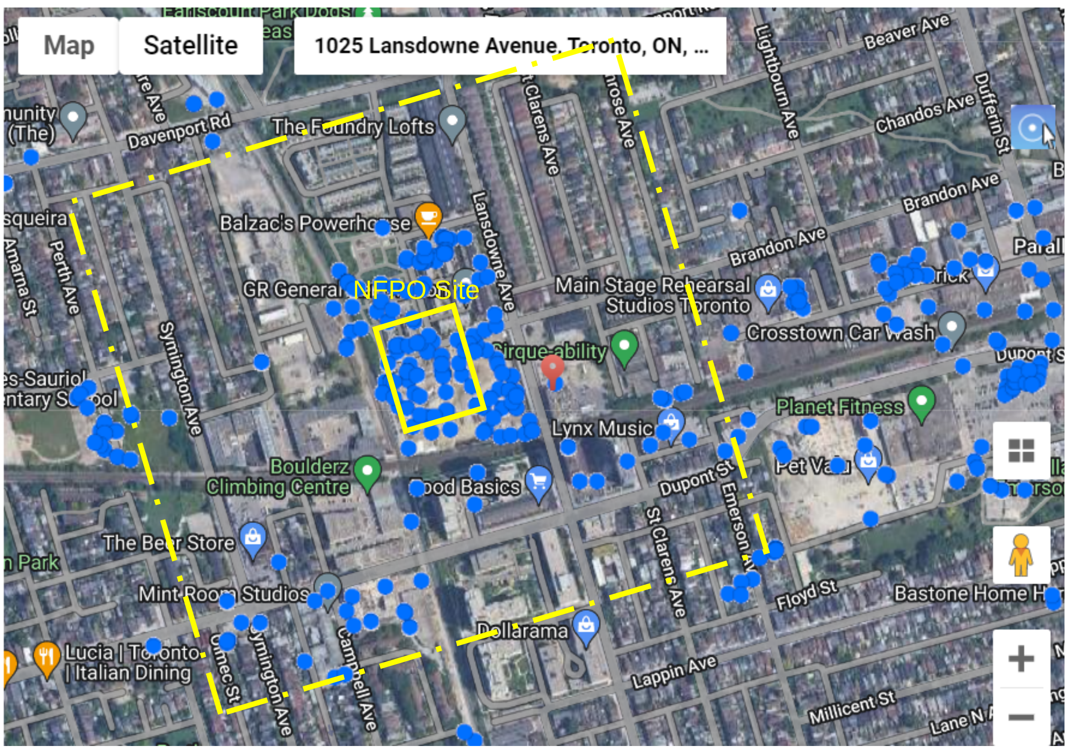


Figure 2-7   Groundwater Wells Around the NFPO Facility (MECP 2021a)

Figure 2-8 Provincial Groundwater Monitoring Network Wells (PGMN) in Toronto

Table 2-7 PGMN Well ID: W0000325-1 Groundwater Quality Data

PGMN_WELL W0000325-1				
Uranium	2003-03-19	0.01	ug/L	+/-0.05
	2007-11-14		ug/L	<0.1
	2008-10-16	0.01	ug/L	+/-0.05
	2009-10-19	0	ug/L	+/-0.18
	2010-10-20	0	ug/L	+/-0.18
	2011-10-07	0	ug/L	+/-0.18
	2012-10-05	0	ug/L	+/-0.20
	2013-10-23	0	ug/L	+/-0.20
	2014-09-26	0	ug/L	+/-0.20
	2015-09-16	0	ug/L	+/-0.20
	2016-10-05	0	ug/L	+/-0.20
	2017-10-06	0	ug/L	+/-0.20
	2018-10-31	0	ug/L	+/-0.20
	2019-10-09	0	ug/L	+/-0.17
	2020-11-20	0	ug/L	+/-0.17

Source: (MECP 2022a)

2.2.5 Surface Water

Surface water concentrations are considered in the range of natural background and low compared to water quality guidelines. Uranium concentrations are well below the drinking water guideline.

The NFPO site is entirely industrial with no surface water features. The immediately adjacent land to the NFPO site is mostly a developed urban area with no natural surface water features. The nearest natural surface water body is approximately 2.5 km to the southwest. The NFPO does not directly use surface water, with water needs met by the City of Toronto municipal water system which extracts and treats water from the Lake Ontario.

2.2.5.1 Surface Water Quality

Water quality data for Lake Ontario is summarized in Table 4-3. Surface water monitoring (SWM) data are also available from the Provincial (Stream) Water Quality Monitoring Network. Data for the most recent five years (2017-2021) at two stations, Station ID: 06008301902 – Humber River located in the Old Mill Rd, Etobicoke and Station ID: 06008501402 – Don River located in Pottery Rd, Toronto (see Figure 2-9) are presented in Table 2-8 (MECP 2022b).

The maximum concentration measured for uranium during this time period was 38 µg/L in the Don River. Average annual uranium concentrations are slightly above to approximately three times the Ontario Interim Provincial Water Quality Objective (PWQO) of 5 µg/L (MOEE 1994) and below the Canadian Environmental Quality Guideline of 15 µg/L long term for the protection of aquatic life (CCME 2023), the Ontario O. Reg. 169/03: Ontario Drinking Water Quality Standard of 20 µg/L and the Health Canada drinking water guideline of 20 µg/L (Health Canada 2022). Groundwater and surface water concentrations are low and in any event associated with natural background and hence exposures associated with the NFPO are not expected.

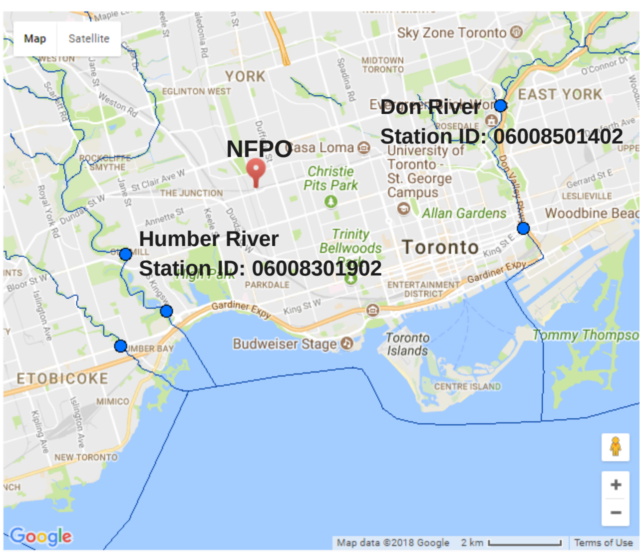


Figure 2-9 Provincial Surface Water Monitoring Stations in Toronto

Table 2-8 Toronto Surface Water Monitoring Station

Station ID	Parameter	2021	2020	2019	2018	2017
Humber River Station No 06008301902	**Uranium (µg/L)**	13.4	7.47	12.9	0.96	16.9
		25.1	17.3	20.8	-1.07	24
		6.51	4.11	3.32	9.24	13.3
		10.2	1.6	2.96	8.27	4.8
		4	17.5	1.09	8.26	11.1
		<3		3.47	8.35	7.63
		3.21		4.15	5.93	6.13
		<3		16.3	3.19	3
		<3			6.52	5.04
		<3			6.07	4.03
		<3			6.73	5.64
					10.8	4.94
						6.96
	Max	25.1	17.5	20.8	10.8	24
	Min	3	1.6	1.09	-1.07	3
	Average	7.0	9.6	8.1	6.1	8.7
Don River Station No 06008501402	**Uranium (µg/L)**	7.8	12.7	14.4	13.5	30.5
		38	27.7	6.35	16.9	29.4
		9.01	2.97	3.98	10.5	23.5
		19.2	4.74	2.82	25.1	17.2
		<6	23.9	0.737	12.9	11.3
		<6		3.04	15.9	11.8
		<3		10.3	6.82	6.43
		4		13.5	4.71	4.99
		<3			6.92	5.49
		3.07			9.79	6.71
		<9			5.14	5.08
					17.1	3.95
						10.8
	Max	38	27.7	14.4	25.1	30.5
	Min	3	2.97	0.737	4.71	3.95
	Average	9.8	14.4	6.9	12.1	12.9

Note: A negative concentration indicates sample was analyzed but concentration was below the determination limit.

Source: (MECP 2022b)

2.2.6 Air Quality

The measured airborne uranium concentrations in air were well below the ambient air quality objectives and are in the range of natural background.

The Ministry of Environment Ontario Air Standards for Uranium document (MOE 2011) identified an annual average uranium in air concentration of 0.0001 ug/m^3 for urban environments.

As described in Appendix A, the IEMP collected samples of uranium in air at several locations in the vicinity of the NFPO since 2014. The results of these samples are presented in Table 2-9. The maximum measured airborne uranium concentration was 0.00013 µg/m^3 in 2014 and below the method detection concentration for all other years (CNSC 2022). Concentrations were well below the MECP annual ambient air quality criteria of 0.03 µg (U in PM10)/m^3 and 0.06 µg (U in suspended particulate matter)/m^3 based on health effects (MECP 2020) and consistent with the measured annual average uranium in air concentration of 0.0001 ug/m^3 for urban environments (MOE 2011).

Table 2-9 IEMP Air Monitoring Results

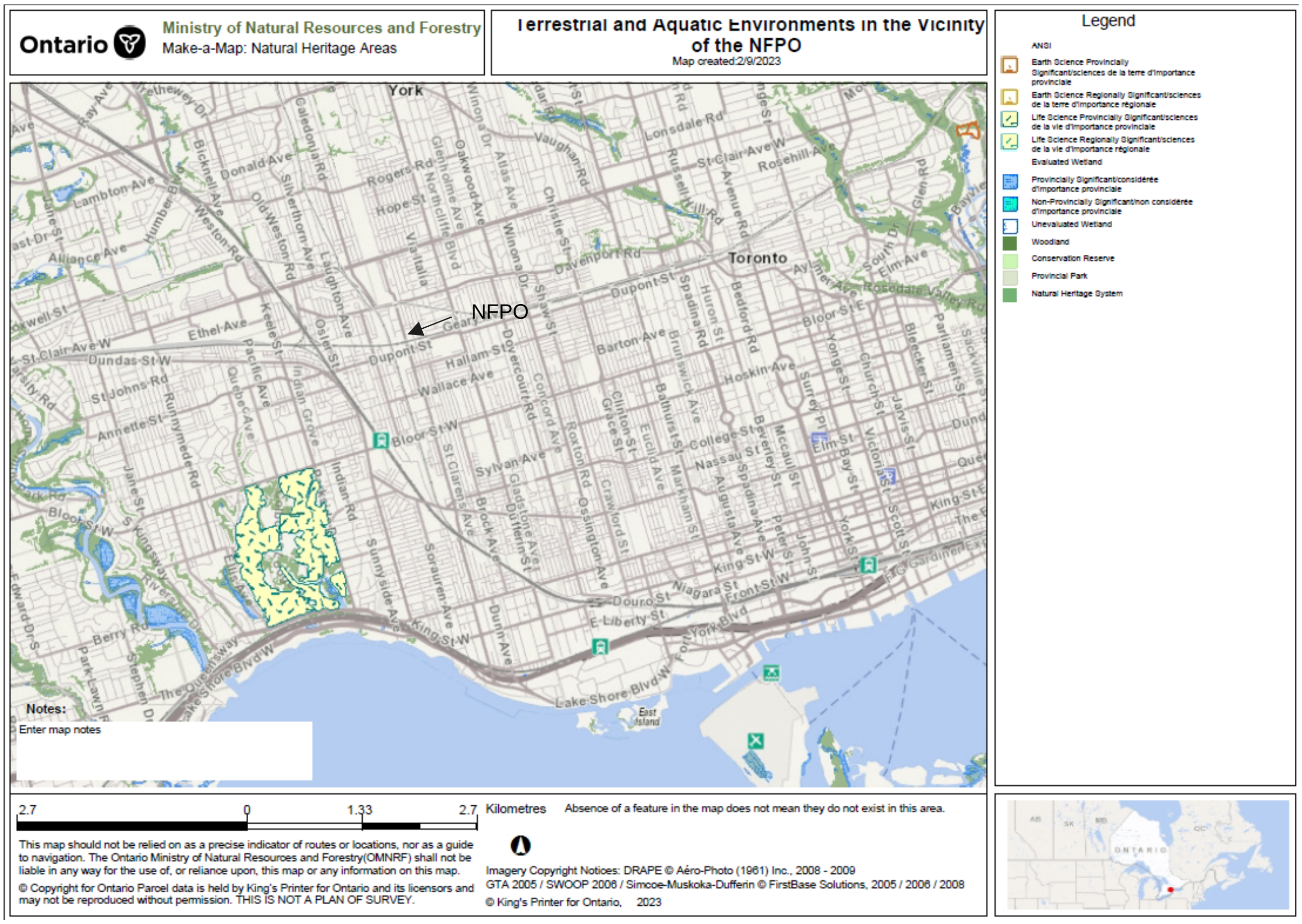
Location	Uranium in Air (µg/m³)				
	2014	2016	2018	2019	2022
GT01-A01	0.000128	N/A	<0.003	<0.00005	<0.00014
GT07-A02	0.0000488	<0.0009	<0.003	N/A	<0.00014
GT08-A08	N/A	N/A	<0.003	<0.00005	<0.00016
GT10-A03	N/A	<0.0009	<0.003	<0.00005	<0.00014

2.2.7 Terrestrial and Aquatic Environments

The major components of terrestrial and aquatic environments within the area surrounding the NFPO are shown in Figure 2-10. All natural features within the City of Toronto are identified in the City of Toronto Ravine and Nature Feature By-law. High Park, approximately 1.9 kilometres (km) southwest of the facility, contains an Area of Natural Heritage and Scientific Interest (ANSI), Environmentally Significant Area (ESA), and a Provincially Significant Wetland (PSW). Bodies of water that surround the NFPO include Grenadier Pond (3.2 km southwest), Lake Ontario (3.4 km southwest), and the Humber River (3.9 km east).

Toronto is located within the Lake Erie Lowlands Ecoregion of the Mixedwood Plains Ecozone (Environment Canada and Agriculture and Agri-Food Canada, 1995). The Mixedwood Plains Ecozone is bounded by the western portion of Lake Ontario, the southern portion of Lake Huron, the northern shore of Lake Erie (Windsor to the Niagara River). The dominant land cover is cropped land and urban areas with limited areas of mixed and deciduous forests on the Niagara Escarpment (Environment Canada and Agriculture and Agri-Food Canada 1995).

Native trees in the southcentral region of Ontario, including the Toronot area, are characterized by Alternate-Leaf Dogwood, American Beech, American Chestnut, American Elm, American Mountain-Ash, Balsam Fir, Balsam Poplar, Basswood, Bitternut Hickory, Black Ash, Black Cherry, Black Oak, Black Srpuce, Black Walnut, Black Willow, Blue Beech, Bur Oak, Butternut, Chokechery, Eastern Flowering Dogwood, Eastern Hemlock, Easter Redcedar, Eastern White Cedar, Eastern White Pine, Gray Birch, Green/Red Ash, Hawthrones, Ironwood, Jack Pine, Largetooth Aspen, Manitoba Maple, Northern Hackberry, Peachlife Willow, Pin Cherry, Pin Oak, Red Maple, Red Mulberry, Red Oak, Red Pine, Red Spruce, Sassafras, Serviceberries, Shagbark Hickory, Showy Mountain Ash, Silver Maple, Striped Maple, Sugar Maple, Swamp White Oak, Sycamore, Tamarack, Trembling Aspen, White Ash, White Birch, White Oak, White Spruce and Yellow Birch (MNRF n.d).



Source: (Ministry of Natural Resources and Forestry 2022b)

Figure 2-10 Terrestrial and Aquatic Environments in the Vicinity of the NFPO

Climax vegetation in the Lake Erie Lowlands Ecoregion is characterized by sugar maple, beech, white and red oak, shagbark hickory, black walnut, and butternut. Moist sites are characterized by white elm, eastern cottonwood, balsam poplar, red and black ash, and silver maple. Drier and warmer sites contain black, chestnut, and chinquapin oak. Tulip tree, sycamore, and bitternut hickory occur on moist slopes (Environment Canada and Agriculture and Agri-Food Canada 1995).

Land immediately adjacent to the NFPO is mostly developed urban area with a mix of residential, commercial and industrial uses. Interspersed within the urban area are small recreational green spaces. The NFPO property is a fenced-off area with very limited vegetative growth. There are no natural features within the BWXT NEC NFPO site. There are no water-bodies located in the study area.

Characteristic wildlife species in the Lake Erie Lowlands Ecoregion include white-tailed deer, grey and red squirrel, and chipmunk. Bird species include the cardinal, wood thrush, screech owl, mourning dove, green heron, pileated and red-bellied woodpecker, and wild turkey (Environment Canada and Agriculture and Agri-Food Canada 1995).

The urban wildlife that may be found around the NFPO would be limited to typical urban wildlife of Southern Ontario including: big brown bat, striped skunk, racoon, Eastern chipmunk, Eastern grey squirrel, woodchuck (groundhog), Virginia opossum, house mouse, meadow vole and Eastern cottontail (City of Toronto 2012). Given the lack of habitat found on and in the vicinity of the NFPO, red squirrel, white-footed mouse and deer mouse and larger mammals, such as the red fox, white-tailed deer, and coyote which are commonly found in ravines and naturalized corridors in Toronto, are unlikely to be present.

Toronto is home to hundreds of bird species (City of Toronto 2011). Some of the more common birds that are likely present in the area of the NFPO could include the American crow, Northern cardinal, house sparrow, rock pigeon, mourning dove, and the ring-billed gull.

Land immediately adjacent to the NFPO is mostly developed urban area with a mix of residential, commercial and industrial uses. Interspersed within the urban area are small recreational green spaces. The NFPO property is a fenced-off area with very limited vegetative growth. There are no natural features within the NFPO site. Endangered species threatened species and species of special concern identified within the Natural Heritage Information Centre (NHIC) grids including and immediately surrounding the NFPO (see Figure 2-11), as recorded in the Natural Heritage Information Centre (NHIC) database, are summarized in Table 2-10. There are no recent records of species of concern on site or the immediately surrounding area.

Table 2-10 Endangered or Threatened Species Records for the Area Surrounding the NFPO

OFG ID	Common Name	Scientific Name	SARO Status	SARA Status	ATLAS NAD83 IDENT
Birds					
1023801	Bank Swallow	Riparia riparia	THR	THR	17PJ2637
1023789 1023790 1023791 1023799 1023800 1023801	Chimney Swift	Chaetura pelagica	THR	THR	17PJ2535 17PJ2536 17PJ2537 17PJ2635 17PJ2636 17PJ2637
1023799	Common Nighthawk	Chordeiles minor	SC	SC	17PJ2635
1023781 1023789 1023791 1023799	Eastern Meadowlark	Sturnella magna	THR	THR	17PJ2437 17PJ2535 17PJ2537 17PJ2635
1023790 1023791 1023800 1023801	Wood Thrush	Hylocichla mustelina	SC	THR	17PJ2536 17PJ2537 17PJ2636 17PJ2637
Mammals					
	None				
Reptiles					
1023779 1023789	Eastern Musk Turtle	Sternotherus odoratus	SC	SC	17PJ2435 17PJ2535
1023779	Eastern Ribbonsnake	Thamnophis sauritus	SC	SC	17PJ2435

OFG ID	Common Name	Scientific Name	SARO Status	SARA Status	ATLAS NAD83 IDENT
1023789					17PJ2535
1023779 1023780 1023781 1023789 1023790 1023791 1023799 1023800 1023801	Old-field Toadflax	Nuttallanthus canadensis			17PJ2435 17PJ2436 17PJ2437 17PJ2535 17PJ2536 17PJ2537 17PJ2635 17PJ2636 17PJ2637
1023779 1023780 1023781 1023789 1023790 1023791 1023799 1023800 1023801	Queensnake	Regina septemvittata	END	END	17PJ2435 17PJ2436 17PJ2437 17PJ2535 17PJ2536 17PJ2537 17PJ2635 17PJ2636 17PJ2637
1023779	Snapping Turtle	Chelydra serpentina	SC	SC	17PJ2435
Insects					
1023779 1023780 1023781 1023789 1023790 1023791 1023799 1023800 1023801	American Burying Beetle	Nicrophorus americanus	EXP	EXP	17PJ2435 17PJ2436 17PJ2437 17PJ2535 17PJ2536 17PJ2537 17PJ2635 17PJ2636 17PJ2637
1023779 1023780 1023781 1023789 1023790 1023791 1023799 1023800 1023801	Speckled Giant Lacewing	Polystoechotes punctata			17PJ2435 17PJ2436 17PJ2437 17PJ2535 17PJ2536 17PJ2537 17PJ2635 17PJ2636 17PJ2637
Fish and Mussels					
	None				
Plants					
1023779 1023780	Black Snakeroot	Actaea racemosa			17PJ2435 17PJ2436

OFG ID	Common Name	Scientific Name	SARO Status	SARA Status	ATLAS NAD83 IDENT
1023781					17PJ2437
1023789					17PJ2535
1023790					17PJ2536
1023791					17PJ2537
1023799					17PJ2635
1023800					17PJ2636
1023801					17PJ2637

Note: SARO = Committee on the Status of Species at Risk in Ontario SARA = federal Species at Risk Act

THR = Threatened END = Endangered

EXP = "Extirpated" meaning the species lives somewhere in the world, and at one time lived in the wild in Ontario, but no longer lives in the wild in Ontario

SC = Special Concern (those Wildlife Species that are particularly sensitive to human activities or natural events but are not endangered or threatened Wildlife Species)

Source: (MNRF 2022)

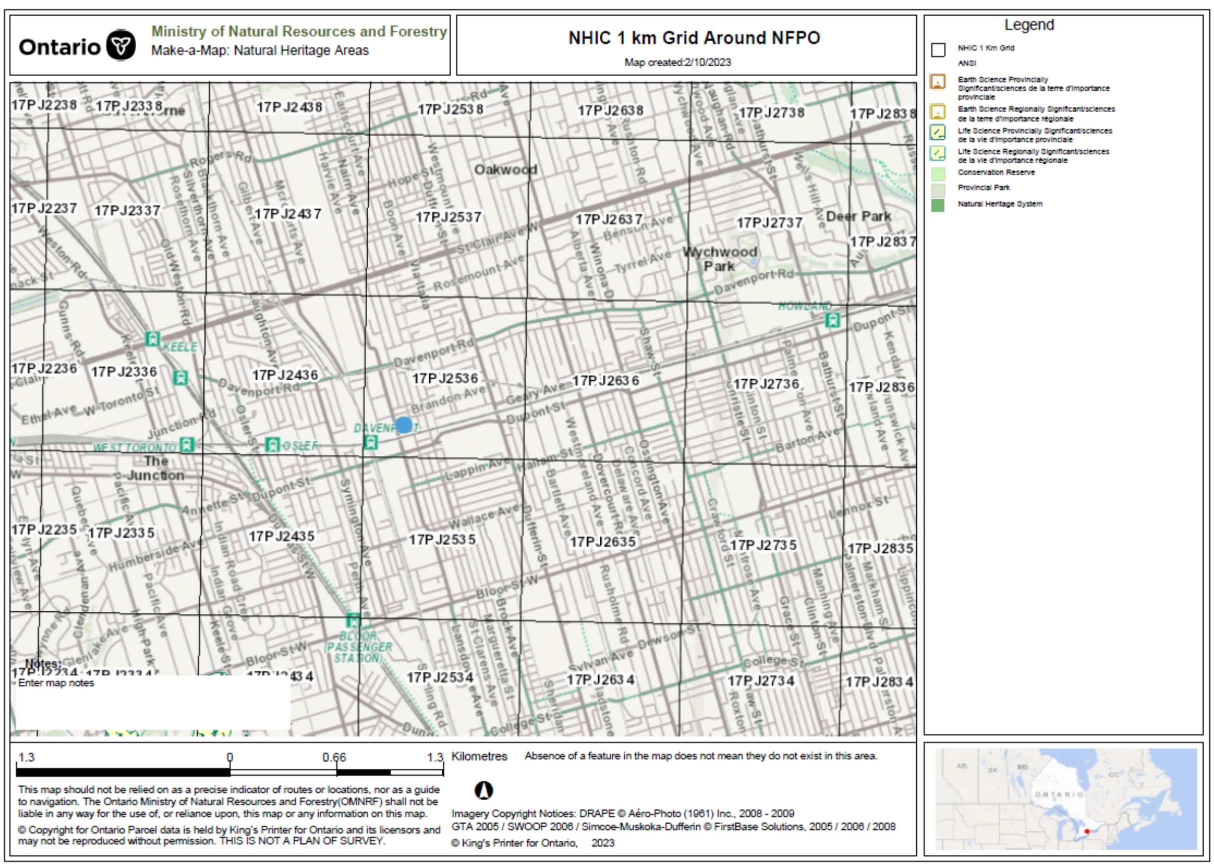
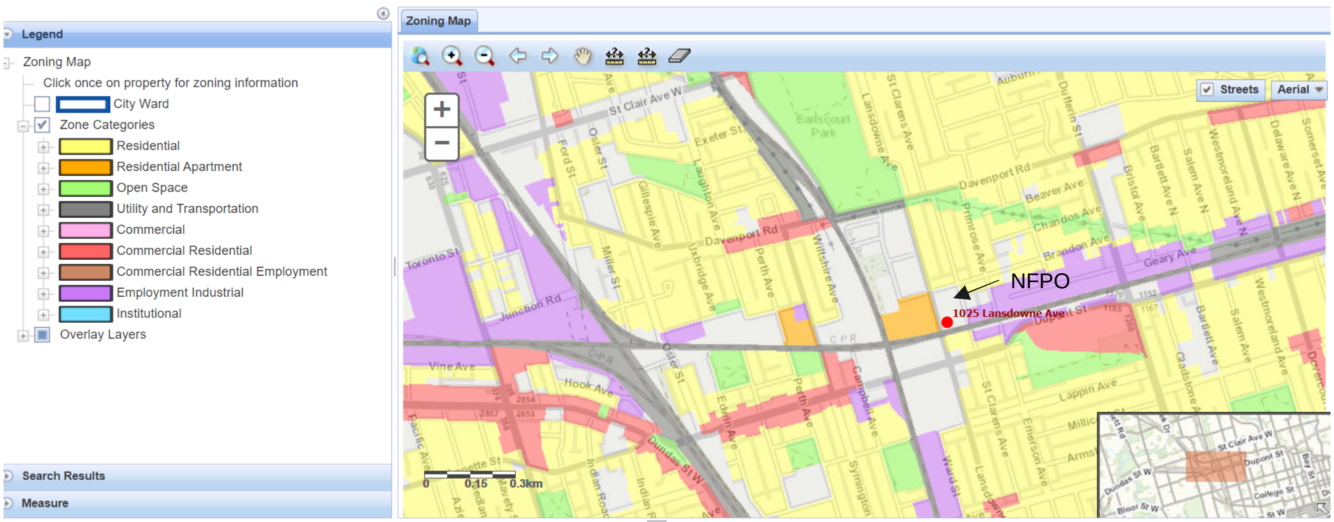


Figure 2-11 NHIC Grid Around the NFPO (MNRF 2022)

2.2.8 Land Use

The NFPO is located in a mixed industrial, commercial and residential area. General land use within the area is shown in Figure 2-12.



Source: (City of Toronto n.d.)

Figure 2-12 Land Use in City of Toronto

2.2.9 Population

By 2021, the population of Toronto was 2,794,356, or 8.0% of Canada's total population. Between 2016 and 2021, Toronto's population grew by 62,785 residents, an increase of 2.3%. Demographic trends are summarized in Table 2-11. The City of Toronto comprises a land area of 631.1 km2 with a population density of 4,427.8 persons/km^2. The Toronto census management area (CMA) comprises a land area 5,902.75 km^2 with a population density of 1,050.7 persons/km^2. Demographic trends are summarized in Table 2-11.

Table 2-11 City of Toronto Demographic Trends (2001 – 2021)

Age	2006		2011		2016		2021	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
0-4	134,980	5.4	140,510	5.4	136,000	5	123,550	4.4
5-14	274,640	11	260,350	10	262,130	9.6	260,745	9.3
15-24	318,655	12.7	333,515	12.8	340,275	12.5	320,465	11.5
25-34	385,925	15.4	413,015	15.8	457,525	16.7	490,740	17.6
35-44	415,615	16.6	387,805	14.8	378,700	13.9	399,625	14.3
45-54	362,425	14.5	398,915	15.3	393,330	14.4	359,930	12.9
55-64	257,585	10.3	303,495	11.6	336,670	12.3	362,305	13.0
65-74	178,995	7.2	188,630	7.2	224,140	8.2	260,465	9.3
75-84	131,350	5.2	133,845	5.1	136,790	5	144,670	5.2
85+	43,100	1.7	54,965	2.1	66,000	2.4	71,855	2.6
Total	2,503,270	100	2,615,045	100	2,731,560	100	2,794,350	100

Source (Statistics Canada 2012, 2017, 2022)

2.2.10 Effluent and Environmental Monitoring Programs

Measured uranium emissions to air and water are well below licence release limits and Action Levels.

Radiological and non-radiological substances are released to the environment as the result of the operation of the NFPO. Long-standing effluent monitoring programs and environmental monitoring programs have been established by BWXT NEC to monitor releases and potential environmental effects.

The "Environmental Protection" Safety and Control Area covers programs that monitor and control all releases of nuclear and hazardous substances into the environment, as well as their effects on the environment as a result of licenced activities. These long-standing effluent monitoring and environmental monitoring programs have been established by BWCT NEC to monitor releases and potential environmental effects.

As required by the CNSC, the effluent and environmental monitoring programs are designed, completed, reviewed and updated in accordance with the CSA N288 series of standards. CSA N288.4-10, *Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* which addresses the monitoring of both radiological and hazardous substances and their potential impacts to human and non-human biota. Similarly, the effluent monitoring program is designed, completed, reviewed and updated in accordance with CSA N288.5-11, *Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* which addresses the design, implementation, and management of an effluent monitoring program that meets legal and business requirements and incorporates current best practices and technologies used internationally. CSA N288.0:22 *Environmental management of nuclear facilities: Common requirements of the CSA N288 series of Standards* came into effect after data considered in the current ERA was collected. CSA N288.0:22 captures the common elements of the CSA N288 series of Standards for the purposes of minimizing duplication of requirements within the series.

Given that NFPO's effluent and environmental monitoring programs conform with requirements of the CNSC and CSA standards and have been accepted by the CNSC, program data are considered to be of an acceptable quality for use in the HHRA and EcoRA. Programs and associated monitoring data are described in Sections 2.2.10.1 and 2.2.10.2.

In support of monitoring programs, BWXT NEC has established facility specific CNSC approved *Action Levels* for various radiological and non-radiological parameters. An *Action Level* is defined in the *Radiation Protection Regulations* "a specific dose of radiation or other parameter that, if reached, may indicate a loss of control of part of a licensee's radiation protection program, and triggers a requirement for specific action to be taken." *Action Levels* are set below regulatory limits; however, they are CNSC reportable events. Accordingly, BWXT NEC has established *Internal Control Levels* for various radiological and environmental parameters that are set even lower than *Action Levels* to act as an early warning system. An *Internal Control Level* exceedance results in internal investigation and corrective action.

To complement existing and ongoing compliance activities and site monitoring programs, the CNSC implemented an Independent Environmental Monitoring Program (IEMP) to verify that the public and environment around CNSC-regulated nuclear facilities are not adversely affected by releases to the environment. This verification is achieved through independent sampling and analysis by the CNSC. This program applies to the NFPO.

2.2.10.1 Effluent Monitoring at the NFPO

Airborne and waterborne radiological and non-radiological emissions to the environment from the NFPO are monitored as part of the facility's effluent monitoring program.

Air

Monitoring of airborne emissions is limited to uranium.

The facility performs continuous in-stack sampling for uranium. The in-house filter papers are analyzed in-house daily and verified externally. The external independent laboratory tests the filter papers by delayed neutron activation analysis. The minimum detection limit is 0.01 µg uranium. Results are compared to the previous results, and to the relevant *Action Levels* for a process exhaust sample measurement of 1 µg uranium/m^3. This level is set based on past facility performance. A result above the Action Level would be considered outside the concentration range expected for routine operation. Continuous sampling from the three furnace stacks was implemented in September 2016 and the results were included in this report. A summary of 2021 air effluent sampling results is provided in Table 2-12

A summary of 2017 to 2021 air effluent sampling results are provided in Table 2-13. As shown in the tables, air emissions are well below regulatory and Action Levels.

Figure 2-14 shows trending of annual uranium emissions over the 2017 to 2020 four-year period. Uranium air emission are well below the previous licence release limit of 760 g/year (Note: the total release was not reported for 2021).

Table 2-12 Summary of Uranium Air Effluent Sampling Results (2021)

Stack Description	Total Number of Samples	Action Level (µg/m³) (# Samples Exceeding Level)	Highest Value Recorded (µg/m³)	Average Value Recorded (µg/m³)
Rotoclone	251	1 µg/m³ (0)	0.197	0.013
6H-68	251	1 µg/m³ (0)	0.461	0.010
4H-48	251	1 µg/m³ (0)	0.072	0.012
Furnace #1	251	1 µg/m³ (0)	0.224	0.029
Furnace #2/4	251	1 µg/m³ (0)	0.395	0.090
Furnace #5/6	251	1 µg/m³ (0)	0.250	0.027

Source (BWXT NEC 2022)

Table 2-13 Summary of Air Effluent Sampling at Exhaust Stack (2017 to 2021)

Parameter	Year				
	2017	2018	2019	2020	2021
Number of Uranium Air Exhaust Samples Taken	1488	1500	1506	1506	1506
Number of Uranium Samples > *Action Level* (1 µg/m³)	0	0	0	0	0
Average Uranium Concentration (µg U/m³)	0.0072	0.0038	0.027	0.056	0.030
Highest Uranium Value Recorded (µg U/m³)	0.44	0.467	0.245	0.908	0.461
Total Uranium Discharge to Air (g)	7.44	6.28	7.05	8.2	N/A (1)

(1) Total Uranium discharge in grams was not reported in 2021

Source (BWXT NEC 2018 to 2022)

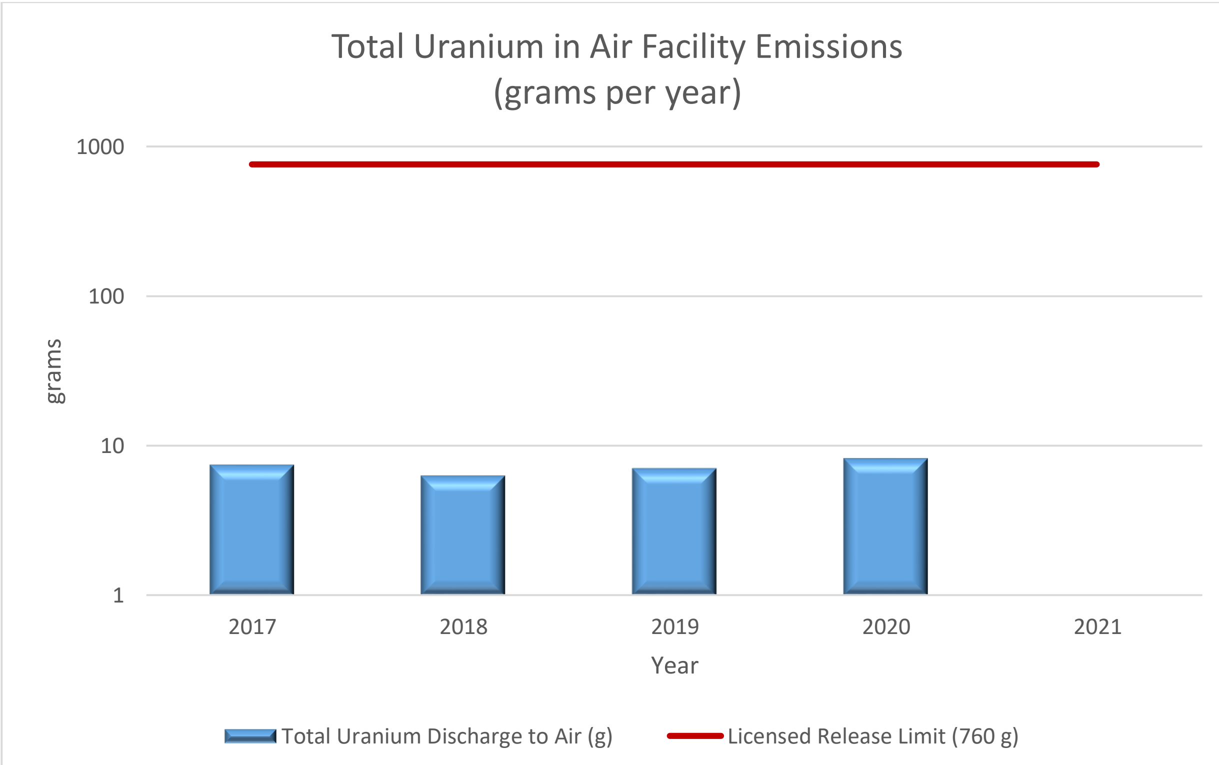


Figure 2-13 Five-year Trend Graph of Annual Uranium Air Releases

Water

Water is used to clean protective clothing, walls, floors, equipment and in various other janitorial functions. The water is treated to remove uranium dioxide (UO_2) and the concentration of UO_2 in wastewater leaving the treatment system is measured in-house.

The water effluent treatment system at the Toronto facility operates as follows:

1. Wastewater is held in batches;
2. Each batch is treated, then sampled;
3. Each batch is only released when in-house sample results confirm the concentration is less than 3 ppm (note: *Action Level* for a batch is 6 ppm).

The BWXT NEC monitors discharges from the wastewater treatment system. The concentration of UO_2 in the total wastewater leaving the plant premises is calculated and compared to the *Internal Control Level* of 3 ppm and the *Action Level* of 6 ppm (per batch). A weekly composite sample is prepared and sent for independent analysis at an external laboratory. The minimum detectable quantity is 0.000001 mg U/L. The facility uses alpha counting for uranium determination of water effluent samples. Sample analyses are audited by laser fluorimetry or delayed neutron activation analysis. Averages and annual releases are calculated from the weekly composite samples.

Wastewater holding tank discharges are sampled semi-annual by an environmental consulting firm and analyzed by an ISO/IEC 17025 certified laboratory for compliance to the Toronto Municipal Code Chapter 681, Sewers by-law.

Wastewater released from the holding tanks mixes within the plant sewer system with wastewater from other, non-nuclear operations in the Toronto facility prior to discharge to the municipal sewer. It is not the intention to imply that dilution is used as a control. It is mentioned here as a matter of fact so that the magnitude of release concentrations entering the environment are clear and understood. In-plant dilutions factors vary day-to-day but typically range from 4 to about 12. Reported results do not include dilution, i.e., sample measurements are taken prior to mixing with non-process water.

A summary of uranium water releases over the 2017 to 2021 water release results is provided in Table 2-14. As shown in the table, uranium releases are well below the *Action Level* of 6 ppm per batch. Figure 2-14 shows trending of uranium effluent monitoring results over a five-year period. The five-year trend graph of uranium water releases shows a trending downward consisting of very low uranium water releases. Decreased average uranium concentrations at the point of release is attributed to changes in chemical usage for water treatment.

Water release results continue to remain low and below the A*ction Levels* of 6 ppm (per batch) and 3 ppm (annual average). The maximum total annual release of 0.94 kg during the reporting period is well below the derived release limit of 9,000 kg/year (Note: the total release was not reported for 2021).

Table 2-14 Uranium Liquid Effluent Monitoring Results

Parameter	2017	2018	2019	2020	2021
Total Amount of Liquid Discharged (L) from Uranium Processing Areas	1,140,225	1,295,560	1,232,765	1,493,860	1,368,270
Maximum Uranium Concentration in Water (ppm)	2.56	2.95	2.58	2.79	2.55
Average Uranium Concentration in Water (ppm)	1.12	0.72*	0.46	0.24	0.28
Number of Samples Exceeding *Action Level* (6 ppm per batch)	0	0	0	0	0
Total Uranium Discharge to Sewer (g)	941	935	572	357	N/A

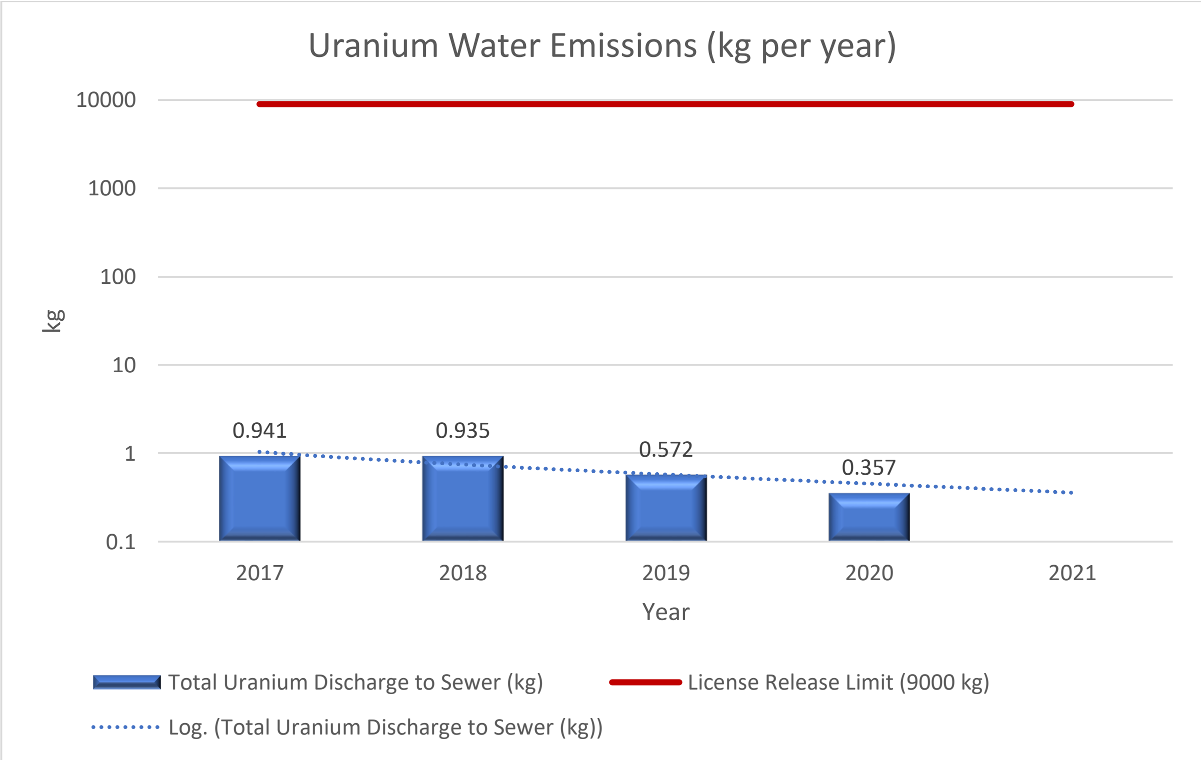


Figure 2-14 Five-Year Trend Graph of Annual Uranium Water Releases

Table 2-15 and Table 2-16 summarize results on the semi-annual UO_2 holding tank sampling. Samples are taken directly from the discharge of the holding tank, prior to any dilution from other contributions to the combined sanitary/storm sewer discharge. Table 2-15 summarizes results for parameters which were measured at or above detection limits in at least one sampling event over the five-year 2017 to 2021 period. Table 2-16 summarizes all other parameters monitored for but never detected above their respective detection limits.

In 2021, BWXT NEC intalled a new combined sewer sampling maintenance access manhole near the main building entrance fronting Lansdowne Avenue. In 2022, spring and fall sewer samples were collected. The sampling was completed during the discharge of the holding tank. A consultant collected a grab sampleof the sewer water following the increase of water flow that signalled the discharge of the holding tank water. Table 2-17 and Table 2-18 summarizes the 2022 sewer effluent results.

<u>Radiological Emissions</u>

Radiological emissions from the NFPO, other than uranium emissions, are not monitored.

Table 2-15 Holding Tank Monitoring – Parameters Above Detection Limits

Parameter	Units	Sewer Use By-Law Criteria[1]	May 2017	Dec 2017	May 2018	Dec 2018	Mar 2019	Sep 2019	Apr 2020	Oct 2020	June 2021	Nov 2021
Calculated Parameters												
Total Animal/Vegetable Oil and Grease	mg/L	150	2.3	27	17	16	11	10	7.4	11	5.0	4.6
Inorganics												
Total Biochemical Oxygen Demand (BOD)	mg/L	300	**380**	170	**480**	180	27	230	170	120	85	190
Fluoride (F-)	mg/L	10	0.18	0.17	0.23	0.13	0.18	0.17	0.15	<0.10	0.22	0.27
Total Kjeldahl Nitrogen (TKN)	mg/L	100	12	15	14	13	2.3	9.9	14	2.6	5.0	11
pH	pH	6.0 to 11.5	7.28	7.75	7.67	7.49	7.9	7.82	7.05	6.90	7.79	7.63
Phenols-4AAP	mg/L	1.0	1.1	**3.4**	**9.8**	0.47	0.0020	0.020	**2.5**	0.024	0.017	0.0047
Total Suspended Solids	mg/L	350	10	<10	<10	11	<10	<10	<10	<10	<10	<10
Total Cyanide	mg/L	2	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0071	0.19	<0.005	0.019
Petroleum Hydrocarbons												
Total Oil & Grease	mg/L	-	3.0	27	19	17	12	11	8.7	13	5.0	5.4
Total Oil & Grease Mineral/Synthetic	mg/L	15	0.70	<0.50	1.6	0.90	1.6	0.70	1.3	1.6	<0.50	0.80
Miscellaneous Parameters												
Nonylphenol Ethoxylate (Total)	mg/L	0.2	**<25**[3]	**<13**[3]	**<2.5**[3]	**<0.25**[3]	<0.005	<0.05	**<2.5**[3]	<0.005	0.015	<0.01
Nonylphenol (Total)	mg/L	0.02	<0.001	0.001	<0.01	0.001	<0.001	<0.001	<0.001	0.002	0.001	<0.002
Metals												
Total Aluminum (Al)	mg/L	50	0.1	0.3	0.5	0.2	1.0	0.4	.01	0.2	0.3	0.2
Total Chromium, Hexavalent (Cr VI)	µg/L	2000	<0.50	<0.50	<0.50	<0.50	1.1	<0.50	0.56	0.57	<9.50	0.69
Total Copper (Cu)	mg/L	2	<0.01	0.04	<0.01	0.05	0.2	<0.01	0.05	0.09	0.06	0.04
Total Manganese (Mn)	mg/L	5	0.006	0.005	0.004	0.005	0.001	0.007	0.008	0.009	0.008	0.006
Total Molybdenum (Mo)	mg/L	5	0.028	0.087	0.026	.012	0.012	0.35	0.86	0.081	0.20	0.090
Total Nickel (Ni)	mg/L	2	<0.005	0.007	<0.005	<	<	0.007	<0.005	<0.005	0.008	0.009
Total Phosphorus (P)	mg/L	10	0.09	<0.05	0.10	0.52	<0.05	0.09	0.19	<0.05	0.09	0.08

Parameter	Units	Sewer Use By-Law Criteria[1]	May 2017	Dec 2017	May 2018	Dec 2018	Mar 2019	Sep 2019	Apr 2020	Oct 2020	June 2021	Nov 2021
Total Zinc (Zn)	mg/L	2	0.013	0.017	<0.005	0.022	0.010	0.032	0.13	0.18	0.098	0.091
Semivolatile and Volatile Organics												
Di-N-butyl phthalate	µg/L	80	28	16	17	45	2	15/18(4)	32	4	5	3
Bis(2-ethylhexyl)phthalate	µg/L	12	<2	10	9	3	2	<2/<2(4)	<2	<2	<2	<2
Chloroform	µg/L	40	<10	<10	<10	<10	<10	<10	<10	30	<10	12

Notes: 1 Criteria: Toronto Sanitary and Combined Sewers Discharge Guidelines. Referenced to the Chapter 681, dated March 28, 2019.; '-- = no criteria established

2 '-' = Not sampled or not reported

3 Reportable Detection Limit (RDL) exceeds criteria

4 Two tanks were sampled.

=Above Sewer Use By-law

Source: (Trinity Consultants 2017, 2018a, 2018b, 2018c, 2019a, 2019b, 2020a, 2020b, 2021, 2022)

Table 2-16 Holding Tank Monitoring – Parameters Below Detection Limits

Parameter	Units	Criteria By-Law Limit[1]	Lowest Detection Limit
Metals			
Total Antimony (Sb)	mg/L	5	<0.02
Total Arsenic (As)	mg/L	1	<0.01
Total Cadmium (Cd)	mg/L	0.7	<0.002
Total Chromium (Cr)	mg/L	4	<0.01
Total Cobalt (Co)	mg/L	5	<0.002
Total Lead (Pb)	µg/L	1	<0.01
Total Mercury (Hg)	mg/L	0.01	<0.0001
Total Selenium (Se)	mg/L	1	<0.02
Total Silver (ag)	mg/L	5	<0.01
Total Tin (Sn)	mg/L	5	<0.02
Total Titanium (Ti)	mg/L	5	<0.005
Semivolatile Organics			
3,3'-Dichlorobenzidi ne	µg/L	2	<0.8
Pentachlorophenol	µg/L	5	<1
Phenanthrene	µg/L	-	<0.2
Anthracene	µg/L	-	<0.2
Fluoranthene	µg/L	-	<0.2
Pyrene	µg/L	-	<0.2
Benzo(a)anthracene	µg/L	-	<0.2
Chrysene	µg/L	-	<0.2
Benzo(b/j)fluoranthene	µg/L	-	<0.2
Benzo(k)fluoranthene	µg/L	-	<0.2
Benzo(a)pyrene	µg/L	-	<0.2
Indeno(1,2,3-cd) pyrene	µg/L	-	<0.2
Dibenz(a, h)anthracene	µg/L	-	<0.2
Benzo(g,h,i)perylene	µg/L	-	<0.2
Dibenzo(a,i)pyrene	µg/L	-	<0.2
Benzo(e)pyrene	µg/L	-	<0.2
Perylene	µg/L	-	<0.2
Dibenzo(a,j) acridine	µg/L	-	<0.4
7H-Dibenzo(c,g) Carbazole	µg/L	-	<0.4
1,6-Dinitropyrene	µg/L	-	<0.4
1,3-Dinitropyrene	µg/L	-	<0.4
1,8-Dinitropyrene	µg/L	-	<0.4
Volatile Organics			
Benzene	µg/L	10	<10.0
1,2-Dichlorobenzene	µg/L	50	<25
trans 1,3-Dichlorobenzene	µg/L	-	<25
1,4-Dichlorobenzene	µg/L	80	<25
cis-1,2-Dichloroethylene	µg/L	4000	<25
trans-1,3-Dichloropropene	µg/L	140	<20
Ethylbenzene	µg/L	160	<10
Methylene Chloride (Dichloromethane)	µg/L	2000	<100
1,1,2,2-Tetrachloroethane	µg/L	1400	<25
Tetrachloroethylene	µg/L	1000	<10
Toluene	µg/L	16	<10
p+m-Xylene	µg/L	-	<10
o-Xylene	µg/L	-	<10
Total Xylenes	µg/L	1400	<10

Parameter	Units	Criteria By-Law Limit[1]	Lowest Detection Limit
Pesticides & Herbicides			
Aldrin	µg/L	-	<0.05
Dieldrin	µg/L	-	<0.05
a-Chlordane	µg/L	-	<0.05
g-Chlordane	µg/L	-	<0.05
o,p-DDT	µg/L	-	<0.05
p,p-DDT	µg/L	-	<0.05
o,p-DDT	µg/L	-	<0.05
p,p-DDT	µg/L	-	<0.05
Lindane	µg/L	-	<0.03
Endosulfan I (alpha)	µg/L	-	<0.05
Endosulfan II)beta)	µg/L	-	<0.05
Endrin	µg/L	-	<0.05
Heptachlor	µg/L	-	<0.05
Heptachlor epoxide	µg/L	-	<0.05
Hexachlorobenzene	µg/L	-	<0.05
Methoxychlor	µg/L	-	<0.1
Aroclor 1016	µg/L	-	<0.5
Aroclor 1221	µg/L	-	<0.5
Aroclor 1231	µg/L	-	<0.5
Aroclor 1241	µg/L	-	<0.5
Aroclor 1242	µg/L	-	<0.5
Aroclor 1248	µg/L	-	<0.5
Aroclor 1254	µg/L	-	<0.5
Aroclor 1260	µg/L	-	<0.5

Parameter	Units	Criteria By-Law Limit[1]	Lowest Detection Limit
Pesticides & Herbicides (cont'd)			
alpha-BHC	µg/L	-	<0.05
beta-BHC	µg/L	-	<0.05
delta-BHC	µg/L	-	<0.05
Endosulfan sulfate	µg/L	-	<0.05
Endrin aldehyde	µg/L	-	<0.05
Endrin ketone	µg/L	-	<0.05
Mirex	µg/L	-	<0.05
Oxychlordane	µg/L	-	<0.05
Toxaphene	µg/L	-	<0.05
Miscellaneous			
Total PCB	µg/L	1	< 0.05
Nonylphenol (Total)	mg/L	0.02	<0.001

1 Criteria: Toronto Sanitary and Combined Sewers Discharge Guidelines. Referenced to the Chapter 681.

Source: (Trinity Consultants 2017, 2018a, 2018b, 2018c, 2019a, 2019b, 2020a, 2020b, 2021, 2022)

Table 2-17 Combined Sewer Effluent Monitoring – Parameters Above Detection Limits

Parameter	Units	Sewer Use By-Law Criteria[1]	Spring 2022	Fall 2022
Calculated Parameters				
Total Animal/Vegetable Oil and Grease	mg/L	150	12.5	19.9
Inorganics				
Total Biochemical Oxygen Demand (BOD)	mg/L	300	109	119
Fluoride (F-)	mg/L	10	0.23	0.157
Total Kjeldahl Nitrogen (TKN)	mg/L	100	6.09	4.60
pH	pH	6.0 to 11.5	7.52	7.66
Phenols-4AAP	mg/L	1.0	0.0439	0.211
Total Suspended Solids	mg/L	350	24.4	35.4
Total Cyanide	mg/L	2	0.0039	<0.0020
Petroleum Hydrocarbons				
Total Oil & Grease (gravimetric)	mg/L	-	-	19.9
Total Oil & Grease Mineral/Synthetic	mg/L	15	<2.5	<5.0
Miscellaneous Parameters				
Nonylphenol Ethoxylate (Total)	mg/L	0.2	<0.001	<0.002
Nonylphenol (Total)	mg/L	0.02	<0.002	<0.001
Inorganic				
Total Aluminum (Al)	mg/L	50	0.287	0.750
Total Cobalt (Co)	mg/L	5	<0.0010	0.00110
Total Copper (Cu)	mg/L	2	0.0284	0.234
Total Lead	mg/L	1	0.00065	0.00589
Total Manganese (Mn)	mg/L	5	0.0087	0.0115
Total Molybdenum (Mo)	mg/L	5	0.156	0.0631
Total Nickel (Ni)	mg/L	2	0.0104	0.00560
Total Phosphorus (P)	mg/L	10	0.245	0.197
Total Zinc (Zn)	mg/L	2	0.088	0.0972
Semi-volatile and Volatile Organics				
Chloroform	µg/L	40	15.7	1.04
Phenanthrene	mg/L	-		0.0000260

Notes: 1 Criteria: Toronto Sanitary and Combined Sewers Discharge Guidelines. Referenced to the Chapter 681, dated March 28, 2019.; '-- = no criteria established

2 '-' = Not sampled or not reported

3 Reportable Detection Limit (RDL) exceeds criteria

=Above Sewer Use By-law

Source: (Northern Applied Sciences 2022b, 2022c)

Table 2-18 Combined Sewer Monitoring – Parameters Below Detection Limits

Parameter	Units	Criteria By-Law Limit[1]	Lowest Detection Limit
Metals			
Total Antimony (Sb)	mg/L	5	<0.00100
Total Arsenic (As)	mg/L	1	<0.00100
Total Cadmium (Cd)	mg/L	0.7	<0.0000800
Total Chromium (Cr)	mg/L	4	<0.00500
Total Mercury (Hg)	mg/L	0.01	<0.0000050
Total Selenium (Se)	mg/L	1	<0.000500
Total Silver (ag)	mg/L	5	<0.000100
Total Tin (Sn)	mg/L	5	<0.00100
Total Titanium (Ti)	mg/L	5	<0.00300
Total Chromium, hexavalent (CR VI)	mg/L	-	<0.00050
Semivolatile Organics			
3,3'-Dichlorobenzidine	mg/L	2	<0.40
Pentachlorophenol	mg/L	5	<0.50
Anthracene	mg/L	-	<0.000010
Fluoranthene	mg/L	-	<0.000010
Pyrene	mg/L	-	<0.000010
Benzo(a)anthracene	mg/L	-	<0.000010
Chrysene	mg/L	-	<0.000010
Benzo(b/j)fluoranthene	mg/L	-	<0.000010
Benzo(k)fluoranthene	mg/L	-	<0.000010
Benzo(a)pyrene	mg/L	-	<0.0000050
Indeno(1,2,3-cd) pyrene	mg/L	-	<0.000010
Dibenz(a,h)anthracene	mg/L	-	<0.0000050
Benzo(g,h,i)perylene	mg/L	-	<0.000010
Dibenzo(a,i)pyrene	mg/L	-	<0.000050
Benzo(e)pyrene	mg/L	-	<0.000011
Perylene	mg/L	-	<0.000010
Dibenzo(a,h) acridine	mg/L	-	<0.000050
Dibenzo(a,i) acridine	mg/L	-	<0.000010
7H-Dibenzo(c,g) Carbazole	mg/L	-	<0.000050
1,6-Dinitropyrene	mg/L	-	<0.0010
1,3-Dinitropyrene	mg/L	-	<0.0010
1,8-Dinitropyrene	mg/L	-	<0.0010
Methylcholanthrene, 3-	mg/L	-	<0.000050
PAHs, total (ON Sewer Use)	Mg/L	0.005	<0.00175
Volatile Organics			
Benzene	µg/L	10	<0.50
1,2-Dichlorobenzene	µg/L	50	<0.50
1,4-Dichlorobenzene	µg/L	80	<0.50

Parameter	Units	Criteria By-Law Limit[1]	Lowest Detection Limit
cis-1,2-Dichloroethylene	µg/L	4000	<0.5
dichloromethane	µg/L	2000	<0.50
trans-1,3-Dichloropropene	µg/L	140	<0.30
Ethylbenzene	µg/L	160	<0.50
1,1,2,2-Tetrachloroethane	µg/L	1400	<0.50
Tetrachloroethylene	µg/L	1000	<0.50
Toluene	µg/L	16	<0.50
p+m-Xylene	µg/L	-	<0.40
o-Xylene	µg/L	-	<0.30
Total Xylenes	µg/L	1400	<0.50
Phthalate Esters			
Bis(2-ethylhexyl) phthalate	µg/L	12	<4
di-n-butyl-phthalate	µg/L	80	<6.6
Nonylphenols			
Nonylphenol diethoxlates	µg/L	-	<0.10
PCBs			
Aroclor 1016	µg/L	-	<0.021
Aroclor 1221	µg/L	-	<0.021
Aroclor 1232	µg/L	-	<0.021
Aroclor 1242	µg/L	-	<0.020
Aroclor 1248	µg/L	-	<0.020
Aroclor 1254	µg/L	-	<0.020
Aroclor 1260	µg/L	-	<0.020
Aroclor 1262	µg/L	-	<0.021
Aroclor 1269	µg/L	-	<0.021
Total PCBs	µg/L	1	<0.040

Source: (Northern Applied Sciences 2022b, 2002c)

2.2.10.2 Environmental Monitoring at the NFPO

The measured uranium concentrations in ambient air and soil were well below established guidelines and standards and no environmental impacts are expected.

Air and water emissions are routinely measured to demonstrate compliance with the Canadian Nuclear Safety Commission's environmental protection requirements and the As Low As Reasonably Achieveable (ALARA) principle. All measurements were below BWXT NEC Action Levels and annual releases were a small fraction of regulatory limits. The effluent monitoring results from BWXT NEC show a consistent trend of very low air and water releases of uranium for which routine environmental monitoring is not warranted; however, because of the residential environmental around the Toronto facility, environmental monitoring is completed. Environmental air monitoring, boundary gamma radiation monitoring and annual uranium in soil sampling is conducted at the Toronto facility. Surface water and well monitoring are not required at or around the facility.

To complement existing and ongoing compliance activities and site monitoring programs, the CNSC implemented an Independent Environmental Monitoring Program (IEMP) to verify that the public and environment around CNSC-regulated nuclear facilities are not adversely affected by releases to the environment. This verification is achieved through independent sampling and analysis by the CNSC. This program applies to the NFPO. IEMP sampling was conducted in 2014, 2018, 2019 and 2022. The results of this program are presented in Appendix A.

In 2013, the MECP also completed a uranium in soil analysis in the vicinity of the NFPO. The results of this program is presented in Appendix A.

Air

The Toronto boundary air monitor program monitors environmental uranium levels. Boundary samples are collected using high volume air samplers (Hi-vols) located at five positions strategically located around the facility perimeter (see Figure 2-15). An accredited external independent laboratory tests the filter papers by delayed neutron activation analysis. The minimum detection limit is 0.01 µg uranium. Results are compared to the previous results, and to relevant Internal Control Levels and Action Levels.

The facility perimeter air quality results are summarized in Table 2-19.

The average and maximum facility perimeter air quality monitor results are trended over five years in Figure 2-16 and consist of very low uranium in air concentrations well below the Action Level of 0.08 µg/m^3 and the MECP ambient air quality objective of 0.3 µg (U in TSP)/m^3 over a 24-hour averaging period (MECP 2020) corresponding to the sample collection period. Overall, the five-year trend graph of boundary air monitor concentrations shows a slightly decreasing trend consisting of very low measurements (see Figure 2-16).

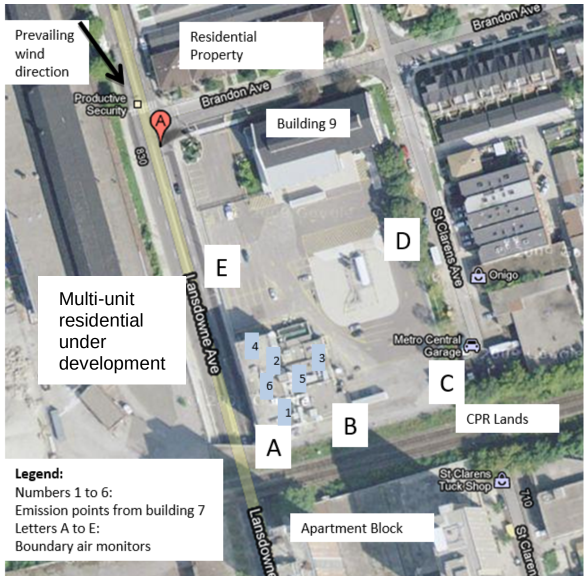


Figure 2-15 Toronto Air Emission Points and Air Monitors

Table 2-19 Uranium Facility Perimeter Air Monitoring Results

Parameter	2017	2018	2019	2020	2021
Number of Facility Perimeter Air Samples Taken	260	260	260	265	260
Number of Samples > Action Level (0.08 µg/m^3)	0	0	0	0	0
Average Concentration (µg U/m^3)	0.000	0.000	0.000	0.000	0.000
Highest Value Recorded (µg U/m^3)	0.008	0.003	0.001	0.003	0.003

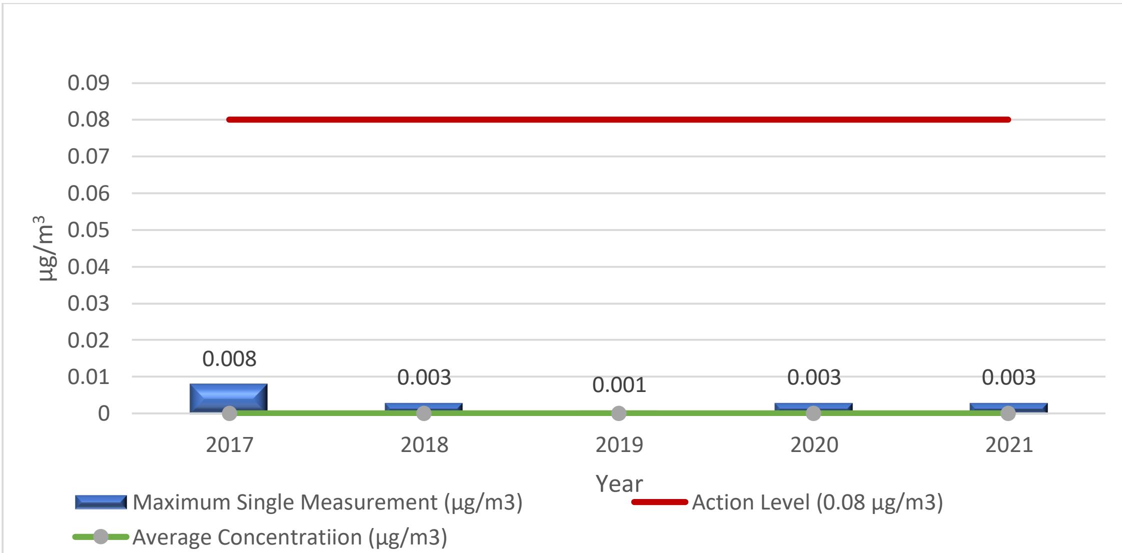


Figure 2-16 Five-year Trend Graph of Boundary Uranium Air Monitoring

<u>*Soil*</u>

Facility UO_2 air emissions are the primary pathway for potential release into the natural environment by impingement on the ground surface in the immediate vicinity of the facility depending on the wind direction. UO_2 is insoluble in water but may be washed into the soil by rainfall, snow, etc. Surface uranium levels will indicate deposited emissions. Continuous ambient air monitoring units are installed at the perimeter of the facility (boundary air monitors) to verify the effectiveness of the emission control systems (see above). No concerns have been detected regarding release of uranium as sampled at the perimeter/boundary air monitoring units which is consistent with very low emissions as measured at the emission stacks.

Once per year, BWXT NEC collects soil samples around the Toronto facility. Until 2021, samples were collected from 49 locations according to a documented plan. In 2021, the sampling plan was modified from previous years due to restricted access to some sampling locations. Samples of surface soil were retrieved from 34 locations in accordance with a revised documented plan. Due to issues with access to Canadian Pacific Railway property, 33 previously sampled locations were not sampled and 18 alternate samples were taken at new locations in their place. The sampling methodology used is based on the MECP *Guidelines on Sampling and Analytical Methods for Use at Contaminated Sites in Ontario* (MOEE 1996). Annually, the five-year average wind data obtained from the Toronto Pearson International Airport climate data centre (located approximately 12 kilometers west of the facility), is reviewed and used to confirm the appropriateness of the selected soil sampling locations. The data shows prevalent winds from north to south-west. Three quality control soil samples at a background location approximately 15 km north of the facility are also taken, along with three blind duplicate samples for field quality control purposes. Samples are retrieved by a third-party consultant and analyzed by an accredited independent laboratory by Inductively Coupled Plasma Mass Spectrometry for the amount of natural uranium in parts per million (i.e., µg U/g). The minimum detectable limit is 0.5 parts per million (0.5 µg U/g). Results are compared to previous years and the Canadian Council of Ministers of the Environment (CCME) guidelines.

The guideline values for uranium in soil established by the Canadian Council of Ministers of the Environment (CCME) is 23 µg U/g dry weight for parkland and residential uses, 33 µg U/g dry weight for commercial uses and 300 µg U/g dry weight for industrial uses (CCME 2023).

The MECP released soil and groundwater standards under O. Reg. 153/04 (as amended) and which are included in *Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act*" (MECP, 2021b). These generic standards are presented in the MECP document in Tables (1 through 9) that vary according to background, potable or non-potable groundwater, stratified or full depth standards, property use, shallow soil conditions, and proximity to a water body. The results of the soil siltation sampling program for off-site receptors were compared to the most stringent standard of 2.5 µg/g in MECP Table 1 (Full Depth Background Site Condition Standards) for residential, parkland, institutional, industrial, commercial, and community property uses (MECP, 2021b). The Table 1 value is the same as the Ontario background level for uranium in soil which is generally below 2.5 mg/kg (MOEE, 2011).

Table 2-20 provides a summary of the 2017 to 2021 uranium in soil sampling program. Locations are colour coded according to their area classification. The BWXT NEC NFPO property is **blue**, industrial/commercial lands are **purple**, and all other locations are **green**.

Table 2-20 2017 to 2021 Uranium in Soil Sampling Results

	Location Description		
	On BWXT NEC NFPO property	**On industrial/commercial lands (i.e., south rail lands)**	**All other locations (i.e., residential)**
Relevant CCME Guideline (µg U/g)	**300 µg U/g**	**33 µg U/g**	**23 µg U/g**
MECP Standard (µg U/g)	**33 µg U/g(1)**	**33 µg U/g(2)**	**2.5 µg U/g(3)**
2021			
Number of Samples Taken	3	2	29
Average concentration µg U/g	2.4	1.0	1.0
Maximum concentration µg U/g	4.6	1.0	1.1
2020			
Number of Samples Taken	1	34	14
Average concentration µg U/g	1.3	2.9	1.0
Maximum concentration µg U/g	1.3	17.6	1.0
2019			
Number of Samples Taken	1	34	14
Average concentration µg U/g	1.2	1.5	1.1
Maximum concentration µg U/g	1.2	2.8	1.7

	Location Description		
	On BWXT NEC NFPO property	On industrial/commercial lands (i.e., south rail lands)	All other locations (i.e., residential)
2018			
Number of Samples Taken	1	34	14
Average concentration µg U/g	1.3	2.3	0.0
Maximum concentration µg U/g	1.3	11.9	1.0
2017			
Number of Samples Taken	1	34	14
Average concentration µg U/g	1.7	3.0	1.0
Maximum concentration µg U/g	1.7	20.6	1.6

Notes:
(1) Table 3: Full Depth Generic Site Condition Standards in a Non-Potable Ground Water Condition (MECP 2021b)
(2) Table 3: Full Depth Generic Site Condition Standards in a Non-Potable Ground Water Condition (MECP 2021b)
(3) Table 1: Full Depth Background Site Condition Standards (the most stringent standard) (MECP 2021b)

Due to increasing public concern and discussion in the press concerning the uranium emissions (to air) from the facility, in 2013 the MECP undertook independent soil sampling to verify the findings reported by BWXT NEC (CNSC 2013a, MOE 2013a). The CNSC also implemented an Independent Environmental Monitoring Program (IEMP) to verify that the public and environment around CNSC-regulated nuclear facilities are not adversely affected by releases to the environment (See Appendix A for more details on both sampling programs).

As described in Appendix A, limited soil sampling was undertaken by the CNSC from 2014 through 2022 in the vicinity of the NPPO. The CNSC laboratory began using a partial digestion method as opposed to the total digestion method used before 2020. This change was made so that results could be compared with the Canadian Council of Ministers of the Environment Environmental Quality Guidelines (CCME 2023) and the MECP Soil Quality Standards (MECP 2021b). As a result, soil concentrations in 2022 are lower than in previous years and are not directly comparable to samples from prior years. Samples prior to 2022 were therefore not further assessed.

CNSC sample results are summarized in Table 2-21.

Table 2-21 IEMP Soil Monitoring Results

	Uranium
MECP Guideline (MECP 2021b)	2.5 µg U/g
CCME Canadian Soil Quality Guideline for Protection of Residential/Parkland (CCME 2023)	23 µg U/g
Number of Samples Taken Analysed with Full Digestion (not comparable to MECP and CCME guidelines)	34
Number of Samples Taken Analysed with Partial Digestion	8
Average Concentration (partial digestion only)	0.85 µg U/g
Maximum Concentration (partial digestion only)	0.69 µg U/g

Source: (CNSC 2022)

Analytical results for uranium concentrations for all soil samples analyzed are, without exception, well below the applicable CCME guidelines and MECP standards. Uranium concentrations in residential soil samples also were lower than the Ontario background level which is generally below 2.5 mg/kg (MOEE 2011).

Gamma Radiation

Environmental Thermoluminescent Dosimeters (TLDs) are placed at the Toronto plant boundary to monitor gamma radiation and for use in estimating a public gamma dose (see Table 2-22). While BWXTNEC also undertakes spot gamma dose rate measurements on an approximately quarterly basis, TLD readings provide a more reliable indication of gamma exposures than the spot gamma measurements. In broad terms, the spot environmental gamma dose rate measurements are comparable to the levels measured with the environmental TLD. Environmental TLDs are therefore used in estimating annual effective doses as a result of direct exposure to gamma radiation which ranged from a low of 0.0 µSv in 2018 to a high of 23 µSv to a member of the public (BWXT NEC 2018 to 2022).

Table 2-22 Environmental Monitoring TLDs (2017 – 2022)

Environmental TLDs Monitoring (µSv/hr) [a]							
Year	Survey Period	Control	137 Madison Ave. - 3.4 Km (Background)	B.M #3	B.M #4	N.E. Corner B9 (Exterior)	N.W. Corner B9 (Exterior)
2017	Q1-Q4	0.15	0.10	0.11	0.10	0.15	0.09
2018	Q1-Q4	0.16	0.11	0.10	0.10	0.15	0.10
2019	Q1-Q4	0.15	0.10	0.10	0.11	0.13	0.09
2020	Q1-Q4	0.15	0.10	0.10	0.09	0.09	0.09
2021	Q1-Q4	0.13	0.09	0.10	0.09	0.11	0.11
2022	Q1-Q4	0.10	0.09	0.10	0.09	0.08	0.08

a) Converted from mR to µSv using a conversion factor of 8.7 µSv per mR and assuming the TLD was exposed for 8760 hour per year.

2.2.11 Uncertainties in the Natural and Physical Environment

Well established and long running effluent and environmental monitoring programs are in place to measure the key Contaminants of Potential Concern (COPCs) (uranium, and gamma radiation) increasing the likelihood of identifying maximum emission cases and reducing the uncertainty in the risk assessment. In the risk assessment, maximum concentrations, emissions and/or measurements were used in the screening, providing a further degree of conservatism into the assessment.

The CNSC IEMP is operated independently of BWXT NEC in accordance with quality programs established in accordance with CNSC internal requirements. This indepent data assists in validating that the low level of emisisons from the NFPO have minimal impact on the environment.

There are some uncertainties in the characterization of the natural and physical environment. In particular, there is limited data on surface and groundwater quality, site-specific groundwater flow and depth and site soil characteristics. There are no human or ecological exposure pathways to COPCs from on-site groundwater and there are no indications to suggest contamination or potential impacts on local groundwater resources. Indirect emissions of COPCs to surface water are very low, with concentrations further reduced during dispersion in the air and mixing in surface waters. As such, human and ecological exposure pathways to COPCs from groundwater and local surface water are trivial and these uncertainties do not affect the risk assessment.

3 Human Health Risk Assessment

An HHRA is the evaluation of the probability of health consequences to humans caused by the presence of chemical contaminants at a facility. The requirement for, approach to, and scope of, a HHRA is based on a fundamental understanding of: site conditions, including the nature, extent and distribution of the radiological and chemical hazards; the potential exposure pathways; and opportunities for human receptors that will frequent, use or populate the area on or surrounding the facility.

As allowed under CSA N288.6:22, HHRAs apply to off-site receptors (i.e., members of the public) and on-site non-nuclear energy workers (non-NEWs) that are not covered under the facility's radiation protection program or health and safety program. In this report, the receptors considered for the HHRA consist of off-site members of the public. Health and safety of on-site workers is protected by BWXT NEC's Radiation Protection Program and Conventional Safety Program, which are discussed in section 3.1.1.

3.1 Problem Formulation

The prime hazards to the environment from the NFPO are uranium and gamma radiation through emissions to air and water.

Pathways for human exposure considered include:

- *Air inhalation/skin absorption;*
- *Air immersion (external exposure).*
- *Soil deposition gamma and beta ground shine*
- *Soil re-suspension and inhalation*
- *Ingestion through backyard gardens*
- *Drinking water*

Tier 1 screening did not identify any radiological or non-radiological COPCs requiring preliminary quantitative or detailed quantitative risk assessment, consequently detailed receptor characterization was not required.

Potential physical stressors to humans identified include noise exposure.

Problem formulation is a step undertaken early in the ERA process to constrain and focus the ERA on the key questions. For the NFPO ERA, the problem formulation focuses the assessment to the key contaminants and identifies the receptors and exposure pathways that are relevant to the proposed undertaking. The following discussion describes the approach taken to focus the HHRA.

3.1.1 Health and Safety of On-site Workers

Exposure to workers is considered and controlled through the application of BWXT NEC's well-established Occupational Safety and Health Procedures. On-site employees, contractors, and visitors are protected with the implementation of BWXT NEC's Radiation Protection Safety and Control Area and conventional safety program.

On-site workers, such as BWXT NEC employees, contractors, and visitors are protected through the "Radiation Protection" Safety and Control Area which covers the implementation of the radiation protection program, in accordance with the *Radiation Protection Regulations*. This program ensures that contamination and radiation doses received are monitored and controlled.

BWXT NEC has an established radiation protection program to address the hazards from uranium dioxide (UO_2) and keep employee doses ALARA. The major potential hazard is inhalation of airborne uranium dioxide particles. A respiratory protection program is in place. Measurements are performed of airborne and surface traces of uranium as an indicator of process containment efficiency. Urine samples provided by employees are used to indicate if inhalation may have occurred and to monitor clearance of uranium from the body. A lesser potential hazard exists in the form of low-level external gamma and beta doses to employees. The BWXT NEC program ensures that surface and airborne contamination and radiation doses to employees are monitored and controlled.

Whole body, skin and extremity dose measurements are performed using TLDs to ensure compliance with the CNSC's radiation dose limits and the ALARA principle.

On-site workers could also potentially be exposed to non-radiological substances. These exposures are considered and controlled through the application of BWXT NEC's well-established Occupational Safety and Health procedures.

As it is expected that the health and safety of on-site employees, contractors, and visitors is protected with the implementation of BWXT NEC's "Radiation Protection" Safety and Control Area and conventional safety program, no further risk assessment will be performed for these individuals.

3.1.2 Receptor Selection and Characterization

A toddler (0.5 – 4 years) was identified as the critical receptor for assessment purposes. However, because the Tier 1 screening did not identify any radiological or non-radiological COPCs requiring preliminary quantitative or detailed quantitative risk assessment, detailed receptor characterization was not required.

3.1.2.1 Receptor Selection

The critical receptor for the general public is defined as the "*most affected neighbour*" in order to be inclusive of all types of receptors.

The MECP, for land use categories where people of all ages are expected to have access (i.e. residential, parkland, institutional), consider the toddler (0.5 – 4 years) to be the more highly exposed receptor. Toddlers are considered to be the more highly exposed receptors because they eat, drink, and breathe more in proportion to body size, and exhibit behaviours (e.g., hand-to-mouth activity) that increased exposure to media such as soil (MOE, 2011). Based on this rationale, and the fact that toddlers could spend most of their time in a residence near the facility, toddlers were identified as the critical receptor.

3.1.2.2 Receptor Characterization

As discussed in Sections 3.2 and 3.3, as the Tier 1 screening did not identify any radiological or non-radiological COPCs requiring preliminary quantitative or detailed quantitative risk assessment, detailed receptor characterization was not required.

3.1.3 Selection of Chemical, Radiological, and Other Stressors

The NFPO has a long history of operations in Toronto which has allowed for the identification, assessment and monitoring of emissions over an extended period of time. Generally, there are small emissions associated with the production of natural uranium fuel pellets. The prime hazards to the environment from the NFPO are uranium and gamma radiation.

Uranium is both a radioactive substance (it decays at a slow rate by primarily emitting alpha radiation and, at lower levels, beta and gamma radiation) and a hazardous substance (since exposure to uranium can lead to chemical toxicity). Uranium is classified as a low specific activity radionuclide and emits very low amounts of radiation as compared to certain other isotopes. The main chemical effect associated with exposure to uranium and its compounds is kidney toxicity.

Release of uranium is controlled at the source by judicious design of machines, material handling equipment and dust collection systems. Dust collection system design and controls are described in the Radiation Protection Manual.

In addition to these contaminants, the NFPO emits a number of contaminants to air which are associated with dust collectors, furnaces, and rotoclones for the wet grinding area. These contaminants have been identified in the Toronto Emission Summary and Dispersion Modelling Report (Northern Applied Sciences Inc., 2022a).

Consistent with CSA N288.6:22, noise was also selected as a physical stressor for human receptors.

The tiered approach to HHRA, requires these contaminants to undergo a Tier 1 preliminary screening where conservative estimates of emissions and environmental concentrations are compared to screening criteria. The objective of this preliminary screening process is to identify COPCs which are those contaminants that have undergone preliminary screening and have been selected for evaluation in higher tiers of assessment.

3.1.4 Selection of Exposure Pathways

Pathways for human exposure considered include:

- *Air inhalation/skin absorption;*
- *Air immersion (external exposure).*
- *Soil deposition gamma and beta ground shine;*
- *Soil re-suspension and inhalation;*
- *Ingestion through backyard gardens; and,*
- *Drinking Water.*

Exposure through soils and the terrestrial food chain are not expected to be relevant due to the negligible amounts of uranium released to air and the low concentration of this substance in soil. Exposures through surface water consumption and exposure and the aquatic food chain are also not relevant due to the negligible amount of uranium released indirectly to surface waters and stormwater. Given the low concentration of uranium in stormwater runoff and soil and the absence of any soil or groundwater contamination on site, pathways associated with groundwater are also not considered pathways of concern.

Radiological and non-radiological materials are released to the environment as a result of the NFPO. Consequently, this could result in the emissions to various media, potentially including air, surface water, soil, sediment, groundwater, and other media such as vegetation. Receptors could be exposed to contamination through various pathways, as shown generically in Figure 3-1.

BWXT NEC has implemented track out control measures to minimize the potential for on-site contamination and associated contamination of stormwater. Therefore, any on-site or off-site contamination of runoff is associated with the emission of uranium through plant stacks and its subsequent deposition to the ground. Uranium emissions from Toronto are very low at 6.28 to 8.2 g U/y over the 2017 to 2021 period. Conservatively assuming a depositional radius around the facility of 1 km, the estimated stormwater runoff concentrations assuming equal deposition within this area is:

- average precipitation = 786 mm = 0.786 m

- Impacted area = 3.14 km^2 (very conservative as uranium emissions would be in the form of a very fine particulate and dispersed over a larger area – if for example we assume all stack emissions are deposited in a 2-km radius the average deposited uranium would be 4 times smaller)
- Maximum annual uranium emission 2017 to 2020 = 8.2 g
- Assuming all deposited uranium is picked up in precipitation (very conservative as much of the dust fall will work its way into the surface soil horizon)

$$Avg\ Concentration\ of\ U\ in\ Stormwater = \frac{8.2\ g}{0.786\ m * 3140000\ m^2} = 3.3\ x\ 10^{-6}\ \frac{g}{m3} = 0.003\ ppb$$

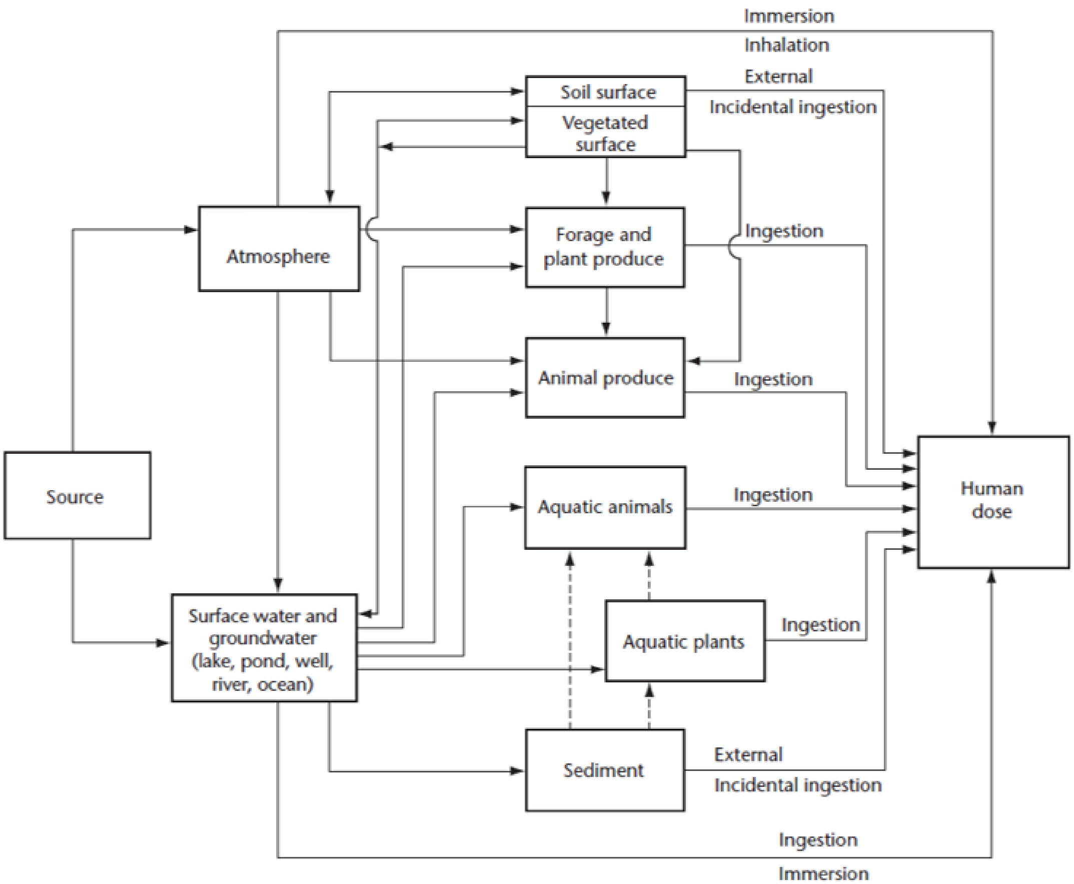
Completing similar calculations for soil deposition, conservatively assuming a soil density of 1.6 g/cm^3 a mixing zone of 5 cm (CSA, 2014) the average annual increase in soil concentrations are

$$Avg\ annual\ increae\ in\ U\ in\ Soil = \frac{8.2\ gU}{0.05\ m * 3140000\ m^2} * \frac{1\ cm^3}{1.6\ gSoil} * \frac{1\ m^3}{1000000\ cm^3} = 3.3\ x10^{-5}\ \frac{\mu gU}{g} dry\ weight$$

Therefore, exposure through soils and the terrestrial food chain are not relevant due to the negligible amounts of uranium released to air and the low concentration of these substances in soil. Exposures through surface water consumption and exposure and the aquatic food chain are also not relevant due to the negligible amounts of uranium released indirectly to surface waters through plant sewer effluent, the low concentrations of uranium in stormwater runoff and the absence of any surface waters in the immediate area of the facility. Given the low concentrations of uranium in stormwater runoff and soil and the absence of any soil or groundwater contamination on site, pathways associated with groundwater are also not considered pathways of concern.

Of the generic pathways shown in Figure 3-1, the primary potential pathways for COPCs associated with the NFPO are:

- Air inhalation/skin absorption
- Air immersion (external exposure)
- Soil deposition gamma and beta ground shine
- Soil re-suspension and inhalation
- Ingestion through backyard gardens
- Drinking water



Source (CSA, 2022)

Figure 3-1   Sample Human Pathway Model

3.2 Assessment of Radiological Impact

Radiological materials expected to be released include uranium to air and water. Direct gamma radiation from the facility and internal exposure through pathways such as consumption of locally-sourced food and water is also a consideration.

The estimated annual effective dose as a result of air releases and direct gamma exposure radiation from the combined operation is expected to be a small percentage of the public dose limit. There are no radiological effects to the public due to the operations of NFPO, and there is no radiological risk posed to off-site human receptors, thus, no further assessment is required.

Radiological materials are released to the environment as a result of the NFPO. In this section, the impacts of radiological releases on human health are assessed at the screening level (Tier 1) first. PQRA (Tier 2 assessment) and DQRA (Tier 3 assessments) is not required based on the screening level review.

Radiological materials released include uranium to air through stack emissions and water through discharges to sewer. Direct gamma radiation from the facility and internal exposure through pathways such as consumption of locally-sourced food and water is also a consideration.

Uranium has both radiological and non-radiological (primarily on kidney toxicity) effects. Uranium releases are discussed in more detail in Section 3.3.

3.2.1 Screening Criteria

Radiological releases to air and water were screened to identify COPCs. The CNSC's regulatory dose limit for members of the public, as defined in the *Radiation Protection Regulations,* is 1 mSv (1,000 µSv) per year. The Canadian average effective dose from background radiation is 1.8 mSy per year (CNSC 2013b). The ICRP (Publication 103 at para 268) suggests a risk based constraint for members of the public of $1x10^{-5}$ per year (ICRP 2007). Assuming the combined radiological detriment of about 5% per Sievert (ICRP 102 at para e), this converts to an annual dose of about 200 µSv per year which coincidentally, is about 10% of the unavoidable annual dose from natural background (ICRP 2007). For present purposes, we have assumed an annual reference dose of 200 µSv for the purpose of screening.

3.2.2 Dose to Members of the Public

Off-site receptors could receive radiation doses from direct external exposure to gamma radiation from the NFPO and internal and external exposure through pathways such as air, water and soil exposure.

Liquid effluent is not included in the calculation of public dose as the effluent from the facility is discharged directly to the city combined sanitary/storm sewer system and is not used directly for drinking. Liquid effluent discharges are less than 1 kg of U/year and are less than approximately 0.01% of the conservatively established derived release limit of 81 Mg/y. Further, the maximum uranium concentrates in discharges from the wastewater treatment holding tanks prior to dilution is 2.95 mg/L. With site dilution, the maximum discharge to sewer is approximately 0.25 to 0.73 mg/L at an average daily flow of approximately 6,500 L/d. Allowing for further dilution of water discharged within the sanitary/storm sewers (e.g., dilution in the treatment systems of approximately 40,000 times, based on an average daily flow of 249,900,000 L to the Humber Treatment Plant (City of Toronto 2022)), further dilution in lake water, and for removal of uranium in the City of Toronto wastewater and water treatment processes, uranium concentrations in drinking water attributable to the NFPO would be well below the Health Canada Maximum Allowable Concentration drinking water guideline (Health Canada 2022) and the Ontario O. Reg. 169/03: Ontario Drinking Water Quality Standard of 20 µg/L or 0.02 mg/L. Exposures through water consumption and the aquatic food chain are therefore not relevant due to the low concentrations discharged into the natural environment and the absence of any drinking water and surface waters in the immediate vicinity of the facility.

Exposure through ingestion through backyard gardens and internal and external exposure through soils is also minor given that uranium in soils are consistent with backgrounds levels in Ontario (see Section 2.2.10.1). Based on IEMP monitoring, the CNSC concluded that “The levels of radioactivity and hazardous substances measured in soil and air were below available guidelines and our own laboratory screening levels.Our screening levels are based on conservative assumptions about the exposure that would result in a dose of 0.1 mSv per year (one-tenth of theregulatory public dose limit of 1 mSv per year). IEMP measurements to date have consistently found levels of radioactivity in the environment to below and well within the range of natural background radiation levels. As a result, no effects on human health are expected” (CNSC 2022).

The external dose rates at the boundary of the NFPO are routinely measured (see Section 2.2.10.2), with external exposure to radioactivity falling off with distance from the facility. Beginning in 2014, environmental Thermoluminescent Dosimeters (TLDs) were put in place and are used to estimate a public gamma dose at the NFPO plant boundary. Based on TLD data, the facility estimated that the highest public dose due to gamma radiation exposure from the NFPO over the 2017 to 2021 period was 23 µSv (BWXT NEC 2018 to 2022) or 12% of the screening dose criteria of 200 µSv/y).

The facility has developed Derived Release Limits to account for the realistic pathways occurring as a result of air emissions and direct gamma exposure as described in the facilities Radiation Protection Manual (see Table 3-1) to restrict dose to a member of the public to 1 mSv per year. The Derived Release Limits assume that a member of the public occupies the NFPO boundary continuously (24 hours per day, 365 days per year).

Table 3-1 Radiological Exposure Pathways

Pathway	Description
Air immersion	Airborne uranium dioxide particles (UO_2) can expose members of the public via direct radiation
Soil deposition gamma ground shine	Gamma ground shine dose from direct radiation This is accounted for in the BWXT NEC NFPO Derived Release Limit
Soil deposition beta ground shine	Beta ground shine dose from direct radiation This is accounted for in the BWXT NEC NFPO Derived Release Limit
Soil re-suspension and inhalation	Soil re-suspension and inhalation dose This is accounted for in the BWXT NEC NFPO Derived Release Limit
Air inhalation	Airborne uranium dioxide particles (UO_2) can expose members of the public via inhalation. This is accounted for in the BWXT NEC NFPO Derived Release Limit

As discussed in annual reports and shown in Table 3-2, through direct correlation with the facility Derived Release Limits, over the 2017 to 2021 period, the estimated annual effective dose as a result of air releases and direct gamma exposure radiation ranged from a low of 0.4 µSv/yr in 2018 to a high of 23.5 µSv/yr in 2019 (BWXT NEC 2022). These doses represent from <0.1% to 2% of the 1 mSv (1,000 µSv) per year effective dose limit to a member of the public and 0.2% to 12% of the 0.2 mSv (200 µSv) per year screening criterion for radiological releases to air and water.

Table 3-2 Estimated Annual Public Dose

Year	Estimated Annual Public Dose (µSv)	% of Public Dose Limit (1,000 µSv = 1 mSv)	% of Screening Limit (200 µSv = 0.2 mSv)
2021	17.5	1.8%	8.8%
2020	5.7	0.6%	2.9%
2019	23.5	2.4%	11.8%
2018	0.4	0.04%	0.2%
2017	17.5	1.8%	8.8%

Utranium emissions to air are very low at a maximum of 8.2 g/y. Based on Derived Release Limit calculations, BWXT NEC has estimated a maximium effective dose as a result of air releases of 0.51 µSv/y, representing 0.3% of the screening dose criteria of 200 µSv/y (BWXT NEC annual reports 2017 to 2021). Air emissions and associated atmospheric pathways are therefore not relevant due to the low concentrations in the natural environment.

Therefore, it can be concluded that there are no radiological effects to the public due to the NFPO, and there is no radiological risk posed to off-site human receptors. No further assessment of radiological human health risks is required.

3.3 Assessment of Non-Radiological Impact

No non-radiological airborne or waterborne substances have been identified as COPCs for further assessment in the HHRA.

Non-radiological releases to the environment occur as a result of the NFPO. In this section, the impacts of non-radiological contaminants on human health are assessed at the screening level (Tier 1) first. Based on the results of the screening level assessment, PQRA (Tier 2 assessment) and DQRA (Tier 3 assessments) are not required.

3.3.1 Screening Criteria

The non-radiological substances in air and water were screened to identify COPCs. Screening criteria are identified in each section below.

3.3.2 Air

Non-radiological airborne emissions considered included uranium, particulate matter, hydrogen, nitrogen oxides, zinc hydroxide, zinc stearate and octadecanoic acid. All but particulate matter had modelled air concentrations which were screened out as negligible. Particulate matter had a modelled air concentration of 13% of the screening criterion and uranium had a modelled air concentration of 2% or less of the screening criteria. Furthermore, non-radiological substances with CNSC licence limits, BWXT NEC Action Levels, BWXT NEC Internal Control Levels were well below these limits and are therefore expected to be negligible.

Therefore, no non-radiological airborne substances have been identified as COPCs for further assessment in the HHRA.

Non-radiological substances, such as Uranium, Particulate Matter (PM), Hydrogen, Nitrogen Oxides, Zinc Hydroxide, Zinc Stearate and Octadecanoic Acid could be released to air from the NFPO. The primary airborne emission sources at the facility include:

- Uranium dioxide (UO_2) from Dust Collectors, a Rotoclone and Sintering Furnace Exhaust;
- Particulate matter from Sintering Furnace Exhausts, Dust Collectors, a Rotoclone, and Sintering Furnace Cooling Towers;
- Zinc stearate, zinc hydroxide and octadecanoic acid from Sintering Furnace Exhausts;
- Hydrogen from a Pressurized Hydrogen Storage Tank Vent; and
- Nitrogen oxides (NO_x) emissions from the Dryers' Exhaust (Northern Applied Sciences Inc. 2022a)

The NFPO has licence release limits for uranium and has established facility specific CNSC approved *Action Levels* for uranium. BWXT NEC has also established *Internal Control Levels* for uranium that are set even lower than Action Levels to act as an early warning system. *Internal Control Level* exceedances trigger an internal investigation and corrective actions; however, they are not CNSC reportable events.

The Environmental Protection Act of Ontario (R.S.O. 1990, c. E. 19) and Ontario Regulation 419/05 *Air Pollution – Local Air Quality Regulation* also determine permitted concentrations of contaminant releases, as published in in the MECP publication *Air Contaminants Benchmarks List (ACB List): standards, guidelines and screening levels for assessing point of impingement concentrations of air contaminants* (MOECC 2018a).

To assess the airborne emissions of non-radiological COPCs from the NFPO, emission estimates, based on measurements, engineering calculations and emission factors, and modelling of airborne emissions conducted in support of the facility's Emissions Summary and Dispersion Modelling Report (ESDM Report) (Northern Applied Sciences Inc. 2022a) were used. For each contaminant, the ESDM includes a determination of negligibility, and, if required, calculation of the maximum Point of Impingement (POI) concentrations for the averaging periods (10-minute, ½-hour, 24-hour or one year) for which standards exist. The calculations are based on the operating conditions, including start-up and shut-down, where all significant sources are operating simultaneously at their individual maximum rates of production. The maximum emission rates for each significant contaminant emitted from the significant sources were calculated in accordance with section 11 of O.Reg. 419/05.

Prior to modelling, contaminants with MECP Limits were screened by Northern Applied Sciences Inc. for significance using the "Emissions Threshold" analysis method as documented in section 7.1.2 of the MECP publication *Guideline A-10: Procedure for Preparing an Emission Summary and Dispersion Modeling (ESDM) Report* (MOECC 2018b). Any emission below the following threshold was screened out as negligible:

Emission Threshold (g/s) = [0.5 x MECP POI Limit] / [Dispersion Factor]

All air contaminants except particulate matter were out as negligible; however, uranium was still carried through for analysis in the ESDM.

The estimated maximum POI concentrations for the significant contaminant (total suspended matter) as well as uranium are presented in Table 3-3, along with applicable standards. As shown in Table 3-4, all non-radiological substances are below CNSC licence limits, the NFPO Action Levels and MECP POI limits.

Table 3-3 Air Quality Screening – Human Health Risk

Contaminant	Total Facility Emission Rate (g/s)	Averaging Period (hours)	Air Dispersion Model Used	Maximum Ground Level Concentration (µ/m³)	Screening Criteria (µ/m³)	Limiting Effect	% of Criteria	Carried Forward to Tier 2 Assessment
Uranium and uranium compounds	4.81E-06	Annual	AERMOD	0.00074	0.03 (U in PM_{10}) (1)	Health	2%	No
	4.81E-06	Annual	AERMOD	0.00074	0.15 (U in PM_{10}) (2)	-	0.5%	No
	4.81E-06	24-h	AERMOD	0.0032	1.5 (U in PM_{10}) (3)	-	0.2%	No
Total Suspended Particulate Matter (PM)	0.0318	24-h	AERMOD	15.9	120	Visibility	13%	No

Notes: 1: ACB Standard (MOECC 2018a).

2: Annual Assessment Value (AAV), which represents the maximum yearly POI concentrations based on the maximum daily emission rate maintained over a whole year (i.e., peak operations for an entire year) (MOECC 2018a).

3: Daily Assessment Value (DAV), which represents the maximum daily exposure possible based on the maximum daily emission rate (i.e., highest POI concentrations that could result over a day with the worst weather condition) (MOECC 2018a).

24-hour maximum uranium boundary concentration measurements (i.e., environmental samples) are below the *Action Level* of 0.08 µg/m³ and well below the MECP ambient air quality criteria of 0.3 µg (U in TSP)/m³ for a 24-hour averaging period as well as below the annual ambient air quality criteria of 0.06 µg (U in TSP)/m³ average of (MECP 2020).

All concentrations are well below CNSC licence limits, BWXT NEC *Action Levels,* BWXT NEC *Internal Control Levels* and MECP Benchmarks limits, and are therefore negligible, and not assessed further. CNSC IEMP environmental air sampling (see Appendix A) confirms that uranium are very low (<5% of applicable standards). Therefore, no non-radiological airborne substances have been identified as COPCs for further assessment in the HHRA.

3.3.3 Surface Water

There are no surface waters present in the vicinity of the NFPO operations and limited liquid effluent from the facility, therefore no measurable effects on surface water and sediment components are expected. Uranium is the key contaminants in NFPO effluent which discharges to sewer. For discharges to sewer, after passing through the municipal wastewater treatment plant, concentrations of uranium and other parameters are well below drinking water quality guidelines and standards.

Therefore, no non-radiological waterborne substances have been identified as COPCs for further assessment.

Uranium is the key COPC in the NFPO effluent. Facility releases are diluted within the plant sewer system by wastewater from other non-production activities at the NFPO prior to discharge to the municipal sewer. In-plant dilutions factors vary day-to-day but typically range between 4:1 to about 12:1 with an annual average of 8:1 (Trinity Consultants 2020a).

There are no surface waters present in the vicinity of the NFPO and limited liquid effluent from the facility. Therefore, no measurable effects on surface water and sediment components are expected. Interactions are not expected between NFPO activities and municipal drinking water quality. Therefore, no measurable effects on drinking water quality are anticipated. However, as effluent is discharged to the municipal sewer system and ultimately to the natural environment, screening of non-radiological contaminants in this effluent was conducted based on the comparison of effluent concentrations against appropriate screening criteria.

Neither the Toronto Sanitary and Combined Sewers Discharge By-law nor the CCME Model Sewer Use Bylaw (Marbek Resources Canada Ltd. 2009) specify limits for uranium compounds. For purposes of screening, effluent discharges were therefore screened against licence and internal limits as well as drinking water quality standards.

The maximum detected uranium discharge from a holding tank of 2.95 mg/L is below both the individual batch (6 mg/L) and annual (3 mg/L) *Action Levels* and the batch (3 mg/L) *Internal Control Level* but above the drinking water criteria of 0.02 mg/L. The dilution of approximately 150 that is required to achieve the drinking water criteria is more than expected through dilution in the municipal combined sanitary/storm sewer treatment system, removal in the municipal wastewater treatment plant, dilution in the lake, and treatment in the municipal water treatment plants prior to use in Toronto's drinking water system. The Canadian drinking water MAC is based on chemical effects on the liver and not radioactive effects as uranium is only weakly radioactive. As uranium is rapidly eliminated from the body and kidney effects may be rapidly reversible after exposure, health effects are not expected from water emissions from the Toronto facility. As discussed in section 3.2.2, uranium in wastewater effluent does not present a human health risk due to extremely low concentrations that would exist in receiving waters. Uranium in water is therefore screened out and not assessed further.

Parameters other than uranium which are monitored semi-annually were screened against available sewer use by-law limits and drinking water standards. Parameters which were monitored but never detected in wastewater were considered negligible (see Table 2-16 and Table 2-18). Parameters sampled but with no limits (see Table 2-15 and Table 2-17) were also not assessed as these substances, when present, are at very low concentrations (e.g, phenanthrene).

It is noted that the general public has no direct access to sewer discharges and that significant additional dilution (approximately 40,000 times) is expected in transit to and within the sewage treatment plant with further significant dilution expected when effluent from the municipal sewage treatment plant is discharged to Lake Ontario and further treatment in the City of Toronto water treatment plant prior to potential use as drinking water. Therefore, direct comparison of NFPO holding tank discharges and combined sewer effluent to drinking water quality criteria is extremely conservative. It is worth noting that there is no requirement for holding tank discharges or combined sewer effluent to meet drinking water criteria. The comparison is made to demonstrate the low levels of contaminants in undiluted holding tank effluent to sewer and sewer effluent and to provide a very conservative assessment of effluent quality relative to human health risks.

Table 3-4 summarizes holding tank effluent monitoring data for the 2017 to 2021 period and combined sewer effluent for 2022 for parameters measured at above detection limits for which criteria exist. Any parameters in the Table that were below the applicable drinking water criteria, or sewer use by-law criteria where drinking water criteria do not exist were screened out and not assessed further as criteria are met, not accounting for the substantial dilution following discharge to the municipal sewer system.

Only biochemical oxygen demand (BOD), nonylphenol ethoxylate (total) and phenols exceed sewer use by-law limits in holding tank discharges but not in the combined sewer discharge. BOD is not an issue as the City of Toronto wastewater treatment plants are designed for BOD removal. Nonylphenol ethoxylate (total) in holding tank effluent exceeded the sewer use limit only when the detection limit was above the by-law limit. Any holding tank samples of nonylphenol ethoxylate (total) with detection limits lower than the by-law limits were alll below the by-law limit, suggesting that “exceedances” are not true exceedances but artifacts of detection limit issues due to the laboratory diluting the sample as a result of sample foaming (Trinity Consultants 2019b). In previous discussions with BWXT NEC, the City of Toronto reportedyl accepted that the process samples are subject to a further dilution of between 4:1 and 12:1, and having an annual average dilution of 8:1 (Trinity Consultants 2017). Penols (with the exception of one holdinng tank sample, met without dilution, or would meet the sewer discharge limit at average dilutions), with 2022 combined sewer sampling confirming compliance with sewer effluent limits. As such, these contaminants were not carried forward for further assessed.

Table 3-4 Surface Water Screening – Human Health Risk

Parameter	Units	Sewer Use By-Law Criteria[1]	HC / Ontario Drinking Water Guidelines / Standard[2,7,8]	Maximum Undiluted Holding Tank Discharge[6]	Maximum In Combined Sewer Effluent 2022	Carried Forward to Tier 2 Assessment
Uranium	mg/L	6 mg/L Batch[5] 3 mg/L Annual[5]	0.02 / 0.02	2.95	N/AV	No
Biochemical Oxygen Demand (BOD)	mg/L	300	-	480	119	No
Total Kjeldahl Nitrogen (TKN)	mg/L	100	-	15	6.09	No
Total Animal/Vegetable Oil and Grease	mg/L	150	-	17	19.9	No
Total Oil & Grease Mineral/Synthetic	mg/L	15	-	1.6	< 5.0	No
Fluoride (F-)	mg/L	10	1.5	0.23	0.23	No
Total cyanide	mg/L	2	0.2	0.0039	<0.0020	No
pH	pH	6.0 to 11.5	7-10.5	6.9 – 7.9	7.52 – 7.66	No
Total Suspended Solids	mg/L	350	-	11	35.4	No
Nonylphenol Ethoxylate (Total)	mg/L	0.2	-	< 2.5 [(4)]	<0.002	No
Nonylphenol (Total)	mg/L	0.02		0.003	<0.002	No
Di-N-butyl phthalate	µg/L	80	-	45	<6.6	No
Bis(2-ethylhexyl)phthalate	µg/L	12	-	10	<4	No
Phenols-4AAP	mg/L	1.0	-	9.8	0.211	No
Chloroform	µg/L	40	0.1[#]	30	15.7	No
Total Aluminum (Al)	mg/L	50	2.9	1.0	0.75	No
Total Chromium, Hexavalent (Cr VI)	µg/L	2000	50 / 50	1.1	<0.00050	No
Total Cobalt (Co)	mg/L	5	-	<0.0010	0.00110	No
Total Copper (Cu)	mg/L	2	2	0.2	0.234	No
Total Lead (Pb)	mg/L	1	0.005 / 0.010	<0.01	0.00589	No
Total Manganese (Mn)	mg/L	5	0.12	0.009	0.0115	No
Total Molybdenum (Mo)	mg/L	5	-	0.86	0.156	No
Total Nickel (Ni)	mg/L	2	0.07 (WHO)[3]	0.009	0.0104	No
Total Phosphorus (P)	mg/L	10	-	0.52	0.245	No
Total Zinc (Zn)	mg/L	2	≤5.0 (AO)	0.18	0.0972	No

Notes: 1 Toronto Sanitary and Combined Sewers Discharge Guidelines. Referenced to the Chapter 681, - = no limit
2 Health Canada (2022) Maximum Acceptable Concentration (MAC) unless otherwise stated. AO = Aesthetic Objective; # = MAC for trihalomethanes; - = no guidelines established
3. WHO (2017)
4 Reportable Detection Limit (RDL) exceeds criteria
5. Action Levels
6. Holding tank discharges for the 2017 to 2021 period. Highest value above detection limits reported, unless detection limit was maximum value.
=Above Sewer Use By-law = Above Drinking Water Criteria
7. Ontario Regulation 169/03, Ontario Drinking Water Quality Standards. If a standard exists, it is included after the "/" mark
8 There is no requirement for holding tank discharges to meet drinking water criteria. The comparison is made to demonstrate the low levels of contaminants in undiluted holding tank effluent to sewer and to provide a very conservative assessment of effluent quality relative to human health risks.

In the undiluted discharge from the holding tanks, three parameters exceed drinking water limits: uranium; chloroform; and, total lead. Total lead in holding tank discharges exceeded the Health Canada drinking water standard as the detection limit was above the Health Canada, but not the Ontario drinking water standard. With typical dilution (dilutions of 4 to 12) from other plant wastewater, total lead would meet drinking water standards. Combined sewer sample results for 2022 which had lower dectections limits showed total lead concentrations well below both Health Canada and Ontario drinking water standards. Lead was therefore screened out for further assessment.

Trihalomethanes, (with chloroform usually found in the highest concentrations) are the most important group of compounds created during chlorination of drinking water. There are no processes at the Toronto facility which would be expected to generate trihalomethanes. Any chloroform in sewer discharges are likely a residual of the City of Toronto chlorination of drinking water. As such, chloroform was therefore screened out for further assessment.

Therefore, no non-radiological waterborne substances have been identified as COPCs for further assessment in the HHRA.

3.4 Assessment of Physical Stressors

Noise was identified as a potential physical stressor for human health. The NFPO operations comply with MECP NPC-300 noise criteria. Therefore, it is expected that noise levels from the proposed facility will pose no adverse effects to human health.

Noise is the only physical stressor to be considered for the HHRA, consistent with CSA N288.6:12.

3.4.1 Screening Criteria

The criteria specified in the Ontario Ministry of the Environment, "Environmental Noise Guideline Stationary and Transportation Source – Approval and Planning" Publication NPC-300 (MOE 2013b) are used for the noise assessment:

3.4.2 Noise

An Acoustic Assessment Report (AAR) prepared by Northern Applied Sciences Inc. (2022c) estimates that the steady state sound levels at the identified sensitive receptors (Points of Reception) near the Facility comply with the NPC-300 criteria of 50 dBA. for the 7 a.m. to 11 p.m. period and 45 dBA at the plane of window of noise sensitive spaces for the 11 p.m. to 7 a.m. period as applicable to an urban (Class 1) setting. PORs considered included two residences to the north of the Facility, two residences to the east of the Facility, two apartment buildings to the south of the Facility (multiple heights), and two proposed future multiresidential buildings (multiple heights) to the west of the Facility.

Noise modelling completed in support of the AAR shows that the noise level from the NFPO meet the MECP noise criteria. As such, it can be it can be concluded that the current noise levels from the facility pose no adverse effects to human health.

3.5 Risk Characterization

For the radiological emissions, direct gamma radiation and air emissions are the major pathways. The estimated doses are a small percentage of the screening dose limit. Therefore, no adverse radiological effects to human health are expected as a result of the consolidate operations, and additional assessment is required.

Non-radiological emissions are generally well below applicable screening criteria and pose no threat of adverse effects to human health. No additional assessment is required.

Noise levels from the NFPO are compliant with the NPC-300 for all locations and time periods. Therefore, the NFPO poses no adverse effects to human health.

The screening level risk assessment takes into account emissions to and concentrations in different applicable media including air and surface water and uses conservative estimates of emissions and effects criteria.

For the radiological emissions, direct gamma radiation and air emissions are the major pathways. Doses from water exposure are trivial due to the extremely small quantity of uranium released, its weak radiological properties and the absence of surface water in close proximity. Uranium in soil concentrations, with isolated marginal exceedances at non-residential locations, are generally at or below Ontario background soil concentrations. The maximum estimated annual effective dose to the general public as a result of direct gamma radiation and air releases from the NFPO occurred in 2019 and was estimated to be 23.5 µSv/y, representing 2.4% of the public dose limit (12% of screening dose limit), with 23 µSv attributable to direct gamma radiation. Therefore, no adverse radiological effects to human health are expected due to the NFPO and no additional assessment is required.

Non-radiological contaminants emitted to air and water as a result of operations are generally well below applicable screening criteria and pose no adverse effects to human health. No additional assessment is required.

For noise, the analysis of the modelling results shows that noise levels from the NFPO are compliant with the NPC-300 for all locations and time periods. Therefore, the NFPO poses no adverse effects to human health.

Therefore, the NFPO poses no adverse effects to human health.

3.6 Uncertainty Associated with the Human Health Risk Assessment

Uncertainty could be introduced into the risk assessment during the screening level assessment or risk characterization. This uncertainty can be minimized through the use of longer term data sets, along with the use of conservative assumptions to ensure that human health is protected. A qualitative analysis of the uncertainty associated with the HHRA is presented below.

The HHRA followed the process defined in N288.6:22 providing a level of assurance that the screening HHRA was completed in an acceptable manner.

There is uncertainty in the selection of the critical receptor and associated behaviours. Given that only a screening level risk assessment was necessary, detailed receptor characteristics were not required.

For the radiological risk assessment, site monitoring data were used along the CNSC accepted approach to calculating the derived release limit. Calculated doses to the general public using this CNSC approved approach have been consistent over a number of years, and are well below the regulatory dose limit.

The key non-radiological contaminant, uranium, is frequently monitored in air emissions and liquid effluent increasing the likelihood that the monitored results are representative of actual emissions and able to detect any adverse trends. The detection limits used are very low allowing for the detection of these contaminants in facility emissions. During the screening process, to be conservative, the maximum concentrations of uranium detected over a number of years were compared against a range of screening criteria accepted by the CNSC or published by reputable agencies. Further, monitoring results were well below screening criteria, providing additional confidence that the screening criteria are not exceeded. These conservatisms built into the screening process helps ensure that the conclusion of the screening assessment is valid, with a high level of confidence.

For other non-radiological air emissions, the calculations are based on the operating conditions, including start-up and shut-down, where all significant sources are operating simultaneously at their individual maximum rates of production. The maximum emission rates for each significant contaminant emitted from the significant sources were calculated in accordance with s. 11 of O. Reg. 419/05. Therefore, these emission rates are not likely to underestimate the actual emission rates. Further, screening criteria established by the MECP for its environmental compliance approval process on the basis of scientific review and analysis were used.

There is uncertainty in the AERMOD model used to predict atmospheric dispersion of air releases. These include uncertainty in modelling building-induced turbulence on the effective release height and plume spread and the use of a given meteorological dataset. In general air dispersion models can vary by a factor of two. The air assessment was completed using a methodology established and a model approved by the MECP, based on criteria established by the MECP, and reviewed by the MECP through the environmental compliance approvals process. The conservatisms built into the screening process helps ensure that the conclusion of the screening assessment is valid, with a high level of confidence.

There is uncertainty in both the noise measurements and the modelling. Sound level monitoring units generally have a measurement error of within +/- 1 dBA. For noise modelling, uncertainty arises in the assessment of source sound levels in the noise modelling of sound propagation. The noise assessment was completed using a methodology established and a model approved by the MECP, based on criteria established by the MECP, and reviewed by the MECP through the environmental compliance approvals processTherefore, it is expected that the uncertainty associated with the noise levels has no impact on the conclusions.

In summary, the assessment method and the conservative assumptions used for the HHRA ensure that the actual risks are not underestimated. Therefore, the uncertainty associated with the assessment has no impact on the conclusions of the HHRA.

4 Ecological Risk Assessment

The prime hazards to the environment from the NFPO operations are uranium and gamma radiation through emissions to air and water.

Pathways for ecological exposure considered include:

- *Air inhalation/skin absorption;*
- *Air immersion (external exposure).*
- *Soil deposition gamma and beta ground shine; and*
- *Soil ingestion and resuspension inhalation*

Tier 1 screening did not identify any radiological or non-radiological COPCs requiring preliminary quantitative or detailed quantitative risk assessment, consequently detailed receptor characterization was not required.

Potential physical stressors to biota include heat, road kill, bird strikes, heat, noise or artificial lighting.

4.1 Problem Formulation

As noted in Section 3.1, Problem formulation is a step undertaken early in the ERA process to constrain and focus the ERA on the key questions. The following discussion describes the approach taken to focus the EcoRA.

4.1.1 Receptor (Valued Component) Selection and Characterization

Valued Components identified include:

- *Doses to non-humans;*
- *Soil invertebrates.*
- *Terrestrial vegetation; and*
- *Mammals and birds.*

However, because the Tier 1 screening did not identify any radiological or non-radiological COPCs requiring preliminary quantitative or detailed quantitative risk assessment, detailed receptor characterization was not required.

4.1.1.1 Receptor Selection

It is not practical to assess the radiological or non-radiological dose to each species residing in the vicinity of the NFPO. For the purpose of the ecological risk assessment (EcoRA), Valued Components (VCs) were chosen for assessment.

VCs, as defined by the Impact Assessment Agency of Canada, refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous peoples or the public. The value of a component may be determined on the basis of cultural ideals or scientific concern (CEAA 2018). Examples of VCs are provincially significant wetlands, fish habitat, species (flora and fauna), and significant landscapes.

Selection of ecological VCs is based on knowledge of the site and surrounding areas ecology and habitats. In addition, VCs are also selected to be representative of different guilds that could be found on the site and surrounding areas.

Three potential sub-components were identified as part of the terrestrial environment: terrestrial vegetation (species and communities); and wildlife (species and community) and wildlife habitat. In order to capture changes in these sub-components, a total of six measurable indicators were chosen:

- Soil invertebrates, as represented by earthworms;
- Vegetation as represented by grass (contamination levels);
- Insectivorous birds as represented by the American Robin;
- Herbivorous birds as represented by the American Robin
- Small mammalian omnivores as represented by the Deer Mouse; and
- Small mammalian herbivores as represented by the Shrew.

The American Robin relies on seeds and vegetation for a portion of the year and on insects for a different portion of the year, and therefore can be a surrogate for both insectivorous and herbivorous avian species. Potential sub-components associated with the aquatic environment were not considered as there is no aquatic environment present on or near the site.

Table 4-1 identifies the VCs applicable to the NFPO and provides a rationale for the selection of these VCs.

Table 4-1 Valued Components

Environmental Components	Sub-components	VCs	Indicator/Receptors	Rationale
Radiation and Radioactivity	Radiation	Doses to non-humans	• Non-human biota as identified by Terrestrial Environment	• Non-human biota are potentially exposed to stressors produced by the NFPO • Protection of ecological health
Terrestrial Environment	Soil Quality	Soil invertebrates	• Earthworm	• Protection of ecological health
	Vegetation Communities and Species	Terrestrial Vegetation	• Grass	• Protection of ecological health
	Wildlife Communities and Species	Mammals & birds	• Deer Mouse (omnivore mostly insects) • Shrew (herbivore) • American Robin (insectivore and herbivore)	• Terrestrial species are potentially exposed to stressors produced by the NFPO • Protection of ecological health

4.1.1.2 Receptor Characterization

As discussed in Sections 4.2 to 4.4, as the Tier 1 screening did not identify any radiological or non-radiological COPCs requiring preliminary quantitative or detailed quantitative risk assessment, detailed ecological receptor characterization was not required.

4.1.2 Assessment and Measurement Endpoints

Assessment endpoints are directly related to management goals but are usually stated in terms of an attribute of populations or communities. When it is not practical to quantify those attributes, measurements endpoints representing more readily measured or predicted surrogates are used (CSA 2022). The assessment endpoint for each VC in this EcoRA is either population success or contaminant level, as shown in Table 4-2.

Table 4-2 Assessment Endpoints for Indicator Species

VC/ Indicator Species	Assessment Endpoint			
	Individual Success	Population Success	Community Success	Contaminant Level
Grass	-	-	-	✓
Earthworm	-	✓	-	-
Shrew	-	✓	-	-
Deer Mouse	-	✓	-	-
American Robin	-	✓	-	-

4.1.3 Selection of Chemical, Radiological, and Other Stressors

The key stressors to the environment from the NFPO operations are uranium and gamma radiation. Artificial night lighting and noise were identified as potential physical stressors.

Radiological and non-radiological stressors used in the EcoRA are identical to those used for the HHRA. Key stressors are uranium and gamma radiation.

CSA N288.6:22 also identifies heat, wildlife-vehicle/bird-structure mortalities, and intake cooling water withdrawal as the physical stressors applicable to ecological receptors. None of these stressors are relevant to the NFPO. Artificial night lighting and noise also have the potential to interact with receptors.

The tiered approach to EcoRA, requires these contaminants to undergo a Tier 1 preliminary screening where conservative estimates of emissions and environmental concentrations are compared to screening criteria. The objective of this preliminary screening process is to identify COPCs which are those contaminants that have undergone preliminary screening and have been selected for evaluation in higher tiers of assessment.

4.1.4 Selection of Exposure Pathways

Pathways for ecological exposure considered include:

- *Air inhalation/skin absorption;*
- *Air immersion (external exposure).*
- *Soil deposition gamma and beta ground shine; and*
- *Soil ingestion and resuspension inhalation*

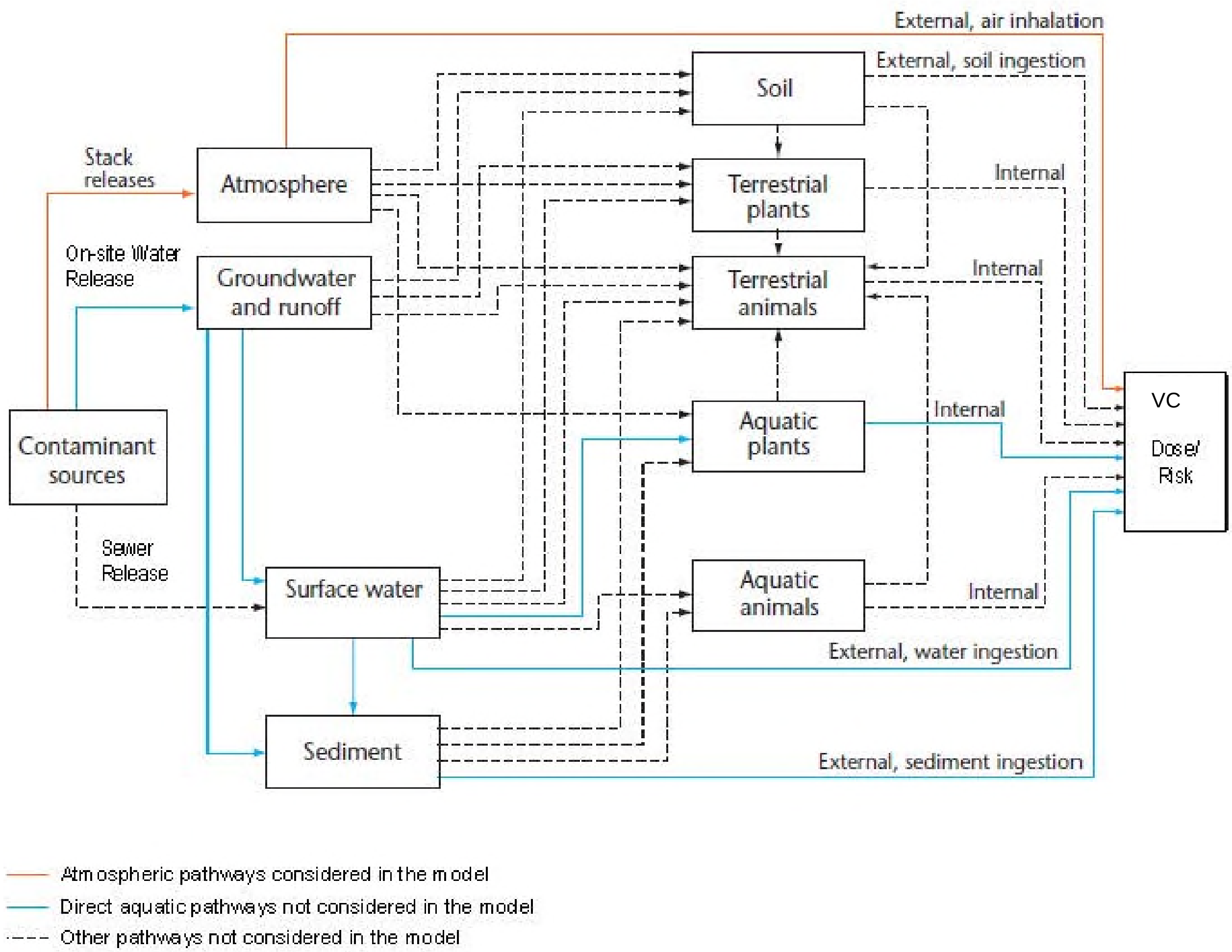
Radiological and non-radiological materials are released to the environment as a result of the NFPO. Consequently, this could result in the emissions to various media, potentially including air, surface water, soil, sediment, groundwater, and other media such as vegetation. VCs could be exposed to contamination through various pathways, as shown in Figure 4-1.

Of the pathways shown in Figure 4-1, the primary pathways for COPCs associated with the NFPO are:

- Air inhalation/skin absorption; and,
- Air immersion (external exposure).

Exposure through soils and terrestrial plant chain are not relevant due to the negligible amounts of uranium released to air and consequent negligible contribution to soil levels. This is confirmed through CNSC IEMP sampling (see Appendix A) which measured uranium concentrations around background in soil.

Exposures through surface waters and the aquatic food chain are not relevant due to the negligible amounts of uranium released to water (see Section 2.2.10) and the absence of any surface waters in the immediate area of the facility. Exposures through groundwater and surface runoff are not expected.



Source (Adopted from CSA 2022)

Figure 4-1 Sample Ecological Exposure Pathway Model

4.2 Assessment of Radiological Impact

Radiological materials expected to be released which may affect non-human biota include uranium to air and water and direct gamma radiation from the facility and internal exposure through soil and food.

Radiation (external and internal) exposure due to uranium emissions to air and water is negligible as the concentrations of uranium in air, soil and surface water associated with the operation of NFPO are negligible, consequently inhalation and soil ingestion are not expected to be of concern, nor are surface water pathways. Direct external exposure to gamma radiation is estimated to be well below levels that are known to cause adverse effects. Therefore, it can be concluded that no radiological effects to VCs are expected due to the NFPO and no further assessment is required.

Radiological materials are released to the environment by the NFPO. In this section, the impacts of radiological releases on non-human biota are assessed at the screening level (Tier 1) first. PQRA (Tier 2 assessment) and DQRA (Tier 3 assessments) is not required, based on the screening level review.

Radiological materials released include uranium to air and water. Direct gamma radiation from the facility and internal exposure through soil and food ingestion pathways is also a consideration. Exposure through water pathways is considered insignificant based on uranium being a low specific activity radionuclide which emits very low amounts of radiation as compared to other isotopes, the absence any surface waters in the immediate vicinity of the facility and the substantial dilution of uranium through the municipal sewer system and wastewater treatment plant in effluent prior to discharge to Lake Ontario

Uranium has both radiological and non-radiological effects. Uranium releases are also discussed in Section 4.3.

4.2.1 Radiation Benchmark

Currently, dose limits to non-human biota have not been set by the CNSC or other regulatory agencies in Canada (CSA, 2022). Radiological releases to air and water will be screened to identify COPCs. The following dose benchmark values, as recommended in CSA N288.6:22, are used in this assessment:

- 100 µGy/h for terrestrial biota, and;
- 400 µGy/h for aquatic biota.

In accordance with N288.6:22, risk to radiation will be quantified for each category based on the calculation of a hazard quotient (HQ) defined as:

$$HQ = \frac{Calculated\ radiation\ dose}{Radiological\ criteria\ (Benchmark)}$$

For radiological risk, the HQ is calculated based on the total dose received by each receptor from all radionuclides through all pathways. If the HQ for radiological exposure is less than one, then no adverse effects are likely as levels are below those that are known to cause adverse effects. If the HQ exceeds one, it may be inferred that adverse effects to individuals are possible. In general terms, an increase in exposure is associated with an increase in risk. As the magnitude of the HQ increases so does the potential for environmental effects. An HQ greater than1 indicates that there is the potential for adverse effects and further assessment is required.

4.2.2 Radiation Exposure to VCs

VCs could receive radiation doses from direct external exposure to gamma radiation from the NFPO and external and internal exposure through pathways such as air exposure.

The external dose rates at the boundary of the facility are routinely measured (see Section 2.2.10.1). As shown in Table 2-22 the annual gamma dose rate ranged from 0.08 µSy/h to 0.15 µSy/h, inclusive of background, over the 2017 to 2022 period. Measured total dose rates at the property boundary are similar to and of the same order of magnitude as background doses and are well below the benchmark of 100 µGy/h for terrestrial biota. These external exposures to radioactivity decrease with distance from the facility.

Radiation (external and internal) exposure due to uranium emissions are trivial as only between 6.28 to 8.2 g per year have been emitted from the NFPO over the 2017 to 2020 period. Measured airborne concentrations of uranium in the environment were also very low, with a maximum value of 0.008 µg U/m^3. Further, as per CSA N288.6:22, Clause 7.3.4.2.5, “inhalation exposures to biota are usually minor compared to soil and food ingestion pathways and can be ignored in most EcoRAs. For particulate substances released to air and accumulating over time in the soil, the steady state concentration is usually high enough that soil and food components of dose are dominant”. As discussed in Section 2.2.10.1, uranium in soil concentrations are at or below the Ontario background level of 2.5 µg U/g dry weight. Therefore, exposure of VCs to facility emissions through direct inhalation and soil ingestion are not of concern.

As a result, direct external exposure to gamma radiation is the only pathway for radiation exposure to VCs. The resulting HQ of approximately 0.0015 (assuming continuous exposure at the maximum gamma radiation level measured) is well below one, the value at which no adverse effects are likely as levels are below those that are known to cause adverse effects.

Therefore, it can be concluded that there are no radiological effects to VCs due to the NFPO and no further assessment is required.

4.3 Assessment of Non-Radiological Impact

No non-radiological airborne or waterborne substances have been identified as COPCs for further assessment in the EcoRA.

Non-radiological releases to the environment occur from the NFPO. In this section, the impacts of non-radiological contaminants on VCs are assessed at the screening level (Tier 1) first. Based on the results of the screening level assessment, PQRA (Tier 2 assessment) and DQRA (Tier 3 assessments) are not required.

4.3.1 Screening Criteria

The non-radiological substances in air were screened to identify COPCs. CSA N288.6:22, Clause 7.2.5.3.1, indicates that "For non-radiological COPCs, the most restrictive applicable federal or provincial guidelines for environmental quality should be used as screening criteria, if such guidelines are available, because their values are intended to be protective of all or most organisms in the media to which they apply."

Non-radiological airborne emissions considered included uranium, particulate matter, hydrogen, nitrogen oxides, zinc hydroxide, zinc stearate and octadecanoic acid. All but particulate matter had modelled air concentrations which were screened out as negligible. Particulate matter had a modelled air concentration of 13% of the screening criterion and uranium had a modelled air concentration of 2% or less of the screening criteria. Furthermore, non-radiological substances with CNSC licence limits, BWXT NEC Action Levels, BWXT NEC Internal Control Levels were well below these limits and are therefore expected to be negligible.

Therefore, no non-radiological airborne substances have been identified as COPCs for further assessment in the EcoRA.

4.3.2 Air

As per CSA N288.6:22, Clause 7.3.4.2.5, "inhalation exposures are usually minor relative to soil and food ingestion pathways and can be ignored in most EcoRAs. For particulate sustances released to air and accumulating over time in the soil, the steady state concentration is usually high enough that soil and food components of dose are dominant." Some gaseous substances [e.g. nitrogen oxides (NO_x)] that do not partition well to soil might need to be addressed. These substances are usually addressed relative to air concentration benchmarks, without calculating dose. Under current conditions nitrogen oxides (NO_x) are emitted only from the combustion equipment at the site (natural gas fired boilers and hot water heater).

Environmental air monitoring of non-radiological substances, other than uranium, is not completed by the NFPO. As such, airborne concentrations predicted in the NFPO's ESDM (See Section 3.3) were used to screen on-radiological substances, such as Uranium, Particulate Matter (PM), hydrogen and other miscellaneous contaminants that could be released to air as the result of operations. The only contaminant not screened out as insignificant was total particulate.

As discussed in Section 3.3, the maximum POI concentrations modelled for contaminants emitted by the NFPO are below limits published in the MECP publication *Air Contaminants Benchmarks List: standards, guidelines and screening levels for assessing point of impingement concentrations of air contaminants* (MOECC 2018a), and are not likely to have potential effects on ecological receptors located on site. BWXT NEC and CNSC IEMP environmental air sampling (see Appendix A) confirms that uranium concentrations are very low (<5% of applicable standards).

Further, per CSA N288.6:22, soil and food components are dominant pathways sources for uranium. As discussed in Section 2.2.10.2, uranium in soil concentrations are at or below the Ontario background level of 2.5 µg U/g dry weight. Therefore, exposure of VCs to uranium through soil ingestion is insignificant.

Therefore, no non-radiological airborne substances have been identified as COPCs for further assessment.

4.3.3 Water

Non-radiological waterborne emissions considered included uranium, fluoride, pH, nickel. Based on conservative screening criteria, all waterborne emissions from the NFPO operations were eliminated from further consideration.

Therefore, no non-radiological airborne substances have been identified as COPCs for further assessment in the EcoRA.

Environmental water quality monitoring of non-radiological substances is not completed by BWXT NEC as there are no surface waters in the immediate vicinity of the facility. Water discharges to sewer are routinely monitored. For screening purposes, holding tank water and combined sewer discharge concentrations were screened against the more stringent of:

- Ontario Environment and Energy (MOEE). 2004. Water Management: Policies, Guidelines, Provincial Water Quality Objectives. ISBN 0-7778-8473-9 rev; and
- Canadian Council of Ministers of the Environment (CCME). 2023. Canadian Environmental Quality Guidelines (for the Protection of Aquatic Life).

Where guidelines did not exist, holding tank effluent and combined sewer discharges were screened against water quality in Lake Ontario. Non-detected contaminants were screened out given the low detection limits used in effluent analysis.

The undiluted uranium holding tank effluent is discharged to the facility sewer system where it undergoes a dilution of between 4 and 12 times. This water is further diluted in the municipal sanitary/storm water system and effluent treatment plant approximately 40,000 times based on average daily flow to the Humber Wastewater Treatment Plant (WWTP) (City of Toronto 2022). On discharge from the Humber Wastewater Treatment Plant, the effluent is further diluted by Lake Ontario before exposure to aquatic life.

Comparing ecological criteria for the protection of aquatic life to undiluted holding tank effluent is therefore highly conservative. As such, contaminants were progressively screened in the following order: undiluted holding tank effluent concentrations; combined sewer concentrations; and WWTP diluted combined sewer effluent concentrations. Each screening level is progressively less restrictive, but still protective of aquatic life as concentrations are all prior to discharge into the environment.

Screening results are shown in Table 4-3 for each contaminant measured above detection levels at the maximum detected level over the 2017 to 2021 period in holding tank effluent or combine sewer effluent samples. Several conventional sewer use parameters were screened out using other criteria, as shown in Table 4-3.

Three contaminants (fluoride, pH and nickel) were screened out based on the most conservative screening of undiluted discharges meeting aquatic protection water quality criteria. Four additional contaminants (total hexavalent chrome, total cyanide, phenanthrene and Bis(2-ethylhexyl)phthalate) were screened out based of the slightly less conservative screening of combiend sewer efflient meeting aquatic protection water quality criteria or lake water quality objectives were crieteria do not exist. Thirteen additional contaminants (nonylphenol ethoxylate (total), nonlyphenol (total), di-N-butyl phthalate, phenols, aluminum, cobalt, copper, lead, manganese, molybdenum, phosphorus, uranium, and zinc) were screened out based on the less conservative screening of WWTP diluted discharges meeting aquatic protection water quality objectives or lake water quality objectives were standards do not exist. The maximum dilution required to meet aquatic protection water quality criteria is 590 for uranium versus the approximately 40,000-fold dilution available.

Conventional paramaters such as BOD, TSS, TKN are below typcial municipal WWTP influent and oil and grease are well within by-law limits. Therefore, screening on the basis of WWTP diluted discharges, prior to mixing in Lake Ontario is still highly conservation.

Therefore, no non-radiological waterborne substances have been identified as COPCs for further assessment.

4.4 Assessment of Physical Stressors

The NFPO facility is located in a highly urbanized area which limits the site-specific potential for physical stressors such as wildlife-vehicle/bird-structure mortalities, heat, noise or artificial lighting. As such, none of these stressors are particularly relevant to NFPO and no further assessment is required.

CSA N288.6:22 identifies heat, wildlife-vehicle/bird-structure mortalities, and intake cooling water withdrawal as the physical stressors applicable to ecological receptors. Artificial night lighting and noise also have the potential to interact with receptors.

For noise, the analysis of the modelling results shows that noise levels from the operation of the NFPO are compliant with the NPC-300 for all locations and time periods. The noise generated by the NFPO is common to other noise sources in the urban setting which must meet MECP noise limits and would have similar impacts on exposure to ecological receptors in the vicinity of the facility. Therefore, the NFPO poses no adverse noise effects.

Aritifical light from the facility is not substantively different than that of the surrounding urbanized environment.

The NFPO is located in a highly urbanized area which limits the site-specific potential for physical stressors (artificial night lighting or noise) to impact on VCs. As such, neither of these stressors are particularly relevant to the NFPO and no further assessment is required.

Table 4-3 Surface Water Screening – EcoRA

Parameter	Units	Maximum Concentration	*Provincial Water Quality Objective(1)*	*CCME Guidelines for Protection of Aquatic Life(2)*	Water Quality in Lake Ontario(3) (min, mean, max)	Carried Forward to Tier 2 Assessment
Undiluted Holding Tank Effluent Below Criteria						
Fluoride (F-)	mg/L	0.23		120 LT		No – Below Criteria
pH	pH	6.9 to 7.9	6.5 – 8.5	6.5 – 9.0		No – Meets Criteria
Total Nickel (Ni)	µg/L	7	25	25 to 150 LT hardness dependent	(0.6, 0.7, 1)	No – Below Criteria
Combined Sewer Effluent Below Criteria or Lake Water Quality when Criteria does not exist						
Total Chromium, Hexavalent (Cr VI)	µg/L	<0.50	1			No – Below criteria in combined sewer effluent
Total Cyanide (CN)	µg/L	3.9	5			No – Below criteria in combined sewer effluent
Phenanthrene	µg/L	0.0260		0.4 LT		No – Below criteria in combined sewer effluent
Bis(2-ethylhexyl)phthalate	µg/L	12		16 LT		No – Below criteria in combined sewer effluent
Combined Sewer Effluent Achieves Criteria or Lake Water Quality when Criteria does not exist with 40,000 x dilution in City of Toronto Wastewater Treatment Plant (WWTP)						
Nonylphenol Ethoxylate (Total)	µg/L	<2	-	1 LT		No – Well below criteria with WWTP dilution
Nonylphenol (Total)	µg/L	<2	0.04	1 LT		No – Well below criteria with WWTP dilution
Di-N-butyl phthalate	µg/L	<6.6	0.04	19		No – Meets Ontario criteria in sewer and well below CCME criteria with dilution in City WWTP
Phenols-4AAP	mg/L	0.211	0.001			No – Well below criteria with WWTP dilution
Chloroform	µg/L	30		1.8 LT		No – Likely a result of water supply to plant. No source of chloroform generation at NFPO. Well below criteria with WWTP dilution
Total Aluminum (Al)	µg/L	750	75 (clay-free sample)	100 (for pH ≥ 6.5)	(4.6, 100, 2800)	No – Well below criteria with WWTP dilution
Total Cobalt (Co)	µg/L	1.100	0.9			No – Well below criteria with WWTP dilution
Total Copper (Cu)	µg/L	28.4	1 – 5 i	2 to 4 LT hardness dependent	(0.9, 1, 1.5)	No – Well below criteria with WWTP dilution
Total Lead (Pb)	µg/L	6.5	1 – 3 i	1 to 7 LT hardness dependent	(0.05, 0.2, 2)	No – Well below criteria with WWTP dilution
Total Manganese (Mn)	µg/L	11.5			(0.5, 1, 3)	No – Well below criteria with WWTP dilution

Parameter	Units	Maximum Concentration	*Provincial Water Quality Objective[(1)]*	*CCME Guidelines for Protection of Aquatic Life[(2)]*	Water Quality in Lake Ontario[(3)] (min, mean, max)	Carried Forward to Tier 2 Assessment
Total Molybdenum (Mo)	µg/L	156	40	73 LT	(1.2, 1.3, 1.6)	No – Well below criteria with WWTP dilution
Total Phosphorus (P)	µg/L	245	10 – 30		(3.7, 5.8, 8.7)	No – Well below criteria with WWTP dilution
Total Uranium (U)	µg/L	2950	5	33 ST 15 LT	(3, 4, 6)	No – Well below criteria with WWTP dilution
Total Zinc (Zn)	µg/L	97.2	200 i	30 LT	(0.6, 2,4.9)	No – Well below criteria with WWTP dilution
Combined Sewer Effluent Criteria relative to City of Toronto Wastewater Treatment Plant (WWTP) Performance						
Biochemical Oxygen Demand (BOD)	mg/L	119				No – Below average BOD of 247.6 to 287.2 in City WWTP influent over 2017 to 2021 period (City of Toronto 2021)
Total Kjeldahl Nitrogen (TKN)	mg/L	6.09			(0.25, -, 0.25)	No – Below average TKN of 38.1 to 41.2 in City WWTP influent over 2017 to 2021 period (City of Toronto 2021)
Total Suspended Solids (TSS)	Mg/l	35.4			(1, 1.7, 6.3)	No – Below average TSS in City treatment plant influent of 280.8 to 366.2 over 2017 to 2021 period (City of Toronto 2021)
Total Animal/Vegetable Oil and Grease	mg/L	19.9				No – Approximately 13% of sewer use by-law limit
Total Oil & Grease Mineral/Synthetic	mg/L	<5				No – Not detected in combined sewer effluent, with detection limit at 30% of sewer use by-law limit

Notes: 1 Source: (MOEE 2004). Values set for protection of aquatic life. "i" = interim value
2 Source: (CCME 2023). LT – Long Term; ST = Short Term
3. Source: (SENES 2009). Regional (Lake Ontario) Background Concentrations

4.5 Risk Characterization

The estimated radiological doses to non-human biota are estimated to be at or marginally above background. Potential non-radiological contaminants are estimated to be well below applicable screening criteria and pose no adverse effects to the environment.

No physical stressors to non-human biota were identified.

The screening level risk assessment takes into account emissions to and concentration in different applicable media including air and surface water and uses conservative estimates of emissions and effects criteria.

For the radiological emissions, gamma dose rates at the fenceline are at or marginally above background. Doses from water exposure are trivial due to the extremely small quantity of uranium released. Radiation (external and internal) exposure due to uranium emissions are trivial as only between 6.28 to 8.2 g of uranium per year have been emitted from the NFPO over the 2017 to 2020 period. As a result, direct external exposure to gamma radiation is the only pathway for radiation exposure to VCs. The resulting HQ of approximately 0.0015 (assuming continuous exposure at the maximum gamma radiation level measured, inclusive of background) is well below one, the value at which no adverse effects are likely as levels are below those that are known to cause adverse effects. Therefore, it can be concluded that there are no radiological effects to VCs due to the NFPO and no further assessment is required.

Non-radiological contaminants emitted to air and water as a result of the NFPO are well below applicable screening criteria and pose no adverse effects to the environment. No additional assessment is required.

For noise, the analysis of the modelling results shows that noise levels from the operation of the NFPO are compliant with the NPC-300 for all locations and time periods. The noise generated by the NFPO is common to other noise sources in the urban setting which must meet MECP noise limits and would have similar impacts on exposure to ecological receptors in the vicinity of the facility. Therefore, the NFPO poses no adverse noise effects.

The NFPO is located in a highly urbanized area which limits the site-specific potential for physical stressors (artificial night lighting or noise) to impact on VCs. As such, neither of these stressors are particularly relevant to the NFPO and no further assessment is required.

4.6 Uncertainty Associated with Ecological Risk Assessment

Uncertainty could be introduced into the risk assessment during the screening level assessment or risk characterization. This uncertainty can be minimized through the use of longer term data sets, along with the use of conservative assumptions to ensure that human health is protected. A qualitative analysis of the uncertainty associated with the EcoRA is presented below.

The EcoRA followed the process defined in N288.6:22 providing a level of assurance that the screening EcoRA was completed in an acceptable manner.

The key non-radiological contaminant, uranium, is frequently monitored in air emissions and liquid effluent increasing the likelihood that monitoring results are representative of actual emissions and able to detect any adverse trends. Detection limits used are very low allowing for the detection of these contaminants in facility emissions. For both the radiological and non-radiological EcoRA, long term site monitoring data were used.

For other non-radiological air emissions, the calculations are based on the operating conditions, including start-up and shut-down, where all significant sources are operating simultaneously at their individual maximum rates of production. The maximum emission rates for each significant contaminant emitted from the significant sources were calculated in accordance with s. 11 of O. Reg. 419/05. Therefore, these emission rates are not likely to underestimate the actual emission rates. Further, screening criteria established by the MECP for its environmental compliance approval process on the basis of scientific review and analysis were used. Conservatively, all emissions from the Toronto facility, including non-radiological operations not related to BWXT NEC were used in the screening process. The air assessment was completed using a methodology established and a model approved by the MECP, based on criteria established by the MECP, and reviewed by the MECP through the environmental compliance approvals process. The conservatisms built into the screening process helps ensure that the conclusion of the screening assessment is valid, with a high level of confidence.

Both uranium in ambient air and soil and boundary gamma radiation monitoring data are frequently monitored. Environmental concentrations of uranium in air and soil are very low allowing for a wide margin of safety in the screening process. MECP surface water monitoring data confirm that environmental uranium concentrations are low. Additional information on environmental uranium in air and soil concentrations is provided through the CNSC IEMP program which confirms BWXT NEC ambient air and soil monitoring results.

During the screening process, to be conservative, the maximum concentrations of uranium and maximum monitored boundary gamma radiation levels detected over a number of years were compared against a range of screening criteria published by reputable agencies, and, in the case of the radiation risk assessment, N288.6:22 recommended benchmark criteria. Further, monitoring results were well below screening criteria, providing additional confidence that the screening criteria are not exceeded. These conservatisms built into the screening process helps ensure that the conclusion of the screening assessment is valid, with a high level of confidence.

There is some uncertainty in the selection of critical human receptors, VCs and exposure pathways assumed. Given the very low levels of emissions, screening was undertaken based on abiotic concentrations, negating any uncertainty in the selection of VC and exposure pathways assumed.

In summary, the assessment method and the conservative assumptions used for the EcoRA ensure that the actual risks are not underestimated.

5 Conclusions And Recommendations

5.1 Conclusions

Overall, emissions associated from the NFPPO and associated risks are low.

5.1.1 Human Health Risk Assessment

5.1.1.1 Radiological Exposure

The screening level HHRA concluded that emissions of radioactive materials from the facility were very low and that the maximum estimated annual effective dose as a result of air releases and direct gamma radiation from the facility is negligible at 23.5 µSv/y or 12% of the screening dose criteria of 200 µSv/y. Exposure to water releases are also estimated to be trivial. Based on the screening level risk assessment, it is concluded that emissions of radiological materials from the NFPO pose no adverse effects to human health. Further assessment of the impact of radiological materials on human health is not required.

5.1.1.2 Non-Radiological Exposure

The screening level HHRA concluded that air emissions of non-radioactive contaminants from the facility were below, and often substantially below, MECP Point of Impingement standards. Exposure to water releases is also estimated to be trivial based on the concentrations and quantities released compared to screening criteria. Based on the screening level risk assessment, it is concluded that emissions of non-radiological substances resulting from the BWXT NEC NFPO pose no adverse effects to human health. Further assessment of the impact of non-radiological contaminants on human health is not required.

5.1.1.3 Physical Stressors

Noise was the only physical stressor requiring consideration. The screening level HHRA concluded that noise levels were below MECP established criteria. Based on the screening level risk assessment, it is concluded that noise emissions resulting from the NFPO pose no adverse effects to human health. Further assessment of the impact of non-radiological contaminants on human health is not required.

5.1.2 Ecological Risk Assessment

5.1.2.1 Radiological Exposure

The screening level EcoRA concluded that emissions of radioactive materials from the facility resulted in exposure to non-human biota well below the benchmark criteria of 100 µG/h for terrestrial biota. Based on the screening level risk assessment, it is concluded that emissions of radiological materials from the NFPO pose no adverse effects to non-human biota. Further assessment of the impact of radiological materials on non-human biota is not required.

5.1.2.2 Non-Radiological Exposure

The screening level EcoRA concluded that emissions of non-radioactive contaminants from the facility were below, and often substantially below, MECP Point of Impingement standards. Exposure to water releases is also estimated to be trivial based on the concentrations and quantities released. Based on the screening level risk assessment, it is concluded that emissions of non-radiological substances from the NFPO pose no adverse effects to non-human biota. Further assessment of the impact of non-radiological contaminants on non-human biota is not required.

5.1.2.3 Physical Stressors

The NFPO is located in a highly urbanized area which limits the site-specific potential for physical stressors (artificial night lighting or noise) to impact on VCs. The screening level EcoRA concluded that the NFPO poses no physical stressors on VCs. Further assessment of the impact of physical stressors on VCs is not required.

5.2 Recommendations for the Monitoring Program

Based on the results of the HHRA and EcoRA, the following change to the effluent and environmental monitoring program is recommended:

1. Incorporate uranium sampling in semi-annual combined sewer effluent sampling.

5.3 Risk Management Recommendations

Based on the results of the HHRA and EcoRA, there are no specific recommendations for changes in risk management practices.

6 Quality Assurance / Quality Control

The ERA was conducted by Arcadis Canada Inc. (Arcadis) in accordance with the requirements of Arcadis' Quality Management System. The Arcadis Quality Management System is ISO 9001 registered and the scope of the ISO 9001:2008 registration covers "environmental consulting services to the nuclear fuel cycle".

BWXT NEC collects emissions and environmental monitoring data in accordance with Toronto EHS documents in the EHS series, including:

- EHS-P-RPM-001 - Radiation Protection Manual (Toronto and Peterborough)
- EHS-P-E-1.0T - Air Monitoring
- EHS-P-E-2.0T - Wastewater Sampling
- EHS-P-E-6.0T - General Environmental
- EHS-WI-RPM-114T - Exhaust System Verifications
- EHS-WI-RPM-116T - Exhaust Air Sampling
- EHS-WI-RPM-117T - Liquid Effluent Sampling
- EHS-WI-RPM-118T - Boundary Radiation Monitoring
- EHS-WI-RPM-119T - Continuous Boundary Air Sampling
- EHS-WI-RPM-120T - Soil Sampling
- EHS-WI-RPM-121T - Radiation Instrumentation
- EHS-WI-RPM-122T - Radiation Instrumentation Calibration

BWXT NEC also operates these monitoring programs in accordance with the *Licensed Activity Quality Assurance Program* documentation (BMS series), including BMS-BP-004; BMS-P-001 to 016; BMS-P-41 BMS-P-42; and BMS-P-057.

All data used in the risk assessment has been submitted to and reviewed by regulatory agencies, including:

- BWXT NEC Annual Compliance Reports prepared in accordance with Canadian Nuclear Safety Commission's *Annual Compliance Monitoring and Operational Performance Reporting Requirements for Class 1 A & B Nuclear Facilities* and reviewed by the CNSC;
- Emission Summary and Dispersion Modelling Report (ESDM) reviewed by the MECP Approvals Branch;
- Acoustic Audit Report (AAR) reviewed by the MECP Approvals Branch.

Under the BWXT NEC NFPO Environmental Compliance Approval (Air) Number 5460-ACWHBS, both the ESDM and AAR must be kept up to date, with annual reports submitted to the MOECC.

Internal monitoring programs undergo QA/QC and comparative analysis including:

- in-house filter papers used for monitoring uranium stack emissions analyzed in-house are verified by an external independent laboratory by delayed neutron activation analysis;
- alpha counting results for uranium determination of water effluent samples are audited by laser fluorimetry or delayed neutron activation analysis;

- a weekly composite sample is prepared and sent for independent uranium analysis at an external laboratory to validate in-plant batch sampling; and
- wastewater holding tank discharges are sampled semi-annual by an environmental consulting firm and analyzed by an ISO/IES 17025 certified laboratory.

Independent monitoring by regulatory agencies provides additional information for confirming site monitoring programs. The Independent Environmental Monitoring Program (IEMP) completed by the CNSC provides an additional level of QA/QC through additional sampling of parameters monitored by the NFPO. The IEMP involves taking samples from public areas around the facilities and measuring and analyzing the amount of nuclear and hazardous substances in those samples. CNC staff collect the samples and send them to the CNSC's state-of-the-art laboratory for testing and analysis. The MECP has also completed uranium in soils analysis in the community surrounding the NFPO. Results of the IEMP and MECP sampling are consistent with facility monitoring program results.

7 References

BWXT NEC. 2018. *2017 Annual Compliance Report*.

BWXT NEC. 2019. *2018 Annual Compliance Report*.

BWXT NEC. 2020. *2019 Annual Compliance Report*.

BWXT NEC. 2021. *2020 Annual Compliance Report*.

BWXT NEC. 2022. *2021 Annual Compliance Report*.

Canadian Environmental Assessment Agency (CEAA). 2018. *Determining Whether a Designated Project is Likely to Cause Significant Adverse Environmental Effects under the Canadian Environmental Assessment Act, 2012 Interim Technical Guidance*. March 2018. Version 1. Catalogue Number: En106-154/2016E-PDF. ISBN: 978-0-660-06385-0

Canadian Council of Ministers of the Environment (CCME). 2023. Canadian Environmental Quality Guidelines. https://ccme.ca/en/summary-table.

Canadian Nuclear Safety Commission (CNSC). 2013a. *Uranium Levels in Soil Samples Around GE Hitachi Nuclear Energy Canada Inc., Toronto Facility*. October. PWGSC catalogue number CC172-102/2013E-PDF. ISBN 978-1-100-22841-9.

Canadian Nuclear Safety Commission (CNSC). 2013b. Fact Sheet – Natural Background Radiation.

Canadian Nuclear Safety Commission (CNSC). 2020. *REGDOC-2.9.1, Environmental Principles, Assessments and Protection Measures*. Version 1.2. September.

Canadian Nuclear Safety Commission (CNSC). 2022. Independent Environmental Monitoring Program: BWXT Nuclear Energy Canada Inc. -Toronto http://nuclearsafety.gc.ca/eng/resources/maps-of-nuclear-facilities/iemp/bwxt-toronto.cfm, Modified on December 12, 2022.

Canadian Standard Association (CSA). 2022. N288.6:22, *Environmental risk assessments at class I nuclear facilities and uranium mines and mills*.

City of Toronto. n.d. Citywide Zoning By-Law. Retrieved from: https://map.toronto.ca/maps/map.jsp?app=ZBL_CONSULT

City of Toronto. 2011. Birds of Toronto, *A Guide to Their Remarkable World. City of Toronto Biodiversity Series*. ISBN 978-1-895739-67—1.

City of Toronto. 2012. Mammals of Toronto, *A Guide to Their Remarkable World. City of Toronto Biodiversity Series*. ISBN 978-1-895739-65-7.

City of Toronto. 2022. Humber Wastewater Treatment Plant 2021 Annual Report. March 31.

Environment and Climate Change Canada (ECCC). 2022a. *Canadian Climate Normals 1981-2010 Station Data*. https://climate.weather.gc.ca/climate_normals/results_1981_2010_e.html?stnID=1839&autofwd=1. Last modified 2022-12-01.

Environment and Climate Change Canada (ECCC). 2022b. *Historical Data.* https://climate.weather.gc.ca/historical_data/search_historic_data_e.html Date modified: 2022-12-01.

Environment Canada and Agriculture and Agri-Food Canada. 1995. Ecological Framework of Canada - *Ecoregions of Canada: Manitoulin-Lake Simcoe.* http://www.ecozones.ca/english/region/135.html. Ecosystems Science Directorate of Environment Canada, and the Center for Land and Biological Resources Research, of Agriculture and Agri-Food Canada.

Health Canada. 2022. *Guidelines for Canadian Drinking Water Quality - Summary Tables.* Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario.

International Commission on Radiological Protection (ICRP) 2007. *The 2007 Recommendations of the International Commission on Radiological Protection*. Annals of the ICRP, ICRP Publication 103, Vol. 37, Nos. 2-4.

Marbek Resources Canada Ltd. 2009. Model Sewer Use Bylaw Guidance Document - Final. Submitted to: Canadian Council of Ministers of the Environment (CCME) February 3, 2009. PN 1421.

Northern Applied Sciences Inc. 2022a. Emission Summary & Dispersion Modelling (ESDM) Report BWXT Nuclear Energy Canada (Lansdowne Ave., Toronto). October.

Northern Applied Sciences Inc. 2022b. Spring 2022 Combined Sewer Sampling Results BWXT – Lansdowne Facility, 1025 Lansdowne Avenue, Toronto, ON NAPSCI Ref. 22-012-004. April 8, 2022.

Northern Applied Sciences Inc. 2022c. Fall 2022 Combined Sewer Sampling Results BWXT – Lansdowne Facility, 1025 Lansdowne Avenue, Toronto, ON NAPSCI Ref. 22-012-004. November 16, 2022.

Ontario Ministry of Agriculture, Food and Rural Affairs. 2011. Ontario Climate. April 7, 2011. Retrieved June 3, 2011.

Ontario Ministry of the Environment and Energy (MOEE) 2011. *Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated sites in Ontario*. April. Standards Development Branch.

Ontario Ministry of the Environment (MOE). 2013a. Technical Memorandum - Soil Survey in the Vicinity of GE-Hitachi, Toronto, Ontario 2013. September. Report No. Phyto-S3061-2013. PIBS 9546e.

Ontario Ministry of the Environment (MOE). 2013b. Environmental Noise Guideline Stationary and Transportation Source – Approval and Planning" Publication NPC-300. 16, August 2013.

Ontario Ministry of the Environment and Climate Change (MOECC). 2018a. *Air Contaminants Benchmarks List: standards, guidelines and screening levels for assessing point of impingement concentrations of air contaminants* https://www.ontario.ca/page/air-contaminants-benchmarks-list-standards-guidelines-and-screening-levels-assessing-point. Version 2.

Ontario Ministry of the Environment and Climate Change (MOECC). 2018b. *Guideline A-10: Procedure for Preparing an Emission Summary and Dispersion Modeling (ESDM) Report*. PIBs # 3614e04.1. version 4.1.

Ontario Ministry of the Environment, Conservation and Parks (MECP). 2020. *Ambient Air Quality Criteria*. Human Toxicology and Air Standards Section, Technical Assessment and Standards Development Branch.

Ontario Ministry of the Environment, Conservation and Parks (MECP). 2021a. Map: Well Records. https://www.ontario.ca/page/map-well-records, Updated October 18, 2021.

Ontario Ministry of the Environment, Conservation and Parks (MECP). 2021b. *Soil, ground water and sediment standards for use under Part XV.1 of the Environmental Protection Act. https://www.ontario.ca/page/soil-ground-water-and-sediment-standards-use-under-part-xv1-environmental-protection-act. Updated July 20, 2021.*

Ontario Ministry of the Environment, Conservation and Parks (MECP). 2022a. https://www.ontario.ca/page/map-provincial-groundwater-monitoring-network, Updated May 29, 2022.

Ontario Ministry of the Environment, Conservation and Parks (MECP). 2022b. https://www.ontario.ca/page/map-provincial-stream-water-quality-monitoring-network. Updated May 29, 2022.

Ontario Ministry of the Environment and Energy (MOEE). 1996. *Guidelines on Sampling and Analytical Methods for Use at Contaminated Sites in Ontario*.

Ontario Ministry of the Environment and Energy (MOEE). 1994. *Water management: policies, guidelines, provincial water quality objectives*. ISBN 0-7778-8473-9 rev. PIBS 3303E.

Ontario Ministry of the Environment and Energy (MOEE). 2004. Water Management: Policies, Guidelines, Provincial Water Quality Objectives. ISBN 0-7778-8473-9 rev.

Ontario Ministry of Natural Resources and Forestry (MNFR). n.d. The Tree Atlas. Available online at: https://www.ontario.ca/environment-and-energy/tree-atlas. Retrieved February 10, 2023.

.SENES Consultants Ltd. (SENES). 2009: Ecological Risk Assessment and Assessment of Effects on Nonhuman Biota Technical Support Document New Nuclear – Darlington NK054-REP-07730-00022 Rev 000.

SENES Consultants Ltd. (SENES). 2011: Toronto’s Future Weather and Climate Driver Study.

Sharpe, D. R. 1980: Quaternary Geology of Toronto and Surrounding Area; Ontario Geological Survey Preliminary Map P. 2204, Geological Series. Retrieved from: http://www.geologyontario.mndm.gov.on.ca/mndmfiles/pub/data/imaging/P2204/p2204.pdf

Statistics Canada. 2012. *Focus on Geography Series, 2011 Census*. Statistics Canada Catalogue no. 98-310-XWE2011004. Ottawa. Analytical products, 2011 Census. Last updated October 24, 2012.

Statistics Canada. 2017. *Focus on Geography Series, 2016 Census.* Statistics Canada Catalogue no. 98-404-X2016001. Ottawa. Analytical products, 2016 Census. Last updated November 8, 2017.

Statistics Canada. 2022. *Focus on Geography Series, 2021 Census.* Statistics Canada Catalogue no. 98-404-X2021001. Ottawa. Released February 9, 2022.

Trinity Consultants. 2017. Sampling Results for Holding Tank 2017 Semi-Annual Sewer Sampling Program – Spring Sampling Event Trinity Project 177201.0131. June 19, 2017.

Trinity Consultants. 2018a. Sampling Results for Holding Tank 2017 Semi-Annual Sewer Sampling Program – Fall Sampling Event Trinity Project 177201.0131. January 16, 2018.

Trinity Consultants. 2018b. Sampling Results for Holding Tank 2018 Semi-Annual Sewer Sampling Program – Spring Sampling Event Trinity Project 187201.0049. June 12, 2018.

Trinity Consultants. 2018c. Sampling Results for Holding Tank 2018 Semi-Annual Sewer Sampling Program – Fall Sampling Event Trinity Project 187201.0049. December 17, 2018.

Trinity Consultants. 2019a. Sampling Results for Holding Tank 2019 Semi-Annual Sewer Sampling Program – Spring Sampling Event Trinity Project 197201.0019. April 1, 2019.

Trinity Consultants. 2019b. Sampling Results for Holding Tank 2019 Semi-Annual Sewer Sampling Program – Fall Sampling Event Trinity Project 187201.0049. October 15, 2019

Trinity Consultants. 2020a. Sampling Results for Holding Tank 2020 Semi-Annual Sewer Sampling Program – Spring Sampling Event Trinity Project 207205.0004. June 3, 2020.

Trinity Consultants. 2020b. Sampling Results for Holding Tank 2020 Semi-Annual Sewer Sampling Program – Fall Sampling Event Trinity Project 207205.0004. December 31, 2020.

Trinity Consultants. 2021. Sampling Results for Holding Tank 2021 Semi-Annual Sewer Sampling Program – Spring Sampling Event Trinity Project 217201.0042. July 19, 2021.

Trinity Consultants. 2022. Sampling Results for Holding Tank 2021 Semi-Annual Sewer Sampling Program – Fall Sampling Event Trinity Project 217201.0042. March 15, 2022

World Health Organization (WHO). 2017. *Guidelines for drinking-water quality: fourth edition incorporating the first addendum*. Geneva: World Health Organization; 2017. Licence: CC BY-NC-SA 3.0 IGO.

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Appendix A

NFPO Toronto CNSC IEMP & MECP Soils Investigation

APPENDIX A – BWXT NEC NFPO TORONTO CNSC IEMP & MECP Soils Study

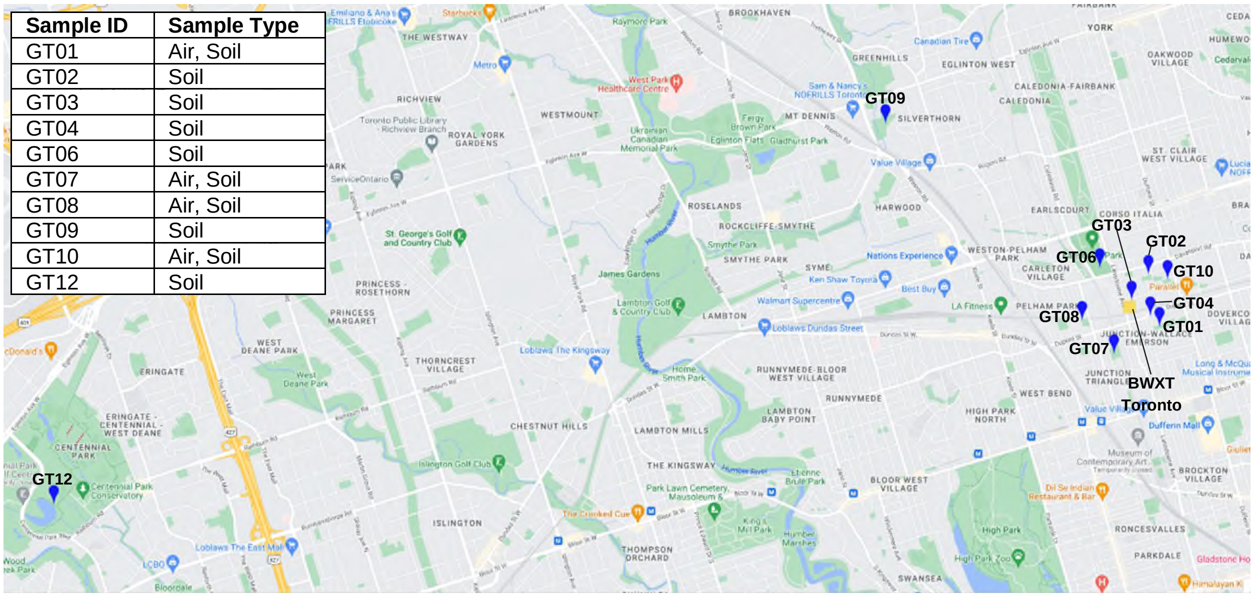
To complement existing and ongoing compliance activities and site monitoring programs, the Canadian Nuclear Safety Commission (CNSC) implemented an Independent Environmental Monitoring Program (IEMP) to independently verify that the public and the environment around licensed nuclear facilities are safe. The IEMP is carried out by CNSC staff in publicly accessible areas and consists of sampling environmental media and analyzing radioactive and hazardous substances (as applicable) released from a facility. This program applies to the BWXT Nuclear Energy Canada Inc. (BWXT NEC) Nuclear Fuel Pellet Operation (NFPO).

The IEMP sampling plan for NFPO focused on uranium. "Uranium is both a radioactive substance (it decays at a slow rate, primarily emitting alpha radiation and, at lower levels, beta and gamma radiation) and a hazardous substance (since exposure to uranium can lead to chemical toxicity)" (CNSC 2022).

The most recent IEMP sampling was in June 2022 for the NFPO and focused uranium in air and soil samples in publicly accessible areas outside the facility perimeter. IEMP sampling at thNPFO for July 2014, June 2016, June 2018, June 2019 also focused on uranium in air and soil. Site-specific sampling plans were developed based on the licensee's approved environmental monitoring program and CNSC regulatory experience with the site (CNSC 2022). IEMP sampling locations are shown in Figure A-1.

The CNSC concluded that:

> *The levels of radioactivity and hazardous substances measured in soil and air were below available guidelines and laboratory screening levels. Screening levels are based on conservative assumptions about the exposure that would result in a dose of 0.1 mSv per year (one-tenth of the regulatory public dose limit of 1 mSv per year). IEMP measurements to date have consistently found levels of radioactivity in the environment to be low and well within the range of natural background radiation levels …*
>
> *Our Independent Environmental Monitoring Program (IEMP) results from 2014, 2018, 2019 and 2022 are consistent with the results submitted by BWXT, supporting our assessment that the licensee's environmental protection program is effective. The results add to the body of evidence that people and the environment in the vicinity of BWXT Nuclear Energy Canada Inc. – Toronto are protected and that there are no anticipated health impacts from the operation of the facilities on the site* (CNSC 2022).



Sample ID	Sample Type
GT01	Air, Soil
GT02	Soil
GT03	Soil
GT04	Soil
GT06	Soil
GT07	Air, Soil
GT08	Air, Soil
GT09	Soil
GT10	Air, Soil
GT12	Soil

(Source produced based on CNSC - IEMP Technical Report 2022)

Figure A-1 CNSC Independent Environmental Monitoring Program – Monitoring Locations

CNSC IEMP Radioactive Substances Monitoring

The CNSC IEMP completed limited sampling of environmental air and soil quality for uranium around the facility starting in 2014. Sample results are summarized in in Table A-1 for radioactive substances.

Table A-1 CNSC IEMP Radioactive Substances Monitoring Data

Sample Type	Sample Description	Parameter	2014	2016	2018	2019	2022	Guideline/ Reference Level	Expected Health Impact (Yes/No)	Sample Code
Air	Ambient (Particulate)	Uranium	0.000128 µg/m³	N/A(1)	<0.003 µg/m³	<0.00005 µg/m³	<0.00014 µg/m³	0.03 µg/m³	No	GT01-A01
Air	Ambient (Particulate)	Uranium	0.0000488 µg/m³	<0.0009 µg/m³	<0.003 µg/m³	N/A	<0.00014 µg/m³	0.03 µg/m³	No	GT07-A02
Air	Ambient (Particulate)	Uranium	N/A	<0.0009 µg/m³	<0.003 µg/m³	<0.00005 µg/m³	<0.00016 µg/m³	0.03 µg/m³	No	GT08-A08
Air	Ambient (Particulate)	Uranium	N/A	N/A	<0.003 µg/m³	<0.00005 µg/m³	<0.00014 µg/m³	0.03 µg/m³	No	GT10-A03
Soil	0-5 cm	Uranium(2)	1.5 mg/kg dry weight	N/A	1.17 mg/kg dry weight	0.98 mg/kg dry weight	0.68 mg/kg dry weight	23 mg/kg dry weight	No	GT01-S01
Soil	0-3 cm	Uranium	1.68 mg/kg dry weight	N/A	N/A	N/A	N/A	23 mg/kg dry weight	No	GT02-S02
Soil	0-5 cm	Uranium	N/A	1.3 mg/kg dry weight	1.47 mg/kg dry weight	1.02 mg/kg dry weight	0.53 mg/kg dry weight	23 mg/kg dry weight	No	GT02-S02
Soil	0-5 cm	Uranium	1.05 mg/kg dry weight	1.6 mg/kg dry weight	1.57 mg/kg dry weight	1.54 mg/kg dry weight	0.85 mg/kg dry weight	23 mg/kg dry weight	No	GT03-S03
Soil	0-5 cm	Uranium	0.72 mg/kg dry weight	1.5 mg/kg dry weight	1.37 mg/kg dry weight	1.2 mg/kg dry weight	N/A	23 mg/kg dry weight	No	GT04-S04
Soil	0-5 cm	Uranium	1.72 mg/kg dry weight	1.7 mg/kg dry weight	1.63 mg/kg dry weight	1.62 mg/kg dry weight	0.68 mg/kg dry weight	23 mg/kg dry weight	No	GT06-S06
Soil	0-5 cm	Uranium	0.87 mg/kg dry weight	1.5 mg/kg dry weight	1.55 mg/kg dry weight	1.24 mg/kg dry weight	0.76 mg/kg dry weight	23 mg/kg dry weight	No	GT07-S07
Soil	0-5 cm	Uranium	1.13 mg/kg dry weight	1.8 mg/kg dry weight	1.91 mg/kg dry weight	1.49 mg/kg dry weight	0.65 mg/kg dry weight	23 mg/kg dry weight	No	GT08-S08
Soil	0-5 cm	Uranium	N/A	1.3 mg/kg dry weight	1.81 mg/kg dry weight	1.34 mg/kg dry weight	0.71 mg/kg dry weight	23 mg/kg dry weight	No	GT09-S09
Soil	0-7 cm	Uranium	0.93 mg/kg dry weight	N/A	N/A	N/A	N/A	23 mg/kg dry weight	No	GT09-S09
Soil	0-5 cm	Uranium	N/A	1.7 mg/kg dry weight	1.78 mg/kg dry weight	1.88 mg/kg dry weight	0.66 mg/kg dry weight	23 mg/kg dry weight	No	GT10-S10
Soil	0-5 cm	Uranium	N/A	N/A	N/A	1.89 mg/kg dry weight	N/A	23 mg/kg dry weight	No	GT12-S12

Notes:

1) N/A = No sample collected
2) For soil samples, the CNSC laboratory began using the partial digestion method as opposed to the total digestion method used before 2020. This change was made so that the 2020 results could be compared with the Canadian Council of Ministers of the Environment guidelines. As a result, soil concentrations are lower than in previous years.

Source: (CNSC 2022)

Air

Under the IEMP, uranium in air samples have been collected since 2014 at the location shown in Figure A-1, as detailed in Table A-1. The maximum measured airborne uranium concentration was 0.00013 µg/m^3 in 2014. Results have been below the method detection limit for all other years. All results are well below the MECP ambient air quality objective of 0.03 µg (U in PM10)/m^3 over a 24-hour averaging period (MECP 2020) corresponding to the sample collection period.

Soil

For uranium soil samples, the CNSC laboratory began using the partial digestion method as opposed to the total digestion method used before 2020. This change was made in 2021 so that 2021 and later results could be compared with the Canadian Council of Ministers of the Environment guidelines. As a result, soil concentrations in 2022 are lower than in previous years and are not directly comparable to samples from prior years. Samples prior to 2022 were therefore not further assessed.

Under the IEMP, uranium in soil samples have been collected since 2014 at the location shown in Figure A-1, as detailed in Table A-1.

In 2022, uranium in soil concentrations measured ranged from 0.53 to 0.85 mg/kg dry weight. All IEMP uranium in soil samples results were below the Ontario background levels which is generally below 2.5 mg/kg and well below the Canadian Council of Ministers of the Environment (CCME) guidelines of 23 mg/kg dry weight for parkland and residential uses. At these low levels, it is expected to see natural variations in the concentrations measured in soil.

NFPO MECP Study

Due to increasing public concern and discussion in the press concerning the uranium emissions (to air) from the facility, in 2013 the m undertook independent soil sampling to verify the findings reported by BWXT NEC (CNSC 2013 and MOE 2013a).

The CNSC served as an observer of both the NFPO and the MECP programs and obtained split samples from both programs to be analyzed by the CNSC's laboratory. The results of all samples were found to be below the applicable CCME and MOECC soil quality guidelines/standards for uranium. Uranium levels in residential area were all within the range of natural variability of uranium in soil.

The MOECC collected samples in 24 public area locations surrounding the Toronto facility (see Figure A-2). The CNSC's laboratory analysis of these samples showed that concentrations of uranium in MECP samples varied from 0.3 to 2.9 µg/g. All samples collected by the MECP staff demonstrated that the uranium concentrations were below the background standards in Ontario, except for location 23 (up to 2.56 µg/g for surface soil: 0-5 cm) and for location 19 (up to 2.93 µg/g for deeper layers of soil). These two sampling locations (19 and 23) are in close vicinity immediately to the east of the facility, at 70 m and 110 m from the facility respectively.

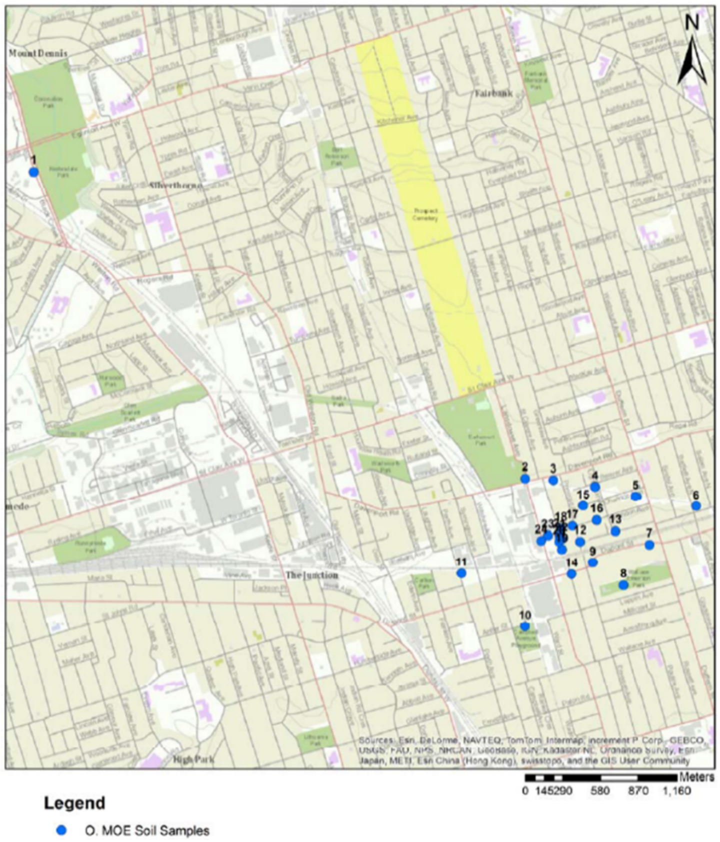


Figure A-2   MOECC 2013 Soil Sample Locations

The MECP concluded that there was “no pattern of either increasing or decreasing soil uranium concentrations with distance from GE-Hitachi. All soil uranium concentrations in this survey were relatively low and there is little evidence that uranium emissions from GE Hitachi have had a measurable impact on soil uranium concentrations in the surrounding residential neighbourhoods” (MOE 2013a).

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